Groundwater & Planning

INTERNATIONAL ASSOCIATION OF HYDROGEOLOGISTS - Irish Group

Proceedings of the 43rd Annual Groundwater Conference

Tullamore Court Hotel, 18th and 19th April 2023

INTERNATIONAL ASSOCIATION OF
HYDROGEOLOGISTS
(IRISH GROUP)

Presents

Groundwater & Planning

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Introduction

Founded in January 1976, the IAH-Irish Group has grown from 10 members to over 150 and draws individuals from professional backgrounds ranging from academic to state agencies to private consultancies. The IAH committee consists of: President, Secretary, Treasurer, Burdon Secretary, Northern Region Secretary, Fieldtrip Secretary, Education & Publicity Secretary, Conference Secretary, plus a conference sub-committee.

Regular activities of the Irish Group include our annual two-day conference (currently held in Tullamore), an annual weekend fieldtrip, and a series of monthly lectures and technical meetings. Funding for the association is derived from membership fees and the annual conference. We welcome the participation of non-members in all our activities. Other activities of the IAH (Irish Group) include submissions to the Irish Government on groundwater, the environment and matters of concern to members, organising the cataloguing of the Burdon library and papers which are now housed in the Geological Survey of Ireland Library, the invitation of a guest expert speaker to give the David Burdon Memorial Lecture on a topic of current interest in the field, and informing the broader research community by contributing to the Geological Survey of Ireland's Groundwater Newsletter.

The Irish Group also provides bursaries to students undertaking postgraduate degrees in hydrogeology and pays the annual subscriptions of a few members in other countries as part of the IAH's Sponsored Membership Scheme. If you would like to apply for a student bursary, details can be found on the IAH (Irish Group) website shown below. IAH are encouraging members to highlight their local IAH Group to their colleagues/ students and to invite anyone they feel may be interested to join.

The IAH (Irish Group) is also a sponsoring body of the Institute of Geologists of Ireland (IGI).

For more information please refer to:	www.iah-ireland.org
Future events:	www.iah-ireland.org/upcoming-events/
IAH Membership (new or renewal):	www.iah.org/join_iah.asp
	www.iah.org/payonline

2023 IAH (Irish Group) Conference **Groundwater & Planning**

It gives me great pleasure, on behalf of all of us on the organising committee, to welcome you to the 43rd Annual IAH Irish Group Conference, and to welcome you to our first in-person conference since 2019. Your continued involvement and support of the IAH Irish Chapter is invaluable.

The theme of the conference this year is *Groundwater & Planning*. Planning impacts or requirements in relation to groundwater usually appear in some form or another at the conference, and when we started talking about a theme of this year it seemed appropriate to make planning the focus. With the publication of the Water Abstraction Act 2023 at the start of the year, this is also bringing a sharper focus on the cross over between groundwater and planning requirements.

While this theme has an Irish focus, we are conscious that 2022 was designated year of groundwater by the United Nations. Looking beyond our border and taking a European and global perspective, the reliance on transboundary groundwater is increasing. The challenges associated with assessment and management of these resources are also increasing. Sanchez and Eckstein (2020)* note that physical assessments of these complex systems are not sufficient by themselves; social, economic, political, cultural and historical perspectives are also required. Dr Karen Villholth (Water Cycle Innovation) will deliver a keynote address on how transboundary aquifers can be managed.

Day One of the conference starts with Donal Grant's keynote overview of the Water Abstraction Act (Department of Housing, Local Government & Heritage), and the early part of the day will have three presentations that focus on planning and environmental law (Dr Rónán Kennedy and Brendan Slattery will present the legal perspective, and Brian Deegan will talk about the outcome of a particular case). This will be followed by presentations that focus on the role of expertise and experience on the island as a whole, and will give practitioners experience and insights into that space where water and planning cross over. Paul Johnston will reflect on his experiences with wetlands and the law, Teri Hayes will consider the role of the expert witness and Paul Wilson will talk about the groundwater environment in Northern Ireland. We'll also have a presentation by Rebecca Ní Chonchubhair – the 2023 IAH Irish Group's Early Career Award Winner.

The final session of the first day will focus on groundwater challenges raising issues that will inform planning choices and decisions, from specific settings (Eileen McCarthy and Andy Trafford will consider peatland site hydrogeology) to climate change implications (Joan Campanya will talk about the likely changes in groundwater flooding scale and magnitude) to Uisce Eireann's insights (Olwyn James).

On Day Two the focus will be on developments in planning. Katie Tedd (GSI) will give an update on Groundwater 3D and the plan for 2023. J.P. Moore will talk about how to constrain groundwater flow direction (especially in the context of assessment and EIAR). Conor Lydon's presentation on Geothermal Planning Submissions is also timely and fits in with the theme of the meeting, as does Padraig Doyle's talk on basement impact assessments.

The final session of this year's conference will focus on communications (and also on the future!). The session kicks off with five short presentations made by the shortlisted Early Career Award candidates – giving us a really good indication (along with Rebecca's presentation) that the future of hydrogeology in Ireland is in good hands! The final two presentations (by Prof Pat Brereton and Maeve Boland) will focus on the importance of communicating complex science to practitioners and non-practitioners, and will send us away with much to think and mull about.

And, after the wrap up lunch, we'll have the welcome return of the exhibitor demonstrations.

Following the conference, we will be sending out a survey to all registrants and we are keen to hear your feedback, thoughts, ideas and suggestions.

The organising committee wishes to express their gratitude to all of those attending this year's and conferences in previous years, and we extend a huge thanks to all of the speakers. We hope you find the conference interesting, educational and thought provoking.

Tiernan Henry
IAH (Irish Group)
Conference Secretary

*Sanchez, R. & Eckstein, G. (2020). Groundwater management in the borderlands of Mexico and Texas: the beauty of the unknown, the negligence of the present, and the way forward. *Water Resources Research* 56: e2019WR026608. (doi.org/10.1029/2019WR026068)

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For more information and contact details please refer to: *www.iah-ireland.org*

Cover Photo Credit: Christopher Newton, ARUP - Artesian Trial Well drilled in the Old Red Sandstone at Kilcolman, Co. Limerick

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The IAH (Irish Group) would also like to acknowledge the support of the following members and organisations whose staff have worked on the committee of the IAH-Irish Group throughout the year and helped to organise the conference:

'Groundwater & Planning'

International Association of Hydrogeologists – Irish Group
43rd Annual Groundwater Conference – Tullamore Court Hotel
Tuesday 18th April – Wednesday 19th April 2023

Programme Day 1, Tuesday 18th April

08:30 – 09:30 Conference Registration: tea, coffee & exhibits

INTRODUCTION

09:30 – 09:45 Welcome: Gerry Baker (*President IAH Irish Group*)

SESSION I

09:45 – 10:15 **KEYNOTE 1: Donal Grant** (Department of Housing, Local Government & Heritage): *Water Abstraction Act 2023*

10:15 – 10:45 **KEYNOTE 2: Dr Karen Villholth** (Water Cycle Innovation): *Transboundary aquifers – What do we know and how can these water resources bring cooperation rather than conflict?*

10:45 – 11:00 Q&A

11:00 – 11:30 Tea & Coffee

SESSION II The Planning Process

11:30 – 11:50 **Dr Rónán Kennedy** (University of Galway): *Planning & Environmental Law*

11:50 – 12:10 **Brendan Slattery** (McCann FitzGerald Solicitors): *The protection of water resources in the planning process: recent legal cases*

12:10 – 12:30 **Brian Deegan** (Uisce Eireann): *Lough Talt IROPI Case*

12:30 – 12:45 Q&A

13:00 – 14:00 Buffet lunch in Tullamore Court Hotel

SESSION III The Role of Expertise & Experience

14:00 – 14:20 **Paul Johnston** (TCD): *Wetlands and the law: a hydrogeological perspective*

14:20 – 14:40 **Teri Hayes** (AWN): *The role of Expert Witness and Oral Hearings*

14:40 – 15:00 **Paul Wilson** (GSNI): *Northern Ireland's Groundwater Environment*

15:00 – 15:20 **Early Career Award Winner: Rebecca Ní Chonchubhair**

15:20 – 15:35 Q&A

15:35 – 16:00 Tea & Coffee

SESSION IV **Groundwater Challenges**

16:00 – 16:20 **Joan Campanya** (SETU): *Assessing the impact of climate change on groundwater flooding*

16:20 – 16:40 **Eileen McCarthy** (UCC): *Peat Stability on Upland Sites: The role of hydrogeology*

16:40 – 17:00 **Andy Trafford** (UCD): *Use of geophysics for ground investigation at peatland sites*

17:00 – 17:20 **Olwyn James** (Uisce Eireann): *Uisce Eireann Planning Applications*

17:20 – 17:35 *Q&A*

17:35 *Posters & Wine Reception (sponsored by iCRAG)*

19:00 *Social event sponsored by IAH – Irish Group*

'Groundwater & Planning'

International Association of Hydrogeologists – Irish Group
43rd Annual Groundwater Conference – Tullamore Court Hotel
Tuesday 18th April – Wednesday 19th April 2023

Programme Day 2, Wednesday 19th April

08:30 – 09:30	Conference Registration: tea, coffee & exhibits
SESSION V	**Developments in Planning**
09:30 – 09:50	**Katie Tedd** (GSI): *Groundwater 3D 2023 Updates*
09:50 – 10:10	**J.P. Moore** (IE Consulting): *Groundwater Flow Direction: EIAR & hydrogeological assessments*
10:10 – 10:30	**Conor Lydon** (Tetra Tech): *Geothermal Planning Submissions*
10:30 – 10:50	**Padraig Doyle** (DCC): *Basement Impact Assessment*
10:50 – 11:05	*Q&A*
11:05 – 11:30	*Tea & Coffee*
SESSION VI	**Communication**
11:30 – 11:50	**Early Career Short Presentations**: *Corine Oggel, Ciaran Higgins, Robert Watson, Sodiq Oguntade*
11:50 – 12:10	**Prof Pat Brereton** (DCU): *Communicating Water Literacy through Active Engagement*
12:10 – 12:30	**Maeve Boland** (iCRAG): *Communicating Complex Science*
12:30 – 12:45	*Q&A*
12:45	*Conference Closing Address: Tiernan Henry (Conference Secretary – IAH Group)*
13:00	*Buffet lunch in Tullamore Court Hotel*

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SESSION I

OVERVIEW OF THE WATER ENVIRONMENT (ABSTRACTIONS AND ASSOCIATED IMPOUNDMENTS) ACT, 2022

Donal Grant, *Department of Housing, Local Government & Heritage, Head Office: Custom House, Dublin, D01 W6X0*

ABSTRACT

Article 11 (3) of the Water Framework Directive requires all Member States to implement measures to control the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water. This provision of the Water Framework Directive has not been transposed into Irish law before now, and this Act is a significant milestone in Ireland's overall environmental protection measures.

Unfortunately, the absence of a comprehensive and modern abstraction management and control regime in Ireland has led to the European Union opening infringement proceedings against Ireland for failure to fully transpose the Directive. This Act will form a considerable part of Ireland's response to these proceedings.

In general, abstraction pressures on our water environment are relatively low compared to some of the more significant pressures identified in the Draft River Basin Management Plan 2022-2027. Detailed assessments of our water bodies by the Environmental Protection Agency (EPA) and the Local Authority Waters Programme (LAWPRO) as part of our river basin management planning cycles will aim to refine and identify the most significant abstraction pressures. This will give us a better picture of the nature of these pressures and the water bodies that are most affected.

Changes to our climate and meteorological pattern in recent years have also given rise to concerns over the management of our water resources. We not only want to have waters of sufficient quality, we also want sufficient quantity of water to supply our growing population centres and industries and help us to continue to produce high quality foods on our land.

Key words: *groundwater, surface water, impoundments, abstractions*

OVERVIEW OF THE ACT

At a high level, this Bill provides for a modern registration, licensing and control regime for water abstractions. Its focus is on the largest abstractions in Ireland, and those smaller abstractions that may be causing short-term or ongoing environmental damage. It is designed to be based on the risk of a waterbody not meeting its environmental objectives under the Water Framework Directive and is not intended to control all abstractions. This risk-based approach is in keeping with the principles of the Directive and is similar to the approach taken in other EPA environmental licensing regimes.

The Bill also includes provisions relating to water impoundment infrastructure associated with abstractions. For example, where a dam or other barrier is interrupting the flow of a river for the purposes of abstracting water, the controls in the licence will extend to the operation of the impounding infrastructure.

KEY ELEMENTS OF THE ACT:

- Modernises the regime for water abstractions which is outdated and limited in scope, being based on legislation enacted in 1942 and 1964;
- Provides for a licensing regime, administered by the EPA, for water abstractions over a specified threshold, and a simple registration system for abstractions below that level, subject to minimum threshold where registration is not required;
- Partially transposes Article 11(3)(e) of the EU Water Framework Directive requiring certain controls over abstractions and impoundments, including prior authorisation, and the Act provides for the registration and licensing of impoundments associated with an abstraction;
- Responds to infringement proceedings initiated by the European Commission;
- Provides an updated power for Uisce Éireann, as the national authority for water services, to take abstractions, subject to EPA licensing, and also subject to an appeal to An Bord Pleanála in relation to possible impacts on third party water rights. Emergency powers will be available to Uisce Éireann to take abstractions where required due to drought or other stated reasons;
- Provides for compensation for material adverse effects caused by interference with water rights by a public abstraction;
- Makes specific provision to allow Uisce Éireann abstract water from ESB reservoirs with the agreement of the ESB,
- Gives specific recognition and protection for canals and other navigable waters under the control of Waterways Ireland; recognise the role of the ESB and Waterways Ireland.
- Ensures that an appropriate legal framework and consenting process is in place to facilitate consideration and determination of the Eastern Midlands Water Supply Project to abstract water from the River Shannon, and for any other large scale water abstractions for public drinking water supplies and other purposes; and
- Gives necessary environmental protections to water sources.

TRANSBOUNDARY AQUIFERS – WHAT DO WE KNOW AND HOW CAN THESE WATER RESOURCES BRING COOPERATION RATHER THAN CONFLICT?

Karen G. Villholth, *Director, Water Cycle Innovation, South Africa*

ABSTRACT

Transboundary aquifers are groundwater resources shared across jurisdictional boundaries, at national or sub-national level. These resources have come to the fore over the last half century, since the mid-late 2000s, as critical for human development and a potential source of cooperation or conflict among sovereign governments. In this paper, the latest knowledge and facts and figures related to transboundary aquifers are presented demonstrating the critical technical advancement in the field, while also highlighting the challenges and opportunities in terms of management and governance of these resources. The UN 223 Water Conference in New York, 22-24 March, 2023, marked a critical moment in humanity's struggle to manage water resources sustainably globally, as it took stock of the mid-term achievements of the UN Water Action Decade (2018-2028) as well as the UN 2030 Sustainable Development Agenda (2015-2030). Based on the outcomes of the UN 2023 Water Conference and previous work, the paper draws lessons and commitments towards better addressing groundwater, and in particular transboundary aquifers globally, as a key component of achieving the UN sustainable development goals.

Key words: *Transboundary aquifers, groundwater, facts and figures, UN 2023 Water Conference, global and regional initiatives*

BACKGROUND

Water is becoming a key global challenge of the 21st century, as manifested and declared at the UN 2023 Water Conference in New York, 22-24 March 2023.[1] Water issues can no longer be viewed simply as a local or national concern, but warrants approaches and cooperation at all levels, including regional, international, and global. This is because the issues faced are increasingly of a transboundary nature, mediated through transboundary water resources flows and exchanges, climate change and atmospheric processes, as well as wide-scale human influences, such as demographic shifts and virtual water flows.

Groundwater, as the largest store of freshwater on earth, is both a fundamental component of the water cycle undergoing increasing stress from overdevelopment and use, as well as being one of the key resources to carefully protect and manage, as it holds one of the most critical solutions to climate change adaptation and water security in the future. How we deal with our groundwater resources in the 21st century will be a testament to our ability to curb many of our contemporary development challenges, including those that have transboundary ramifications. Hence, this paper addresses the advances and challenges related to transboundary aquifers, which over the last 25 years have gained increased attention in the international water management and cooperation agenda. Much has been achieved in terms

[1] https://news.un.org/en/story/2023/03/1135022

of knowledge generation and creating frameworks for cooperation around these resources while much is left for achieving the substantially needed efficient improvements and goals.

Groundwater satisfies a significant part of the world's water demand, particularly in areas with a relatively dry and/or variable climate, and increasingly also in high density population areas (UNESCO and UN-Water, 2022). The utilisation of water resources in transboundary aquifers is expanding to cover increasing demands. However, the institutional capacity and the effectiveness of governance of transboundary aquifers are generally lagging behind, as traditionally focus has been on surface waters (Stephan et al., 2022) . As a result, shared groundwater resources serve as intermittent, but partly underrecognized, gap-filling backstop resources while the resource base at the same time is being undermined in the process, which in turn could lead to future fragility. Hence, it is of utmost importance that transboundary cooperation is set up around these resources in a pre-emptive and integrated way, which ultimately drives shared benefits, in particular relating to peace and security, regional integration, water security and climate resilience.

FACTS AND FIGURES

Significant processes and projects were put in motion in the late 1990s to identify and map shared aquifers globally, building on the increasing recognition of these resources (UNESCO, 2022). This mapping exercise has been an evolving, and still ongoing process, with today 468 transboundary aquifers being mapped globally (IGRAC, 2021). Transboundary aquifers are ubiquitous across continents, and are equally, if not more, prolific than international river basins, of which 286 have been identified globally, with 153 countries having territory within at least one transboundary water body (UNECE and UNESCO, 2021). These aquifer resources are very diverse, ranging from smaller and shallow renewable aquifers shared between two countries, to large deep, and often little-renewable resources under present climate, spanning parts of several nations. Most aquifers link in intricate ways to dependent ecosystems and biodiversity as part of terrestrial and aquatic systems (Villholth et al., 2022). They may differ significantly in the dependence of rural and urban communities on their resources and services (Stephan et al., 2022). However, the gap in managing transboundary aquifers is large. There is currently only about a handful of formal agreements related to transboundary aquifer management globally (Stephan, 2021).

CHALLENGES AND OPPORTUNITIES

Transboundary aquifers suffer from the challenges related to their hidden and underground nature, as evident to aquifers in general. Their transboundary nature adds to the complexity of their management, as the inertia to address emerging issues may be even higher when transactions needed are of a bi- or multilateral character. While groundwater presents additional challenges in terms of understanding and mapping the resources, identifying up- and downstream relations, and cause-effect relationships, opportunities also present themselves to support better transboundary aquifer management through, *inter alia*:

1. The vast experience from addressing surface water cooperation in international river basins (Giordano et al., 2013)
2. The fact that many substantive principles of international water law are similar for surface water and groundwater, e.g., related to the equitable and reasonable utilization, causing no-harm, and informing neighbour states of planned action. However, specific attention to aquifers have been accorded through additional water law instruments, in addition to the most well-known ones developed primarily for surface water, the 1992 Convention on the Protection and Use of Transboundary

Watercourses and International Lakes (the Water Convention)[2], and the 1997 Convention on the Law of Non-Navigational Uses of International Watercourses (the Watercourses Convention)[3]:

   a. The UNILC Draft Article on the Law of Transboundary Aquifers (UNESCO, 2009)
   b. The UNECE Model Provisions on Transboundary Groundwaters (UNECE, 2014)

3. The existence of operational agreements and institutions in place on surface water resources in the same areas, where aquifers could be linked to river or other surface water systems

Yet, monitoring under the SDG 6 framework related to indicator 6.5.2 on "Proportion of transboundary basin area with an operational arrangement for water cooperation", indicate that only 24 nations have all their transboundary waters covered by operational arrangements and only 32 nations have 90% or more of their transboundary basin area covered by operational evidence (UNECE and UNESCO, 2021).[4]

LESSONS, COMMITMENTS, AND INITIATIVES

There is a growing recognition of the need for integrating cooperation on surface water and groundwater, and possibly other resources (like land and source-to-sea processes). There is also a growing acknowledgement of the need for cooperation across sectors, through the nexus approach, in order to fully embrace and tackle wider issues of water in a systemic and coherent manner (UN DESA, 2023). Reflecting this, there is a growing community of practice related to transboundary water cooperation. A significant one launched at the UN-Water Summit on Groundwater in Dec 2022 in Paris, France,[5] the Transboundary Water Cooperation Coalition comprises more than 40 diverse, multi-stakeholder partners from national governments, international organisations, donor organisations, basin organisations, NGOs, civil society organisations and academic institutions. The objective of the coalition is to promote and support both the sustaining and the advancement of transboundary water cooperation in the context of the Water Action Agenda and SDG 6, in light of growing risks, including those linked to climate change[6]. Ambitions include to:

- Increase the proportion of transboundary basin area with an operational arrangement in place in line with SDG indicator 6.5.2.
- Increase the number of Parties to the 1992 Water Convention and the 1997 Watercourses Convention.
- Increase the impact and effectiveness of River Basins Organizations and operational transboundary arrangements to foster regional development and prevent conflicts.
- Increase the number of projects and interventions supporting transboundary water cooperation (e.g., dialogue, analysis of benefits of cooperation, data-sharing, transboundary climate change adaptation, etc.)
- Increase international and national funding for transboundary water cooperation.

[2] https://unece.org/DAM/env/water/documents/brochure_water_convention.pdf

[3] https://legal.un.org/ilc/texts/instruments/english/conventions/8_3_1997.pdf

[4] SDG 6.5.2 criteria for an operational arrangement:

- There is a joint body or mechanism for transboundary cooperation in place.
- There are at least annual meetings between riparian countries.
- A joint or coordinated water management plan or joint objectives have been established.
- At least annual exchanges of data information take place.

[5] https://groundwater-summit.org/

[6] https://sdgs.un.org/partnerships/transboundary-water-cooperation-coalition

The objective and ambitions will be achieved by:

- Lifting the voice of the transboundary water community in an inclusive, diverse but unified manner.
- Demonstrating and communicating the benefits of effective and sustainable transboundary water cooperation, including for upstream countries and in the adaptation to new climate challenges, and how to overcome bottlenecks to cooperation.
- Financial and technical support to initiate dialogue, support and advance cooperation efforts and assess their impacts.
- Providing impetus for concrete actions and commitments related to equitable and sustainable transboundary water cooperation, to "push" progress towards mutually beneficial outcomes.
- Giving particular emphasis on cooperation in transboundary aquifers considering how far behind it lags with respect to international rivers and lakes.

Another significant commitment submitted to the UN 2023 Water Conference relates to Switzerland committing to support transboundary aquifer management in three regions (Central Asia, Middle East and (West) Africa), over the period 2023-2035, channelled through UNESCO's Intergovernmental Hydrological Programme (IHP) and their Groundwater Sustainability and Water Cooperation (GSW) Programme.[7]

Illustrating the interest in sharing lessons and building communities of practice can also be seen from initiatives to co-convene workshops and training programs and building more harmonized approaches to transboundary groundwater assessment and cooperation through guideline development and application, and integration of groundwater management into river basin organisations (UNESCO and IWMI, 2021; UNESCO-IHP and IGRAC, 2021; IGRAC et al., 2013; Villholth and Vaessen, 2013).

CONCLUSIONS

While transboundary water cooperation on rivers date back to the 1800s (Giordano et al., 2013), the same for aquifers only started in the second half of the 20th century (Lautze et al., 2018). Cooperation will be key to peace and stability, and progress is evident. However, while there is currently good momentum around further investments, initiatives, and commitments related to transboundary aquifer cooperation, as well as more conjunctive and integrated approaches, there is still significant work outstanding.

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[7] https://sdgs.un.org/partnerships/switzerlands-contribution-unesco-ihp-governance-transboundary-aquifers-programme

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SESSION II

THE ROLE OF SCIENCE IN PLANNING LAW

Dr Rónán Kennedy, *School of Law, University of Galway*

ABSTRACT

This paper provides a brief overview of the planning law system in Ireland, including its context and purpose. It underlines the complexity of the planning code. It discusses some misconceptions of the system, including the relatively limited control that it provides, the limited capacity of planning authorities to intervene, the disconnection between central spatial planning, climate and other environmental policies, and development plans. It highlights the limits to judicial review, which is deferential to the views of first instance decision-makers. It also discusses the role of science in the planning process, including the views of the Irish courts on the standard of scientific expertise and endeavour which is required and the importance which the Aarhus Convention places on public participation and access to environmental information. It concludes by critically examining the changes to plannnig law which the government is proposing to make in the near future.

Key words: *planning law, judicial review, role of science, scientific standards, Aarhus Convention, planning bill*

THE IRISH PLANNING LAW SYSTEM

HISTORY OF PLANNING LAW

The planning law system in Ireland is intended 'to provide, in the interests of the common good, for proper planning and sustainable development including the provision of housing' (according to the preamble to the Planning and Development Act 2000. However, its history indicates that achieving this lofty goal is not straightforward or universally embraced.

Planning law was developed in response to industrialisation and urbanisation. The Town and Regional Planning Act 1934 was the first comprehensive, coherent scheme of positive planning, but it was not very heavily used due to the economic circumstances of the time and the fact that local authorities needed to pass resolutions to grant themselves planning powers. By 1952 only 17 of 27 had done so, and by 1962 (when the legislation was replaced) there were three who had not done so. The Acts also required planning authorities to prepare a planning scheme 'with all convenient speed'. Only one was prepared, for Dublin in 1957, and only after protracted litigation. The reluctance of planning authorities to be proactive about planning is a constant theme.

The 1934 Act was repealed by the Local Government (Planning and Development) Act 1963, which created a new system with the Minister for the Environment at the core. This came into force on 1 October 1964. Any structure or use that existed before this date is protected and can continue even if it would not be given planning permission now.

The 1963 Act was amended extensively and was replaced by the Planning and Development Act 2000, which 'consolidated' (brought together in one document) all of the changes. However, the 2000 Act has been amended on a more-or-less annual basis, as has the associated Regulations (which provide more detail on the operation of the planning

code), making the system confusing and difficult to follow. The constant tinkering with the law, often in response to some political crisis, is also a recurring theme.

BRIEF OVERVIEW OF PLANNING LAW

The central concept in planning law is 'development'. The general rule is that planning permission (PP) is needed in advance of carrying out any development. Development is either 'the carrying out of any works on, in, over or under land or the making of any material change in the use of any structures or other land' (Section 3(1) of the 2000 Act). 'Works' includes 'any act or operation of construction, excavation, demolition, extension, alteration, repair or renewal' (and cosmetic changes to protected structures). Note that material change of use does not require any works to take place, and that the change of use must be 'material' (significant from a planning perspective) before permission is needed. Certain types of development are exempted and do not need permission. If permission is not granted before development takes place, it is unauthorised and 'retention permission' must be sought or it could be subject to enforcement proceedings.

The central entity in planning law is the planning authority (PA), which is generally the local authority (LA) for the area. The PA will create a 'development plan', which is an 'overall strategy for the proper planning and sustainable development of the area of the development plan' including development objectives. The drafting of the plan must involve an opportunity for public consultation and it is adopted by the elected members of the local authority. The plan provides the constraints within which applications for PP are considered. As planning law limits the constitutional right to property, it must do so in line with the common good as set out in the democratically-adopted plan. Planning permissions that are in 'material contravention' of the plan can only be granted after going through a special procedure.

Applications for PP are made to the PA, following notification to the public through a site and newspaper notice, and should follow a fixed timeline within which a decision to refuse, grant, or grant subject to conditions should issue. Members of the public can make observations on the application, whether or not they have any direct interest in it or the land concerned. In practice, the PA will often request further information from the applicant, which will reset the timeline.

If the applicant or a third party who made observations is unhappy with the outcome, they can appeal the decision to An Bord Pleanála, where the substance of the application will be entirely reconsidered. The legislation sets down an indicative time limit of 18 weeks for this but it is not always met. It is also possible to take a judicial review (JR) case before the High Court, on technical legal grounds only; this can be costly. Individuals must have a 'sufficient interest' in the matter to take a JR; environmental non-governmental organisations (ENGOs) are not subject to this restriction.

Some applications, such as Strategic Housing Developments or Strategic Infrastructure, go directly to An Bord Pleanála. This has not always worked well: the board has made many errors of law (because of a lack of expertise and tight timelines) and decisions have been 'quashed' (overturned) following judicial review by the courts, usually taken by environmental non-governmental organisations.

Under European law, where projects are likely to have significant effects on the environment, they must be subjected to a process of Environmental Impact Assessment (EIA) before any decision is made to grant development consent (in other words, PP). A EIA Report (EIAR) must be prepared and submitted to the PA with the application for PP.

Also under European law, some sites are designated as part of the Natura 2000 pan-European network. These are Special Protection Areas (relevant to the Birds Directive) and Special Areas of Conservation (relevant to the Habitats Directive). Where a plan or project is likely to have a significant effect on a Natura 2000 site, there must be an 'appropriate

assessment' (AA) of its implications in advance. In general, the PA will not grant PP for an application that requires AA 'only after having ascertained that it will not adversely affect the integrity of the site concerned and, if appropriate, after having obtained the opinion of the general public', unless there are 'imperative reasons of overriding public interest' (IROPI), in which case compensatory measures must be taken.

It is important to note that EIA is a technique or a process, not an evaluation, unlike AA. An EIAR could, in theory, be quite negative about a development but PP might still be granted, whereas a negative AA will prevent PP unless IROPI apply.

There are other elements of environmental law which interact with the planning system, such as the Irish Wildlife Acts or European waste management law (which has a certain precedence over domestic planning law).

There is some limited capacity for private individuals or ENGOs to enforce planning laws directly, particularly in emergency situations, but generally this is a matter for the PA, who can apply to court for extensive orders, including complete restoration of a site. However, this process can take a considerable time.

POSSIBLE MISCONCEPTIONS OF THE PLANNING SYSTEM

LIMITS TO CAPACITY TO CONTROL DEVELOPMENT

The planning system limits the capacity of landowners to engage in 'development' but the system is itself limited by the importance which the Constitution places on property rights, which it mentions twice. These can be 'regulated by the principles of social justice' and 'delimit[ed] by law … with a view to reconciling their exercise with the exigencies of the common good', and the courts have accepted that planning law is valid in light of this, even relatively far-reaching measures such as Part V of the Planning and Development Act 2000 (which required that housing estates include affordable housing) but have also held that (for example) the compulsory acquisition of land for the laying of electricity cables without the payment of compensation was an 'unjust attack' on property rights.

CO-ORDINATION AND CENTRAL CONTROL IN PLANNING LAW

The planning system itself is not that well planned. There was significant disconnection between the various geographic levels in the past. The National Spatial Strategy was to inform regional planning guidelines, which would then inform development plans and local area plans. It was sometimes ignored in practice, particularly in the government's decentralisation plan in 2003. This is improving and the National Planning Framework (valid until 2040) has a statutory basis. The new Climate Action Plans are also important, and the Climate Action and Low Carbon Development Acts 2015-21 require LAs to perform their functions in a manner consistent with that legislation, to develop local climate action plans, and for PAs to address the need to reduce anthropogenic greenhouse gas emissions and address the necessity of adaptation to climate change in their development plans. The Planning Regulator has an important role in assessing LA plans for compliance with national strategies.

JUDICIAL REVIEW AND JUDICIAL DEFERENCE

The power of the courts to reconsider planning decisions is limited. JR is a technical process, and is limited to questions of law rather than questions of 'fact and degree'. In a well-known case (*O'Keeffe v An Bord Pleanála* [1993] 1 IR 39), the court articulated a principle of 'judicial deference':

> The court cannot interfere with the decision of an administrative decision-making authority merely on the grounds that (a) it is satisfied that on the facts as found it would have raised different inferences and conclusions, or (b) it is satisfied that the

> case against the decision made by the authority was much stronger than the case for it.

In other words, the courts will not set aside the decision of an expert body because it disagrees with it. Judges do not have scientific expertise and they will not assess scientific evidence directly. Conversely, if decisions of bodies such as An Bord Pleanála are set aside by the courts, that means that the law was not complied with. In planning cases, this will tend to involve a procedural irregularity, such as a failure to consider a factor which the law identifies as necessary.

ROLE OF SCIENCE IN PLANNING

INTEGRATING SCIENCE INTO LEGAL PROCESSES

The legitimacy (and legality) of the planning process relies on informed public participation. Science and scientific information has an important role in this. EIA and AA are particular examples of where the process requires the creation of scientific information, which is intended to be used by decision-makers and by the general public in coming to conclusions about a proposed development. However, this scientific information is not always good quality or well-communicated, particularly to those without expertise. Science is often uncertain and always socially-constructed but sometimes presented as objective fact rather than another element in a decision-making process. Lawyers tend to favour familiar formats and processes, which can ossify the types of science that are used in planning processes and the ways in which it is presented. A key challenge for scientists who produce data for legal, policy, and administrative purposes is to understand the social and economic order that gives rise to the need for this data, to see how their input can itself influence this order, and to determine how best it can be communicated.

LEGAL STANDARDS FOR SCIENTIFIC EXPERTISE AND ENDEAVOUR

In *Ní hEilí v Environmental Protection Agency* [1999] IESC 64, the Supreme Court stated that the Environmental Protection Agency (EPA) must carry out its duties to the highest professional standards but it does not need to do exhaustive research. This principle can be extended to other instances where scientific information is an input into legal processes.

AARHUS CONVENTION

The Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, agreed at Aarhus on 25 June 1998 is an example of a new approach to environmental regulation which tries to involve the public much more in environmental decision-making. It codifies what are known as ‘three pillars’ of access to environmental information, public participation, and access to justice. These are claimed to enhance fairness, legitimacy, accountability, and the ability of the public to protect itself. This
approach has its roots in Principle 10 of the 1992 Rio Declaration on Environment and Development.

ACCESS TO ENVIRONMENTAL INFORMATION

The public have the right to environmental information (EI) that is held by public authorities without stating an interest in that information, unless that information is already publicly available. Many public bodies, such as the EPA, will provide public access to EI through their websites. The definition of EI in Article 3 of the European Communities (Access to Information on the Environment) Regulations 2007–2018 (which echoes the language of the Convention and the European legislation which implements it) is quite broad and arguably captures non-scientific data such as artistic works:

> ‘environmental information’ means any information in written, visual, aural, electronic or any other material form on —
>
> > (a) the state of the elements of the environment, such as air and atmosphere, water, soil, land, landscape and natural sites including wetlands, coastal and marine areas, biological diversity and its components, including genetically modified organisms and the interaction among these elements,
> >
> > (b) factors, such as substances, energy, noise, radiation or waste, including radioactive waste, emissions, discharges and other releases into the environment, affecting or likely to affect the elements of the environment,
> >
> > (c) measures (including administrative measures), such as policies, legislation, plans, programmes, environmental agreements, and activities affecting or likely to affect the elements and factors referred to in paragraphs (a) and (b) as well as measures or activities designed to protect those elements,
> >
> > (d) reports on the implementation of environmental legislation,
> >
> > (e) cost-benefit and other economic analyses and assumptions used within the framework of the measures and activities referred to in paragraph (c), and
> >
> > (f) the state of human health and safety, including the contamination of the food chain, where relevant, conditions of human life, cultural sites and built structures inasmuch as they are, or may be, affected by the state of the elements of the environment referred to in paragraph (a) or, through those elements, by any of the matters referred to in paragraphs (b) and (c);

Access to environmental information (AEI) is distinct from freedom of information (FOI) although sometimes complementary. It has been used extensively by journalists and activists to access EI, has been interpreted broadly by the courts, and has led to the release of limited elements of documents considered by the Cabinet (which are generally confidential under Irish law).

PUBLIC PARTICIPATION

Irish planning law includes significant public participation elements. However, certain aspects of environmental regulation such as forestry, aquaculture and foreshore licencing have been criticised for setting high thresholds for EIA and for high fees for public involvement, particularly appeals.

ACCESS TO JUSTICE

Under European law, decisions involving EIA and Industrial Emissions Directive (IED) licences must be reviewable ‘before a court of law or another independent and impartial body established by law to challenge the substantive or procedural legality of decisions, acts or omissions’. It is also a requirement that ‘[a]ny such procedure shall be fair, equitable, timely and not prohibitively expensive.’

Not all relevant decisions can be appealed to An Bord Pleanála, and it is debatable whether JR meets the requirement of substantive review, as it is a procedural review only.

Court proceedings in Ireland are often slow, and can be costly. There is no legal aid for environmental litigation. The Environment (Miscellaneous Provisions) Act 2011, section 3 provides protection from the usual rule that ‘costs follow the event’ (in other words, the losing party in a court case pays their own costs and the costs of the other side) and in the recent decision in *Heather Hill Management Co. v An Bord Pleanála* [2022] IESC 43, the Supreme Court re-affirmed a High Court decision that a literal interpretation of the 2011 Act is that costs protection applied to ‘proceedings’ as a whole rather than to individual ‘grounds’ (in

other words, once a case involved an EIA/IED point, costs protection extended to the entire case, not simply to that element of it).

PROPOSED CHANGES IN PLANNING LAW

The Government plans to make changes to planning law in the near future, in response to criticisms of the operation of An Bord Pleanála and other issues with the planning system. The main elements of this are:

- Strengthening the legal status of Ministerial planning guidelines
- Extending the lifetime of local development plans from 6 to 10 years
- Statutory mandatory timelines for all consent processes
- Timelines for JR processes
- Enabling An Bord Pleanála to correct an error of fact or law without the permission under challenge being quashed
- Renaming An Bord Pleanála to An Coimisiún Pleanála and re-structuring it
- Designating certain projects as presumed IROPI
- ENGOs must be limited liability companies and must have at least 10 members to be eligible for the access to justice provisions of the domestic implementation of the Aarhus Convention right
- Raising the threshold for standing in JR to 'materially affected'
- Eliminating 'no foal, no fee' litigation

The proposals have been criticised by Community Law and Mediation and Environmental Justice Network Ireland, amongst others, for overly restricting rights under the Aarhus Convention and European law.

SUGGESTED FURTHER READING

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THE PROTECTION OF WATER RESOURCES IN THE PLANNING PROCESS: RECENT LEGAL CASES

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ABSTRACT

Matters of environmental assessment, including the assessment of risk to water resources, now receive more attention in the Irish courts. This is most clear for cases heard in the Commercial Planning and Environmental List. Where such an issue is properly proven and raised in a legal challenge, the court will examine the matter in great detail. Also, the awaited answers to questions asked of the Court of Justice of the European Union about the burden under the Water Framework Directive will be relevant to many assessments. Pending those answers, the only solution is to demonstrate that there is no real risk to water.

Key words: *Water Framework Directive, Environmental Impact Assessment Directive, Habitats Directive, one-off houses, unauthorised waste disposal, water abstractions, Proposed Recast Directive on Urban Wastewater*

RECENT CASE-LAW

WATER FRAMEWORK DIRECTIVE

Whether characterisation and classification of a water body is a pre-condition to permission

On 15 January 2021, the High Court identified serious issues with how Ireland has given effect to the Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy - the Water Framework Directive: *Sweetman v. An Bord Pleanala (Bradán Beo Teo)* [2021] IEHC 16.

The court concluded that a Member State must refuse authorisation for a project that will impact upon a surface water body if either (a) it will cause a deterioration of the status of the body and/or (b) it will jeopardise the attainment of good surface water status or good ecological potential and good surface water chemical status. It is clear both from the very precise wording of the answer given by the CJEU - and indeed the entirety of the decision - in *Case C-461/13 Bund für Umwelt und Naturschutz Deutschland (Weser)* and from the detailed provisions of the Directive itself that the concepts of deterioration and good surface water status are inextricably tied to the complex evaluation framework identified in the Directive.

Taking deterioration first, the obligation is to avoid a deterioration in the "status" of the body. Given the extent to which the assignment of status is regulated by the Directive, status cannot be interpreted, as An Bord Pleanála (the "Board") and the developer had sought, as meaning simply the existing base line of the water body measured in whatever way the body who grants authorisation deems appropriate.

The Board was presented with reports that sought to evaluate the existing status of the lake, including in respect of fish, by reference to certain concepts said to emanate from the Directive, and then to compare that status with the status of the lake post-permission.

The court found there was an insurmountable difficulty in that the status in question was not one assigned following the application of the very precise and detailed methodology of the Directive, by the Environmental Protection Agency ("EPA"). The court found that was the only method of determining status meeting the requirements of the Directive as implemented in Ireland.

Accordingly, without a status as determined in accordance with the Directive, the court concluded it is not possible to evaluate whether there has been a deterioration in that status.

The response of the CJEU to the second and third questions in *Weser* indicates the extent to which deterioration in status is bound up with the assignment of status.

The Board, as an emanation of the State, has an obligation under EU law to refuse permission if either a deterioration in status or a jeopardization of the attainment of good water status will occur, as required by Article 4(1). Where the status has not been determined, the court found a red light ought to have gone off for the Board, and it ought to have realised that it could not evaluate compliance with the requirements of Article 4 (1) until the EPA assigned the water body a status.

On 6 December 2021, after the court was invited to revisit the matter by the EPA, several questions were referred to the Court of Justice of the European Union: [2021] IEHC 777.

In short, the EPA suggested that it did not believe it was necessary that the lake, Loch an Mhuilin, be identified as a Directive water body. This was not a view that had ever been communicated to the court during the hearing of the matter prior to the judgment of 15 January 2021. As the Board observed in their submissions on the re-opening of the case of 30 April 2021: "[i]t is fair to say that all parties and the Court proceeded on the "common assumption" that the status of Loch an Mhuilin for the purposes of the WFD required to be and/or would be determined and that it now emerges that there is at least a possibility that that common assumption was mistaken". The court was satisfied the threshold for re-opening the case is comfortably met under Irish law: the point raised goes to the core of the decision.

The court then referred the following questions:

Question 1:

(a) Are member states required to characterise and subsequently classify all water bodies, irrespective of size, and in particular is there a requirement to characterise and classify all lakes with a topological surface area below 0.5 km²?

(b) To what extent is the position different with respect to water bodies in a protected area, if at all?

Question 2

If the answer to question 1(a) is yes, can a competent authority for the purposes of development consent grant development consent for a project that may affect the water body prior to it being categorised and classified?

Question 3

If the answer to question 1(a) is no, what are the obligations on a competent authority when deciding upon an application for development consent that potentially affects a water body not characterised and/or classified?

The answer from the court in Case C-301/22 is awaited.

Whether risk to groundwater proven

On 16 December 2022, the High Court dismissed complaints about impact on water quality in a challenge to a proposed solar farm in County Offaly: *Concerned Residents of Treason and Clondoolusk v. An Bord Pleanála* [2022] IEHC 700. The court concluded that it had not been factually established that impact on water quality was not assessed, or that the development would result in deterioration of water quality. Essentially, the conclusion of the assessment was that there would not be *any* impact on water quality. Thus, there would not be an adverse impact or other risk of deterioration.

ENVIRONMENTAL IMPACT ASSESSMENT DIRECTIVE

Whether upstream consequences are relevant to assessment

On 16 February 2022, the Supreme Court dismissed the challenge to the permission for a cheese factory in Kilkenny: *An Taisce v. An Bord Pleanála* [2021] IESC 8 (on appeal from [2021] IEHC 254).

An Taisce sought to appeal the decision of the High Court to refuse to quash a decision of the Board dated the 30th June 2020 to grant planning permission in respect of an application by the developer notice party to construct a cheese factory at Slieverue, Co. Kilkenny. The developer is a joint venture between Glanbia and a Dutch company, Royal-a-Ware. The central issue in this appeal is whether the Board was under an obligation to assess – for the purposes of environmental assessment – the upstream consequences of the operation of the proposed cheese factory and, specifically, the milk that is necessary to supply the factory. The High Court (Humphreys J) dismissed the application for judicial review. By a subsequent decision the High Court refused leave to appeal to the Court of Appeal. The Supreme Court granted leave for a direct appeal to this Court pursuant to Article 34.5.4 of the Constitution.

The Supreme Court held that the upstream consequences of the proposed cheese factory were not indirect significant effects liable to be assessed under EIA Directive or the Habitats Directive. The Supreme Court also dismissed the appellant's challenge under the Water Framework Directive.

Hogan J first addresses An Taisce's objection based on alleged noncompliance with the EIA Directive, which requires direct and indirect significant environmental effects of a project to be assessed. At the heart of this objection is the contention that the Board was required to assess the effect of the proposed factory on milk supply as a significant indirect effect that fell within the ambit of Article 3(1) of the EIA Directive.

The court highlighted that the proposed factory would not in and of itself create a demand for milk, since the milk supplied to the factory would be sourced using existing supplies and a projected increase in productivity. While accepting this on its face, the court acknowledged it would reinforce and strengthen the overall demand for milk if only in the particular sense that "in its absence the demand for milk generally would be reduced".

The court observed two possible interpretations of the words of Article 3(1), one which gives the words an open-ended meaning, and a second (adopted by Holgate J in *R.(Finch) v. Surrey County Council* [2020] EWHC 3566) which requires indirect effects to be those which the development itself has on the environment. Subject to one important caveat, the court considered [at 104-105] the second interpretation to be better suited to the particular circumstances of this case, ruling out the open-ended interpretation on the basis that it would in principle lead to almost no limits to the range of possible inquiry required by the EIA Directive and "lead to the imposition of an impossibly onerous and unworkable obligation on developers preparing an [environmental impact assessment report]." The court observed [at 102] that this meant that "matters such as the construction of the plant or emissions from the plant etc. must be identified and assessed, but, generally speaking, not matters such as

environmental impacts of the inputs (e.g., milk production) or outputs of the factory (e.g., the environmental consequence of the plastic wrapping of the cheese).” Although, there may well “be special and unusual cases where the causal connection between certain off-site activities and the operation and construction of the project itself is demonstrably strong and unbreakable. In those special and particular cases the significant indirect environmental effects of these off-site activities would fall to be identified and assessed.”

The court concluded that because any effect on the general milk supply in the State by reason of the establishment of the cheese factory “remains entirely elusive, contingent and speculative”, the effect cannot be the sort of significant indirect effect which Article 3(1) of the EIA Directive must be taken necessarily to contemplate.

The final issue addressed by the Court was whether the Board was precluded by Article 4(1) of the Water Framework Directive from granting planning permission for the proposed factory. The court considered this issue on the merits notwithstanding the contention that it was never pleaded and fell outside the scope of the proceedings. As the lower River Suir (where discharges from the proposed factory would enter) had achieved a “good status” for the purposes of Article 28 of the Surface Water Regulations 2009, there was no impediment to the Board granting permission by reference to Article 4(1)(a) of the WFD in light of the Court of Justice decision in Weser (Case C-461/13, EU:C: 2015: 433). Hogan J further rejects the argument that the effect on watercourses from individual farms supplying milk to the factory preclude the Board from granting permission since these farms fell outside the “project” of the proposed factory.

HABITATS DIRECTIVE

What mitigation measures are relevant to screening for appropriate assessment

After the decisions in *Heather Hill Management Company clg v. An Bord Pleanála* [2019] IEHC 450 (refusing the appeal certificate), *Uí Mhuirnín v. Minister for Housing Planning and Local Government* [2019] IEHC 824, *Sweetman v. An Bord Pleanála (IGP Solar)* [2020] IEHC 39 and *Highland Residents Association v. An Bord Pleanála* [2020] IEHC 622, it seemed the view on “mitigation measures” at screening was settled.

The state of the law was synthesised in *Sweetman (IGP Solar)* as follows:

> “(a) In carrying out a screening exercise, the precautionary principle must be applied;
>
> (b) A stage 2 appropriate assessment must be carried out if, on a screening exercise, it is not possible to exclude the risk that a proposed development will have a significant effect on a Natura site;
>
> (c) The appropriate time to consider measures capable of avoiding or reducing any significant effects on the site concerned is at the stage 2 appropriate assessment when a comprehensive analysis of those measures can be carried out and a determination reached as to whether they will or will not be effective;
>
> (d) Taking account of such measures at the screening stage is liable to undermine the protections afforded by the Habitats Directive. To take account of the measures at the screening stage runs the risk of circumventing the stage 2 assessment which constitutes an essential safeguard under the Habitats Directive;
>
> (e) It is accordingly impermissible, at the screening stage, to take account of measures intended to avoid or reduce the harmful effects of a proposed development;
>
> (f) The question of the intention underlying the measures in question is to be assessed objectively. Thus, the language used in any document generated in the course of the screening exercise is not determinative;

> (g) On the other hand, there may be cases where, having regard to the language used by the competent authority (or in some document relied upon by the competent authority) it is obvious that the measures in issue were designed to avoid and reduce any impact on the relevant site. As Simons J. observed in Heather Hill, this is what happened in People over Wind where the measures concerned were expressly described as "protective" with reference to the relevant site;
>
> (h) On the other side of the coin, there may be cases where it is clear that the measures in question were adopted not for the purpose of avoiding or reducing the potential impact on the relevant site but were adopted solely and exclusively for some other purpose. This is exemplified in the decision of Barniville J. in Kelly where the relevant measures were found, as a matter of fact, to be a standard component in virtually all projects; they were not in any way directed to the protection of any Natura site.
>
> (i) On the other hand, the fact that one of the purposes of the measures in question may have no connection with a Natura site does not exclude the possibility that there may be more than one purpose for the measures. In cases where such an unconnected purpose is identified, it is therefore necessary to consider whether, as a matter of fact, the measures were also intended to avoid or reduce the impact of the development on the Natura site.
>
> (j) That said, it is not legitimate to work backwards from the existence of measures and to assume from their existence that the proposed development must be likely, in the absence of such measures, to have a significant effect on the relevant site. As Simons J. observed in Heather Hill, any such temptation to take that course must be resisted;
>
> (k) In considering whether measures fall foul of the People over Wind principle, it is not usually helpful to consider whether the measure is "integral" to the project or is something "additional". This is because it may be difficult in practice to draw a meaningful distinction between the two. A developer may well anticipate the need for particular mitigation measures and arrange for those to be "built in" to the project.
>
> (l) In each case, it is essential to analyse the measures in question in the context of the screening exercise carried out by the competent authority (and any documents relevant to that exercise) and to determine, on an entirely objective basis, whether the measures can be said to have been intended to avoid or reduce harmful effects on a Natura site or whether the measures were designed solely for some other purpose."

On 27 May 2021, that changed, when Humphreys J delivered judgment in *Eco Advocacy clg v. An Bord Pleanála* [2021] IEHC 265. He indicated that he would refer a question to the Court of Justice on whether the competent authority is entitled "to take account of features of the plan or project involving the removal of contaminants that may have the effect of reducing harmful effects on the European site solely on the grounds that those features are not intended as mitigation measures even if they have that effect, and that they would have been incorporated in the design as standard features irrespective of any effect on the European site concerned".

The case concerns the proposed development of 320 dwellings in Trim, County Meath near the river Boyne and River Blackwater SAC and SPA, 640 metres to the north, with, it seems, an acknowledged hydrological connection between the development site and the European site. (More correctly, a stream 100m from the site boundary provides that connection.)

The court reviewed the Irish cases and suggested the issue was not so clear:

> "67. Insofar as the People Over Wind judgment has been applied in Irish jurisprudence, there are a medley of cases including Kelly v. An Bord Pleanála [2019]

> IEHC 84 (Unreported, High Court, Barniville J., 8th February, 2019), Heather Hill Management Company CLG v. An Bord Pleanála [2019] IEHC 450 (Unreported, High Court, Simons J., 21st June, 2019), Uí Mhuirnín v. Minister for Housing, Planning and Local Government [2019] IEHC 824 (Unreported, High Court, Quinn J., 5th December, 2019), Sweetman v. An Bord Pleanála [2020] IEHC 39 (Unreported, High Court, McDonald J., 31st January, 2020) and Highlands Residents Association v. An Bord Pleanála [2020] IEHC 622 (Unreported, High Court, McDonald J., 2nd December, 2020). Despite the submission that this point is acte clair, I for one find it not quite as easy to reconcile the multitude of judgments as the board seems to suggest. The primary emphasis in these cases seems to be on whether the measures are intended to reduce the impact on the European site concerned as opposed to whether they have that effect. But at the same time there are suggestions in the jurisprudence that the intention is not decisive. I personally do not necessarily find those two propositions to be self-evidently entirely consistent. If intention isn't automatically decisive in a particular case, something else must be, and that presumably must be effect. One or other of the two approaches has to be right – it can't be both.
>
> 68. There is also some difference in emphasis in the Irish cases as to whether it is relevant that the measures are standard practice or not. Again, I am not sure that I would describe the judicial writings on that point as self-evidently being an entirely clear and consistent line of authority. I certainly do not think that I can be totally confident that the Irish caselaw taken as a whole is completely clear and user-friendly as to what the People Over Wind decision means.
>
> 69. There is an important factual context here which is that there is a pathway in the present case between this site and the European site. The surface water will run off into the tributary that feeds directly into the river the subject of the SAC and SPA."

After hearing from An Taisce and Client Earth, who joined as amicus curiae, the court made the reference on 4 October 2021, [2021] IEHC 610.

The Advocate General has delivered her opinion: AG Kokott put her the answer the following way:

> "107. The taking into account of measures which are adopted irrespective of whether there is a risk that protected sites will be affected cannot, however be regarded as circumventing an appropriate assessment. Disregarding those measures would, on the contrary, amount to a failure to take the project fully into account at the screening stage. This is clearly the case, in my opinion, in the example of the connection to the waste water collecting system: it is hard to imagine residential buildings in the European Union today where the waste water is discharged directly into waterways or even on to the street, as it was in the past. It would therefore be absurd, for the purpose of an appropriate assessment, to assume that such practices might be employed on a housing development. In the case of the contested measures to treat surface water run-off, that position is not quite so obvious but still holds good.
>
> 108. The answer to the fourth question must therefore be that, at the stage of screening the need for an appropriate assessment under Article 6(3) of the Habitats Directive, features of the plan or project involving the removal of contaminants that may have the effect of mitigating a harmful effect on the protected site may be taken into account, where it is clear, on the basis of objective considerations, that those features were incorporated into the design as standard features irrespective of any effect on the protected site concerned, and all reasonable scientific doubt concerning their effectiveness can be ruled out."

Whether risk to groundwater proven

On 3 October 2022, the High Court dismissed complaints about the assessment of the risk of cement leaching to groundwater near the river Shannon: *Environmental Trust Ireland v. An Bord Pleanála* [2022] IEHC 540. The challenge was successful on other grounds. The Board had granted permission for student accommodation, part located on the site of a former petrol station. The court was satisfied with how the developer and the Board assessed the construction of the proposed basement. The court could not find any proven defect in the approach of the Board. Put simply, the burden of proof had not been discharged.

ONE-OFF HOUSES

On 4 May 2022, the High Court dismissed the challenge to a decision of the Board refusing planning permission, at the third attempt, for the construction of a single dwelling, wastewater treatment system and associated works at Roscam Townland in Galway: *Madden v. An Bord Pleanála* [2022] IEHC 257. The court was concerned with the Habitats Directive and the impact of the wastewater treatment system. The court could not find any defect in the approach of the Board.

UNAUTHORISED LANDFILL

Remediation required even where achieving quality standards

On 21 March 2023, the High Court delivered the fifteenth judgment in connection with illegal dumping on a site in Whitestown, County Wicklow: *Brownfield Restoration Ireland Limited v. Wicklow County Council* [2023] IEHC 137. This concerned the draft remediation plan for the site. The court was unimpressed with a suggestion that data was historical, so that results of further testing would be relevant to the standard of remediation required: “The legal system cannot tolerate a situation where the default setting is that every year is year zero as far as the Whitestown dump is concerned ,every time the site is reviewed it must be treated in effect as if it was newly-discovered, everything that has happened to date is “historical”, and in effect “more research is needed” before anything can be done”. For example, at an area were construction and demolition waste had been disposed, while nitrate concentrations were below groundwater quality standards, the court was more persuaded that they were higher than what would be expected as a natural background concentration. The court refused to approve a remediation plan that would leave waste in place.

Punishment for unauthorised waste disposal

On 14 March 2023, the Court of Appeal set aside a penalty imposed for contempt of court, where an order requiring remediation had not been complied with: *Meath County Council v. Hendy* [2023] IECA 55. Groundwater samples from outside and down-gradient of the waste bodies indicated that leachate generated from within the waste body was impacting groundwater quality outside of the landfills’ footprints. An order for remediation was made, compliance with which would have cost between an estimated €2 million and €6 million. The order was not complied with. The High Court found there was contempt of that order, and imposed a fine of €6.2 million, ostensibly to fund the Council to complete the remediation. The Court of Appeal found the cumulative impact of the orders made to be impermissibly expropriative and disproportionately penal. In particular, the Council had no obligation to carry out any works. The owners were precluded from carrying out any works and were ordered jointly and severally to pay a fine the quantum of which, according to the appeal court, “demonstrably, in light of the uncontested evidence with regard to their means, is wholly impossible for either to ever comply with”.

RECENT LEGISLATION

PROPOSED

Water Environment (Abstractions and Associated Impoundments) Act 2022

This Act, enacted on 20 December 2022, but not yet commenced, provides for a modern registration, licensing and control regime for water abstractions including for a right to compensation for damage to or interference with land, or material adverse effect on rights, titles or interests in easements, way-leaves, water rights, fishing rights or other rights over or in respect of water, in consequence of the carrying out of a public, temporary or emergency abstraction by Uisce Éireann.

Proposal for a Directive concerning urban wastewater treatment (recast)

This proposal for revising the rules on treating urban wastewater aims to protect better the health of Europeans and the environment. Several measures are proposed that will be progressively applied until 2040. The revision will enlarge the scope of the current Directive to cover all cities with more than 1,000 inhabitants. New rules will also cover rainwater and will require EU countries to establish integrated urban wastewater management plans in large cities. The proposal introduces a binding energy neutrality target for the whole sector, at Member State level. Producers of pharmaceuticals and cosmetics will be required to pay for the cost of removing micropollutants that come from their products and end up in wastewater and measures are proposed to improve governance in the wastewater sector.

Proposal for a Directive amending Directive 2000/60/EC establishing a framework for Community action in the field of water policy, Directive 2006/118/EC on the protection of groundwater against pollution and deterioration and Directive 2008/105/EC on environmental quality standards in the field of water policy

The proposal fulfils the Commission's requirements to regularly review and update the list of priority substances that pose a risk to the aquatic environment.

LOUGH TALT IROPI CASE

Brian Deegan, *Uisce Eireann*

SESSION III

WETLANDS AND THE LAW – A HYDROGEOLOGICAL PERSPECTIVE

Paul Johnston, *Dept Civil, Structural and Environmental Engineering, Trinity College University of Dublin*

INTRODUCTION

Wetlands, by definition, are wet and hence, inextricably linked to hydrology. Their ecology is thus primarily dependent on climate and water supply as well as the geology on which they reside. Indeed, a wetland forms in the landscape by the temporary retention of precipitation as it runs off or drains to the sea or evaporates in the hydrological cycle. A wetland and its ecology is therefore not a static entity, but dynamic. It is this hydro-ecological dynamic which is the most difficult to define in legal terms sufficient to serve for a wetland's protection and management. There is no law in Ireland at the moment that is devoted exclusively to wetlands, although many EU Directives and their translation into Irish law refer to wetlands as part of their remit. As a result, there has been considerable confusion in decision-making when wetlands have been involved in planning and development issues. The inherent uncertainty in defining and understanding hydrological and hydrogeological conditions has not helped the decision-making. Many planning decisions involving wetlands have resulted in judicial reviews concerning different interpretations of environmental impact and the uncertainties involved.

This brief review is intended to outline the hydrological context for wetland hydro-ecology, the core principles of the legal framework as it exists and two recent case histories illustrating the problems of interpretation. A recommendation for a coherent policy on wetlands and their management is made.

WHAT IS A WETLAND? – THE RAMSAR CONVENTION.

The only legal instrument specifically devoted to wetlands is the Ramsar Convention on International Wetlands which came into force in 1971 and which now has 172 signatory member countries including Ireland (since 1985). Its value is in the enunciated principles for wetland management and a definition of wetlands which is both comprehensive and commonly adopted in other legislation, such as the EU Water Framework Directive (2000/60/EC). A wetland is defined as "areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres". In Ireland, this would include lakes, rivers, floodplains, callows, bogs, fens, and turloughs as well as marine and coastal wetlands, many of which have been significantly altered from their original state. The basic principles of management under Ramsar are twofold: 'conserve, restore and ensure wise use of wetlands' and 'to identify and protect wetland sites of international importance' of which there are currently 45 in Ireland. The key principle is the 'wise use' of all wetlands not only those identified for particular protective measures. This dichotomy has penetrated many of the subsequent EU Directives (eg the Habitats Directive 92/43/EEC) dealing with water and ecology in which some wetland habitats are designated for specific protection (such as SACs, NHAs, SPAs) at the same time as the Directive declares all stated waters and habitats are deserving of protection and sustainable management. For example, this dichotomy frequently leads to confusion when

interpreting what degree of protection a particular turlough (which may be a listed habitat but not a designated site) might have when potentially impacted by some development.

A recent planning case in South Connemara dealing with abstraction from a very small (<50ha) lake has led to questions seeking clarification of the WFD from the European Court of Justice over this point. While the WFD declares protection of all surface waters, it recognizes the difficulty of defining 'status' for very small water bodies (eg over 12000 lakes in Ireland), allowing integration of several such water bodies as a single entity. However, legally the problem remains as to how to interpret potential impact on a single member small lake if it does not have a status of its own?

WETLANDS AS FUNCTIONAL SYSTEMS

Wetlands depend for their existence on a supply of water moderated by the geological setting in the landscape. The dependent vegetation and ecological communities respond to the dynamics of the hydrological/hydrogeological system. Given the definition of a wetland, research has shown the predominant controls on the ecology are the frequency and duration of water levels in the wetland together with any fluctuations in quality. A similar control affects marine wetlands but also related to tidal inundation. Moreover, the water level/quality dynamic is not confined to the wetland itself but is related to the corresponding hydrological dynamics in the area supplying the wetland. Thus, the sustainability of the wetland also depends on the sustainability of the recharge/supply. Ascertaining impact or damage to the wetland involves an understanding of both dynamics. Too often Environmental Impact studies treat wetlands, mostly only designated ones, as a kind of areal minefield which a project development just has to avoid. Legally, however, the connection between supply area and the wetland itself is well recognized, as in the WFD: if a designated wetland is 'at risk of impact', so is the groundwater body supplying it, as in Groundwater Dependent Terrestrial Ecosystems (GWDTE). What happens for listed. but undesignated, wetland habitats remains somewhat vague.

Setting target values for sustainable water levels or quality criteria is fraught with difficulties of interpretation in terms of defining impact. While conventions have emerged as to what appropriate statistics to use, limited violations of a particular target metric may or may not be interpreted as unacceptable impact. Much will depend on site specific conditions and such metrics are not legally binding. More work is needed on defining resilience of particular wetland hydrolo-ecologies which take into account frequency and duration of levels and quality.

Most legislation involving wetlands, however, recognizes the need for holistic analysis over simple metrics but does not specify how to determine a 'sustainable wetland'! The Ramsar Convention talks of 'wise use' of wetlands. Article 6 of the Habitats Directive states 'authorities agree to the plan or project only after having ascertained that it will not adversely affect the integrity of the site concerned'; and the proposed EU Nature Restoration law (2022) will require 'Member States to restore ecosystems also outside the Natura 2000 network'. The interpretation of 'integrity' has already caused confusion legally since the word has tended to be taken literally, in terms of wetland area, rather than function. This approach was endorsed by the ECJ in the first planning case of the Galway outer ring road which was refused permission when a relatively small proportion of the limestone pavement area of the Lough Corrib SAC was at stake. The problem has emerged more recently in the refusal of planning permission for the widening of the N59 to Clifden, in blanket bog, an SAC.

Integrity, on the other hand, can be defined in terms of 'consistency of function' rather than just on area alone (which, in any case, does not take into account the supply/recharge area of the wetland. 'Wise use' also might be considered to imply a more pragmatic interpretation of 'integrity'. A good example is Pollardstown Fen which has been modified to be the

principal supplier of water to the Grand Canal (Waterways Ireland) for over 200 years. Nevertheless, the fen (notwithstanding the case of the Kildare bypass) could be argued still to be a fen in good condition, its natural function, as a wetland, unimpaired by supplying the Canal.

On the other hand, does the construction of a windfarm on a partly excavated raised bog impair the bog's integrity as a wetland? While every site is different, the lack of recognized criteria for defining impact and integrity (especially under wetland restoration law) means many projects will continue to suffer judicial review.

'Restoration' poses similar problems in the sense of differing (or unstated) legally backed targets. The Nature Restoration law merely states the restoration of peatlands as the objective but with carbon sequestration in mind. Ireland's Climate Action Plan (2023) under Land Use Land Use Change, Forestry (LULUCF) states that the restoration and rehabilitation of peatlands is a target for 2030 mainly focused on support for climate change. A legal challenge to the success or otherwise of the restoration of wetlands needs definable criteria and objectives based on corresponding hydrological monitoring.

SUMMARY

As yet, there is no coherent policy in Ireland on wetland management, restoration and sustainability. However, many aspects of wetland management are treated in EU Directives on water and ecology, as translated into Irish statute law. However, the focus is often on designated wetlands such as SACs, SPAs and NHAs rather than on the wider spectrum of wetlands as encouraged in the Ramsar Convention and echoed in the other Directives such as the WFD and the Habitats Directive. But, legally, the interpretation of impact or potential damage on a wetland is made difficult by the lack of appropriate metrics for the functionality of a wetland, rather than its areal extent. A wetland is hydrologically and ecologically a dynamic entity which requires time-based criteria to describe its resilience and sustainability. For the same reasons, restoration and rehabilitation of peatlands as required under the Climate Action Plan (2023) and the proposed EU Nature Restoration Law needs definable targets. To make legal decisions in planning and on determining impact on wetlands, hydro-ecological monitoring is essential both before and after projects are constructed.

CASE STUDIES

POLLARDSTOWN FEN

Perhaps infamous by now, but the tiny whorl snail, Vertigo geyeri, has become the 'fall guy' for delaying the construction of the M7 Kildare bypass by some 10 years. Although the original planning hearing for the 12km road was held in 1993, the delay in starting construction was a classic case of there being a lack of criteria to determine environmental impact (it was in the early days of Appropriate Assessment, AA and before the WFD) as well as being a misguided reliance on areal integrity. Legally it was thought that, as the fen was 4km from the proposed road, that there was not any credible threat to the ecology including the snail. The source of the water for the fen was the vast Curragh outwash gravel plain and in which the road was situated. Initial thoughts about potential impact were credible as the drawdown effects from dewatering the road in a cutting in gravel would be limited in extent. However, the snail, as the most sensitive qualifying species in the fen was known to occupy a very insecure habitat, often on moss covered tufa (skeletal calcium carbonate) on the edge of the wetland. Hence the risk of impact, though it was originally thought to be small, eventually caused the case to be referred to 'Brussels'. Further information was sought which caused extensive hydrogeological and hydrometeorogical investigations to be undertaken both regionally and on the fen, while carefully avoiding any impact on the snail

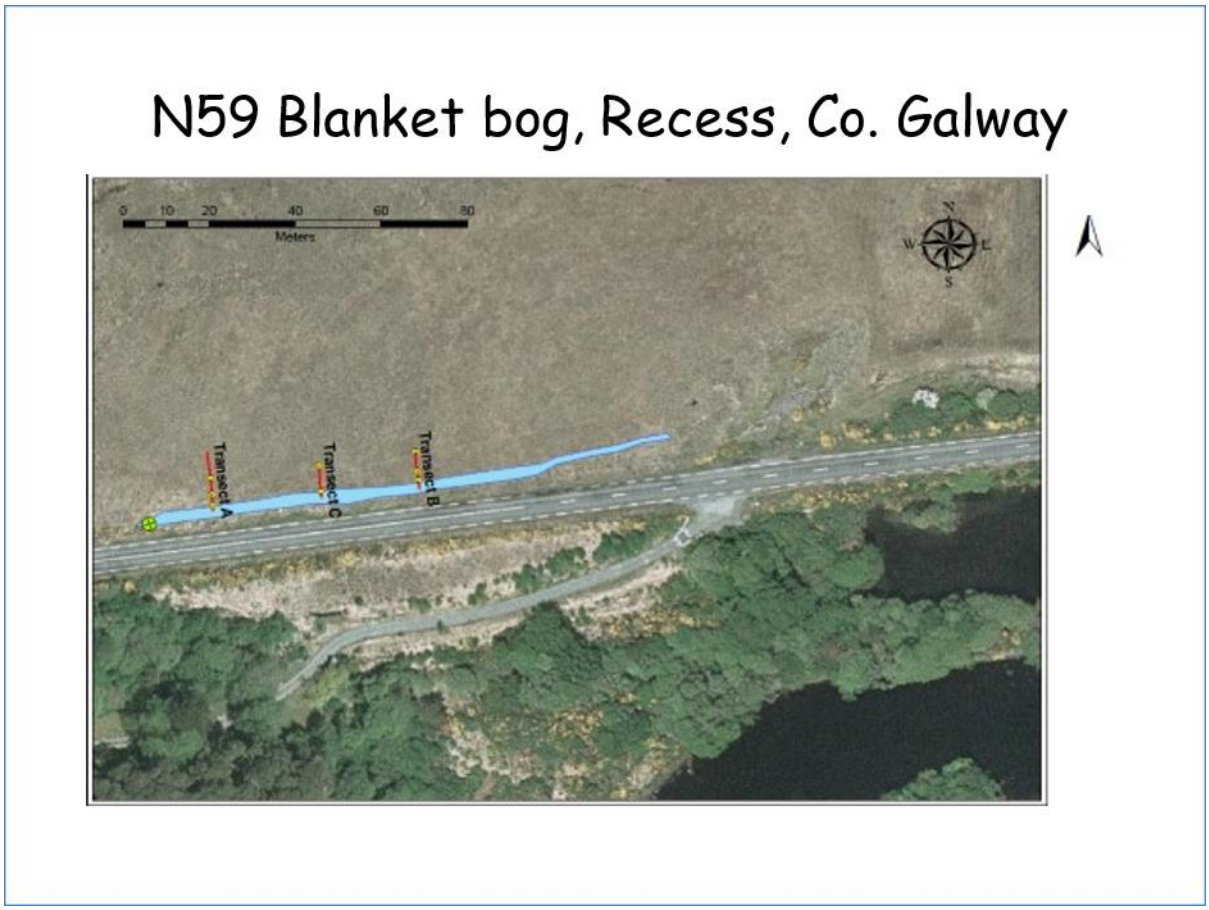
habitat itself. Modelling was also undertaken with international involvement of hydro-ecologists from the UK, Ireland and the Netherlands. Eventually it was determined that the snail and its tufa habitat was indeed very sensitive to a narrow range of water levels (+/- 5cm) which in turn were controlled by very low groundwater seepage rates through a thin layer of peat over the gravel at the margin of the fen. A modest range of water table levels in the upgradient Curragh plain gravels could still maintain the required upward seepage rates at the snail habitat but greater drops in water table while dewatering the road cutting would be detrimental. The changes in water table level at the road were being propagated through to the fen margin since the aquifer is partially confined by a layer of glacial clay till in between. Thus, the risk to the habitat was deemed to be significant. Mitigation measures of tanking and lining the road, aimed at maintaining water levels at the road and seepage rates at the fen habitat, were designed and implemented. Unfortunately, the snail suffered an ill-fated demise during the construction phase of the road when dewatering lowered levels temporarily by over 5m coupled with an unusually dry summer - and in spite of attempts to irrigate the habitat artificially. However, since the successful re-establishment of the seepage rates, the habitat has suffered from other factors such as lack of grazing which also affects the accumulation of plant material in the vicinity as well as an absence of animal movements to assist in snail migration. In retrospect, a lack of understanding of how the fen habitat functioned as well as how the proposed road was likely to affect the water supply to the fen were critical to the decision making at the planning stage. Moreover, in the end, there was no doubt as to the impact of the road affecting the integrity of the fen wetland – the snail is a listed, protected species under the Habitats Directive and a qualifying species for the SAC, so it is integral to defining Pollardstown as a fen wetland and Ramsar site. (Compare the case of the initial Galway ring road for which it could be argued that the small area of affected limestone pavement was not integral to the functioning of the Lough Corrib wetland?)

One consequence of the Pollardstown case is that permanent real-time groundwater monitoring stations have been instrumented at the groundwater divide and at the fen margin. Hydrometric monitoring is an essential adjunct to sustainable management of wetlands.

Figure 1 Pollardstown Fen Catchment area as part of the Curragh Plain

N59 ROAD WIDENING, WEST OF MAAM CROSS

There has been a longstanding proposal to widen and improve the single carriageway road to Clifden west of Maam Cross in Connemara. The road runs on granite and metamorphic outcrop through blanket bog, much of which is an SAC. The initial proposal, although essentially an improvement to the existing road, was refused planning permission on the grounds of the widening cutting into the blanket bog. Again, this was an instance of affecting the integrity of the SAC, mainly on the basis of areal loss. However, the issue here is that the legal basis of such a decision is not addressing the point of either the Ramsar convention or the Habitats Directive – ie the functioning of the bog as an integral unit. In this case, investigation found that the current road, underpinned by gravel, had already compromised the functioning of the blanket bog by providing a drainage route which affected the ecology of the margins. Therefore, a scheme was designed to partially line the proposed widened road not only to reduce the drainage effect but also to raise the water table at the margins of the bog along the road. Unfortunately, the strict interpretation of the Habitats Directive Article 6 precluded the use of the mitigation measure. Such is an example of where legal interpretation should 'integrate' with hydrogeological interpretation – and where the EU principle of subsidiarity and a comprehensive wetland policy could help.



Similar situations have arisen in turlough flooding in the West. Turloughs are listed habitats and many are SACs, but some have been interfered with locally in an attempt to prevent flooding in particularly wet periods. Often, swallow holes or estavelles in the karst have been blocked with various debris in attempts to prevent ingress of water and stop the turlough overtopping and flooding the surrounding landscape. Sometimes, these attempts are misguided as they make the flooding regime worse. However, 'restoration of wetlands' would suggest that such blockages could be removed if natural conditions could be restored and other methods for flood alleviation implemented (providing turlough ecology were conserved). The legal position here is unclear, as the view is often taken that if a blockage

has been in place for some time, it now forms part of the natural regime and should be left as such. Again, the interpretation of 'restoration' (and its objectives) and 'integrity' needs clarification. The hydrogeological perspective is not always in tune with the legal one!

REFERENCE LEGISLATION

EU Habitats Directive, Directive on the conservation of natural habitats and of wild fauna and flora, 92/43/EEC, 1992 as amended by Directive 97/62/EC, Regulation 1882/2003, Directive 2006/105/EC untitled (europa.eu)

EU Environmental Impact Assessment Directive 2014/52/EU on the assessment of the effects of certain public and private projects on the environment DIRECTIVE 2014/•52/•EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL - of 16 April 2014 - amending Directive 2011/•92/•EU on the assessment of the effects of certain public and private projects on the environment - (europa.eu)

EU Nature Restoration Law, 2022, Proposed Regulation 2022/06 Nature Restoration Law (europa.eu)

EU Water Framework Directive, 2000, Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, EUR-Lex - 32000L0060 - EN (europa.eu)

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UNECE Aahrus Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters, UN Economic Commission for Europe, Aahrus, 1998 and EU Directive 2003/35/EU on Public participation

UNESCO, The Ramsar Convention on International Wetlands, 1971, Homepage | Convention on Wetlands (ramsar.org)

EXPERT WITNESS – LESSONS LEARNED

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ABSTRACT

A good Expert Witness is one with both professional qualifications and practical experience. In addition, the ability to clearly communicate in writing, by illustration (e.g. Conceptual Site Model –(CSM)) and verbally is essential. The objective of Expert Witness advice is to inform the Judge/ Inspector. The hydrogeological report prepared for hearings should, at a fundamental level, clearly outline the existing environment and demonstrate the effects of the impact being assessed over time, in language readily understood by the lay person.

Reference to current guidelines provides a sound basis for methodology and is very useful in inspiring confidence in the Inspector/Judge. Some guidelines provide specific assessment plans/ procedures/ steps applicable to the proposed development. Consultation with relevant stakeholders is a key component in determining the appropriate scope of the study undertaken.

Judicial rulings have led to additional hydrogeological assessments in the last few years. Examples include (i) the Balscadden judgement which has resulted in increased assessment of subsurface infrastructure at planning stage and (ii) judgements regarding 'inadequacies' in Appropriate Assessment (AA) Screening which have resulted in the need for hydrogeological/ hydrological risk assessments to support the AA work. In addition, screening for Water Framework (WFD) Assessments has commenced with guidance expected imminently.

Lastly, some points are provided in order to aid the Expert Witness to stay focussed on addressing the Judge/ Inspector's own requirements. The court room/ planning hearing is an unfamiliar world for the Hydrogeologist but with continued practice and focus, this experience can be very satisfying and informative.

INTRODUCTION

There was a time when a Hydrogeologist could show up at an oral hearing/ court and the Inspector or Judge would rely on their professional opinion alone. However, the emergence of 'citizen scientists' (with ready access to good data on the internet) and our more litigious environment has rightly driven the requirement for professional opinion to be fully supported by a 'fact based' approach.

As an Expert Witness, your purpose is to help the Judge/ Inspector in making their final decision. The Judge/ inspector will also generally ask the Expert Witness questions to aid their own understanding of the case material. Cross-questioning by barristers, planners, public authorities, non-governmental organisations and solicitors on behalf of members of the public can be particularly useful in testing the arguments made as well as in exploring areas of difference presented by the experts present.

As a result, Hydrogeologists - like all other scientists - now need good skills in communication (verbal and written) and an ability to engage the listener. Technical assessment and interpretation together with communication are necessary skills in bringing a project from fruition to final grant of planning. There is a requirement for the assessment and conclusions of same to be readily understood by the lay person.

This paper outlines some of the learnings I have had in the planning and licencing process, particularly focussing on presenting as an Expert Witness.

USE OF GUIDANCE DOCUMENTS

A plethora of guidance documents exist to support and guide a Hydrogeologist when undertaking any technical assessment. These guidelines are extremely useful in providing a checklist of what should be addressed within a baseline assessment and provide an analytical approach in this and subsequent assessments with the aim of making such assessments as complete as possible as deemed reasonable for the site in question. That said, a seasoned solicitor once advised me that guidelines are not law. In my view, the role of a good technical Hydrogeologist is to consider guidelines like a shop from which we procure the most relevant aspects for the specific site and environmental setting we are assessing.

The methodology/ approach taken by a Hydrogeologist should be clearly outlined in the report/ Expert Witness statement. It is quite easy for a barrister in cross examination, to criticise conclusions where the methodology is not outlined and supported with reference to particular guidelines.

For Environmental Impact Assessment (EIA) relevant guidance includes the following:

- *Guidelines on the Information to be contained in Environmental Impact Assessment Reports* (EPA, 2022),
- *Guidelines for the Preparation of Soils, Geology and Hydrogeology Chapters of Environmental Impact Statement* (IGI, 2013), and
- *Guidelines on Procedures for Assessment and Treatment of Geology, Hydrology and Hydrogeology for National Road Schemes* (NRA/TII, 2009).

Some guidance documents are specific to development type/ assessment. Examples of these include:

- *Recommended Collection, Presentation and Interpretation of Geological and Hydrogeological Information for Quarry Developments*, (IGI, 2007),
- *Guidance on the Authorisation of Discharges to Ground*, (EPA, 2011), and
- *The Classification of Hazardous and Non-Hazardous Substances in Groundwater,* (EPA 2010).

Designing your assessment approach following these guidance documents can be very useful in giving confidence to the Inspector/ Judge. Having a guidance document to hand can also be helpful in encouraging clients (particularly developers chasing unrealistic deadlines) to facilitate a more thorough assessment as not undertaking such works can ultimately lead to [unnecessary] delays incurred by a Further Information Request (RFI)/ appeal scenario. To build a thorough conceptual understanding of the development site, the Hydrogeologist will need to understand seasonal variability in the water table. Naturally, if it is Summer time (low water levels), your client may not be very happy at having to wait for the winter/ high water table before submission for planning. However, as outlined in the quarry guidance and basement impact guidance (for example Appendix 9), these documents specifically highlight the importance of determining and presenting this sort of information (refer Figure 1 below).

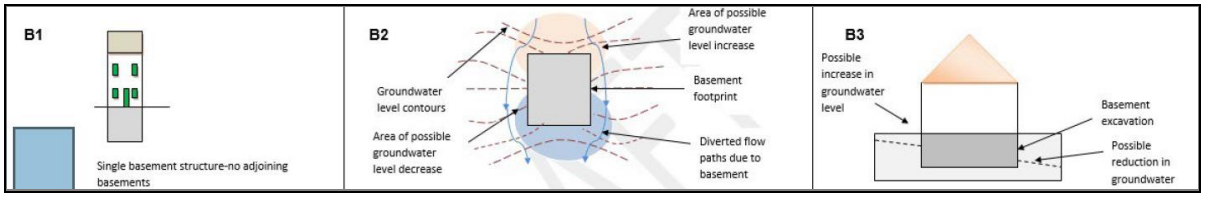

Figure 1: *Extract from Basement Impact Assessment [BIA] Guidance [1] which shows the need for data collection on the groundwater regime in the immediate vicinity of a proposed development.*

EFFECT OF JUDGEMENTS

As a result of challenges to planning approvals in the courts, there have been a number of judicial rulings which impact on what data/ information requirements Hydrogeologists now need to consider when preparing technical assessments and reports as part of planning requirements.

An example is a recent ruling by Mr Justice Humphreys (2020), i.e. the 'Bascaddan Case' [2]. The development (a series of apartments on a hillside) in Howth, Co. Dublin had been approved and following appeal was granted by An Bord Pleanála (ABP). Following this, the case was taken to judicial review on a number of grounds.

Mr Justice Humphreys described the lack of subsurface drawings as "a fundamental problem" as the stability of the site was a crucial issue for the Applicants. He concluded that the drawings were 'inadequate' in terms of demonstrating the adequacy of the mitigation proposed with regard to the subsurface. A relevant section of the actual judgement is presented below:

- 64 "*Structure*" is defined by the Planning and Development Act 2000 s. 2(1) as meaning "*any building, structure, excavation, or other thing constructed or made on, in or under any land, or any part of a structure so defined, and—(a) where the context so admits, includes the land on, in or under which the structure is situate ...*". So the Act reinforces the ordinary meaning in that respect by expressly referencing subterranean structures. Obviously, meanings in an instrument are normally those in the parent Act (Interpretation Act 2005, s. 19), and the 2001 regulations albeit amended by subsequent legislation are themselves made under the 2000 Act.

The court quashed the permission and refused to remit the matter to the Board.

Although, it can be seen by most practitioners, with any understanding of geology, that the risk due to lack of subsurface drawings in this case was high, there is now a drive by some legal teams to close off any risk of an appeal by including drawings and an assessment of subsurface structures, e.g. piling, etc. This requires the Hydrogeologist to demonstrate the impact of such structures on the natural groundwater regime. Sometimes this makes sense, for example where a development substructure could impact on groundwater flow patterns within a sensitive environment, e.g. karst limestone adjacent to a Natura 2000 site. However, matters such as foundation works are part and parcel of most developments and have little risk where bedrock is effectively investigated and assessed as 'competent'.

Another series of judgements regarding Appropriate Assessment (AA) Screenings has led to the need for hydrogeological/ hydrological risk assessments to support the conclusions of the Ecologist(s), e.g. Case C-323/17 People Over Wind v Coillte[3]. In this case, the Court of

[1] Dublin City Development Plan, 2022-2028, Appendix 9 Basement Development Guidelines

[2] 2020_IEHC_586 - Balscadden

[3] Case C-323/17 People Over Wind v Coillte

Justice of the European Union (CJEU) ruled that mitigation measures could not be taken into account at the screening stage of an AA.

Section 177V of the PDA 2000 provides that an AA must include a determination by the planning authority under Art. 6 (3) of the Habitats Directive[4] as to whether or not the draft plan would '*adversely affect the integrity of* ' a European site. The threshold at the screening for AA is a very low one. Thus, full appropriate assessment (i.e. a Natura Impact Assessment (NIS)) is now mandatory where there is a risk that the plan or project will have a 'significant' effect.

There were a number of influential cases in Irish courts which demonstrated the need to be definitive in showing that mitigation had not been considered in determining the conclusions of the AA screening exercise. An AA must include an *'examination, analysis, evaluation, findings, conclusions and a final determination'* [5]. Secondly, it must contain complete, precise and definitive findings and conclusions and may not have *lacunae* or gaps. This requires analysis, evaluation and decisions in light of the best scientific knowledge in the field as outlined in Eoin Kelly v ABP (2019)[6] when Mr Justice Barniville found the Board and its inspector did not, in fact, apply an incorrect test for screening of the development under the Habitats Directive as had been argued. They held that Sustainable Drainage Systems (SuDS) were not unlawful mitigation measures as SuDs were not intended to avoid or reduce harmful effects. The decision also did not contain any "gaps or lacunae" with particular reference to run-off from concrete during the construction of the [Aldi] store.

As an approach to dispel all reasonable doubt, recently there has been a requirement for a competent person (Hydrogeologist) with expertise in source-pathway-receptor (S-P-R) linkage assessment to demonstrate that construction and operational impacts without mitigation do not have a potential to impact the existing water environment at Natura 2000 sites.

Lastly, there is a legal requirement for achievement of Good Status for all waters in compliance with the Water Framework Directive - WFD[7]. Many planning reports are now supported by WFD assessments. Irish guidance on undertaking this type of report is expected imminently. In the meantime, a good UK guidance exists (Advice Note 18 Assessment[8]). The conclusion(s) within the WFD assessment needs to state the assessed impact, e.g. '*There is potential for minor temporary or localised effects on the "XXX" groundwater body. However, it has been assessed that it is likely/ unlikely that the Project will cause any significant deterioration or change in water body status or prevent attainment or potential to achieve the WFD objectives*'. Where non-temporary deterioration is noted (after mitigation) then further assessment is required and consideration of *Article 4.7 Derogation* needs to be undertaken.

SITE ASSESSMENT, CONSULTATION AND SCOPING

A site assessment is generally necessary if a Hydrogeologist is to develop a robust Conceptual Site Model (CSM). A Hydrogeologist may have expert understanding of the regional groundwater regime but needs to build on that at a local or site scale. Showing up at an oral hearing with a desk study and not having walked the site can leave your argument weak, e.g. not being aware of the local holy well or sink hole in the neighbouring field is

[4] Article 6(3) of the Habitats Directive and Section 177U of the Planning and Development Act 2000 (as amended) (the "2000 Act").

[5] *Kelly v ABP* [2014] IEHC 400

[6] *Eoin Kelly v An Bord Pleanála* [2019] IEHC 84

[7] *EU Water Framework Directive (2000/60/EC) – S.I. No. 722/2003 European Communities (Water Policy) Regulations 2003*

[8] *Advice Note 18 (2017), Planning Inspectorate UK Government.*

going to undermine confidence in your argument. The importance of consulting locally and finding out site-specific information from ground truthing is essential at the very minimum.

Another critical assessment is communication with local residents (where feasible) and relevant planning authorities to gather local site specific information. This sort of consultation, including at the pre-planning/ early stages, can focus the scope of the hydrogeological study and improve your site-specific understanding of S-P-R linkages. The new Basement Development Guidelines (DCC)[9] specifically recommend consultation. The document adds: *'This guidance document is intended, therefore, not to be prescriptive, but rather to provide general guidance on the typical scope of information to be included in such assessments. It is advised that applicants engage with the Environment and Transportation Department prior to lodgement of the application to agree the scope and detail of the Basement Impact Assessment'.*

Consultation and scoping therefore provides an opportunity, based on your site-specific details, to target your intrusive/ other ground investigations and assessment(s) rather than just comply with every possible part of the guidance methodology.

EXPERT WITNESS – SOME HINTS TO CONSIDER

An oral hearing is not a place to give an 'unsupported' opinion, and definitely not a place to give opinion on areas you do not have the technical expertise in. Leading an Expert Witness to areas outside of your area of expertise is a classic tactic in cross examination often with the aim to undermine what you actually have to offer in advising the Judge/ Inspector. Remember your reason for attendance at the hearing is to advise the Judge/ Inspector and not the person cross examining. Communicate clearly what you know and have studied about the Project and do not get distracted. It is absolutely fine to respond with "*this is outside of my expertise*" and refer it to someone else in the team who could be more helpful in responding to that particular query.

Never respond to questions about personal opinion. At a hearing for a certain incinerator project, I was frequently asked in cross examination, if I and my family would like to live beside an incinerator. Whether you have experience of living beside incinerators in other European cities is unimportant as that opinion is not why you are present at the hearing. The best policy is to remain polite, but address the Judge/ Inspector and advise that your area of expertise is hydrogeology and it might be better to use the time available to be questioned on this expertise. They will then typically shut down this line of questioning.

Be clear at the beginning, what your qualifications and area of expertise are. If questioned on something that you feel is confusing or has been asked just to distract from the evidence you have to present, turn to the Judge/ Inspector and say you are not clear on what is being asked and perhaps if it is helpful you could outline the findings of your assessment. Generally, the Judge/ Inspector will then ask direct questions and you will have fulfilled your role of helping them make their decision. If you feel something has not been addressed adequately in your cross examination, you can request the Judge/ Inspector to see if you could clarify it. Generally this will be allowed. You are an Expert Witness not the accused!

Check your data. Check your dates and your drawings. Incorrect or errors in data can undermine the impact of your opinion. Barristers will use any weakness to distract from what you have to advise. Entire hours of hearings have been lost where the expert has been shown to have incorrectly labelled laboratory results sent to the laboratory and sample IDs differed to the sample locations on drawings. Getting small things wrong, lowers confidence and distracts from the opinion you are there to impart to the Judge/ Inspector. The same is true in all reporting.

[9] *Dublin City Development Plan, 2022-2028, Appendix 9, Basement Development Guidelines*

At commencement, turn your body to address the Judge/ Inspector – this helps you focus on addressing your advice to them rather than be drawn away by the person cross examining you. One well known cross examiner at oral hearings, is known for walking around, pulling your attention away from your direct communication with the Judge/ Inspector. Stay focussed and be wary of tactics.

If you don't have the answer at hand – e.g. if you need time to do a calculation/ assess data. You can ask for time to do this so that you can give a qualified answer. The Judge/ Inspector may be more than happy to take a break or to allow you revert to this the next day.

At a planning hearing or in reporting as part of a response to further information (RFI) etc. the information you provide will form part of the EIAR. This is an opportunity to give further information if required.

COMMUNICATING WHATS HIDDEN

Typically, the Judge/ Inspector has a lot of data from many experts being presented within a number of days. Presenting a robust CSM in your report/ witness statement and being able to readily and simple communicate it is key to success.

As Hydrogeologists, we are dealing with explaining the dynamics hidden beneath the ground. A visual CSM is therefore a key tool in communication. There are lots of excellent schematics for different hydrogeological environments and processed in the public forum to aid in design. An example for demonstrating why hydrocarbons can be detected intermittently in fractured rock is presented below.

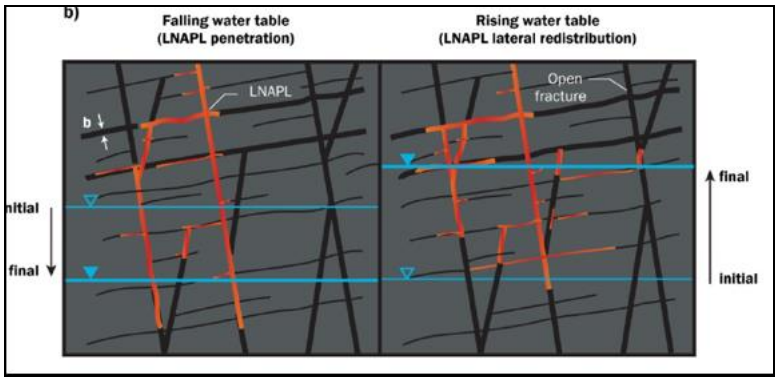

Figure 2: Conceptual representation of diesel LNAPL entrapment by a fluctuating groundwater surface (from CLAIRE, 2014)[10]

Site-specific source pathway receptor CSMs are really useful as a basis for describing processes. Apart from literary descriptions, these can typically take the form of a cross section view across the key attributes on that development site and will usually include for the identified environmental receptors, as shown in the CSM schematic example below.

[10] CLAIRE, (2014). *An illustrated Handbook of LNAPL transport and Fate in the Subsurface*

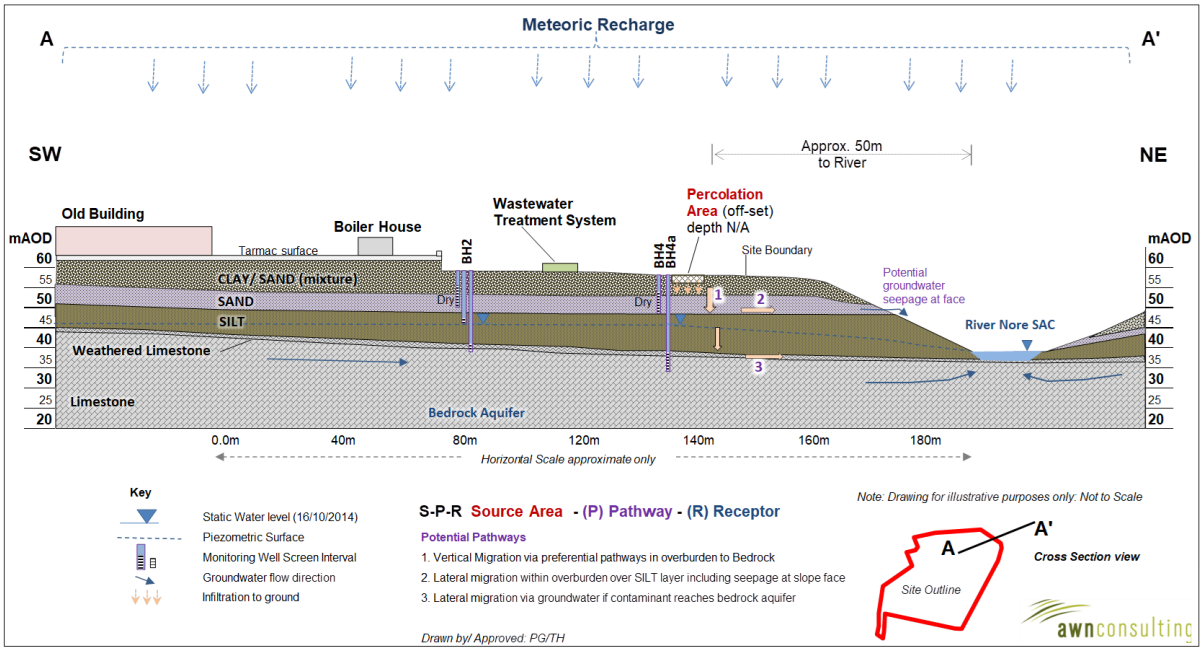

Figure 3: *Example of cross section (discharge to ground S-P-R linkage).*

CONCLUSIONS

The objective of Expert Witness advice is to inform the Judge/Inspector. To achieve this, an Expert Witness should be both suitably qualified and skilled in communicating scientific knowledge. The supporting written report/expert witness statement should provide a clear methodology which follows guidance documents (where appropriate) and be written in language readily understood by the lay person. Use of illustrated CSMs will aid in provision of a clear understanding of the effects of the impact being assessed.

Consultation with relevant stakeholders is a key component in determining the appropriate scope of the study undertaken.

Recent judicial rulings have led to additional assessments to be undertaken by the hydrogeologist. In addition, screening for WFD Assessments has commenced with guidance expected imminently.

Cross examination during hearings can be challenging. However, if the Expert Witness can stay focussed on providing a clear understanding to the Judge/ Inspector and avoid distraction, this experience can be very satisfying and informative.

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NORTHERN IRELAND'S GROUNDWATER ENVIRONMENT

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ABSTRACT

Northern Ireland's Groundwater Environment has been characterised and summarised in a new book by the Geological Survey of Northern Ireland. Until now, Robins (1996) publication, The Hydrogeology of Northern Ireland, has been the main reference on groundwater in Northern Ireland. However, much has changed in the 27 years since it was published. New technologies, research, ways of visualising groundwater as well as new priorities and regulations influence the way we look at, use, and understand groundwater. This book is the starting point for a new wave of groundwater development in Northern Ireland. It provides a consistent approach to conceptualising the different aquifers found in Northern Ireland using the most up to date research and knowledge. This consistency will help hydrogeologists, planners, and regulators to all speak the same language when it comes to Northern Ireland's Groundwater Environment.

Key words: *Northern Ireland, Groundwater, Book, Aquifer, Conceptual Model*

INTRODUCTION

Whether you are exploring for a new groundwater supply or submitting a planning application for a new landfill site, it is important that the hydrogeological community have a consistent approach to how they view and communicate the difficult hydrogeological concepts that underpin their work. To facilitate this, it is the expected role of the Geological Surveys to provide a regional overview of the different aquifers found within their jurisdiction and to characterise the hydrogeological properties and processes they each demonstrate. This is especially important when it comes to applying to acquire planning permission for a major development, a discharge or abstraction license. Both those developing the hydrogeological assessments and those reviewing them should be given the same consistent platform upon which to conceptually understand the groundwater environment in question.

To facilitate this, The Geological Survey of Northern has spent the past 5 years compiling relevant hydrogeological information and data on Northern Ireland's groundwater environment. The result is a new book called 'Northern Ireland's Groundwater Environment' which is being launched at this conference, and an accompanying 1:250,000 – scale aquifer dataset, attributed with all the relevant summary physical and chemical statistics for each aquifer (Figure 1).

This paper explains what the new book contains, how it should be used and what comes next.

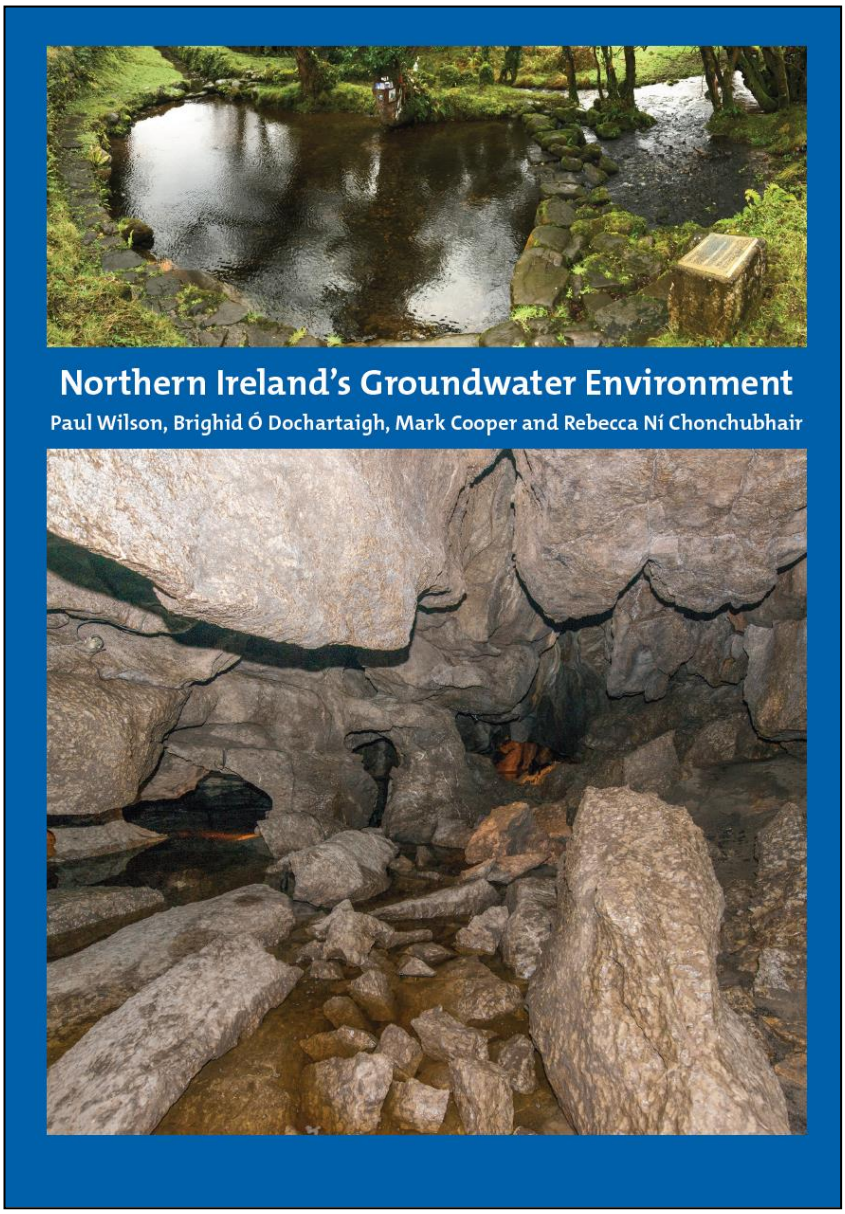

Figure 1: *Northern Ireland's Groundwater Environment book cover*

CONTENTS

The book is laid out as follows:

1. Introduction – This explains how to use the book, provides an overview of the groundwater in Northern Ireland, and explains what roles it has and how it is managed.
2. Groundwater Data – This describes the sources of hydrogeology data that have contributed to the Northern Ireland Groundwater Data Repository (NIGDR), how the data has been handled, provides a summary of all the data statistics, and presents a groundwater recharge map for Northern Ireland.
3. Aquifers and hydrogeology of Northern Ireland – This is the main section of the book which starts by describing how aquifers are defined and discussing some of the hydrogeological concepts that are common to Northern Ireland's aquifers such as fractured aquifers and igneous dykes. A comparative summary of all the eleven different aquifers is then given. A section is then provided for each aquifer, showing

its extent, its key characteristics and presenting a conceptual model of how water recharges, flows through and discharges from each aquifer. Summary statistics are then given for both aquifer properties and baseline chemistry.

4. Groundwater management in Northern Ireland – This section lays out the relevant regulations which serve to regulate and manage groundwater use and protection in Northern Ireland.
5. Hydrogeology in Northern Ireland: a timeline – The final section provides a brief history to the unique story of groundwater use, development, and research in Northern Ireland.

DATA

The aquifer property and chemistry data used to derive summary statistics for each aquifer were supplied from the NIGDR. This contained records of over 2000 boreholes and springs, not all of which had records of aquifer properties and chemistry. Figure 2 below shows a map of the ten different bedrock aquifers and the distribution of the boreholes and springs from the NIGDR that provided useful aquifer properties and/or chemistry data for the summary statistics in the book and aquifer dataset.

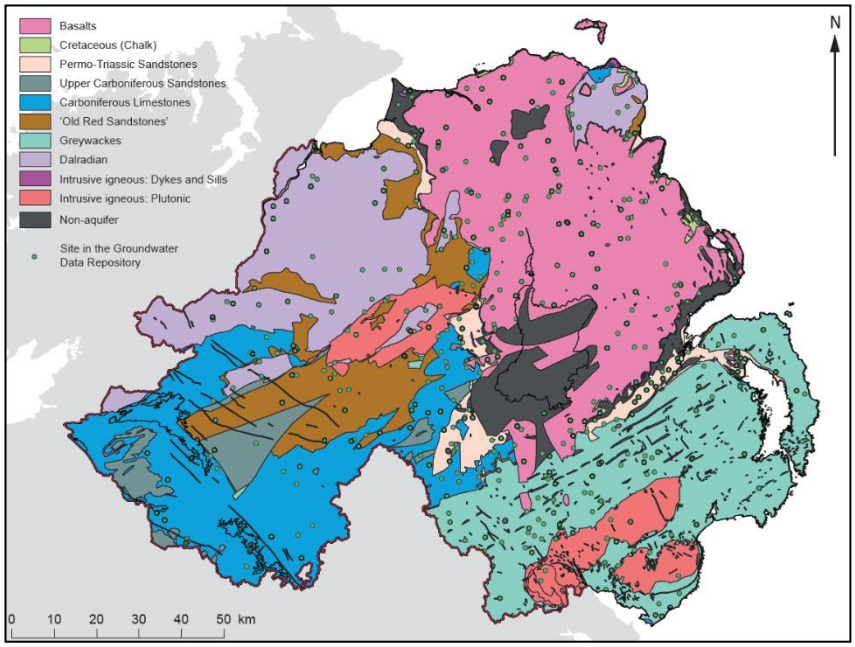

Figure 2: *Northern Ireland's bedrock aquifers, boreholes and springs data points*

Quality assurance procedures were developed that were applied to the aquifer property and chemistry data (Ó Dochartaigh and Wilson, 2021). This was important as not all the data was collected or derived using the same methods. This is represented in the book as a consideration of reliability.

AQUIFER DATASET

With Geographic Information System (GIS) applications the main way that spatial datasets are now viewed and used, alongside this book, a 1:250,000 – scale aquifer dataset has been developed. This is available to be downloaded or to be loaded in using online based applications. Traditionally, printed aquifer maps were developed, and whilst there still is a place for printed maps, one of the unique features of spatial datasets is the ability to attribute features. This new aquifer dataset has been attributed with all the summary aquifer characteristics, properties and chemistry that is provided in the book. This is a significant step forward and will enable a user to click on one of the different aquifers and view the

characteristics of that aquifer. For example, if you are curious about iron concentrations in the Permo-Triassic Sandstones, you can click on them and scroll until you find the 25th, 50th and 75th percentile values. This also means that the dataset can be viewed and presented by a user to represent any of the attributes contained within it. If you wanted to see how iron concentrations compare against all the eleven aquifers, you could generate a map to display that.

CONCEPTUAL MODELS

One of the big challenges hydrogeologists must deal with is conveying complex hydrogeological concepts in a way that is understandable, not overwhelming but still accurate and representative. This is especially important when the audience need to appreciate the concepts as relate to an important decision that they must make. Tackling this challenge was one of the main aims of this book from the start of its development. The use of graphics was built in early in the hope that the concepts, as described in the text, could be represented in a clearer and more understandable way. A graphic designer was brought on to the project team and working with geologists and hydrogeologists, starting first with hand drawn concepts and colouring pencils, 3-dimensional conceptual model drawings were developed. Some examples are shown in Figure 3.

AQUIFER COLOURS

One simple way that has been used in the book to help guide the reader through it has been to use colour as a visual guide. The colours used for each of the aquifers shown in Figure 1 and the Superficial deposits aquifer, are closely related to the main rock types that make up each aquifer. For example, the Basalt aquifers are represented by a pink colour which is like that used for both the Upper and Lower Basalt Formations. This means that the aquifers dataset, visually looks like the bedrock maps from which it is derived, which is deliberate to help with visual recognition.

Further to this, the same colours have been used throughout the book. Figure 4 shows an example boxplot where the colours used in the boxes match those for each aquifer. Rather than having to look at the x-axis to work out which box is which, it should be easier to distinguish between them. The aquifer section in chapter 3 have been given a colour band around the pages so that when referring to a particular aquifer, it should be easier to locate it.

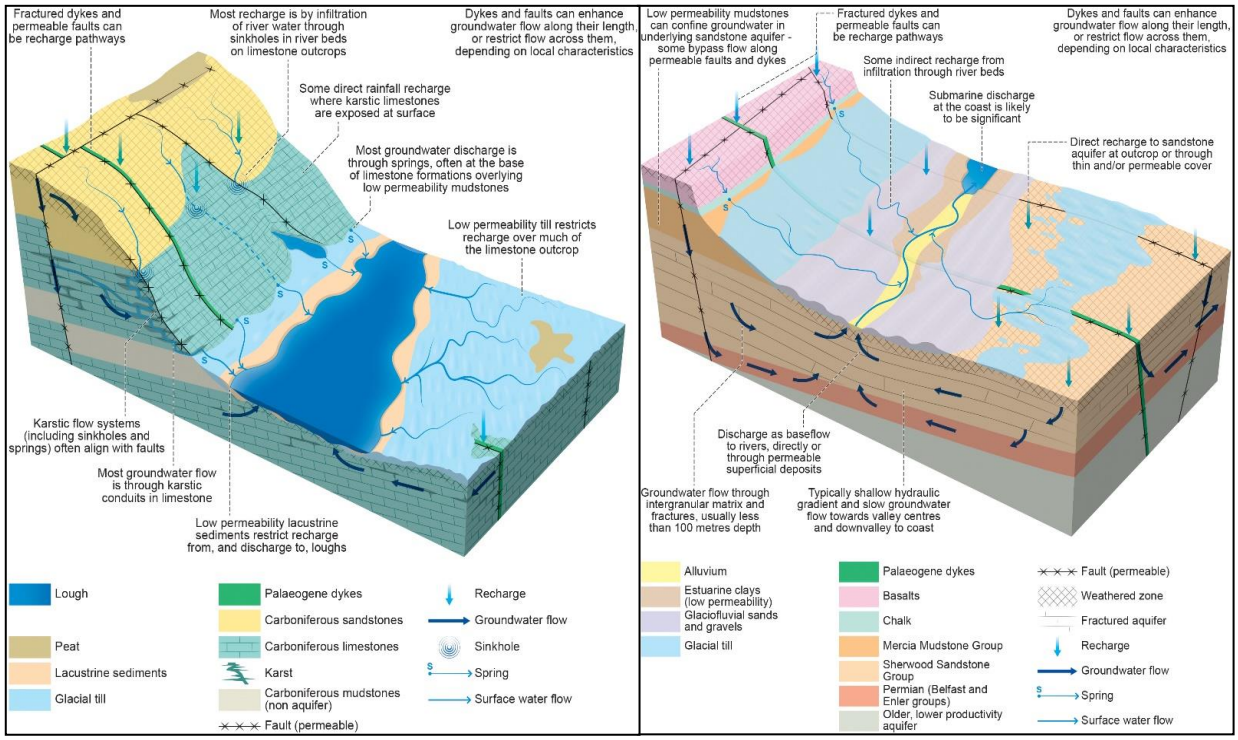

Figure 3: *Example conceptual models of the Carboniferous Limestones and Permo-Triassic Sandstone aquifers of Northern Ireland*

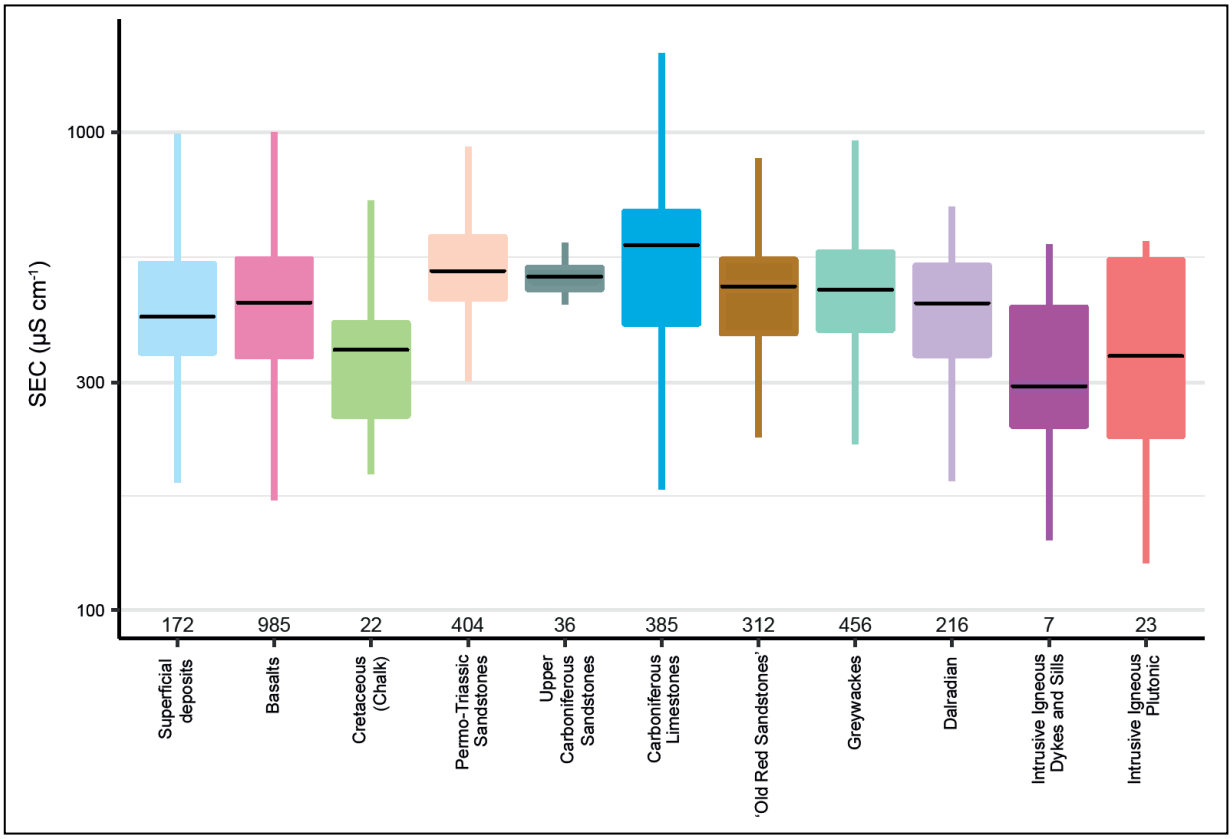

Figure 4: *Box plot showing a statictical summary of groundwater conductivity in groundwater aquifers in Northern Ireland.*

NEXT STEPS

What comes next? Firstly, make sure and get yourself to the GSNI exhibition stand where you can collect your free copy of the book. As was mentioned in the introduction, the hope is that anyone that find themselves engaging with groundwater in Northern Ireland will use the conceptual models as the basis upon which they will do their study and work, therefore uptake is important.

In the GSNI, we have admired what the Geological Survey of Ireland (GSI) have been doing with their Groundwater 3D project. Now having a regional appraisal of the Northern Ireland's Groundwater environment, our next step is to move to a more local scale, and like GSI, we will be focusing on different catchments to carry out more detailed aquifer mapping using 1:10,000 scale geological datasets and analysis. This will include targeted data gathering exercises to collect more aquifer property and chemistry data and to represent each aquifer within the context of the catchments they are found in. This is important because it is known that there are important spatial variations within the same aquifers which cannot be represented at a regional scale.

The first catchment to receive this detailed study will be the Blackwater catchment. A cross-border catchment covering a total area of 1,491km². Outputs will include 1:10,000 scale bedrock and superficial aquifer maps attributed with updated aquifer property and chemistry summary statistics, groundwater vulnerability and recharge datasets.

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THE DYNAMIC NATURE OF KARST; DETERMINING BASELINE CONDITIONS AT LOUGHAREEMA (THE VANISHING LAKE)

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ABSTRACT

Loughareema, known as the 'Vanishing Lake', is part of the Carey Valley Area of Special Scientific Interest (ASSI). Until recently three streams fed into the lake but the only known drainage point was a sinkhole through the Cretaceous Chalk, re-emerging in the Carey River c. 2 km north of the lake. The lake is known to fill in a few hours and empty again in as little as 4 days. Analysis of hydrographs shows that the lake forms following high rainfall events when the capacity of the sinkhole and underground karstic conduit system is fully saturated.

During a visit to the lake by the GSNI and the NIEA in early 2022 the largest of the three streams was noted to be dry. Tracking up the now dry bed a new sinkhole was discovered draining all of the stream water c. 200m upstream of the main sinkhole.

To determine whether and to what degree this newly discovered sinkhole is impacting the formation of the mystical lake, the baseline conditions of the lake need to be understood. This paper summarises the investigations carried out at Loughareema prior to the discovery of the new sinkhole. Through analysing data collected by the GSNI from 2012 to 2016 (timelapse photos, LiDAR data, water level data, rainfall data and stream flow gauging) the hydrological and hydrogeological environment has been assessed. A correlation between the daily maximum volume of water in the lake and the 11-day antecedent conditions has been identified and described and the average flow rate through the main sinkhole has been estimated (413 m^3/hr).

Key words: *Loughareema, Karst, Sinkhole, Groundwater, Northern Ireland*

The authors would like to acknowledge the support and funding provided by the Northern Ireland Environment Agency (NIEA) to carry out this work.

INTRODUCTION

Loughareema, part of the Carey Valley ASSI and better known in Northern Ireland as the Vanishing Lake, is an ephemeral lake in upland Co. Antrim that fills and empties at relatively rapid rates. Three streams flow into the lake and a sinkhole at the base of the lake drains the water to a karstic flow network in the underlying Cretaceous Chalk (Map 1).

GEOLOGY

The location of sinkholes within Loughareema indicates the presence of chalk of the Ulster White Limestone Formation under the lake. A large northeast-southwest orientated fault, that downthrows to the north, has brought the chalk and overlying basalt of the Lower Basalt Formation, down against the much older metamorphic rocks of the Dalradian Supergroup. In

addition, approximately north-south orientated faults have been mapped in the vicinity, and is believed that their intersection with the northeast-southwest fault is important in the overall siting of the lake. Chalk solubility, in combination with fault damage zones, are believed to control the development of conduit systems formed in this region. It is also possible that glacial meltwater may have played a role in the evolution of the karstic system here as witnessed by the presence of a meltwater channel immediately south of the lake (McCabe and Eyles, 1988).

THEORIES ON HOW LOUGHAREEMA FILLS

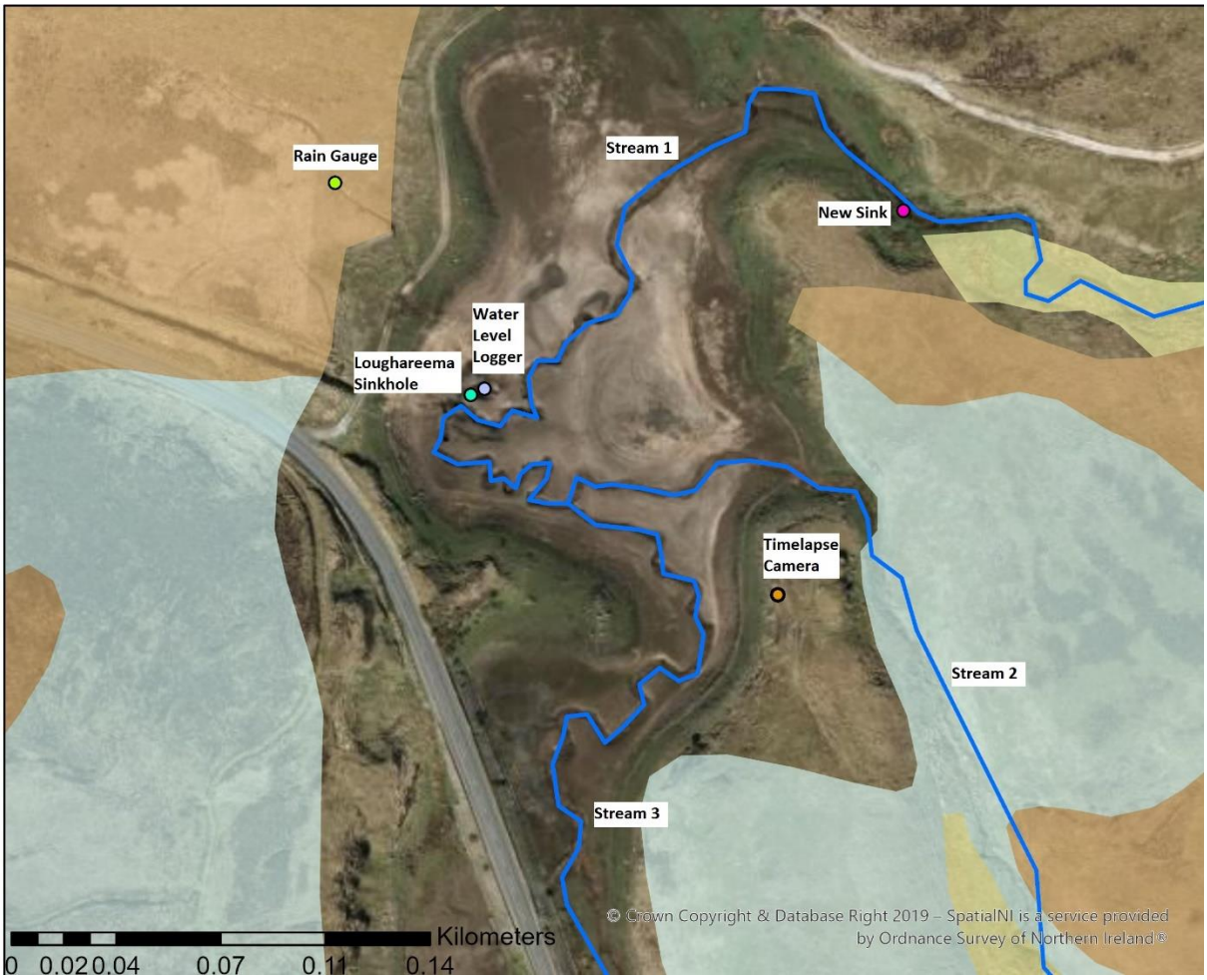
There are currently two theories as to why the lake fills and empties in the way it does. The most prominent theory is that the lake fills when the sinkhole becomes plugged by peat from the surrounding land, particularly after heavy rainfall. When the plug clears, the lake is then allowed to drain rapidly.

The second theory is that the lake acts like a kitchen sink. The volume of the lake increases when the volume of water coming into the lake is higher than the capacity of the sinkhole and underlying karstic network.

This paper examines the lake levels, rate of increase and decrease and their relationship to effective rainfall to determine which theory is most plausible.

NEW SINKHOLE

During a visit to Loughareema by the GSNI and the NIEA in early 2022, the largest of the streams that feed the lake (Stream 1) was noted to be dry. Tracking up the now dry stream bed a new sinkhole was discovered in the stream bed c. 200m upstream of the main sinkhole. This was found to be draining all the water from up catchment of that point (Map 1). This sinkhole has been seen to fill on subsequent visits to Loughareema allowing water to flow to the lake again. Future investigations will determine to what degree this new sinkhole impacts the formation of Loughareema by comparing the hydrological conditions with the ‘baseline’ conditions described in this paper.



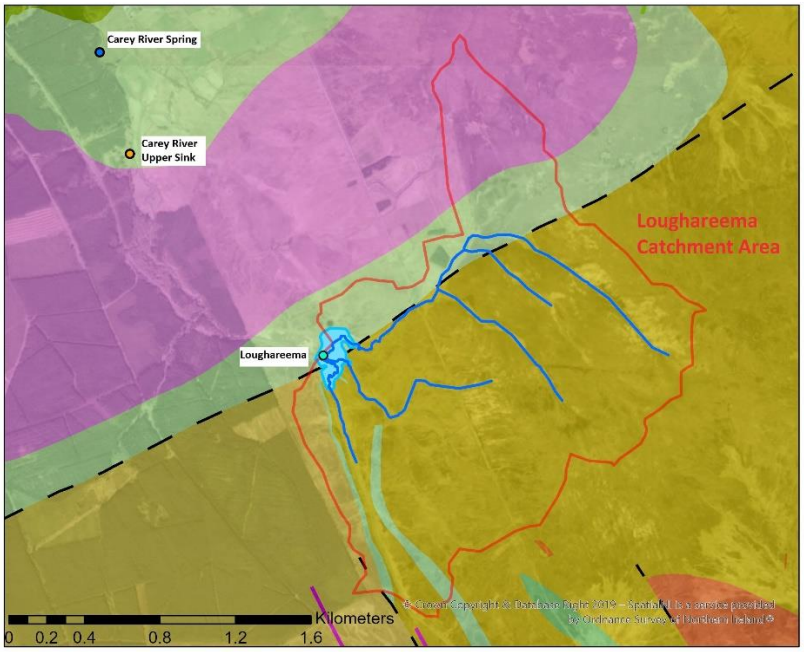
Map 1: *Aerial photograph of Loughareema showing the location of monitoring point. The superficial deposits shown here (Till in blue and Peat in brown) are typical of the catchment.*

MONITORING

DETERMINING WHERE THE WATER GOES

A tracer test was carried out by Barnes (1999). Using Photine CU a positive trace was detected which identified the location of the spring where water draining through the sinkhole remerges. The spring is located c. 2000 m northwest of the sinkhole along the banks of the Carey River (Map 2). The test was carried out during low flow conditions. Tracer flow through time to peak concentration was from 2.8 to 4.1 days, a straight line velocity of 724 to 486 md^{-1}. The large range is due to dispersion associated with the low flow rate and is not thought to indicate influence from fracture flow over discrete conduit flow (Barnes, 1999).

Quantitative dye tracing was carried out using Fluorescein Sodium dye during very low flow conditions. Around 50% of the dye was recovered. As the Carey River Spring is the only notable groundwater discharge in the immediate area it is likely that all the water from the sinkhole will emerge at this point and that the dye loss was due to photochemical decay at the sinkhole where pooling of the dye was observed (Barnes, 1999). Further dye tracing at higher flow rates will assist in confirming the underground flow dynamics and the connectivity between sinkhole and spring.



Map 2: *Aerial photograph of Loughareema showing the location of the sinkhole and spring overlain by the 1:10,000 scale bedrock mapping. The catchment area of Loughareema is outlined in red.*

FLOW MONITORING AT LOUGHAREEMA AND THE CAREY RIVER SPRING

On the 27th August 2013 the Velocity-Area method was used to estimate the flow in the three streams that feed into Loughareema and the flow emerging at the Carey River spring (Table 1).

In order to assess the antecedent conditions daily rainfall data was obtained from the gauging station at Ballypatrick Forest for the month of August 2013, shown in Figure 1.[11]

Table 1: *Flow monitoring data for streams at Loughareema*

Gauging Point	Flow Rate (Ml/day)
Stream 1	1.42
Stream 2	0.38
Stream 3	0.56
Carey River Spring	9.75

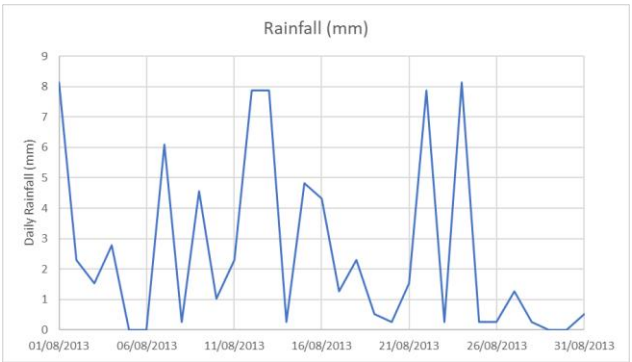


Figure 1: *Rainfall data from Ballypatrick Forest (August 2013)*[1]

MONITORING THE WATER LEVEL AT LOUGHAREEMA

In order to monitor the changing lake level a HOBO water level logger was installed into a perforated tube that was placed in the deepest part of the lake. A measurement was collected at hourly intervals between the 10th December 2014 and 11th October 2016.

[11] https://en.tutiempo.net/climate/08-2013/ws-39160.html

RAINFALL DATA

During this time rainfall data was collected by a tip bucket rain gauge and converted to rainfall intensity (mm/hr). The location of the rain gauge is illustrated in Map 1.

LIDAR SCAN OF THE LAKEBED

A Lidar scan was conducted by John Maneely from the Queen's University of Belfast in October 2016 when the lake level was low (203 mAOD) at a resolution of 20 x 20 cm. This data was used to create a digital terrain model of the lake bed.

ANALYSIS

ESTIMATING THE VOLUME OF WATER IN LOUGHAREEMA

Using the Cut and Fill tool in ArcPRO the digital terrain model was used to estimate the volume of water in the lake at increasing water levels. The extent of the lake at various water levels is shown in Figure 2(a-c). Only the volume of water above the level of the lake at the time of the Lidar scan could be estimated.

Figure 2d shows the estimated volume of water (above the Lidar baseline) within the lake at each water level interval. This curve was broken into line segments and used to convert the water level data to water volume. The rate of change in the lake volume was then estimated (Figure 3).

WATER BALANCE ANALYSIS

Defining the Surface Water Catchment Area

The ArcPro Watershed tool was used to determine the catchment area of the Loughareema sinkhole using the Ordinate Survey Northern Ireland 5m DTM. The catchment area for the 3 streams was c. 3.2 km^2. Approximately 1.9 km^2 is captured by stream 1. The catchment area is shown in Map 2.

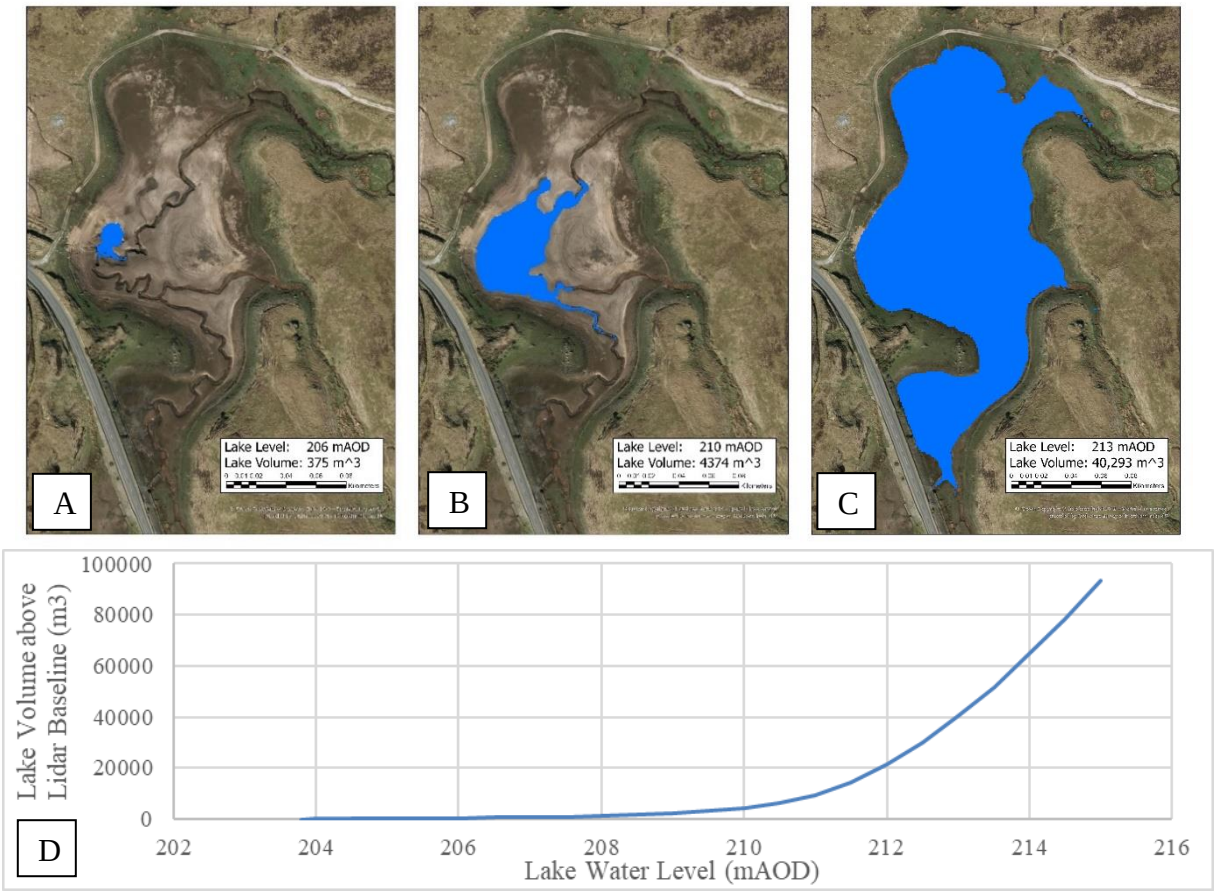


Figure 2: *A-C show the aerial extent of Loughareema at different lake volumes determined using ArcPRO Cut and Fill tool. D shows the increase in lake volume above the lidar baseline (m³) as the water level increases.*

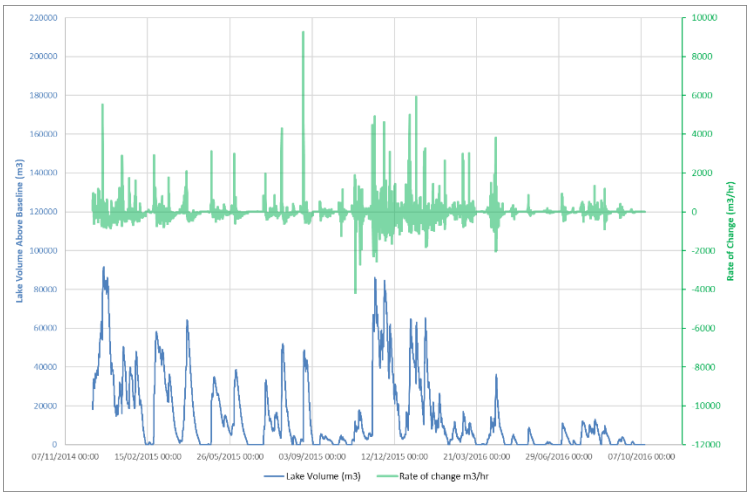


Figure 3: *Hydrograph showing the volume of water in the lake and the rate of change in volume over the monitoring period.*

Estimating Effective Rainfall

Daily effective rainfall was estimated using monthly Potential Evapotranspiration (PET) rates estimated by Betts (1997) using an amended version of Penman's formula for a weather station at Lowtown c. 35km south of Loughareema. Actual Evapotranspiration (AET) was estimated by multiplying PET by 0.95 which is considered reasonable for grasslands in

Ireland (Williams et al., 2013). The estimates for AET were subtracted from daily rainfall values. Where AET exceeded rainfall, effective rainfall was considered to be zero. For simplicity the presence of a soil moisture deficit was not accounted for in the calculation of effective rainfall, therefore effective rainfall may be overestimated, particularly in the summer during dry periods.

Estimating Baseflow

Due to the low permeability of the bedrock and superficial cover within the catchment area (predominantly peat and glacial till) the streams are considered to be mainly supplied by overland flow with minimal baseflow contribution. Baseflow has been estimated based on an infiltration rate of 5% (Williams et al., 2013). Assuming the system is in equilibrium, baseflow to rivers should equal average annual infiltration rates. This is estimated at c.530 m^3/day.

DISCUSSION

WHAT CAUSES LOUGHAREEMA TO FILL?

By analysing the hydrograph (Figure 4) a correlation between rainfall and the lake level is evident where the volume of water in the lake increases following significant rainfall events. A rainfall event on the 11th April 2015 (green broken arrow) did not create an increase in the lake volume however there is a notable gradient shift in the rate of decline in volume. A repeated pattern is also evident in the rate of decline which decreases as the volume of the lake decreases. This would be expected due to decreasing hydraulic pressure from the lake overhead. No evidence was seen to suggest a stable water level, that rapidly begins to decline, which would be expected if a blockage had formed in the sinkhole and then cleared suddenly.

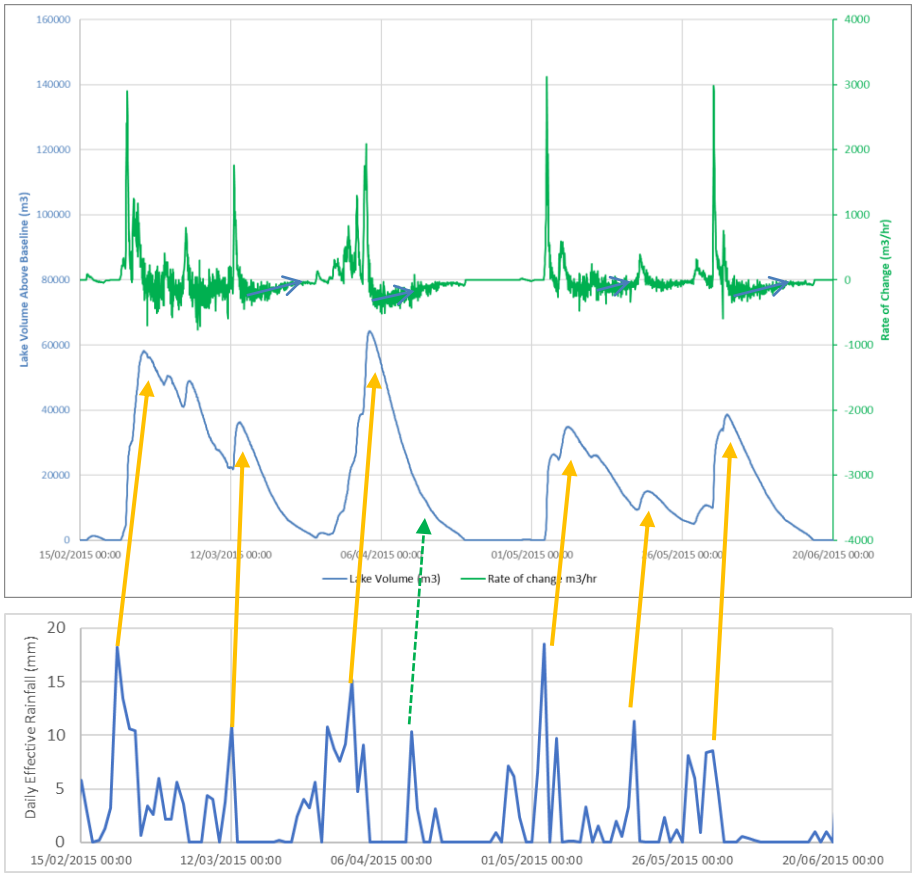


Figure 4: *Hydrograph showing the relationship between lake volume and rainfall and the repeated decreasing trend in drainage rate associated with the decreasing hydraulic pressure.*

RESPONSE TO RAINFALL IN LOUGHAREEMA

Due to the complexity and size of the system a clear linear relationship is not visible between the daily estimates of effective rainfall and the lake volume. To further investigate the relationship between rainfall and the lake volumes, the daily peak volume was plotted against the sum of total rainfall for the previous 'N' number of days and the coefficient of determination was obtained (Figure 5a). The strongest correlation was seen in the 11-day total rainfall plot which had an R^2 value of 0.74 (Figure 5b).

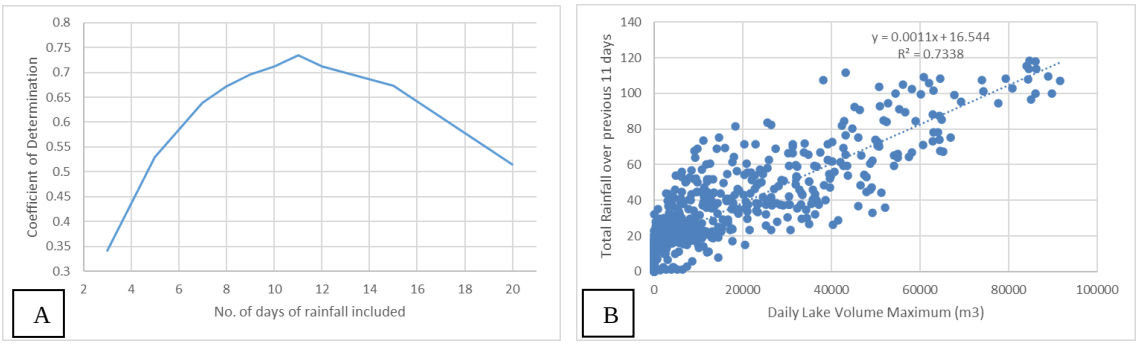


Figure 5: *A: The coefficient of determination for the sum of effective rainfall over N days showing the highest correlation at N=11. B: Relationship between the 11-day total rainfall and the daily maximum lake volume.*

ESTIMATING THE FLOW RATE THROUGH THE LOUGHAREEMA SINKHOLE

Estimating the flow rate through the sinkhole is difficult as it varies depending on the head of water above the sinkhole. Data from where the observed lake levels show a decline does not account for water flowing into the system from the three streams and therefore doesn't represent flow through the sinkhole. Assuming no other sinkhole was active during the monitoring period a simple water balance equation can be used to estimate water leaving through the sinkhole by subtracting the change in storage in the lake (change in average lake volume) from estimates of inflow.

Due to the extensive cover of peat and glacial till (assumed to have low permeability), overland flow has been estimated at 95% effective rainfall using infiltration coefficients provided by Williams et al. (2013). This was combined with average baseflow to estimate inflow into the system.

When outflows are calculated using daily data the estimates show a significant spread with some estimates below zero (Figure 6). It has been shown that the volume in the lake shows a stronger relationship to rainfall over the previous 11 days. Therefore, the average hourly inflow over 11-day periods was calculated using the change in storage and total effective rainfall over 11 days. This provided a narrower spread that is considered more reliable. The average flow rate through the sinkhole over the monitoring period was estimated at 413 m^3/hr.

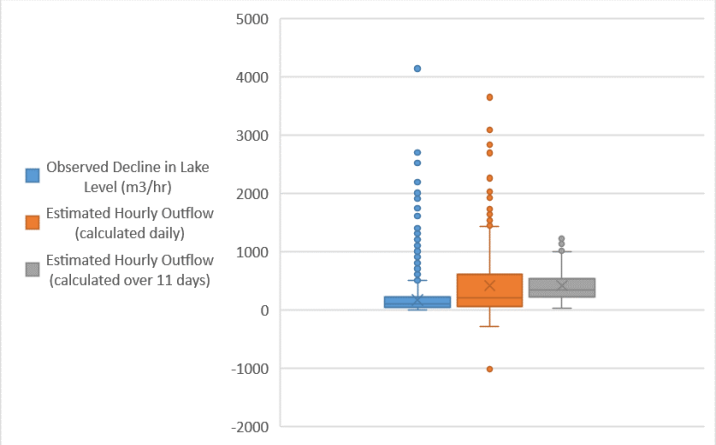


Figure 6: *Box and whisker plot showing the spread of estimated outflow through the Loughareema sinkhole.*

UNDERSTANDING THE FLOW DYNAMICS OF THE KARSTIC AQUIFER

The flow emerging from the main spring is almost 4 times which enters the sinkhole (9.75 Ml/day compared with 2.36 ML/d). Based on the tracer test it is known that a 3-to-4-day delay in response is expected from the sink to the spring during low flow conditions. Rainfall on the 24thAugust 2013 was high. A response delay could explain the increase in discharge compared to input. However as discussed it is rainfall over the previous 11 days that shows the highest relationship with the maximum lake level and therefore flow into the system. The 11-day effective rainfall total over the previous 4 days remains relatively consistent (13.25 to 19.03mm) therefore the lake level and water draining through the system is expected to remain relatively stable. It is likely that conduits sourced from multiple sinking streams in the area converge underground before emerging at the Carey River Spring accounting for the higher flow rate in the spring. At least one other sinkhole has been positively traced in connection with the Carey River Spring (Barnes, 1999).

CONCLUSION

This paper provides a summary of the hydrological conditions at Loughareema between December 2014 and October 2016. Hydrograph analysis shows an observable response to rainfall events and a repeated pattern of decline in lake volume that can be explained by decreasing hydraulic head above the sinkhole. No pattern was identified that could be linked to a blockage of the sinkhole from a peat plug that was then cleared causing the lake to drain abruptly following a period of stable or increasing lake volumes that cannot be related to rainfall. Therefore, it can be concluded that Loughareema fills when rainfall in the catchment exceeds the capacity of the sinkhole.

The hydrological conditions at Loughareema during the monitoring period have been described numerically by the rate at which water is leaving the Loughareema catchment (average estimated as 413 m^3/hr) and the linear relationship between the daily peak in rainfall and the total effective rainfall over the previous 11-days as shown in Figure 5b.

This data can be used to compare with future investigations to determine if and to what degree the newly discovered sinkhole is impacting the formation of the lake. It is expected that this new sinkhole will cause water to drain from the catchment at a higher rate and that higher rainfall will be required to see the same peaks in lake volumes. It could be the case that the Vanishing Lake will now vanish more frequently.

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SESSION IV

ASSESSING THE IMPACT OF CLIMATE CHANGE ON GROUNDWATER FLOODING

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ABSTRACT

A changing climate is expected to increase extreme weather and climate events in Ireland, such as prolonged dry periods, heavy rain episodes and prolonged warm spells. In particular, precipitation is expected to increase during Autumn and Winter months, which will impact the behaviour of groundwater floods, a geohazard prevalent in the limestone lowlands of Ireland. In this study a quantitative approach was developed to assess the impact of climate change on groundwater floods in Ireland. The presented approach includes meteorological data, hydrological models, and climate projections from downscaled Global Climate Models (GCMs) covering 4.5 and 8.5 RCPs. The analysis was applied at 16 sites representative of the range of groundwater flood dynamics that were modelled with Nash-Sutcliffe Efficiencies (NSE) above 0.85. Preliminary results showed a clear trend towards increased flood durations, flood frequency, and magnitude of the floods by mid- and end- of the century. The results of this study contribute towards quantifying climate trend analysis and predictions in terms of groundwater flooding, which are necessary to provide an evidence base to inform relevant national policy-makers, planners and stakeholders of potential climate-related issues and enable the development of pre-emptive mitigation strategies.

Key words: *groundwater flooding, climate change*

INTRODUCTION

It is now accepted beyond doubt that anthropogenic greenhouse gas emissions are significantly altering the Earth's climate (IPCC reports, 2013, 2021). Globally a rise in average temperature of between 0.3 and 4.8°C is projected by the late 21st century, while IPCC estimates the frequency and proportion of heavy precipitation will likely increase and droughts intensify in the 21st century in many regions (Seneviratne et. al., 2017). In an Irish context, there was a 0.5°C increase in mean annual air temperature during the period 1981-2010 compared to 1961-1990 (Walsh, 2012). Analysis of high-resolution regional climate simulations shows this trend continuing with a projected increase in annual temperatures of 1.24°C (RCP4.5) and 1.6°C (RCP8.5) by mid-century (O'Sullivan et al., 2016). Studies have also shown that a warming climate will result in an increase in high-impact weather events such as prolonged dry periods, heavy rain episodes and prolonged warm spells (Nolan et al., 2017; O'Sullivan et al., 2016). Climate change will thus be a major driving force in shaping Ireland's water resources and environment in coming decades, exacerbating existing pressures in terms of water supply, quality, flooding, and drought. Early detection of these

pressures is key to informing adaptation strategies and minimizing adverse environmental and societal impacts. In order to set out a national strategy for addressing current and future risks posed by a changing climate to groundwater resources, the Department of Communications, Climate Action and Environment, created the National Adaptation Framework (NAF), and in 2020 Geological Survey Ireland (GSI) commenced a new project (GWClimate, 2020-2022), in collaboration with South East Technological University (SETU), to evaluate the impact that climate change may have on Irish groundwater resources, with a particular focus on groundwater flooding.

In this study we focused on groundwater flooding in Ireland. Attention on groundwater flooding as a geohazard has increased in recent decades due to an increased frequency of extreme groundwater flood events across Europe (Finch et al., 2004; Naughton et al., 2017; Pinault et al., 2005). In Ireland, the dramatic floods during the winters of 2009/2010 and 2015/2016 caused widespread damage and disruption to communities across the country, particularly in the extensive karstic limestone lowlands on the western seaboard. In these regions, homes were flooded or cut off, roads submerged, and agriculture disrupted, with some affected areas remaining inundated for months after flooding had subsided elsewhere. The introduction of the EU Floods Directive (2007/60/EC), requiring States to consider flooding from groundwater sources, has reinforced the need to improve our understanding of the processes influencing this phenomenon and to assess how groundwater floods will behave in a changing climate. In this study we evaluate the impact that climate change may have on Irish groundwater flooding in the upcoming decades.

STUDY AREA

In Ireland, groundwater flooding is primarily associated with the limestone areas of the western lowlands. The prevalence of groundwater flooding in these regions is mostly due to the purity of the limestones, rendering it to more soluble and susceptible to a high degree of karstification, and to the limestones being well bedded and well jointed, which is important as it provides the initial pathways along which bedrock dissolution can occur and groundwater flow paths develop. Groundwater flow systems in these areas are characterised by high spatial heterogeneity, low storage, high diffusivity, and extensive interactions between groundwater and surface water, which leaves them susceptible to groundwater flooding (Naughton et al., 2018). During intense or prolonged rainfall, the solutionally-enlarged flow paths are unable to drain recharge and available sub-surface storage rapidly reaches capacity. Consequently, surface flooding occurs in low-lying topographic depressions known as turloughs, which represent the principal form of extensive, recurrent groundwater flooding in Ireland (MacDonald, 2010; Naughton et al., 2012). Unlike fluvial flooding where the flood is typically caused by high intensity rainfall, groundwater flooding is primarily driven by cumulative rainfall over a prolonged period. It is this accumulation of water over a period of weeks or months that determines flood severity and duration. Although it rarely poses a risk to life, it commonly causes prolonged damage and disruption because of the relatively long flood duration (Cobby et al., 2009; Morris et al., 2008) and it represents a significant flood hazard for many Irish communities in limestone regions (Naughton et al., 2018, 2017). In addition, potential changes in the behaviours of groundwater floods due to a changing climate are likely to have an impact in the wetland ecosystems that rely on groundwater to sustain habitat structure and function (Bhatnagar et al., 2021; Morrissey et al., 2021). For the purposes of this study, a set of 16 representative sites (Figure 1) were considered to

evaluate the vulnerability of groundwater floods in Ireland to a changing climate. Study sites were chosen to be broadly representative of the continuum of flood behaviour recorded in Irish karst groundwater systems (Naughton et al., 2012).

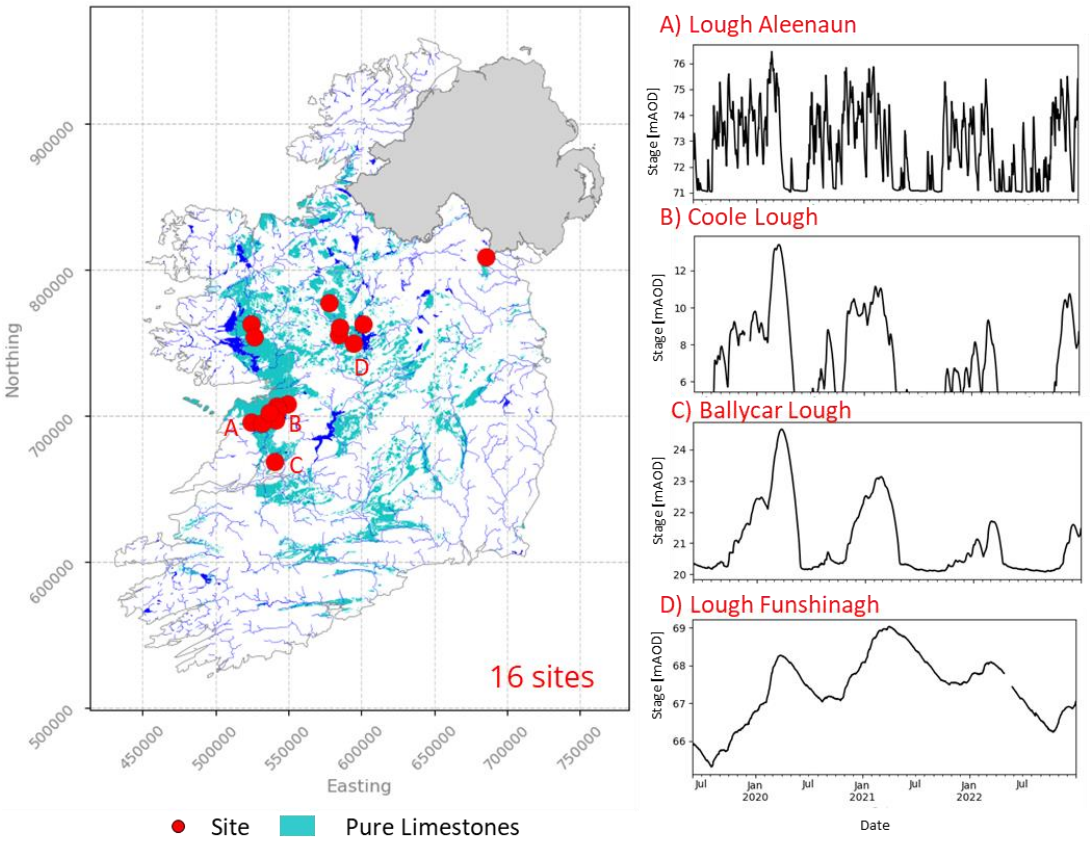

Figure 1: *Left: Location of the representative sites (red dots) on a map of Ireland with the presence of main water bodies and rivers (dark blue) and pure limestone areas (bright blue). Right: Hydrograph of the representative sites monitored by Geological Survey Ireland. Data available at gwlevel.ie.*

The following datasets were considered to assess the impacts of a changing climate to groundwater floods: 1) water level time series from the representative sites monitored by Geological Survey Ireland, which data is available at gwlevel.ie, 2) historical precipitation and evapotranspiration time series provided by Irish Meteorological Service (Met Éireann, www.met.ie), and 3) precipitation and evapotranspiration time series from climate change projections from five downscaled climate models (MIROC5, MPI-ESM-LR, CNRM-CM5, EC-EARTH, HadGEM2-ES) for RCPs 4.5 and 8.5 provided by the Irish Centre for High-end Computing (ICHEC, Nolan and Flanagan (2020)). In terms of hydrological modelling, UISCEmod (Campanyà et al., *Under review*) was used to estimate the water level time series from meteorological input data in order to assess the impact of climate change on groundwater flooding. Figure 2 shows a summary of the materials and data used in this study.

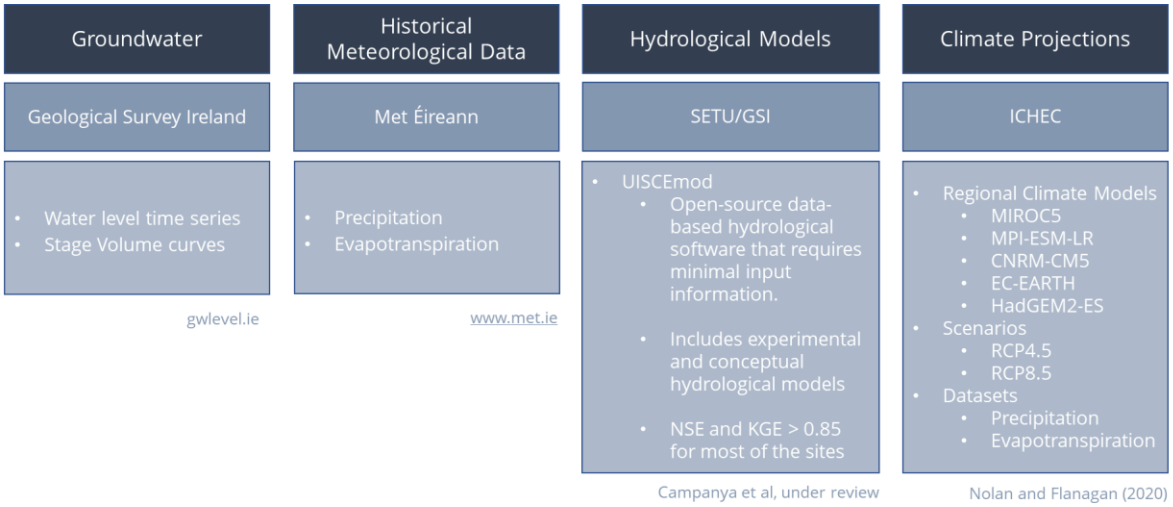

Figure 2: *Materials and data considered in this study to assess the impact of a changing climate to groundwater flooding in Ireland.*

METHOD

The assessment of the impact of a changing climate on groundwater floods was performed by considering the RCP4.5 and RCP8.5 scenarios. Recent studies suggest that currently the RCP8.5 scenario, often described as a business-as-usual scenario, is the most likely scenario despite existing mitigation efforts (Schwalm et al., 2020), and that the RCP4.5 is still more ambitious than current nationally determined contributions under the Paris Agreement, according to UNFCCC8. The hydrological models from UISCEmod were calibrated using historical meteorological data, showing NSE values above 0.85 for the validation datasets.

The meteorological data from the five downscaled climate models were post-processed for input for hydrological models. Meteorological time series from the climate projection were then combined with hydrological models to generate groundwater volume time series between 1975 and 2100 for each site. During the analysis we focused on changes in the volumes of the groundwater floods as they are representative of the amounts of water within the flood and are not influenced by the topography of the site. Conversion from volume to stage and area time series was also performed using stage-volume and area-volume curves generated from digital terrain models (DTM). In addition, the volume time series were normalized to facilitate comparison between sites. The analysis focused on changes in: 1) magnitude, changes in volume of the floods, 2) flood duration, percentage of time a certain volume is equalled or exceeded, 3) frequency, percentage of years that a certain volume is equalled or exceeded, and 4) seasonality, changes in the volume of the floods for each month of the year. Figure 3 shows a workflow of our approach for assessing the impact of climate change on groundwater floods.

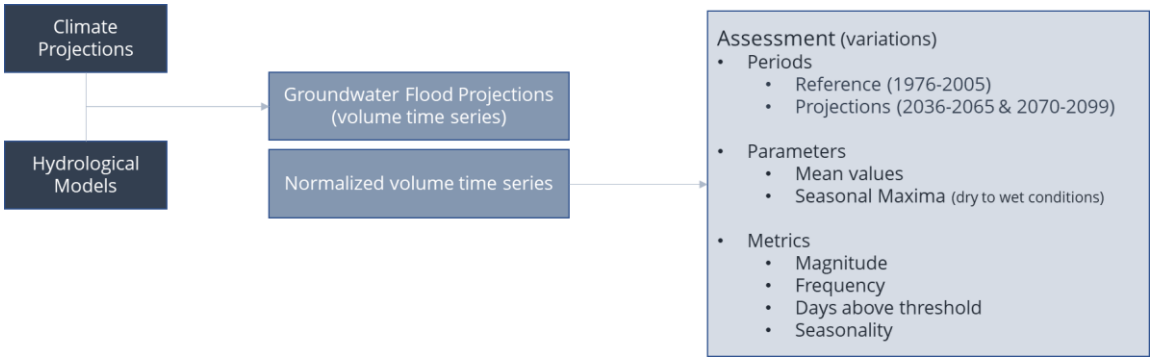

Figure 3: *Workflow summarizing the approach followed to assess the impact of climate change on groundwater flooding.*

RESULTS

Changes in the magnitude of the floods are presented in Figure 4, differentiating between the results provided by each climate model, and between the month of the year. In both cases, the results are shown separately for the RCP4.5 and RCP8.5 scenarios for mid and end of the century and are presented in the form of boxplots showing median, interquartile range (IQR, 50% confidence) and 95% confidence intervals. Uncertainties in the results are related to uncertainties within the climate models, the hydrological models, and to a different impact of climate change to different sites.

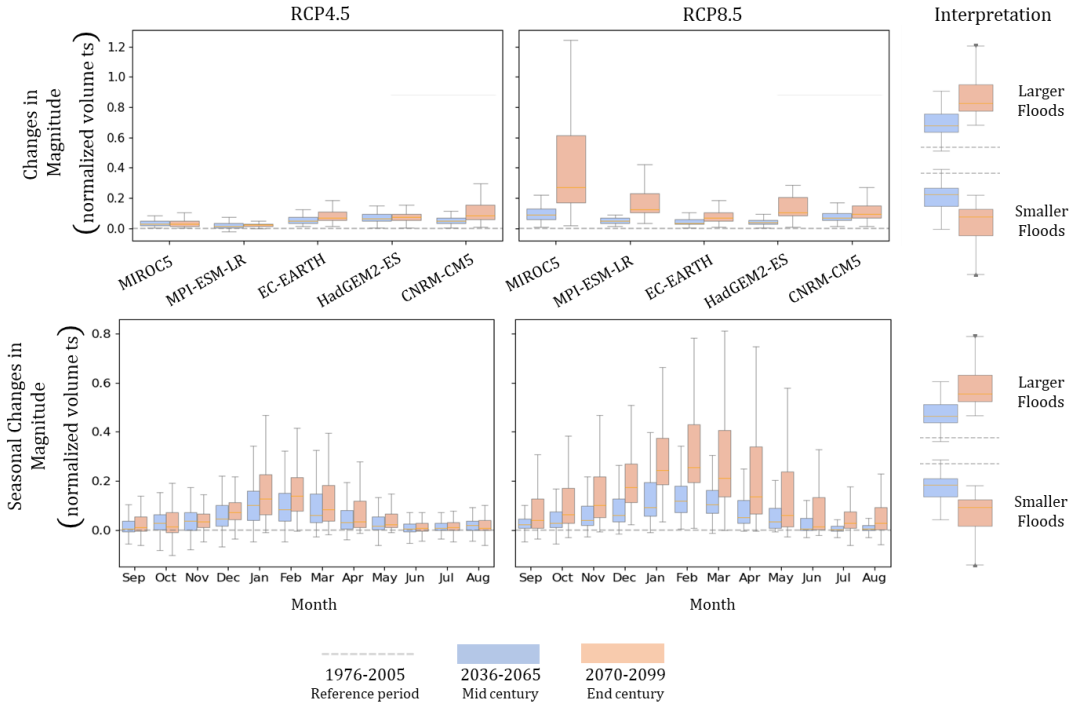

Figure 4: *Summary of climate change impact on groundwater floods in Ireland based on mean values of volute time series including the results from the 16 sites considered in this study. Top: change in magnitude of the mean of the normalized volume time series between the future and the reference period for each climate model. Bottom: change in magnitude of the mean of the normalized volume time series between the future the reference period for each month of the year.*

The main result is that all climate models agree, with over 95% confidence, that the volume of the groundwater floods, based on the mean value, is expected to increase by the mid and end of the century under both RCP4.5 and RCP8.5 scenarios, with the largest impact being observed between December and April months. While these results provide a general insight of what to expect in the upcoming years in terms of groundwater flooding in Ireland, care needs to be taken if generalizing these values to any specific site as large differences were observed between sites. For example, groundwater floods that react fast to precipitation events (short memory) were less affected than sites that react slowly to precipitation events (long memory). The analysis was also extended to assess changes in frequency and duration of groundwater flooding with preliminary results also showing a dominant trend towards increase in the frequency and duration of flooding.

The assessment of the vulnerability of groundwater flooding in Ireland to a changing climate was presented in terms of changes in the normalized volume time series, which facilitates the analysis and comparison between sites. In order to facilitate their practical applications in terms of adaptation, the specific results for each site can be converted to absolute values for stage and area time series. Figure 5 shows an example based on preliminary results for Coole Lough showing stage and area values for representative threshold values, x-axis, associated with stage and area values for small, medium, and large floods that tend to occur under dry, average, and wet conditions.

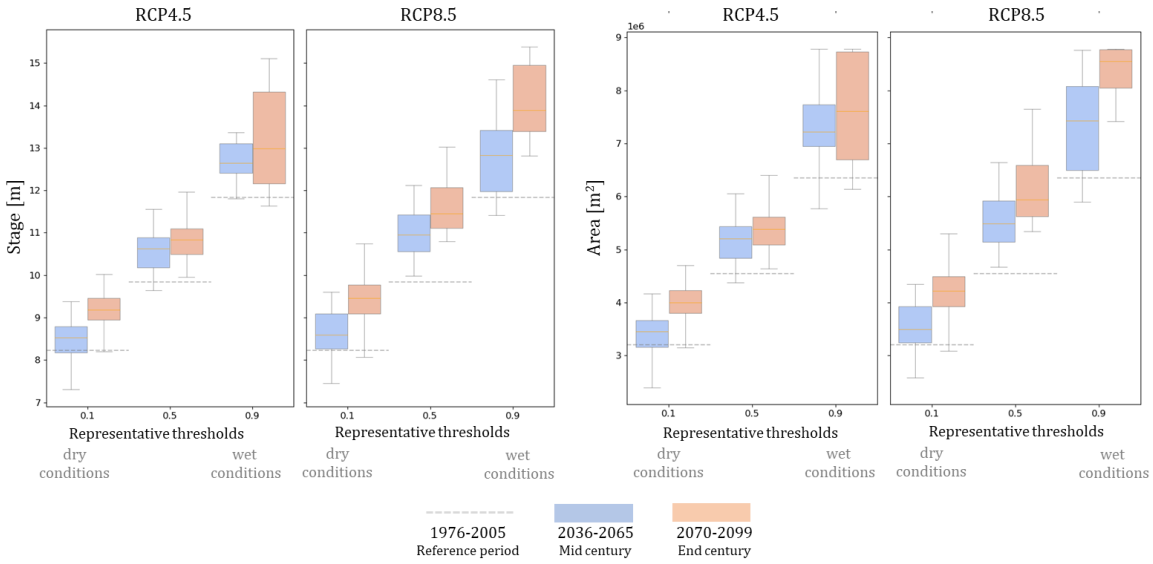

Figure 5: *Expected stage and area values for Coole Lough based on climate projections for specific thresholds representing stage and area values for small, medium, and large floods that occur under dry, average and wet conditions. The dash line is the reference value based on historical data for the reference period. The blue box represents the projections by mid-century and orange box the projections by the end of the century.*

CONCLUSIONS

Preliminary results suggest that climate change is expected to worsen groundwater flooding conditions in Ireland. The results for the representative sites suggest an increase in terms of the magnitude , duration and frequency of flooding, with the largest impacts being observed between December and April. Although all sites showed similar trends towards worsening groundwater flooding conditions, the magnitude of the impact varies significantly between sites depending on the hydrological properties of each site.

The outputs of this study contribute towards quantifying climate trend analysis and predictions in terms of groundwater flooding and provide evidence of a worsening conditions for Ireland in the approaching years. Early consideration of these results by national policy-makers, planners and stakeholders of potential climate-related issues will enable the development of pre-emptive mitigation strategies as called for under the All of Government Climate Action Plan to Tackle Climate Breakdown and contribute to minimize adverse environmental and societal impacts.

ACKNOWLEDGEMENTS

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PEAT STABILITY ON UPLAND SITES: THE ROLE OF HYDROGEOLOGY

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IN SITU CHARACTERISATION OF PEATLANDS USING GEOPHYSICAL TECHNIQUES

Andy Trafford, iCRAG & UCD, Dublin

INTRODUCTION

Engineering on peatlands has always given engineers certain specific problems to overcome, with access, ground stability, sampling, and site classification all posing distinctive challenges. These challenges have been brought further to the forefront due to the acknowledgement that these unique environments are hugely important from and ecological viewpoint with high habitat value, and extensive carbon and water storage properties. Along with the need to develop certain infrastructure projects, there is an increasing pressure to maintain, protect and restore peatlands with the assessment of their characteristic properties become much more relevant in order to reduce the risk in terms of peat slides.

In this paper we show how using light weight portable equipment developed specifically for peat soil assessment we can assess the in situ properties of peat for input into slope stability analysis.

INVESTIGATION METHODOLOGY

By combining the outputs from Ground Penetrating Radar and Vertical Shear Wave Profiling it is possible to determine both the electromagnetic and mechanical response of the peat soil providing the required input parameters for a comprehensive geotechnical assessment to be carried out.

Figure 1: *80MHz GPR antenna operated from GSSI SIR 3000 system. Liffey Head Bog*

Ground Penetrating Radar (GPR) is accepted as being the most effective method for accurately and comprehensively assessing the peat thickness and distribution across a site. This method involves the transmission of high frequency radio waves into the subsurface and recording the reflected waveforms. The method involves the collection of data along survey transects to build up a 2D cross section through the peat (*Figure 1*). By linking the output from the GPR system to accurate elevation data it is possible to generate accurate sub peat elevation maps for use in slope stability assessments.

The shear strength of peat is one of the key parameters in engineering design when dealing with foundation and slope stability issues. Its determination has previously been particularly difficult due to factors such as the fibre content, degree of humification, drainage, water content, organic matter, and also from sample disturbance where laboratory methods are employed (Kazemian et al. 2011; O'Kelly 2017).

A Russian auger (Jowsey 1966) was used to obtain a 45 mm diameter “half core” of the peat over the full depth profile. The peat was logged on site using the extended version (Hobbs 1986) of the von Post and Granlund peat classification scheme (von Post and Granlund 1926). Samples of the peat were taken at 0.1 m intervals for water content measurements. These water content measurements would later be used in conjunction with the field shear wave velocity measurements which were taken at the same depth intervals and frequency and down the same borehole as that used for logging the peat.

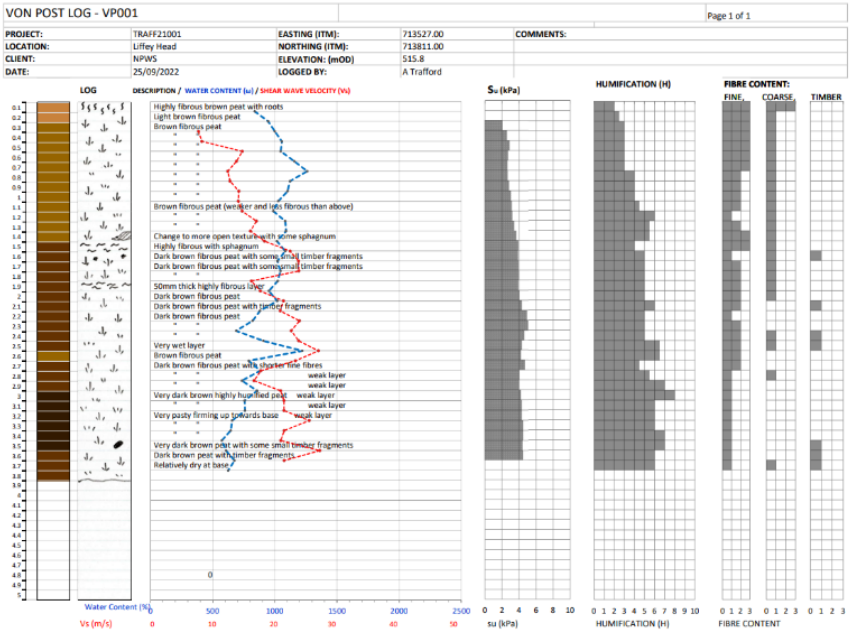

Figure 2: *Typical output from VSWP and peat logging including undrained shear strength and Von Post classification***.**

By using Vertical Shear Wave Profiling (VSWP) along with water content analysis it is possible to determine the required undrained shear strength (s_u) parameter (*Figure 2*). By measuring V_s in situ it is possible to take into account the stress history and the current stress state of the peat (*Figure 3*).

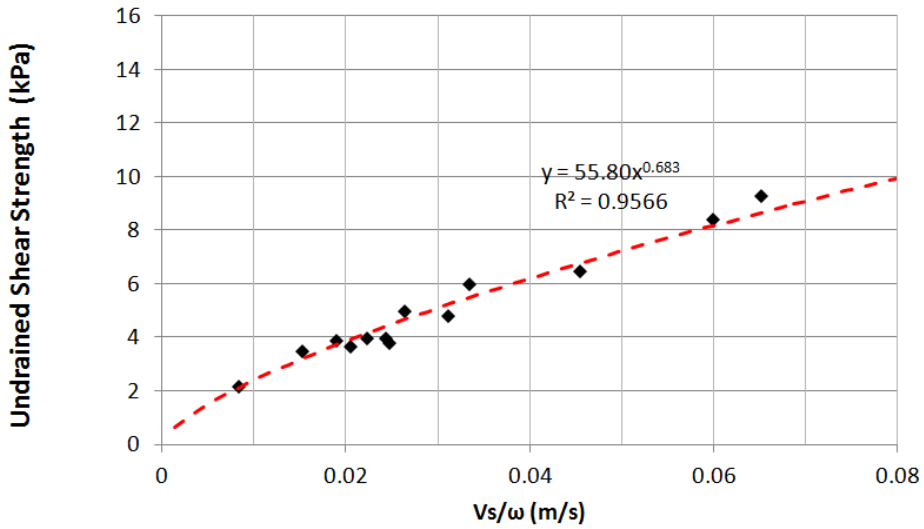

***Figure 3**: Relationship between su, Vs and w for saturated fibrous peat.*

This relationship can be written as:

$$s_u = C\left(\frac{V_s}{w}\right)^n$$

where: C and n constants
(55.8 and 0.683 respectively, for saturated fibrous peat)

The remaining topographical parameters are determined by integration of the GPR data with either traditional survey data or more recently the use of lidar surface mapping (*Figure 4*).

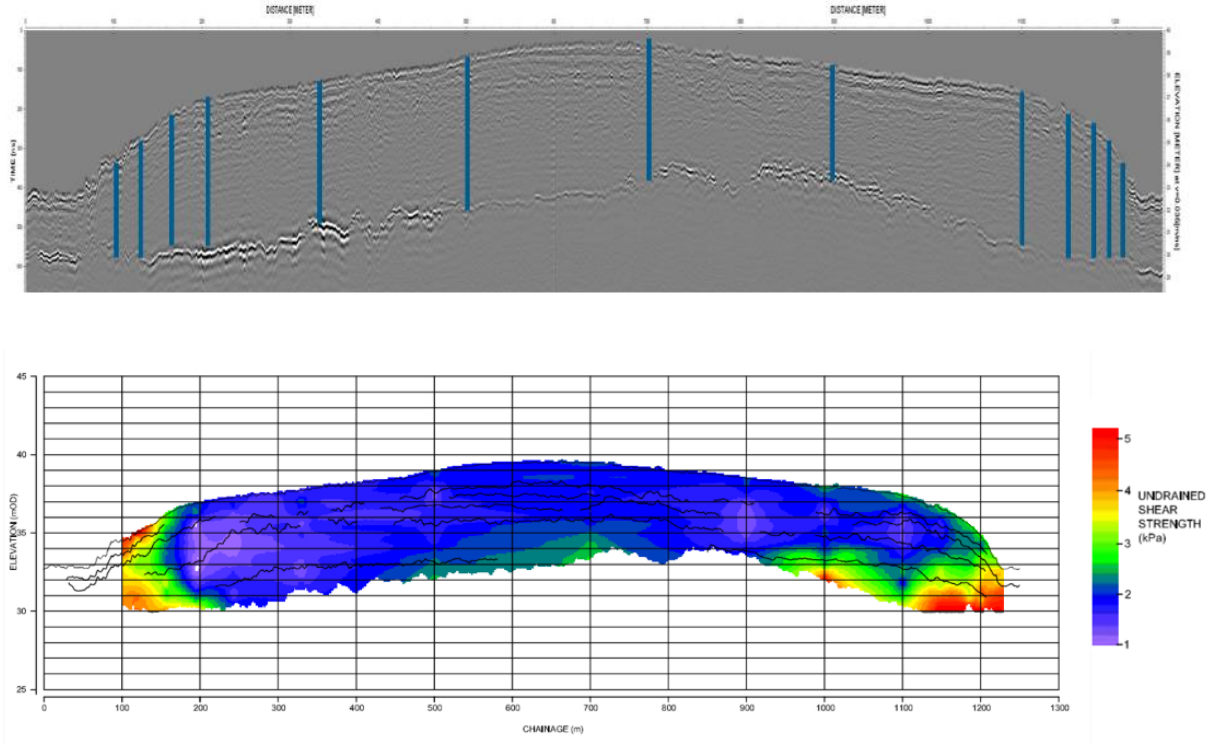

***Figure 4:** Topographically corrected GPR profile (a) with interpolated Undrained Shear Strength profile (b). Moanvenlagh Bog, Co. Kerry.*

SLOPE STABILITY ASSESSMENTS

In order to carry out a quantitative assessment of the risk posed by peat stability an infinite slope analysis to calculate the factor of safety (FoS) is used. The inputs to this analysis include assessing the peat thickness, topography as well as the undrained shear strength of the peat across the site and using the formula:

$$FOS = \frac{c_{u,d}}{\gamma_{sat,d} h (sin\beta)(cos\beta)}$$

$c_{u,d}$	Undrained shear strength
$\gamma_{sat,d}$	Saturated unit weight
h_d	peat depth
β	basal peat slope

The FoS gives an assessment of the instability of a peat slope with a FoS of < 1.0 indicating an unstable slope liable to fail. Typically a FoS of 1.3 is used to represent a stable slope with low risk of failure. Using this approach it is also possible to model the effect of loading of the peat by applying a surcharge to represent the effect of different construction practices. *Figure 5 (d)* shows a surcharge designed to represent the effect of loading of a typical c. 1.5psi ground bearing machine proposed to carry out the restoration works.

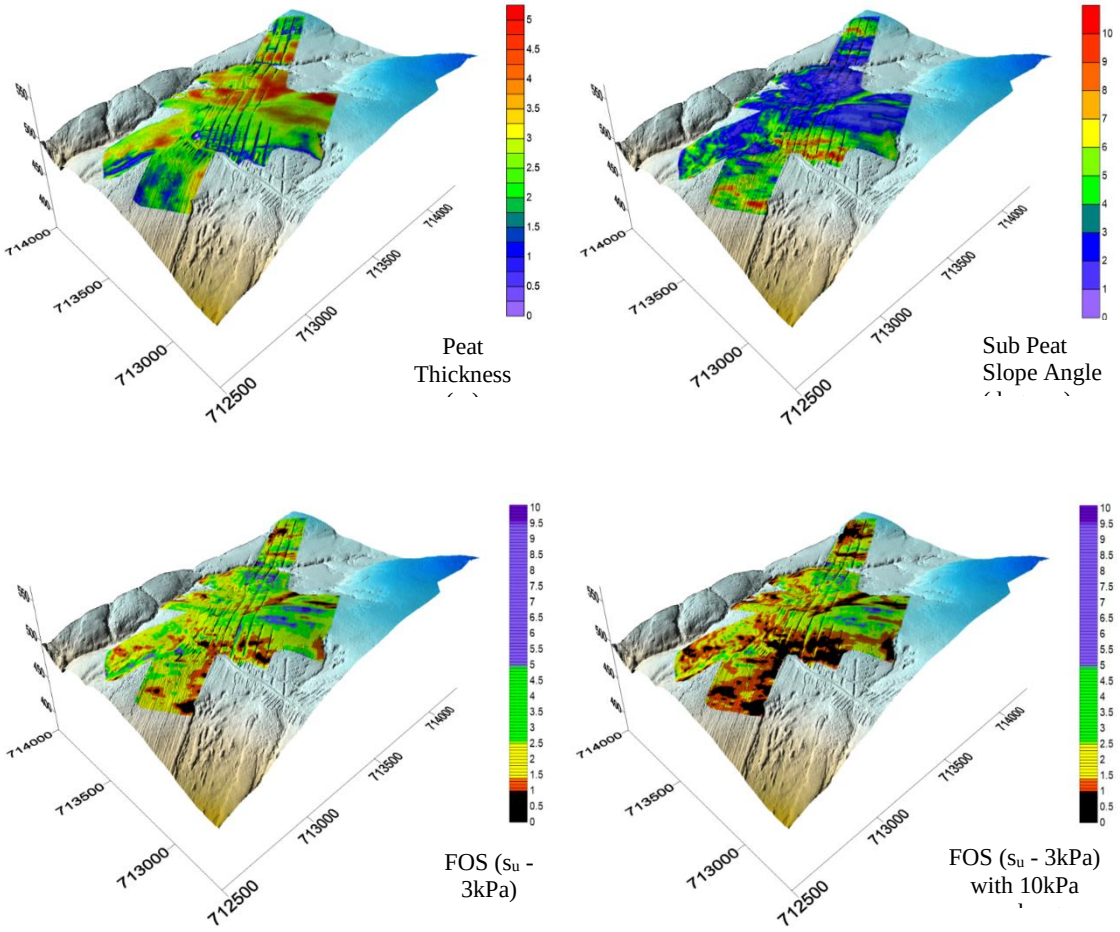

Figure 5: *Topographically corrected plots showing sequence of slope stability analysis. (a) peat thickness, (b) sub peat slope angle, (c) FOS using determined s_u, (d) FOS using determined s_u and 10kPa surcharge.*

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UISCE ÉIREANN AND PLANNING CONSENT

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ABSTRACT

Irish Water is responsible for the public supply of drinking water to over 80% of the population. Our water supply responsibilities extend from the abstraction of (raw) water from wells, rivers, lakes and reservoirs, to treatment of this water such that it is suitable for human consumption and onward delivery to our customers' homes and business premises. Our environmental responsibilities are to ensure that the quantities of water that we abstract are sustainable and that sufficient water remains in water bodies to support the needs of the ecology and other water users. Realising these objectives often results in project delivery, which must be done with strict regulatory framework including the Planning and Development Act, 2000 (as amended), the Planning and Development Regulations, 2001 (as amended) and overlapping environmental legislation.

SETTING THE CONTEXT: UISCE ÉIREANN AND WATER SUPPLY

Irish Water assumed statutory responsibility for the provision of public water services and management of water and wastewater investment for Ireland on the 1stJanuary 2014. We serve 4.2 million people and deliver water services to approximately 87% of the population. We abstract raw water from approximately 290 surface water and 960 groundwater catchments, manage 539 individual water supplies in Ireland and produce over 1.7 billion litres of drinking water every day via 749 water treatment plants.

At present, we abstract more water from surface water sources (rivers and lakes) than from groundwater sources (boreholes and springs) for the provision of public water supply. Although we have 293 surface water sources and 797 groundwater sources, our surface water sources provide 83% of our total supply, whilst groundwater sources provide only 17% of the supply. This percentage increases significantly in certain counties, with groundwater being the main source, for example, in Laois, Offaly, Roscommon and North Cork. Furthermore, Uisce Éireann have almost 800 individual groundwater abstractions, many of which have proven to be a dependable water supply both in terms of yield and natural water quality. The volume of water available to us from our surface water sources naturally varies throughout the year. Less water is typically available from April to September, and significantly less if we experience a drought.

Most Uisce Éireann abstractions have been in operation long before any modern environmental legislation, such as the Habitat's Directive. Surface water and groundwater abstractions that were once regarded as acceptable may now be considered to be unsustainable, particularly in dry weather conditions. We must ensure that our abstractions do not adversely impact the environment so that Ireland can comply with its obligations under the Water Framework Directive (WFD). In light of forthcoming licencing regime these abstractions may be subject to modifications to meet the requirements of the WFD.

Irish Water's first National Water Resources Plan (NWRP) is a 25-year strategy (2019 to 2044) which will identify how we will provide a safe, sustainable, secure and reliable water supply to our customers for now and into the future, while safeguarding the environment. Phase 2 of the NWRP involves the production of four Regional Water Resources Plans that will assess Need and propose a Preferred Approach for each of the 539 water supplies that

make up the national public water supply. In terms of new water sources, the NWRP considers ground water sources in tandem with surface water sources. Groundwater as a resource may be more resilient than surface water in different parts of the country.

UISCE ÉIREANN WATER PROJECTS

There are a number of key issues that impact the quality, sustainability and reliability of our existing water supplies. Addressing these issues form the basis of our water projects and the associated interaction with the planning system. Water projects include addressing treatment capacity, water quality, network performance and water sources including single source supplies and inappropriate water sources. The projects required to address these issues generally fall into one of these categories:

- Upgrades at Existing Water Treatment Plant
- New / replacement Water Treatment Plants at the original source
- Water Storage
- Rationalisation projects
- Development of a new water source
- Change of water source at existing WTPs

This paper focuses on projects associated with water sources and the approach Uisce Éireann takes to planning consent for such projects. Many Water Resource Zones (WRZs) rely on a single source of supply, meaning they are more vulnerable to interruptions to supply. In addition, current supplies often come from small local rivers. Within our existing asset base some abstractions may not be able to provide the supply of water to meet the demand required particularly during dry weather periods. As demand increases over time, this issue will become more evident. We must also continue to provide or improve the level of service to our customers and ensure water is supplied to our customers in accordance with the requirements of treated drinking water regulations.

Developing a Planning Strategy

In delivering projects, Uisce Éireann generally avails of two consent options:

i. Planning Permission or
ii. Exempted Development

Under the Planning Act, planning permission is required in respect of any development not being exempted development. Where possible Uisce Éireann will rely on planning exemptions. Planning permission is only ever be sought for development / works / structures that do not constitute exempted development. To identify the preferred consent route we follow a number of steps:

Step 1: Project Description and Project Need

i. Identify a full project description including the proposed ‘works’ involved
ii. Identify the existing and proposed uses at the site. And,
iii. Identify the project need.

Step 2: ‘Development’, ‘Works’ and ‘Material Change’

i. Confirm if the project falls within the definition of ‘development’, ‘works’ or if the project could be considered to be a ‘material change of use’ as per the Planning and Development Act, 2000 (as amended):

Section 2(1) of the Planning and Development Act (PDA) defines "Works" to include *"any act or operation of construction, excavation, demolition, extension, alteration, repair or renewal and in relation to a protected structure or proposed protected structure, includes any act or operation involving the application or removal of plaster, paint, wallpaper, tiles or other material to or from the surfaces of the interior or exterior of a structure*."

Section 3(1) of the PDA defines "Development" as "*the carrying out of any **works** on, in, over or under land or the making of any **material change in the use** of any structure or other land*".

"Material Change of Use" is not defined in the PDA. However, materially can be identified where, under a planning application scenario, the planning authority would take into account matters that would differ from those taken into account when the original use was assessed. An assessment of the potential intensification of a site / use e.g. an increase in water abstraction and / or treatment must examine if such intensification could be considered as a material change of use and therefore be deemed development and require planning permission.

Step 3: **Exempted Development Provisions**

Part 1 of Schedule 2 of the Planning Regulations lists general types (classes) of exempted development that might be relevant to some or all UÉ projects. Those classes of development that may be most relevant in this respect include UÉ specific exemptions (known as Class 58 exemptions) but it is important to note that it may be possible to rely on some other classes of exemptions.

Table 1: *Sample Class 58 Irish Water Exemptions*

Development by IW, for the purpose of the provision of water services, consisting of one or more of the following:		**Conditions and Limitations**
58(g)	The upgrade of existing water or waste water structures, or both, within existing site boundaries or the alteration or repair of any structure or its replacement with a similar structure.	The upgrading of any such structure shall not increase the existing floor area by more than 10% and the height of the upgraded structure shall not exceed the current height of existing structures.
58(h)	The installation of plant or equipment within the curtilage of an existing water services site only in so far as is necessary to avert serious risks to public health or critical failure of infrastructure.	N/A
58(i)	. The carrying out of any emergency work on an asset owned by IW in order to ensure the continued supply of essential water and waste water services.	. N/A
. 58(k)	. Test drilling for public water supplies.	.

Step 4: **Restrictions to Exempted Development:**

- Article 9 of the Planning Regulations has particular relevance as it sets out important restrictions on exemptions. Therefore, when considering the relevance of an exempted development provisions to the project, it is important to also ensure that no Article 9 restrictions apply to those exemptions. Examples of such exemptions are:
    - Contravene a condition attached to a permission under the Act or be inconsistent with any use specified in a permission under the Act.
    - Consist of or comprise the formation, laying out or material widening of a means of access to a public road the surfaced carriageway of which exceeds 4 metres in width.
    - Interfere with the character of a landscape, or a view or prospect of special amenity value or special interest,
    - Consist of or comprise the excavation, alteration or demolition of any archaeological monument included in the Record of Monuments and Places.
- Appropriate Assessment (AA) / Environmental Impact Assessment (EIA)
    - Comprise development in relation to which a Planning Authority or An Bord Pleanála (ABP) is the Competent Authority in relation to AA and the development would require an AA because it would be likely to have a significant effect on the integrity of a European site.
    - Consist of development to which Part 10 of the Act applies i.e. the development that requires an Environmental Impact Assessment (EIA).
- Inter-connected projects:
    - Connections to EIA development (Uisce Éireann and non Uisce Éireann development) and clarify functional dependencies of projects.

Exempted Development and Sample Uisce Éireann Water Project Scenarios

Each project is assessed on a case be case. We take the following into consideration when determining if exempted development provisions can be relied upon:

- The site boundary
- Existing consents, including planning permission and associated conditions, abstraction orders.
- The project need.
- The project description and extent of works.
- Use – existing and proposed.

Generally, our planning approach for water source projects is as follows:

Table 2 *Exempted Development and Sample Uisce Éireann Water Project Scenarios*

Development Type	Scenario	Planning Consent Type	Reason
Bored Production Well	i) Replacement of an existing production well at the site.	Exempt Development	Class 58(g) may be used provided the volume of water to be abstracted does not increase from what is currently being abstracted from the existing Bore Hole.

	(ii) New production well to supplement the volume abstracted from an existing Bore Hole at the site	Planning Permission	Class 58(g) may not be used as the volume of water being abstracted from both wells will be greater than the volume being abstracted from the existing Bore Hole.
Increase abstraction	Increase the daily abstraction yield of water at a WTP	Planning Permission	Increase abstraction above the maximum production as provided to the EPA in Abstraction Register then planning required unless that it can be demonstrated that the proposed increase in yield does not represent a material change at this site - there are no thresholds
Change water supply source from surface to ground water with same abstraction rate.	(i) New production well replaces a surface water source (river or spring well) with a groundwater source	Planning Permission	Planning permission required unless that it can be demonstrated that the water is being abstracted from the same source (i.e. no material change).
	(ii) Sping well replaced by a Borehole		Planning permission required unless there is evidence that both are abstracting water from the same ground water source (i.e. no material change)
Bored Trial Well	Trial Well	Exempt Development	Subject to no restrictions applying

Uisce Éireann and Planning Permission

Where exempted development cannot be relied upon, Uisce Éireann applies for planning permission. There are a number of types of planning permission:

- Outline Permission
- S. 34 Local Authority planning permission
- Strategic Infrastructure Development (An Bord Pleanála)

- Retention planning permission
- Substitute consent permission (i.e. retention permission for development which should have been subject to EIA, AA or screening for EIA).

Overall Uisce Éireann makes approximately 50-60 planning applications annually, with the vast majority of them being S.34 planning applications to a local authority. Generally, planning applications are made in the first instance to the relevant planning authority, with a right to appeal thereafter to An Bord Pleanála. These include applications which require EIA and / or AA.

Strategic Infrastructure Development (SID) comprises categories of development as defined by the PDA which are considered to be of national or regional strategic importance and SID applications are made directly to An Bord Pleanála. Specific SID project categories proposed by private developers (including Uisce Éireann) are set out in the Seventh Schedule of the PDA. If the development falls within one of the categories set out in Schedule 7 of the PDA then a pre-application consultation process must be undertaken with ABP to determine whether or not the proposed development comprises SID. Seventh Schedule water projects of potential relevance to Uisce Éireann include:

- A groundwater abstraction or artificial groundwater recharge scheme[i], where the annual volume abstracted or recharged is equivalent to or exceeds 2 million cubic metres.
- Any works for the transfer of water resources between river basins, where the annual volume of water abstracted or recharged would exceed 2 million cubic metres.

Having regard to Section 37A(2) of the Planning Act, ABP will decide that a Seventh Schedule development is SID if in its opinion, the proposed development would, if carried out, fall within one or more of the following paragraphs, namely:

- *The development would be of strategic economic or social importance to the State or the region in which it would be situate.*
- *(b) The development would contribute substantially to the fulfilment of any of the objectives in the National Spatial Strategy or in any regional spatial and economic strategy in force in respect of the area or areas in which it would be situate.*
- *(c) The development would have a significant effect on the area of more than one planning authority.*

It should be noted that the Seventh Schedule mirrors classes of development that fall under the EIA Directive and there is a requirement that SID applications are accompanied by an Environmental Impact Assessment Report (EIAR). A new Planning and Development Bill, 2022 was published recently with the purpose of revising and updating the 2000 PDA. As drafted there are revisions to the types and mechanism of making direct applications to ABP, including the removal of the 'tests' in respect of SID, the inclusion of surface water abstraction of a certain scale, and the omission of the requirement that SID applications be accompanied by an EIAR. To date Uisce Éireann has not made any SID applications in respect of water projects.

CONCLUSION

As outlined at the outset, Uisce Éireann seeks to rely on exempted development provisions to deliver water projects where it is appropriate to do so. There are restrictions to exemptions, with the most common being the existing site boundary of a water services site and material change of use of abstraction volumes, which limit their applicability. To date Uisce Éireann has not undertaken any SID applications for water projects but we expect this to change in the future as projects develop from the National Water Resources Plan, together with proposed legislative changes in the Planning and Development Bill 2022.

SESSION V

GROUNDWATER RESOURCE PLANNING: GEOLOGICAL SURVEY IRELAND'S GW3D PROJECT

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ABSTRACT

Geological Survey Ireland has an important role in both groundwater resource planning and groundwater protection planning. This paper will focus on Geological Survey Ireland's Groundwater and Geothermal Unit's GW3D project which provides an improved understanding of Irish groundwater resources. The GW3D project is a regional assessment of potential groundwater resources. These assessments develop an initial hydrogeological conceptual model for surface water catchments and provide a basis for prioritising further investigation into groundwater resources. Progressing on from the aquifer and vulnerability map, the assessments include data on anthropogenic settings, climate change, groundwater and surface water pressures to create a ranked description of each catchment's potential groundwater resources.

Key words: *groundwater resources, groundwater protection, drinking water*

INTRODUCTION

Geological Survey Ireland (GSI) have been providing groundwater resource and protection planning tools and information, in the form of the Groundwater Protection Schemes, since the 1980s (DoELG/EPA/GSI, 1999). The national scheme was completed in 2014 and Ireland was one of the first European countries to have national groundwater resource and protection maps and tools in place. Since this time, GSI have been improving the scale and usability of the data for different and more specific stakeholder needs, albeit all needs revolve around planning, ranging from specific planning applications to fundamental regional or national scale resource planning.

Irish groundwater resources support drinking water supply, industry and agriculture. Sixteen percent of Ireland's public water supply is sourced from groundwater; that percentage increases significantly in certain counties (for example 95% in Laois, 75% in Offaly and 61% in Roscommon). In addition, groundwater also forms an integral part of the water cycle and supports river flows, lake levels and ecosystems. With increasing population, supply – demand deficits and the impact of climate change, there is a need to better understand Irish groundwater resources for water resource planning.

GW3D – GROUNDWATER RESOURCE ASSESSMENTS

GSI's GW3D project involves carrying out regional scale groundwater resources assessments. The project initially covered 32 catchments in the east of Ireland (2019-2022). The project will now address groundwater resources in the Shannon and Corrib catchments (2023-2026) (Figure 1).

The methodology comprises four steps: 1) Identify the groundwater resources within each catchment, 2) Identify any potential constraints to those groundwater resources, 3) Compare across all the catchments and prioritise and 4) Carry out fieldwork to verify and quantify resources.

Groundwater resources within each catchment are assessed using all relevant, readily available information, such as meteorological, geological, hydrogeological etc. These data are used to produce a conceptual model and water balance for each catchment. The potential constraints to future groundwater abstractions which are considered include: 1) hydrogeological constraints, 2) ecological constraints, 3) existing abstractions, 4) groundwater chemistry and 5) impacts of climate change.

The areas with promising groundwater resources and without potential constraints to future groundwater abstractions are identified within each catchment. The results of each catchment are compared across the catchments to identify the areas with the best groundwater resources in the east and south of the country. This information will allow water resource managers to consider the best areas for future groundwater abstractions. The final step of the methodology is to install monitoring boreholes to test the outputs of the desk study.

Further details on the GW3D project and the hydrogeological resources assessments for catchments in the south and east of the country are available on the GSI website: https://www.gsi.ie/en-ie/programmes-and-projects/groundwater/projects/gw3d/Pages/default.aspx

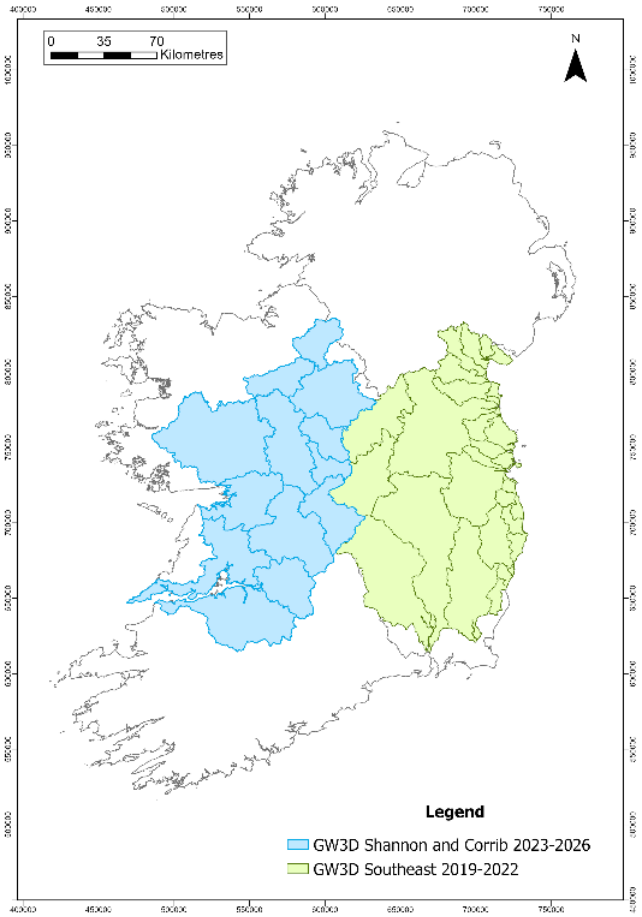

Figure 1: *Catchments included in the GW3D project. 2019-2022 study areas shown in green; 2023-2026 study areas shown in blue.*

ACKNOWLEDGEMENTS

The contribution of the following people to the GW3D projects is acknowledged: Shane Carey, Damien Doherty, Natalie Duncan, Joe Greene, Taly Hunter-Williams, Monika Kabza, Coran Kelly, Monica Lee, Sonja Masterson, Robbie Meehan, Ellen Mullarkey, Melissa O'Keefe, Alasdair Pilmer, Sara Raymond, Phillip Schuler, Simon Vokes and Sean Wheeler.

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GROUNDWATER FLOW DIRECTION: EIAR AND HYDROGEOLOGICAL ASSESSMENTS.

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ABSTRACT

An estimation of groundwater flow direction is the standard in EIARs and hydrogeological assessments and a conceptual model is often not considered complete unless it is provided[1]*. From analysis of the literature, groundwater flow direction is often provided based on either topography and/or hydraulic gradient in subsoil and fractured bedrocks. In this talk the rationale behind these assumptions in fractured rocks is assessed. Fracture density and connectivity increases towards the bedrock surface largely due to unloading and stress release related jointing*[2]*. These are intrinsically conductive fractures therefore the chances two or more separate points in the fracture flow system are hydraulically connected will also increase the closer the points are to the bedrock surface. As a consequence, groundwater flow in fractured bedrock is more likely to be with the gradient of the bedrock surface, closer to the bedrock surface. Whether the bedrock surface gradient is consistent with the topographic gradient depends on the attributes of the subsoil. The estimation of hydraulic gradient is based on a minimum of three wells and it often takes precedence over geological evidence in the estimation of groundwater flow direction even without evidence that the wells are hydraulically connected. Errors associated with making such assumptions are unknown. It is here suggested that in fractured rock flow systems where hydraulic connectivity between wells has not been proven or found not to be evident, constraints on geological and topographical controls on groundwater flow direction are just as or more important than an estimated hydraulic gradient. Any knowledge of conductive fracture geometry and connectivity is important, but so too are constraints on the intrinsically sealed structures. More broadly, an evidenced-based approach is prudent when conceptualising groundwater flow direction in geological media.*

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UNLOCKING GEOTHERMAL POTENTIAL IN NORTHERN IRELAND

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ABSTRACT

Geothermal energy could play a pivotal role in the decarbonisation of the heat sector. Delays in its development will impede progress towards achieving Northern Ireland's Net Zero ambitions. Substantial geothermal energy potential exists across much of Ireland due to the availability of geothermal heat at accessible depths. This creates an opportunity to reduce greenhouse gas emissions, improve energy security and create new jobs in the renewable energy sector. To date, decarbonisation of the heat sector across the island has been slow. This paper focuses on the existing barriers to success for geothermal energy development in Northern Ireland and outlines the legislative changes required to unlock the sector.

Key words: geothermal energy, planning permission, ground source heat

INTRODUCTION

Geothermal energy is the heat derived from the ground, from depths of a few meters to multiple kilometers below the Earth's surface. Shallow geothermal energy is derived largely from solar radiation, whereas deeper geothermal energy is resultant of heat emanating from the Earth's core and the decay of mildly radioactive elements in some geological settings.

There are different grades of heat, from low-grade shallow subsurface heat (stored at depths of <200m) to intermediate and deep (kilometer range). Heat derived from depths of >500m has been defined by the UK government as 'deep geothermal energy' [1], albeit there is no clear legal definition. The Earth's increasing heat with depth, is a phenomenon described as the geothermal gradient.

Geothermal energy is a renewable, clean, and reliable source of energy that can help reduce greenhouse gas emissions and dependence on fossil fuels.

It is estimated that 68% of home heating in Northern Ireland is still fuelled by oil [2]. It is a similar picture in Ireland with approximately 70% of Irish homes still reliant on gas or oil in 2019 [3].

DECARBONISING THE HEAT SECTOR

In March 2023, The Intergovernmental Panel on Climate Change (IPCC), made up of the world's leading climate scientists, delivered a 'final warning' on the climate crisis, as rising greenhouse gas emissions push the world to the brink of irrevocable damage that only swift and drastic action can avert [4].

The decarbonisation of domestic building heat is arguably the biggest energy sector challenge we face over the next few decades and key to reducing greenhouse gas emissions. We as hydrogeologists have an opportunity to help with this green energy transition by supporting the development of a low carbon heat sector.

GEOTHERMAL POTENTIAL

Ireland has significant geothermal energy potential as documented by the Geological Survey of Northern Ireland (GSNI) and Geological Survey Ireland (GSI) [5] [6]. Geothermal heat is available at accessible depths across much of the island of Ireland. A small number of shallow schemes have already been developed and there is increasing interest in use of geothermal for new developments as well as building retrofit. Harnessing this geothermal energy has the potential to make a significant contribution to reducing our dependence on fossil fuels and help decarbonise our heat sector.

GOVERNMENT SUPPORT & NET ZERO TARGETS

Decarbonisation of the Irish heating sector has been slow to date, with Ireland falling well short of 2020 targets for renewable heat [7]. The Climate Action Plan envisages that this sector will be decarbonised by retrofitting 400,000 existing dwellings to a minimum B2 BER standard and installing 600,000 heat pumps in Irish homes by 2030 [8].

Northern Ireland Executive's Energy Strategy '*The Path to Net Zero Energy'* and associated Action Plan published in 2022 [9] [10], signals The Department for the Economy's (DfE's) intention to develop a better understanding of Northern Ireland's potential for geothermal energy. DfE hope to achieve this by commissioning geothermal demonstrator projects that will help educate, demystify and build the geothermal sector.

In February 2023 DfE commissioned two geothermal demonstrator projects in Northern Ireland. These comprise overarching communications and marketing initiatives and two technical feasibility studies: one which includes a shallow geothermal feasibility and exploratory investigation, on the Stormont Estate, Belfast and a second deep geothermal feasibility at Greenmount in County Antrim.

These projects will inform geothermal policy development across government as well as contributing to de-risking future private sector geothermal projects. The geothermal exploratory and feasibility studies will be used to better understand subsurface geothermal potential and to test planning and regulatory processes relevant to implementing geothermal schemes. At the Belfast site, boreholes will be installed and tested to understand site specific conditions. Extensive geophysical surveys and geological modelling will be undertaken at the Antrim site to identify an optimum location and design for a deep borehole source. The data and knowledge from these feasibility studies will be made available to the public and used to demonstrate that a viable geothermal heat resource is accessible at depth. It is hoped that this will encourage private investment and inform the development of a policy and regulatory framework that supports and promotes opportunities to unlock Northern Ireland's geothermal energy potential.

BARRIERS TO SUCCESS

Development of new policies and a regulatory framework that supports and promotes opportunities to unlock Northern Ireland's geothermal energy potential are vital if we are to meet our low carbon heat sector ambitions. In December 2022 the Department for Infrastructure (DfI) closed its public consultation on the suitability of permitted development rights in Northern Ireland. This consultation paper had a specific focus on Ground and Water Source Heat Pumps [11]. The consultation paper acknowledges the potential barriers to success when it comes to building the geothermal sector in Northern Ireland and provides an insight into what regulatory change is required.

Whilst not specifically referenced, the DfI consultation paper states that installing ground and water source heat pumps, within the curtilage of a dwelling, could fall within permitted development rights, subject to certain conditions being met. Class F of Part 2 of the

Schedule to the GPDO outlines these conditions, which are consistent with those set for the positioning of domestic oil storage tanks. The addition of clear wording giving ground and water source heat pumps permitted development rights would be beneficial.

The DfI paper also acknowledges that Northern Ireland is currently out of step with other jurisdictions in relation to ground and water source heat pumps. Permitted development rights currently exist in Scotland, England and Wales with no conditions or limitations. In the Republic of Ireland exempted development is provided for the installation on or within the curtilage of a house of a ground heat pump system (horizontal and vertical) subject to certain restrictions.

The consultation paper outlines DfI's intention to align the permitted development rights with Scotland, England and Wales and recommends permitted development rights for the provision of a ground or water source heat pump within the curtilage of a dwellinghouse with no conditions or limitations.

Whilst the above is a helpful start, the permitted development / exempted development rights don't address the sub surface elements of the installation. Specific reference to the collector system and whether this is considered part of the ground source heat pump (GSHP) system is required.

The Town and Country Planning (General Permitted Development) (England) Order 2015 [12] and The Town and Country Planning (General Permitted Development) (Non-Domestic Microgeneration) (Scotland) Amendment Order 2011 [13] provide a starting point for the sub-subsurface component of the system.

Schedule 1, Part 1B of the Scottish Amendment Order (2011) provides permitted development rights for the installation, alteration or replacement of such microgeneration equipment (including underground pipes) on or within the curtilage of non-domestic buildings, subject to certain limitations and conditions.

Class C and Class L of The Town and Country Planning GPDO (England) 2015, affords permitted development rights to the installation or alteration of water source heat pumps on domestic and non-domestic premises by permitting the installation, alteration or replacement of a microgeneration water source heat pump (including any pipes), subject to certain limitations and conditions.

The existing permitted development rights afforded to mineral exploration in Northern Ireland (through Schedule 2, Part 16 – Mineral Exploration – of The Planning (General Permitted Development) (Amendment) Order (Northern Ireland) 2020) [14] could be extended to geothermal exploration. The 2020 Order permits development on any land consisting of:

a) the drilling of boreholes (other than for petroleum exploration);

b) the carrying out of seismic surveys; or

c) the making of other excavations, for the purposes of mineral exploration, and the provision or assembly on that land or on adjoining land of any structure required in connection with any of those operations.

Extending the above-mentioned development rights to the geothermal sector in Northern Ireland would be extremely beneficial.

NORTHERN IRELAND SPECIFIC BARRIERS TO SUCCESS

This section outlines some of the other planning related considerations that face geothermal **exploration** projects in Northern Ireland. Shallow geothermal schemes completed to date in Northern Ireland have typically been advanced as part of wider development proposals, and therefore planning permission has not been required specifically for this constituent part of the wider development.

Potential Barrier/Constraint #1: Permitted development rights for geothermal exploratory drilling and associated operations (surveys and testing etc.) remain unclear. In the absence of clear legislation drilling operations have, in some instances, been viewed as 'engineering operations' and in that context would be classed as 'development' under the terms of Section 23 of the Planning Act (Northern Ireland) 2011 [15]; thus, requiring planning permission.

The Planning (General Permitted Development) Order (Northern Ireland) 2015 (GPDO) [16] does not provide specific regulations for exploratory drilling for geothermal purposes and therefore presents a potential barrier to those who wish to investigate and or assess the underground heat potential at their site. Whilst the 2015 GPDO gives permitted development rights in respect of borehole drilling for mineral exploration projects, Planning Officers unfamiliar with geothermal investigation techniques are likely to air on the side of caution and determine that the works require planning permission.

Suggested Change #1: Permitted development rights such as those afforded to mineral exploration in Northern Ireland should be extended to shallow geothermal exploratory drilling. Other jurisdictions have sanctioned projects investigating geothermal resources under the relevant provisions (Part 17, Section K) of The Town and Country Planning (General Permitted Development) (England) Order 2015 [12].

Potential Barrier/Constraint #2: Geothermal Drilling does not fall neatly into any development classifications (Schedule 1 or Schedule 2) of The Planning Environmental Impact Assessment (EIA) Regulations (NI) 2017 [17]. Schedule 2, Category 2(d) of the regulations references 'deep drillings' including geothermal drilling. Although the Directive does not define "deep drillings", in other jurisdictions the legal definition of deep geothermal uses a threshold of >500 meters [18]. The threshold and criteria in respect of this category of development triggers an EIA determination when "…drilling is to be undertaken within 100 metres of any waterway or water in underground strata". The threshold appears onerous, as most hydrogeologists investigating shallow geothermal potential (<500m depth) in Ireland will almost certainly be drilling within 100 meters of water in underground strata. It is possible that the regulations were written with deep geothermal drilling or enhanced geothermal systems in mind, but the current wording has potential significant cost implications which could act as a significant barrier to investment.

Suggested Change #2: An update of The Planning Environmental Impact Assessment Regulations (NI) 2017 is required and a clear definition of geothermal drilling included as a minimum. Further consideration should be given to subdividing geothermal into sub-categories based on its potential environmental risk and or depth of exploration. Traditional shallow open and closed loop drilling risks can be managed in line with current industry guidelines such as the IGI Guidelines for drilling wells for private water supplies [19] and correct closed loop standards such as the Vertical Borehole Standard, March 2023 (Issue 3) [20]. These standards seek to maintain a high level of installation quality whilst protecting the water environment and ensure best practice.

The Department for Infrastructure (DfI) in Northern Ireland launched a consultation on 6th April 2023 on Review of Regional Strategic Planning Policy on Renewable and Low Carbon Energy [21]. Within this, geothermal energy is referenced under 'emerging technologies' with a recommended option to revise existing Strategic Planning Policy to better support, guide and facilitate new and emerging technologies. This represents a

further opportunity for geothermal stakeholders to input and shape future policy.

Potential Barrier/Constraint #3: With the absence of grant funding in Northern Ireland to support domestic scale geothermal exploration, it is likely that most of the near-term investment and development will have to come from the non-domestic market. Currently boreholes drilled for the purpose of investigating the geothermal potential at non-domestic sites could constitute a 'Major' Planning Application in Northern Ireland if the total development area exceeds 1 hectare.

Major planning applications are a special category of development under The Planning (Development Management) Regulations (Northern Ireland) 2015. There are several triggers for major development, including "sites of 1 hectare or greater". Major planning applications require the submission of a Proposal of Application Notice (PAN), indicating how you will carry out consultation, twelve weeks before submission of the formal planning application. Application fees are higher and Major applications typically take longer to determine.

Non-domestic scale heating and cooling schemes can comprise multiple abstraction and re-injection wells. Consider a four borehole well field, two abstraction and two re-injection boreholes, each 100m apart. Maximizing the separation distance between points of groundwater abstraction and re-injection increases the efficiency of ground source heat pump installation. This four-borehole system would theoretically trigger a major planning application as the drill sites and the area between would likely exceed 1 hectare when you consider the space required for the drilling compound, temporary material storage areas and access arrangements.

Suggested Change #3: Permitted development rights that recognise the likely scale of typical geothermal systems is required.

NI CASE STUDY

Buildings on the Stormont Estate are currently heated using oil/gas fired boilers. Delivery of the Energy Strategy and Executive's climate change commitments mean that this source of heating will have to be phased out and replaced with a low carbon alternative. The Estate overlies a principal aquifer – the Sherwood Sandstone, which boasts a high thermal conductivity and supports high groundwater yields, that could be used to provide heating and cooling, when combined with a heat pump. This provides an opportunity to use a renewable source of energy that has the potential to deliver higher efficiencies than alternative solutions.

MAJOR PLANNING APPLICATION

In February 2023, DfE commissioned Tetra Tech to carry out two geothermal demonstrator projects in Northern Ireland. This paper focuses on the first of the two projects at Stormont Estate, Belfast. The project includes a shallow geothermal feasibility and exploratory investigation. As part of the Stormont Estate investigation Tetra Tech will identify the most suitable geothermal solution to provide heating and cooling at several pre-identified buildings; including identification of the optimum depth of the borewell(s) and recovery system based on the most efficient and cost-effective means of utilising the shallow subsurface environment. The proposed boreholes are investigatory only at this stage. The investigation findings will be needed before a decision is taken on how best to use the resource.

It is planned to drill four boreholes from Ground Level (GL) to a Total Depth (TD) of approximately 250 metres at 200 mm diameter and a cored borehole up to 500 m depth with a hole diameter of 96 mm. The Stormont Estate is large, and this creates an opportunity to spread the boreholes out across the site to minimise interaction between points of water abstraction and re-injection; thus increasing the efficiency of the system

(open loop). The trade-off is that the site area is greater than 1 hectare and therefore triggers a Major planning application.

The latest statistics [22] published by The Department for Infrastructure for April – September 2022 shows that the average processing time for major planning applications brought to a decision or withdrawal was 56.4 weeks across all Northern Ireland councils. This means that the drilling and testing of the five boreholes proposed at Stormont Estate will likely be delayed by over a year.

To avoid a major planning application, consideration was given to constraining the red line boundary around each of the drill sites in a manner consistent with the approach taken by many windfarm developments. Keeping a very tight red line boundary around the 5 no. compounds (each circa 25m x 50m) linked by a red line does result in a site area of approx. 0.7 – 0.8 hectare. The boundary also needs to encompass any mitigation measures required as part of the works (i.e. points of discharge or locations where water may be directed to as part of the works – i.e. a catch-pit). In order to give the project some flexibility and enable micro-siting of borehole positions following the completion of various technical assessments (i.e. ecology, archeology, noise, hydrological etc.), the decision has been taken to proceed with a major planning application. This means that the borehole positions can be moved within the redline boundary should this be required, without the need to re-start the planning process.

EIA DEVELOPMENT

The requirement for EIA arises from Directive 85/337/EEC as transposed by The Planning (Environmental Impact Assessment) Regulations (Northern Ireland) 2017. On certain large-scale developments the Northern Ireland Environment Agency (NIEA) Development Management Team are asked by Planning Service to assess whether an EIA is required due to its environmental impact. This process is called screening. If Planning Service determines that an EIA is required NIEA will advise what types of surveys and other technical information will be needed to assess the environmental impact.

Because Schedule 2, Category 2(d) of The Planning Environmental Impact Assessment (EIA) Regulations (NI) 2017 [17] references “deep drillings, in particular – geothermal drilling” (see extract below), EIA screening is required. The absence of a clear definition for “deep drillings” means that some uncertainty exists for those having to apply this legislation.

The threshold and criteria used to determine whether the development constitutes EIA is also likely to be met when “…the area of the works exceeds 1 hectare” or “in relation to geothermal drilling…. Drilling is to be undertaken within 100 meters of any waterway or water in underground strata”. The depth to water within the target aquifer is expected to be approximately 25 – 30m at the Stormont site and groundwater is also likely to be encountered at shallower depths within the overlying superficial sand and gravel deposits. It is therefore difficult to see how the drilling of boreholes at the Stormont Estate would constitute anything other than EIA development.

Environmental Impact Assessments add significant time and cost to any development. In contrast, if a large industrial water user wanted to drill a 5 borehole well field for water supply, it is unlikely that this would constitute a major planning application, nor would it constitute EIA development in Northern Ireland.

The absence of permitted development poses a significant barrier to the investment and adoption of geothermal energy in Northern Ireland.

Table 1. *The Planning EIA Regulations (NI) 2017: Descriptions of development and applicable thresholds and criteria for the purposes of the definition of "Schedule 2 development".*

Column 1 **Description of development**	**Column 2** **Applicable thresholds and criteria**
The carrying out of development to provide any of the following—	
1. Agriculture and aquaculture	
(a) Projects for the use of uncultivated land or semi–natural areas for intensive agricultural purposes;	The area of the development exceeds 0.5 hectare.
(b) Water management projects for agriculture, including irrigation and land drainage projects;	The area of the works exceeds 1 hectare.
(c) Intensive livestock installations (unless included in Schedule 1);	The area of floorspace exceeds 500 square metres.
(d) Intensive fish farming;	The installation resulting from the development is designed to produce more than 10 tonnes of dead weight fish per year.
(e) Reclamation of land from the sea.	All development.
2. Extractive industry	
(a) Quarries, open–cast mining and peat extraction (unless included in Schedule 1); (b) Underground mining;	All development (except the construction of buildings or other ancillary structures where the floorspace does not exceed 1,000 square metres).
(c) Extraction of minerals by fluvial or marine dredging;	All development.
(d) Deep drillings, in particular— (i) geothermal drilling; (ii) drilling for the storage of nuclear waste material; (iii) drilling for water supplies; with the exception of drillings for investigating the stability of the soil;	(i) In relation to any type of drilling the area of the works exceeds 1 hectare; or (ii) in relation to geothermal drilling and drilling for the storage of nuclear waste material only, drilling is to be undertaken within 100 metres of any waterway or water in underground strata.

WIDER IMPLICATIONS FOR REPUBLIC OF IRELAND

There is a need to examine whether current planning legislation in the Republic of Ireland supports the installation of geothermal systems in a timely and cost effective manner if The Climate Action Plan targets are to be met.

CONCLUSIONS

The regulation of geothermal schemes is a matter for the devolved administrations in the UK. Northern Ireland lags behind in the development of bespoke planning rules, environmental regulation or licensing systems specific for the development and operation of geothermal schemes. The absence of bespoke regulations mean that geothermal developments are dealt with through existing regulation, which were initially developed with objectives other than geothermal energy production.

Currently, planning consent is required for the development of GSHP systems, and in some cases, an Environmental Impact Assessment (EIA) is also required.

Geothermal heating has an important role to play in the decarbonisation of the heat sector. Delays in its development could impede progress towards reducing greenhouse gas emissions, improved energy security and new job creation. Decarbonisation of the heat sector on the island of Ireland has been slow so far. This paper focuses on the existing barriers to success for geothermal energy development in Northern Ireland and provides suggested legislative changes which would help unlock the sector.

The need to secure planning permission to drill boreholes for shallow geothermal exploration and/or to implement a geothermal scheme could set a dangerous precedent and introduce red tape and unnecessary cost for geothermal development in Northern Ireland, particularly at a time when there is a need to grow the sector.

Thousands of boreholes are drilled for mineral exploration, groundwater abstraction and ground investigation in Northern Ireland annually, none of which require planning permission. Several geothermal schemes have successfully been delivered in Northern Ireland; without required standalone planning permission for the geothermal component of the works. Most have been progressed without planning or have passed through the planning process, often without mention, as part of wider development proposals.

This does not mean that such works should not be subject to some form of control. Existing checks and balances and regulatory controls are in place to deal with drilling works associated with borewells and mineral exploration. These controls include notifying the Geological Survey of Northern Ireland when drilling boreholes to depths of >15m. Consent from The Department of Agriculture, Environment and Rural Affairs (DAERA) is required for associated use of boreholes such as abstraction and discharge. All of which would apply to the Stormont Estate demonstrator project. In addition, promotion of industry developed good practice, potentially linking to financing/insurance, would also offer protection to the environment and customer.

A review and update of the planning and EIA regulatory framework surrounding geothermal exploration and development is required in Northern Ireland. Granting permitted development rights to shallow geothermal exploration including drilling, surveying and testing would streamline the regulatory process and encourage greater adoption of this technology at the domestic and non-domestic scale. Geothermal is an important part of the energy mix required to decarbonise our heat sector and meet our net zero ambitions.

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DCC BASEMENT IMPACT ASSESSMENT

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ABSTRACT

There are an increasing number of basement developments in Dublin City. Whilst basement accommodation can be a useful means to increase the floor space of a development, it can also have significant geological, hydrological and hydrogeological impacts which have an additional significance in the context of climate change. These impacts can be exacerbated by the fact that much of the city centre area includes made ground or tidally influenced groundwater. The impact of basements on neighbouring properties, or future developments, is a key concern.

Dublin City Council has introduced a new policy requiring that a Basement Impact Assessment (BIA) shall accompany all planning applications that include a basement. This is accompanied by a document setting out general guidance regarding basement developments, including an outline of the information to be contained in a Basement Impact Assessment. This would include: Baseline Characteristics of the Project; Site Investigation and Geotechnical Analysis; Impact Assessment; Construction Management Plan; Impact Assessment and Mitigation; Non-technical summary.

At time of writing, the Council are undertaking a procurement process to form a framework of specialist consultants to undertake the role of BIA Auditors. These will review the BIA submission and ensure that the BIA is undertaken in line with the requirements as set out in the Dublin City Development Plan and provide an Audit Report, containing their expert analysis and review. The framework is expected to be in place by the end of April, 2023.

Key words: *Basement, planning, groundwater.*

INTRODUCTION

There are an increasing number of basement developments in Dublin City. Whilst basement accommodation can be a useful means to increase the floor space of a development, it can also have significant geological, hydrological and hydrogeological impacts which have an additional significance in the context of climate change. These impacts can be exacerbated by the fact that much of the city centre area includes made ground or tidally influenced groundwater. The impact of basements on neighbouring properties, or future developments, is a key concern.

A basement or underground development is considered as being an accessible area which may comprise one or more levels positioned below the existing street level or ground level and would include any works that will remain permanently in the ground, such as embedded wall construction below the base of the accessible area. In order to ensure mitigation of some of the impacts referenced above, Dublin City Council has introduced a new policy requiring that a Basement Impact Assessment (BIA) shall accompany all planning applications that include a basement. This is accompanied by Basement Development Guidance in Appendix 9 of the City Development Plan. This can be accessed at:

https://www.dublincity.ie/residential/planning/strategic-planning/dublin-city-development-plan/development-plan-2022-2028/volume-2-appendices-0

The document sets out general guidance regarding basement developments, including an outline of the information to be contained in a Basement Impact Assessment. The guidance document is intended not to be prescriptive but rather to provide general guidance on the typical scope of information to be included in such assessments.

BASEMENTS – POTENTIAL NEGATIVE IMPACTS

The potential impacts to arise from basement development are typically:

- The potential to alter groundwater levels or flow. This can have adverse consequences for adjacent properties including a risk of flooding and increased filtration into sewers. A decline in groundwater levels may affect wells, streams and ponds and can cause subsidence.
- Basement construction can induce ground movements in the surrounding area and impact negatively on adjacent properties and infrastructure.
- Ground anchors that extend outside the property boundaries and can impact on the possible long term development options of adjacent areas. These need to be licensed accordingly by the Roads Authority and relevant utility agencies.
- Surface water flow and flooding can be impacted on.
- The construction of basements including piling, deep excavation as well as associated impacts such as noise, dust, traffic management and discharge of groundwater.
- Excavated material may require analysis for potential contamination.
- Basement excavation may have archaeological implications.
- Basements can have negative impacts on underground services and infrastructure which may need to be addressed.
- Cumulative impacts from all of the above factors can arise from the incremental development of basements in close proximity, and can create significant impacts on hydrological and hydrogeological conditions.

PURPOSE OF A BASEMENT IMPACT ASSESSMENT

The purpose of the Basement Impact Assessment is to identify potential impacts, short and long term; to inform whether a proposed basement is acceptable; and to identify whether appropriate mitigating measures can be incorporated. It must also demonstrate:

- That the construction of the basement will not unduly impact on groundwater conditions and that groundwater quality, quantity and classification will be protected.
- That groundwater or surface water flows will be not be impacted on to the extent that there is likely to be an increase in the risk of flooding.
- That the basement development will not increase groundwater infiltration into existing sewers and drains beyond permitted levels.
- That the basement development will not have an adverse effect on existing patterns of surface water drainage, including infiltration into groundwater and is consistent with best practice in SuDS.
- That the structural stability/integrity of adjoining and neighbouring buildings will not be compromised.
- That the design of the basement relates to the characteristics/proportions of the site.
- That the basement has been designed to an appropriate standard and will be constructed in accordance with a detailed Construction Management Plan and that

an appropriate suite of mitigation measures are proposed to address potential adverse impacts.
- That the construction of the basement will not cause undue nuisance to the residential amenities of existing communities and will not adversely impact on the built and natural environment.
- That the design of the basement considered impacts on future planting including trees and where possible, enhances the biodiversity value of the site.
- That the basement development will not adversely impact on existing protected structures, heritage sites, conservation areas or sites of archaeological interest.
- That the design of the basement should be compliant with all relevant building regulations.

CONTENT OF BASEMENT IMPACT ASSESSMENT

The BIA will be specific to the site and the proposed development and should be undertaken by a person(s) with the appropriate qualifications and experience (Chartered Structural and/or Geotechnical Engineer or equivalent). The level of detail will depend on the location of the proposed basement, its size and complexity, setting and relationship to existing development on and adjacent to the site. The content of the BIA shall reflect the scale of the potential impacts identified during the scoping and site investigation stages. A BIA would typically include the following:

- Baseline Characteristics of the Project
- Site Investigation and Geotechnical Analysis
- Impact Assessment
- Construction Management Plan
- Impact Assessment and Mitigation
- Non-technical summary

PROCUREMENT OF BASEMENT IMPACT ASSESSMENT AUDITORS

Dublin City Council took the view that they needed more specialist expertise to review Basement Impact Assessments, particularly for more complex sites. The Council initiated a procurement process to form a framework of consultants to undertake the role of BIA Auditors.

The auditor appointed will advise and represent DCC's interests throughout the entire planning process for the particular BIA and planning application being assessed. They will review the BIA submission and ensure that the BIA is undertaken in line with the requirements set out in the Dublin City Development Plan and provide an Audit Report, containing their expert analysis and review. They are required to seek further information from the developer, via the City Council, where applicable and to review same. The auditor will outline measured and coherent conditions which they deem necessary to be applied by the City Council (if permission were to be granted).

At time of writing, the procurement process is live. It is intended to have the framework in place by the end of April, 2023.

BASEMENT IMPACT ASSESSMENT – SUBMISSION CHECKLIST

The guidance document includes the following submission checklist. This check list is not exhaustive and the scope of information required is dependent on the scale and location of the basement construction proposed. The scope of the BIA should be agreed in advance with the Environment and Transportation Department of Dublin City Council (as per details provided on the DCC website). The BIA must be completed by a suitably qualified

professional with the necessary expertise to complete such an assessment (Chartered Structural/Geotechnical Engineer or equivalent).

The author would recommend that the BIA should address all items listed below. If some of these are considered to be irrelevant to a particular application, this should be stated and explained/ justified.

Table 1: *Basement Impact Assessment Submission Checklist*

	Item	**Yes/No**
1	Description of proposed development.	
2	Plan showing boundary of development including any land required temporarily during construction.	
3	Plan, maps and photographs to show the location of basement relative to surrounding structures.	
4	Plans, maps and or photographs to show topography of surrounding area with any nearby watercourses/waterbodies including consideration of the relevant maps on the SFRA (Vol 7).	
5	Plans and sections to show foundation details of adjacent structures (reference to pre-condition reports).	
6	Plans and sections to show layout and dimensions of proposed basement and all proposed foundation details.	
7	Modelling evaluation of baseline groundwater levels and flows.	
8	Modelling and evaluation of groundwater levels and flows during construction and following construction of basement.	
9	Programme of enabling works and construction and restoration.	
10	Identification of potential risks to land stability (including surrounding structures and infrastructure and groundwater flooding.	
11	Assessment of potential risks on neighbouring properties and surface groundwater.	
12	Identification of significant adverse impacts.	
13	Ground Investigation Report and Conceptual Site Model including: ▪ Desktop study ▪ Exploratory hole record ▪ Results from monitoring the local groundwater regime ▪ Confirmation of baseline conditions ▪ Factual site investigation report	

	Item	Yes/No
14	Ground Movement Assessment.	
15	Plans, drawings, reports to show extent of affected area.	
16	Construction Sequence Methodology (CSM) referring to site investigation and containing basement, floor and roof plan, sections, sequence of construction and temporary works.	
17	Proposals for monitoring during and post construction (groundwater movement and levels, ground movement, vibration with comparisons to baseline) – limits to be advised in BIA and monitored. Any breaches should be reported to DCC's Environment and Transportation Department.	
18	Consideration of potential impacts to protected structures, conservation areas and archaeology where relevant.	
19	Consideration of potential impacts to biodiversity and amenity.	
20	Construction Management Plan.	
21	Impact assessment and specific mitigation measures to reduce or offset significant adverse impacts with comparisons to baseline study.	
22	Provision for monitoring post construction (post-condition surveys, groundwater levels/flows etc.).	
23	Non-technical summary of full report.	

SESSION VI

THE IMPACT OF CLIMATE CHANGE ON GROUNDWATER RECHARGE IN IRELAND

Corine Oggel, *University of Birmingham*

The Impact of Climate Change on Groundwater Recharge in Ireland.

Corine Oggel

Poster on project submitted for the degree of Master of Science in Hydrogeology at the University of Birmingham in 2020.

UNIVERSITY OF BIRMINGHAM

Introduction

- The objective of this project is to consider the impact of climate change on groundwater recharge in Irish aquifers.
- This project seeks to investigate the following questions:
  - How vulnerable are Irish aquifers to climate change?
  - What are the implications of changing groundwater recharge in Ireland?
- Uses historical climate data to predict changes to groundwater recharge at the synoptic weather stations throughout Ireland.

Background

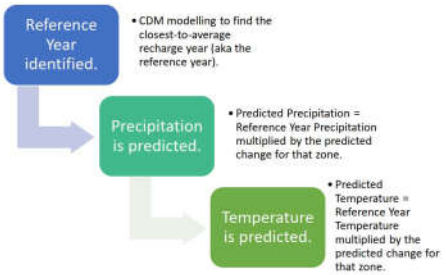
- Aquifer sustainability is contingent on recharge, which is highly dependent on precipitation. Thus, changes in one part of the hydrological cycle will impact the entire system.
- Most climate change models predict an increased frequency of extreme weather events, which will change seasonal climate patterns, thus impacting recharge of groundwater.

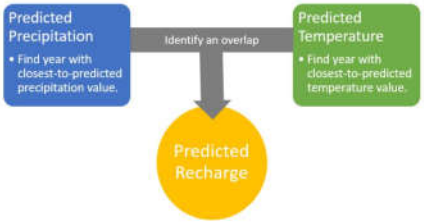
Methods

- Investigation was limited to 20 Met Éireann synoptic weather stations.
- Potential recharge was calculated at each station, and compared to predicted recharge values.
- Climate change model used

Precipitation and temperature predictions

- Calculated the cumulative deviation from the mean (CDM) for each year, thus identifying the year with closest-to-average recharge.
- Annual precipitation and average annual temperature values from this year were taken and appropriately changed according to the climate change zone they were in.



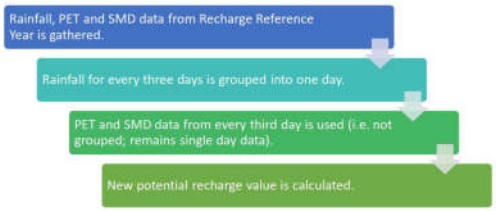


Recharge predictions

- Calculated the deviation of historical annual precipitation to predicted annual precipitation to identify a reference year at each station.
- Repeated for historical and predicted temperature.
- Identify an overlap and use the annual recharge from that year as the predicted recharge value.

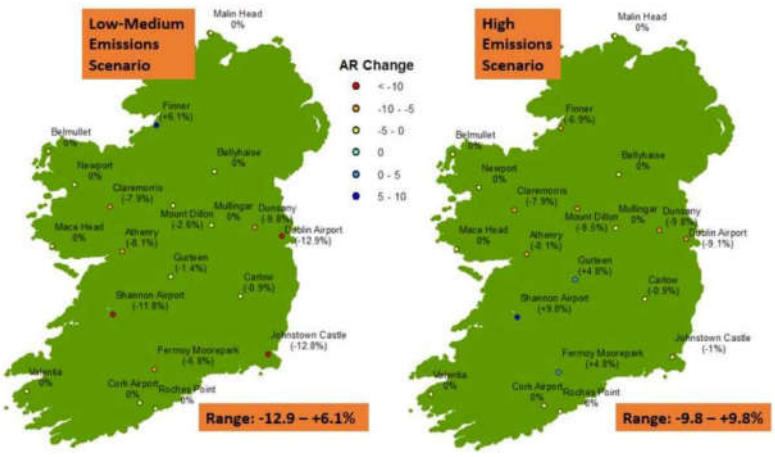
Increased rainfall intensity predictions

- Used the recharge reference year calculated previously.
- Grouped rainfall data for every three days into one day and calculated a new recharge value.



Results

- Under the low-medium emissions scenario, there is a greater decrease observed in the south-east of the country.
- Under the high emissions scenario, there is a greater range of change predicted, with greatest decrease observed in the north, and increased recharge in the southern midlands.
- Under both emissions scenarios, there is a general correspondence between regionally important aquifers and the highest potential recharge values.



Conclusions

- Climate change is predicted to impact recharge in Irish aquifers. Recharge is generally predicted to decrease across the country, particularly in the east and midlands.
- However, changes in rainfall intensity could increase the complexity of such predictions. Typically, increased rainfall intensity is associated with increased recharge, where aquifers can accept this rise.
- Where a recharge cap applies, increased rainfall intensity is likely to bring about increased run-off. Thus, under greater rainfall intensity, the risk of groundwater flooding is heightened.

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HYDRAULIC CONDUCTIVITY ACROSS DIFFERING UNDERLYING GEOLOGICAL SUBSTRATES IN FORMER INDUSTRIAL PRODUCTION SITES

Ciaran Higgins, *RPS & Bord na Móna*

Hydraulic Conductivity Across Differing Underlying Geological Substrates in Former Industrial Peat Production Sites

Ciaran Higgins, Contact: ciaran.higgins@rpsgroup.com

Introduction

The majority of raised bogs in Ireland have been drained, aiming to lower the water table to facilitate peat extraction for fuel or horticultural purposes. Restoration of drained peatland sites by rewetting through drain blocking and bunding can reduce carbon emissions and provide optimal conditions for carbon sequestration.

Figure 1

Successful rewetting relies on a good understanding of the complex interaction raised bogs have with the surrounding environment. Vertical exchanges in groundwater can contribute to the success of rewetting programmes, with rates of exchange being influenced by the type of underlying geological unit.

The Peatlands Climate Action Scheme (PCAS) aims to optimise ecosystem benefits of peatland restoration in former industrial peat production sites (Figure 1).

To further develop the characterisation of restoration sites RPS personnel implemented a hydrological monitoring programme (Figure 2) and conducted a series of field-based piezometer tests, using shallow phreatic wells and deep piezometers, to characterise the hydraulic conductivities of shallow (<1.5m) and deep (>1.5m) peat sites with differing underlying geological conditions.

Figure 2

Methodology

A subset of sites, geographically spread across the project area, were chosen (figure 3) in which estimates of hydraulic conductivity values (K) were obtained using falling head tests. The sites prioritised were comprised of several commonly encountered geological materials that are common across the midlands of Ireland (clay, till, marl, sand) (Figure 4) and had a range of peat depths.

Figure 3

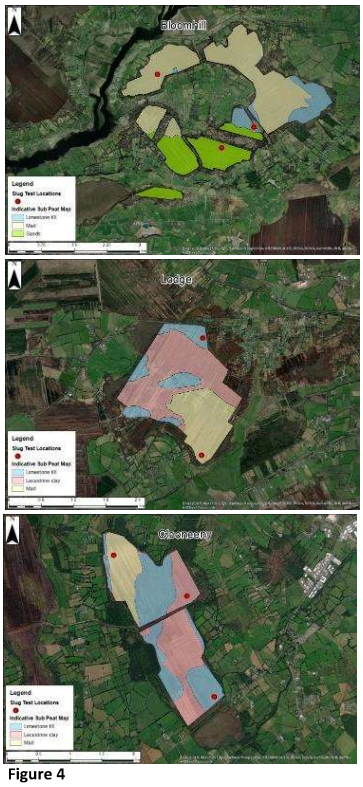


Figure 4

- **Installation of a hydrological monitoring network** (piezometer pairs in deep peat and phreatic wells in shallow peat)
- **Characterise the site** (peat depths, underlying substrate etc)
- Conduct **field-based falling head tests** in selected wells.
  - Increase water level 20cm above the static water level.
  - Use water level transducers to record high-resolution recovery data.

Figure 5

- **Collect response data** after 2 weeks (Figure 5)
- **Analyse raw data** using Hvorslev's (1951) method **to determine the hydraulic conductivity of the surrounding subsoil.**

Results

- Response data was plotted on a liner-log axis to produce a displacement-time graph (Figure 6).
- The AQTSEsolve hydrogeological software was used to derive a K value using Hvorslev's (1951) equation for an unconfined aquifer.
- In this example, the data followed a strong relationship with the line of best fit before tailing off.
- This is commonly observed in peatland studies as displaced water returns to the initial head (h0) and natural variations in the water table begin to take over.

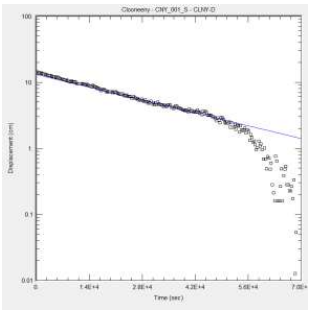


Figure 6

Table 1

Site	Well ID	Type	Underlying Geological Material	Peat Depth (m)	K Value (m/day)
Lodge	LDG_011_D	Deep	Marl	3.1	5.45×10^{-4}
Bloomhill	BLH_009_S	Shallow	Glacial Till	1.95	6.84×10^{-4}
Bloomhill	BLH_009_D	Deep	Glacial Till	1.95	1.14×10^{-3}
Bloomhill	BLH_015_D	Deep	Sand	1.7	1.16×10^{-3}
Clooneeny	CNY_001_S	Shallow	Marl	3.75	1.35×10^{-3}
Clooneeny	CNY_001_D	Deep	Marl	3.75	1.46×10^{-3}
Bloomhill	BLH_004_D	Deep	Marl	2.25	1.81×10^{-3}
Clooneeny	CNY_007_S	Shallow	Lacustrine Clay	1.15	2.74×10^{-3}
Lodge	LDG_007_S	Shallow	Glacial Till	0.6	4.22×10^{-3}
Lodge	LDG_011_S	Shallow	Marl	3.1	4.45×10^{-3}
Clooneeny	CNY_010_S	Shallow	Glacial Till	0.83	5.02×10^{-3}
Bloomhill	BLH_015_S	Shallow	Sand	1.7	9.60×10^{-3}

- Table 1 provides a summary of the results collected across the study sites, detailing the characteristics of each test location and the hydrological conductivity observed.
- Data suggests that K is more statistically related to peat depth than it is to underlying geological strata.
- Figure 7 highlights the variation between tests conducted at shallow and deep piezometers.

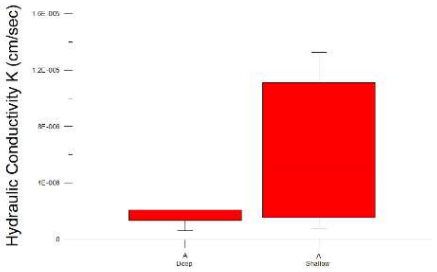


Figure 7

Conclusion

- In former industrial peat production sites hydraulic conductivity (K) values are high in the upper layers of peat but K declines rapidly with depth.
- Compaction and subsidence of peat, caused by drainage and repeated traffic movements during the production process, may have significantly reduced vertical seepage in deep peat.

Figure 8

- Deep peat rehabilitation design should be optimised based on best practice, without being constricted by underlying site geology, however shallow peat rehabilitation design should be tailored based on geological observations and best practice for the individual scenario.

Acknowledgements

Bord na Móna

AN INCEPTION FRAMEWORK HYPOTHESIS FOR KARST DEVELOPMENT IN THE BURREN

Robert A. Watson, *School of Earth Sciences, University College Dublin*

An inception framework hypothesis for karst development in the Burren

Robert A. Watson[1] (robert.watson1@ucdconnect.ie), Colin Bunce[2], Simone Fiaschi[1], Eoghan Holohan[1], John Walsh[1], David Drew[3]

[1] School of Earth Sciences, University College Dublin, Ireland • [2] Palaeoenvironmental Research Unit, University of Galway, Ireland • [3] Department of Geography, Trinity College Dublin, Ireland (retired)

Research Question:

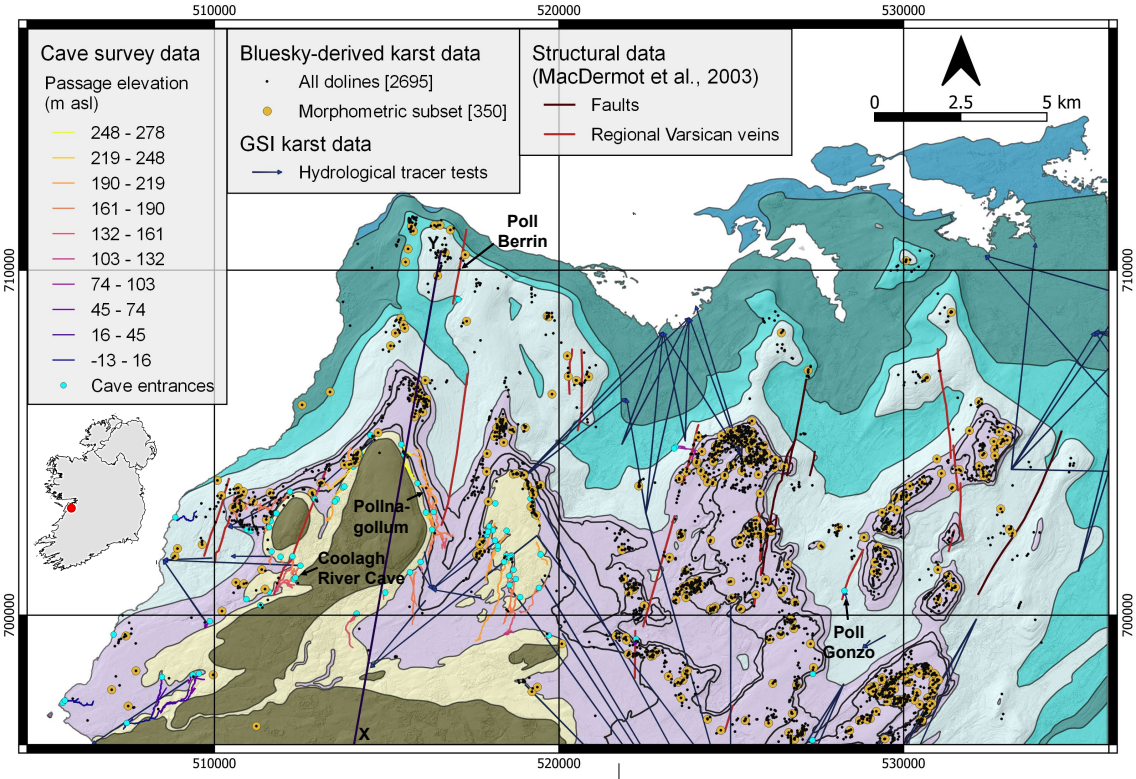
Do structural and lithostratigraphic surfaces control the morphology and distribution of surface and subsurface karst landforms in the Burren?

Data:

- > 60 km cave passage, surveyed 1952 – 2022
- Bluesky aerial imagery (0.25 m GSD) and DSM (1 m GSD)
- Stratigraphic and structural data, GSI and other sources

Methods:

- Desk-based mapping of dolines, geological surfaces
- Morphometric analysis (depressions, caves)
- Fieldwork (groundtruth of all data, further investigation)



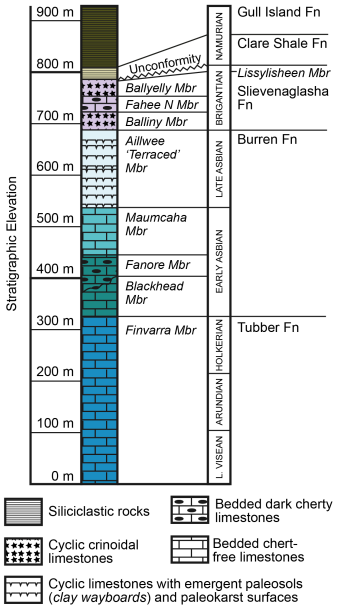


Figure 1: Geological map of the Burren, showing the lithological units (stratigraphic column after Gallagher et al., 2006), geological structures arising from Variscan compression, and karst geomorphological and hydrological features.

Variscan veins: non-stratabound fractures which connect the surface and subsurface

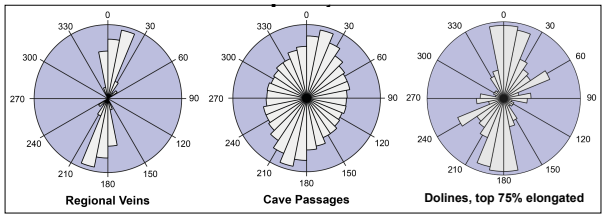


Figure 2: rose diagrams, of landform orientation, with bins weighted by length (veins, cave passages) and area (dolines). Cave and doline morphometries are both clearly controlled primarily by the vein direction.

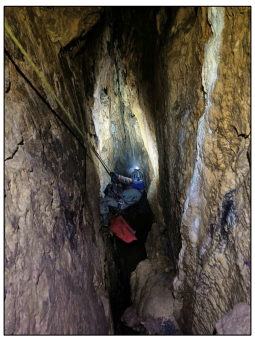


Figure 3: a cluster of silica-rich veins which control vertical cave development in Poll Gonzo (see Fig. 1 for location). The presence of these veins enables a descent of over 90 m and facilitates up-dip flow (Schuler et al., 2020).

Figure 4: Many clusters of highly pervasive non-stratabound fractures, which propagate through multiple bedding planes, at the huge (300 m diameter) doline called Poll Berrin (see Fig. 1 for location; person, circled, for scale).

Inception horizons: lithological surfaces with focused karstification

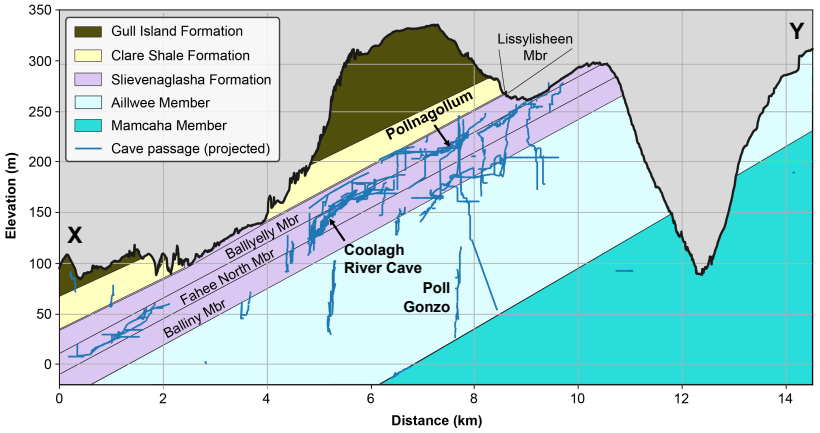


Figure 5: geological cross section (see Fig. 1 for line of section) with all cave passages projected into view. Caves predominantly form in the Slievenaglasha formation, along the tops of the members and the crinoidal cycles within them. Caves which have significant vertical development are formed along highly mineralized veins.

Figure 6: field examples of inception horizons (see Figs 1, 5 for locations). A marker bed containing *productus giganteus* hosts many passages in Pollnagollum. In the Aillwee Formation, clay wayboards impede downward flow, forming horizontal passage in Poll Gonzo (Bunce and Drew, 2019). Chert lenses have a similar, but less pronounced, effect on passage development in the Slievenaglasha Formation, seen here in Coolagh River Cave.

Conclusions:

1. Non-stratabound fractures (veins), arising from Variscan orogenic compression, are of primary importance in providing vertical karstic connectivity between the surface and subsurface.
2. The flow pathways provided by these veins then intersect the following inception horizons, where lateral karst development in the subsurface has become focussed:
   i. boundaries between distinct lithological units in the limestone sequence;
   ii. crinoidal cycle tops within the Slievenaglasha Formation;
   iii. thin horizons of non-carbonates ('clay wayboards') within the Aillwee member;
   iv. chert lenses within the Slievenaglasha Formation.

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EVALUATION OF GROUNDWATER QUALITY AND ASSESSMENT OF SELECTED AQUIFER ATTRIBUTES OF SOME PARTS OF ANAMBRA STATE, SOUTHEASTERN NIGERIA

Sodiq Solagbade Oguntade, *School of the Natural and Built Environment, Queen's University, Belfast*

Evaluation of groundwater quality and assessment of selected aquifer attributes of some parts of Anambra State, southeastern Nigeria

Ifeanyi Emmanuel Anyanwu[1], Sodiq Solagbade Oguntade[2*](sodiqoguntade@yahoo.com), Rachael Abulu[3]

[1]Pee Drilling Company Nigeria Limited, Nigeria

[2]School of the Natural and Built Environment, Queen's University, Belfast, BT9 5AG

[3]York University, Canada

Introduction

- About 60 percent of Nigeria's 200 million population gets water from groundwater resources (Omole 2013).
- Awka, the capital of Anambra State, Southeast, Nigeria, has over half a million people (NPC 2006).
- Urbanization, population and economic demands have stressed the public water supply and caused heavy reliance on groundwater.
- This over-dependence on groundwater resources make it imperative to investigate the vulnerability of aquifers in Awka and its environment (figure 1).

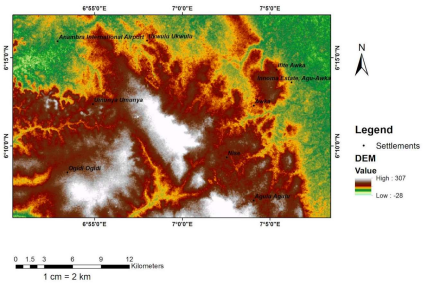


Fig.1: Study area

Geological Condition

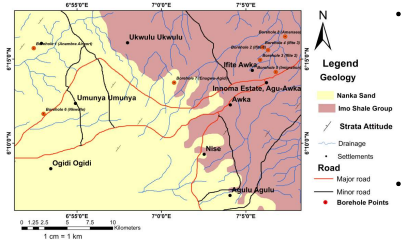


Fig.2: Geology of the study area

- Nanka Formation is a prominent groundwater storage in Anambra State, and consists of 50 – 90 m thickness of sand intercalated with shale.
- Imo Shale consists of a thick sequence of blue and dark grey shales.

Objectives

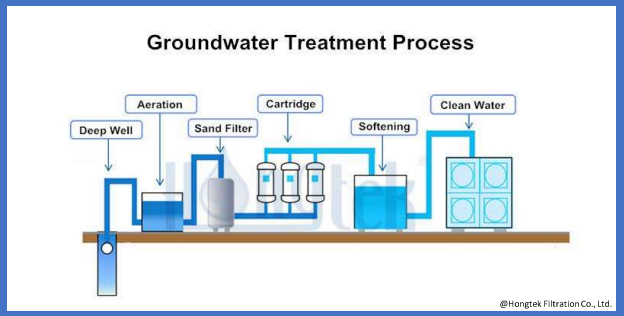
This study aims to:

- Delineate the aquiferous zones from data gotten from drilled boreholes using the geologic log information;
- Assess the groundwater quality in these areas through the appraisal of the hydrogeochemical properties of the water.

Conclusion:

"75% of the boreholes drilled within the study area have confined aquifers, and 25% are unconfined aquifers."

"The groundwater in the study area needs treatment before usage."



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Methods

Delineation of aquiferous zones:

- Drilling cuttings from eight boreholes were recovered during drilling, washed and sampled at intervals.
- A comprehensive sample description was done to characteristically identify the recovered samples' rock types and grain sizes.
- Detailed geologic information were built using modified SedLog 2.1.4™

Groundwater quality assessment:

- Water samples (AVEA, BNLI and IH) from three selected boreholes were collected between July 2021 and August 2021.
- Samples were analysed at the Energy Centre, University of Nigeria, Nsukka for temperature, pH, EC, TDS, turbidity, total hardness, Cl^- content, total alkalinity and salinity.

Results

- The aquiferrous zones vary from 9.27 m to 17 m in thickness and the total drilled depths varies from 81.2 m and 262.2 m (table 1).

Table 1: Geologic log information of the eight boreholes

Borehole Numbers	Borehole Locations	Total Drilled Depths (m)	Probable aquiferous zone thickness (m)	Type of Aquifer
Borehole 1	Anambra Airport	131.5	14.67	Unconfined
Borehole 2	Ifite 1	214.29	9.99	Confined
Borehole 3	Ifite 2	262.2	9.92	Confined
Borehole 4	Ifite 3	224	9.27	Confined
Borehole 5	Immigration, Agu-Awka	224.5	10.93	Unconfined
Borehole 6	Nkwelle	81.2	12.5	Confined
Borehole 7	Enugwu-Agidi	84	17	Confined
Borehole 8	Amansea	155	12.08	Confined

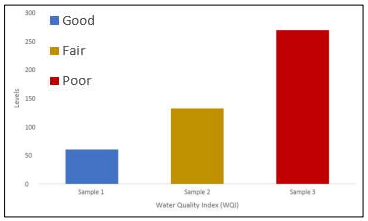

Fig.3: Quality index of the sampled groundwater

Table 2: Grades of Water Quality Index (WQI) and status of water quality (Ramakrishniah et al., 2009)

WQI Levels	Description
< 50	Excellent
50 – 100	Good
100 – 200	Poor
200 – 300	Very poor (bad) water
> 300	Unsuitable (unfit) for drinking

COMMUNICATING ENVIRONMENTAL WATER LITERACY THROUGH ACTIVE ENGAGEMENT

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ABSTRACT

Water remains essential for human life, yet safe drinking water is a limited resource, as evident across many developing countries in particular. Critical to fighting the global water security crisis, are robust and effective strategies addressing the science of water communication at a local, national and global level.

As a growing body of literature illustrates, there are increasing tensions over the best or most appropriate way of communicating environmental issues, including water security. These concerns broadly range from the dangers of preaching and pontificating, as against more interactive and dialogical modes of address, where sometimes the message gets diluted. In particular, there are deeply engrained tensions in communicating messages around conservation and water, with many considering it as a commodity or alternatively a natural right for all to have free access to. This leads to either questioning the ethics of any form of control or management of water, as against total regulation, much less embracing corporate PR strategies and protocols. Nonetheless, all such perspectives concur that water is a precious resource which needs constant scientific measurement and the support of both public and sometimes even private investment.

Key words: deficit model; effective storytelling; media literacy; prosocial behaviour; public service announcements; water charges.

As summarised across several entries in my *Essential Concepts of Environmental Communication: An A-Z Guide* (2022), challenges in communicating varying aspects of climate change, including water security needs careful consideration, while taking into account:

_ the complexity of climate messages.

_ geographical distribution and focus.

_ variety of themes encapsulated by the umbrella term of climate change.

_ responsibility for climate change, from top level global organisations and governments to the 'bottom up' responsibility of individuals and local communities.

_ uncertainty principle, which can lead to adopting a 'wait and see' approach, inferring the real urgency of the problems are not immediately apparent.

_ lack of specialist reporters and media producers available in dealing with the complexities of such environmental issues.

_ competing themes, recalling most especially short-term economic and other immediate concerns, and various other political issues that often take precedence over more longer-term, difficult, or so-called wicked problems around climate change (Filho et al. 2019: 4).

Climate change and water communication programmes coupled with broad-based educational strategies seek to:

a) Inform people about specific risks that climate change may pose to their own surroundings, while making connection with this global phenomenon. An emphasis on doomsday messages for example is known to be far less efficient, than the alternative presentation of positive ones.

b) Persuade people to engage and reflect around how the policies that their countries follow may be associated with climate change and how their behaviour may influence the global climate debate and mobilise people in general to become more involved in implementing climate change mitigation measures (Filho et al. 2019: 4).

Some constructive ways of achieving better environmental communication around water issues include:

_ Avoid focusing on negative messages and using evidence of successful actions/solutions.

_ Use a constructive approach, showing how facts contribute to addressing the problem. For instance, farmers might try new crops or adjust the seeding times to avoid droughts or use banks of trees and vegetation beside rivers and lakes to help reduce water pollution etc.

_ Selecting the best and most appropriate tools to reach specific audiences and groups.

_ Find ways to monitor progress and show incremental development (Brereton 2022: 5).

As an environmental, media and communications scholar, I have spent decades working on ways to marry media and environmental literacy, while also focusing on the power of online media. In a nutshell, it is important when distilling complex scientific data as affirmed through years of teaching, to know your audience and 'keep it simple'! It is not simply a top-down process of disseminating correct attitudes, values and beliefs, much less a clear and unambiguous set of knowledges or facts. Rather it is always best to promote dialogue with all audiences and stakeholders of different persuasions, while finding ways of understanding all their concerns and worries. Communications and media studies remains preoccupied with effective story-telling devices and encouraging empathy with the subject matter, while uncovering new ways to speak to (mass) audiences. Maintaining a sense of humility and not having all the answers in advance and always avoiding viewing audiences as 'blank screens', much less engaging in a PR manipulation process, while dealing with complex environmental-water debates, is essential.

Case Study: Public Service Announcement's (PSA) focused on Water

For example, examining the use of public awareness campaigns, including Public Service announcements, to help call attention to a number of related concerns around water provides a useful case study for investigation. The global water crisis can be conceptualised as two distinct yet interconnected environmental problems; those related to water quantity and water quality. Regarding quantity, people use freshwater at twice the population growth rate, resulting in a critical shortage of the supply necessary to meet current needs (Solomen 2011). Regarding quantity, 1000's of children die daily from waterborne diseases (WHO 2015). Yet nearly 10% of these global diseases could be prevented by simply improving sanitation infrastructure and using better management of water resources. Environmental communication research at both a local Irish level, together with more international global investigations, all highlights the important role that mass media play in shaping public understanding of such stark environmental issues (Ho, Scheufele and Corley 2013).

Short promotional and informational documentaries are freely available on YouTube, together with other online platforms. So-called PSAs are defined as short (30 seconds to 2-minute) televised advertisements sponsored or produced by governmental agencies and non-governmental organisations 'to draw attention to important social issues and promote

socially desirable attitudes and behaviours' (Kononova and Yuan 2015). Promoting *prosocial* behaviours through PSAs are especially advantageous because of their ability to efficiently disseminate messages to widespread audiences, similar to extended advertisements across the media spectrum.

Nonetheless, to effectively transmit environmental messages, such an open access medium and portal has to be fully embraced as part of a broad environmental communications strategy. As the global water situation continues to get worse, even in so-called advanced economies where investment in water infrastructure is not always sufficient, more concerted efforts ought to be taken by communicators to raise awareness of this global crisis and ultimately help persuade politicians and all stakeholders, including the general public, to take appropriate action.

Here in Ireland for instance the so-called 'water charges' debate became a power-keg of political dissent. Such conflict provoked major demonstrations, leading to political parties caving into public disquiet and accepting that Irish citizens should not explicitly pay separate taxes for water, as mandated by EU regulations. Some activists have gone on to argue that this remains a victory for democracy, while the failing water system has to be paid for somehow (see Bresnihan 2019). Meanwhile, across the rest of Europe, it would appear citizens more readily support taxes for water treatment of all kinds and have greater acceptance of various forms of environmental regulation.

How such water stories and conflicts avoid the danger of top-down scientific delivery of information, following a so-called 'Deficit Model', remains open for investigation. The average American, alongside other populations in the broadly defined West, all appear less immediately concerned with water, much less with the complexity of climate change, as they believe that it will probably more directly affect the poor and marginal communities in developing areas living in precarious habitats across the world. While richer and more mobile communities, who have substantial resources at hand, can move away from the ill-effects of flooding and heat, alongside the devastation of hurricanes and freezing temperatures.

Essentially, because one only needs to turn on one of the multiple water taps in their home for unlimited access to safe, clean drinking water, many citizens wonder why all the fuss! Consequently, as environmental communicators, we know there is a distinct lack of motivation for many individuals who seldom worry about water security, much less see the urgent need to change their wasteful habits. Nonetheless, the common use of fear tactics with regards to environmental concerns around scarce natural resources, including water, often seem to fail as an effective communication strategy, especially across most middle-class and wealthy communities. By all accounts, environmental communication efforts to bring a number of vital concerns and long-term natural resource tensions and tipping points around climate change to the forefront of world consciousness has not yet been successful. Consequently, it is more necessary than ever to continue to uncover effective and novel ways to communicate across current and new mass media platforms and apply this scientific knowledge to help improve all aspects of environmental communication in the future (Krajewski et al. 2016: 18).

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LINKING SCIENCE WITH PUBLIC POLICY

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ABSTRACT

Scientists and policy makers operate in very different environments and they have different ways of balancing facts and values in decision making. Scientists must learn to bridge these differences in order to communicate their science and ensure that it is given full and appropriate consideration in the policy-making process.

Key words: *Communication, public policy, geoscience.*

Climate change, energy policy, and environmental policy are just a few of the major topics demanding attention and decisions from public policy makers. All of these decisions involve complex scientific data and uncertainties. While there is general agreement that relevant scientific information should be factored into public policy making, creating an effective link between science and policy making can be challenging. One reason for this is because the goals, methods, and norms of science and policy making are very different, as illustrated by these commonly used definitions:

> **Science:** The pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence. Science Council[1].
>
> **Public Policy:** Anything a government chooses to do or not to do. Thomas Dye (1972), *Understanding Public Policy*.[2]

Linking science with public policy starts with communication, which ideally leads to dialogue and trusted relationships that, in turn, reinforce effective and ongoing communication. This communication is helped by acknowledging the difference between the dominance of observation, experiment, and evidence in science and the important role of values, beliefs, and public sentiment—in addition to evidence—in policy making.

Scientists can also foster mutual dialogue by taking these actions:

i. Clarifying their own position and the role that is appropriate for them to play when dealing with policy makers on a particular topic or in a particular context;
ii. Understanding the context, timelines, and constraints under which various levels of policy makers operate; *and*
iii. Tailoring their messaging to meet the needs of their target audience(s).

[1] Science Council (U.K.), https://sciencecouncil.org/about-science/our-definition-of-science/. Accessed 27 March 2023.

[2] Thomas R. Dye (1972), with multiple new editions). *Understanding Public Policy*. Prentice-Hall.

ROLE OF SCIENTISTS

Roger Pielke[3] has devised a simple but useful classification with four idealised roles that scientists may fill when they are interacting with the policy sector (Figure 1).

Pure Scientist	**Issue Advocate**
Science Arbiter	**Honest Broker of Policy Alternatives**

Figure 1. *Four roles for scientists in policy and politics. Pielke, R. (2007) The Honest Broker.*

Pure scientist: Focusses entirely on science and does not translate it for external audiences.
Science arbiter: Provides additional fact-based context for the scientific results.
Honest broker of policy alternatives: Presents scenarios based on the scientific evidence but leaves decision making to others.
Issue advocate: Promotes a desired policy outcome.

There is a significant philosophical, practical, and sometimes legal line between issue advocates, who promote what "should" be done, and the other categories who do not go beyond what "could" be done.

PATHWAYS BETWEEN SCIENCE AND POLICY

Scientists generally have less problems communicating their science to the technical experts who may be their primary contacts within the policy process. Communicating with non-specialists, who form the majority of policy makers, can pose more significant issues. One way to counter this is to leverage other routes to deliver the information.

There are many pathways that introduce scientific information into the policy process beyond the obvious direct links between geoscientists and policy makers (Figure 2). These pathways provide opportunities for scientists to take alternative roles as knowledge brokers and/or intermediaries in addition to being primary producers of scientific information (and voters). They also provide ways for multiple, diverse individuals and groups to amplify the importance of scientific information to policy makers, although the scientists will have no control over the ways in which their information is presented.

[3] Roger A. Pielke (2007), *The Honest Broker: Making sense of science in policy and politics.* Cambridge University Press.

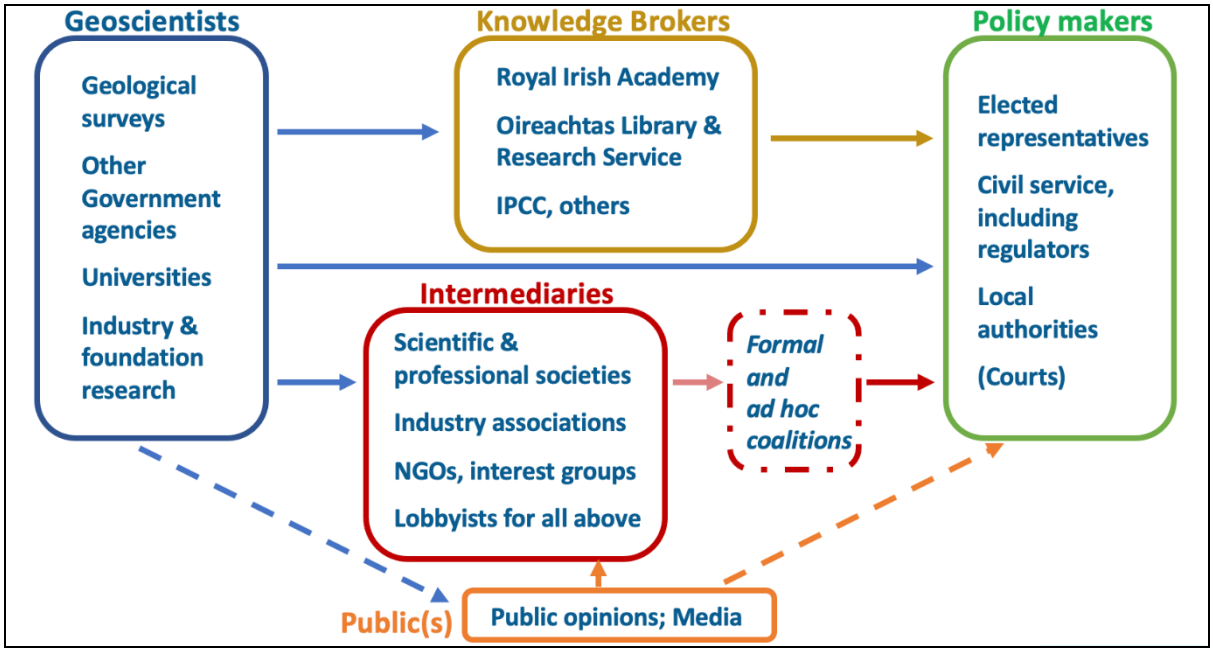

Figure 2: *Pathways to delivering scientific information to policy makers.*

INFLUENCING POLICY

Assuming that you want to help policy makers to include your science in their decision-making process, these questions may help you to prepare to interact with policy makers:

WHAT ACTION ARE YOU SEEKING?
At a minimum, you are probably asking that they factor in your findings when they are making choices about what to do or not to do, but you may have other "asks".

IS YOUR MESSAGE CLEAR?
Prof. Ed Maibach (George Mason University) recommends that your audience should hear a simple message, repeated often, by multiple trusted sources – and note that those are sources trusted by your intended audience.

ARE YOU ASKING THE CORRECT PERSON AT THE RIGHT TIME?
It is important to identify the key players in the decision-making process and to know when they have scope to act. Talking with the wrong person at the wrong time leads to frustration for everyone involved.

WHO ARE YOUR ALLIES?
Be aware of alternative pathways to impact, people who will amplify your message, and emphasise sources different policy makers trust.

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