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THE GSI GROUNDWATER NEWSLETTER

NUACHTÁN SCREAMHUISCE SGÉ

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In This Issue

As more and more **'one off' houses** are built, there is an **increasing threat to human health and the environment from inadequate disposal of wastewater**, in spite of the efforts of the EPA, certain local authorities, the GSI, FÁS and others. This is an issue that must be given a **higher priority at senior management level in local authorities**. There are over 350,000 on-site systems in operation; it is probable that a significant proportion is not functioning adequately, thereby leaving a health and environmental legacy. It is vital that we do not add to this legacy. Therefore, greater **vision and leadership** is now required from **County Managers and Directors of Services** to face up to the potential problems being created and to arrive at solutions that not only will protect health and the environment, but also minimise the likely future cost of resolving problems. While locating houses and wells on the same site in shallow rock areas is probably the highest risk scenario, the commonest problem, in my view, arises where ponding occurs either because the percolation rate is insufficient to enable the effluent to discharge underground readily and safely or because of clogging of the percolation area after a period of time. Some areas are completely unsuitable for underground discharge because the permeability of either or both the underlying subsoil and bedrock is too low or they are saturated at times. Even in suitable or marginally suitable subsoil areas, clogging may arise if on-site systems are not installed and managed properly. One of the means of reducing the likelihood of problems is by using available and inexpensive products, such as **effluent filter screens** and 'off the peg' **distribution boxes** (see further details in the article by Joe Walsh on page 6).

The **cost of energy** and the **depletion of the world's oil resources** are topical issues at present. Could **geothermal energy** play a role in Ireland, even if only a minor one? Two articles outline recent progress: 1) Gareth Ll. Jones and Roisin Goodman describe the availability of **Geothermal Resource Maps of Ireland** (page 18); and Seamus Homan describes the use of groundwater from wells to help heat the new, award winning Offaly County Council headquarters in Tullamore.

Many other issues are dealt with in this **Newsletter** – see details on the left.

Donal Daly, Geological Survey of Ireland

Putting Geoscientific Information and Maps at the Core of Land Use and Environmental Decision-making

The following is an extract from the John Jackson Lecture 2004 and Number Twenty Eight of the RDS Occasional Papers in Irish Science & Technology Series.

Introduction

Geological knowledge and mapping of our bedrock and subsoils has progressed in recent decades due to the work of Universities, mineral exploration companies, Teagasc and the Geological Survey of Ireland (GSI). Information, mapping and the understanding of groundwater flow in Ireland have also advanced significantly. As a consequence, country-wide bedrock (GSI), aquifer (GSI), soils (Teagasc) and subsoils (Teagasc and GSI) maps at a relatively large scale – 1:50,000 and 1:100,000 – are either available or nearing completion. In addition, the GSI are producing vulnerability, depth to bedrock and subsoil permeability maps and information. As a consequence, virtually for the first time, maps of the layers of geological materials that make up the top ~100 m of the land surface of Ireland are available in digital format; while they are not perfect and will require up-dating and improvement, they nevertheless now provide adequate information on the geological framework on which human activity occurs. As the enforcement of environmental legislation has progressed, particularly due to the effort of the Environmental Protection Agency (EPA) and local authorities, and as environmental issues influence land-use planning and public attitudes, geoscientific information, not only **can**, but **must** be at the core of decision-making, for the sake of society in Ireland. In practice, the work of the geoscientific community, both inside and outside the GSI, **is** increasingly being used in decision-making, although continuing progress is needed. While the work and ideas of the geoscientific community are critical to this progress, collaboration and communication with other professions – engineers, ecologists, environmental scientists, planners, environmental health officers – is also essential. This paper will illustrate some of the means by which geoscientific information and maps are increasingly at the core of decision-making in a way that benefits the country.

Context

The interaction between human activities and the natural environment is a key element in the well-being of both the environment and humans as an integral component of the environment.

The pressures on the environment are growing in Ireland. These arise from social and economic developments that entail the exploitation of natural resources and the generation of wastes. In the past decade, there has been unprecedented economic development (Environmental Protection Agency, 2004); GDP per person has increased from well below the EU average to near the top of the range. The population has also grown strongly (Environmental Protection Agency, 2004) especially in Dublin and the Leinster counties adjacent to Dublin. In addition, a high proportion (~35%) of new houses is 'one off', and are not served by public sewerage schemes. As a consequence of these changes, we are not only placing an increasing demand on resources such as land, energy and water, but also increasing the volumes of waste generated. Impacts such as eutrophication of rivers, lakes and estuaries, pollution of wells and springs by microbial pathogens, high nitrates in groundwater in some aquifers and increasing emissions of greenhouses gases all reflect the pressures on the environment. The location, design and management of potentially polluting developments, together with the safe disposal of wastes, whether, for instance, in landfills, by on-site wastewater treatment systems or by landspreading, have become increasingly important issues. However, society is increasingly conscious of the harm that its activities can cause to the environment, the dangers for human health and the loss of quality of life that can result from environmental degradation. This awareness, together with statutory controls, driven largely by EU Directives, and implemented by the Environmental Protection Agency, (EPA) the Department of the Environment, Heritage and Local Government (DEHLG), local authorities and An Bord Pleanála, are helping to mitigate the impacts of the various pressures.

Land use planning and environmental planning (which in this paper is taken to encompass environmental impact assessment, integrated pollution control licensing, waste licensing, water pollution legislation, implementation of the EU Water Framework Directive (European Parliament and Council of the European Union, 2000) and the Nitrates Directive, and so on) are the main approaches used in Ireland for trying to achieve a balance between the need to protect both the environment and human health, and the need for development. However, land use planning is a dynamic process with social, economic and environmental interests and impacts influencing to varying degrees the use of land and water. In a rural area, for example, farming, housing, industry, tourism, conservation, waste disposal and water supply are potentially conflicting interests, and may compete for priority. While impacts on air, flora, fauna, visual amenity, etc., are important issues, usually water is the dominant environmental issue in decision-making.

Can the work of geoscientists, and particularly hydrogeologists, contribute to good land use planning and therefore to the well-being of society in Ireland, in a situation where geological deposits and groundwater are underground, and for many people are 'out of sight, out of mind'? The answer is undoubtedly 'yes'.

The key requirements for optimum decision-making, which are outlined in this paper, are as follows:

- Using a risk-based approach, including an appropriate conceptual understanding of the underground.
- Understanding the role of rocks, soils and groundwater in attenuating and transmitting pollutants.
- Acquiring and making available accurate and relevant information on rocks and groundwater.
- Integrating relevant geoscientific layers of information, usually using a GIS, into the planning and management of development on and under the Earth's surface.
- Communicating the information effectively to regulators, developers, consultants and the general public.

In this paper, the role of risk-based decision-making is outlined. This is followed by describing the role of groundwater protection schemes as a means of presenting geoscientific information on rocks, soils and groundwater and integrating it into land-use planning. Lastly, elements of the implementation of the EU Water Framework Directive are described; this Directive will impact on all of us in future years and will require a significant input of geoscientific information and knowledge.

Using a Risk-based Approach to Decision-making

The interaction between human activity and the environment is complicated and difficult to quantify, and it is not easy to judge where the balance should lie between environmental protection and economic and technological progress (DETR, *et al.*, 2000). In the last 10 years, risk-based analysis and decision-making has established itself as an essential tool in the management of environmental risk. This has been influenced by a shift from reactive measures to protect the environment to more proactive and predictive approaches aimed at preventing or minimising (rather than remediating) environmental damage and loss.

The philosophical basis and language of risk has the advantage that it provides a logical framework which enables a rigorous, iterative and systematic approach to decision-making, and which should be objective, consider uncertainties and provide a rational, transparent and defensible basis for decision-making and communication of decisions. In practice, it puts a recognised framework to what is usually done, virtually intuitively or from 'common sense', but by being systematic helps ensure that all relevant aspects are considered.

'Risk' is a term used to denote the likelihood of a specified adverse consequence to a receptor from a hazard. An environmental hazard is 'an event, or continuing process, which if realised will lead to circumstances having the potential to degrade, directly or indirectly, the quality of the environment' (Royal Society, 1992).

For a risk to exist there must be a source (or hazard or pressure), a pathway, and a receptor (or target). This is the basis for the **source–pathway–receptor (S-P-R) conceptual model** for environmental management. The pathway is a route by which a particle of water, substance or contaminant moves through the environment and comes into contact with, or otherwise, affects a receptor (Environment Agency, 2001). In the remainder of this paper, only those pressures that can impact on water, particularly groundwater, together with the pathways to water, are considered.

The development of a good conceptual understanding or conceptual model is an essential element of risk assessment. A conceptual model is a simplified representation or working description of how a real system is believed to behave (Environment Agency, 2001). It must be based on evidence and be an approximation of reality (Fletcher, 2001). It is dynamic, iterative and evolving with time as new data are obtained, understanding of processes is improved and as the model is tested. Clear graphical representations of conceptual models are recommended.

Use of the risk assessment approach can vary from the site-specific scale to the broad development and strategic planning scale, and from qualitative (based on limited quantitative data and expert judgement) to quantitative (based on numerical analysis, usually using numerical models). While site-specific risk assessment is now well established among environmental professionals and regulatory bodies, risk assessment is increasingly being formalised as a management tool beyond the site-specific level to environmental policy and regulation (Pollard and Carroll, 2001). In practice, many risk issues can be addressed using qualitative analysis, providing the logic is sound and transparent (DETR *et al*., 2000). Risk assessment is, for instance, central to the environmental vision and operational activity of the Environment Agency (England and Wales) (DETR et al., 2000) and is regarded as a key element of the philosophy for contaminated land cleanup in Ireland (Doak, 2004) and the location of houses in rural areas by the EPA (Environmental Protection Agency, 2000). In addition, risk assessment is at the core of the EU WFD requirements for river basin planning.

The original version of this paper, published in the RDS Occasional Papers in Irish Science and Technology Series, outlines (24 pages of text) how these concepts are being applied in Ireland to aid decision-making in the areas of groundwater protection and the implementation of the WFD.

The Future

The recent availability of country-wide geological and hydrogeological maps and information, together with an improved understanding of groundwater and pollutant movement underground represents significant progress for the geoscientific community. While continued progress is essential and is not guaranteed, groundwater protection schemes and the implementation of the EU Water Framework Directive are putting geoscientific information and maps at the core of environmental and land use decision-making.

Modern technology has improved the capacity of geoscientists to collect, analyse and integrate geoscientific data through use of field loggers, numerical models, digital terrain models, digital photogrammetry, databases and Geographic Information Systems (GIS). Consequently, it is now becoming feasible to produce geoscientific maps and information oriented to the specific needs of decision-makers, not just in the environmental and groundwater areas, but also in other fields, such as minerals and aggregate potential, road and pipeline route selection, flood risk mapping, etc.

In particular, GIS usage provides further scope for analysis and presentation of geoscientific data. While GIS is still mainly in 2-D format, increasingly geoscientists are working with maps in 3-D by ‘draping’ maps onto Digital Elevation Models (DEM) and producing derived Digital Terrain Models (DTM). At the GSI this is being done extensively with offshore data from the National Seabed Survey. The advantage of such visualisation techniques is not just that they look good but they allow validation of maps against topography and powerful interpretation and revision of features.

This has been well demonstrated by the use of stereographic digital photography in conjunction with a DEM for the production of new national soils and subsoils mapping by the Spatial Analysis Group at Teagasc. A further iteration of digital mapping is the 3-D modelling of the subsurface, with obvious applications for groundwater flow in aquifers, while more powerful again is the addition of changes over time to create 4-D maps and models. These models allow us to predict the behaviour of pollutants introduced to aquifers, thereby enabling a better understanding of groundwater and pollutant movement, and planning of protection strategies. This modelling has already been taken to a further level in the oil industry where data interpretation rooms have been created to allow holographic projection of 3-D models of oil reservoirs, allowing engineers and geoscientists to 'walk around' within the geology they are seeking to understand. While such developments are some way off for those of us working at GSI, advances in software and hardware should ensure that such systems will become increasingly affordable and accessible.

However, future progress does not just depend on digital technology; collection of geological data, up-dating of maps and improvement of our understanding of the underground environment must continue. Geologists and hydrogeologists in third level colleges, consultancies, EPA and in the GSI all have a role to play. Relevant research, for instance on post-Carboniferous structural geology, has influenced and will continue to influence aquifer delineation and hydrogeological interpretation. The role of GSI digital databases will be critical to maintaining and improving geoscientific data storage and availability. Geologists and hydrogeologists both within and outside the GSI must continue to contribute data to these databases, firstly to discourage duplication of data collection in the future, and secondly to enable the provision of the best possible data as a basis for decision-making.

Easy, quick access to geoscientific maps and data will encourage and facilitate their use. While GISs are starting to fulfill this role in many public bodies, an increasing use of the internet is essential to assist consultants, students, academics, developers and the general public.

While the use of proper geoscientific terminology is necessary in academic discussion and writing, it is seldom necessary when communicating with non-specialists. Therefore, further development of user-friendly language is encouraged as a means of improving communication and usage of geoscientific information.

Without a detailed understanding of the needs of decision-makers, such as engineers, planners and environmental scientists, the optimum role of geoscientific information will not be achieved. Consequently, respect for and effective communication with these professions must be given a high priority by the geoscientific community.

Conclusions

Humankind has much to lose if the relationship with the geological environment is not managed effectively. Decision-makers must use geoscientific information and expertise in land use and environmental planning as a means of achieving the maximum long-term benefit for all. The required information is now available, as are the means of communicating and utilising the information effectively.

Source: Daly, D. 2004. Groundwater At Risk in Ireland – Putting Geoscientific Information and Maps at the Core of Land Use and Environmental Decision-making.
John Jackson Lecture. RDS Occasional Papers in Irish Science and Technology. Number Twenty-Eight. 32pp.

This publication can be purchased from Publications Sales, GSI, for €5 or €6, including postage.

Products to Assist the Performance and Management of Septic Tank Systems

The last GSI Groundwater Newsletter (No. 43) included two very interesting articles by Professor N.F. Gray of Trinity College Dublin's Centre for the Environment. The articles were based on a two year study of septic tank systems. A number of critical areas were identified and discussed and recommendations made on how septic tank systems could be improved.

Professor Gray's article was very timely as there is a growing international awareness of the need for regular management of onsite wastewater treatment systems of all types including septic tank treatment systems.

I would like to highlight the availability of a number of useful and inexpensive products and components that have been used successfully elsewhere to improve the efficiency of septic tanks and their percolation areas.

The US is probably leading the way with the new emphasis on the need for system management. The level of importance they have attached to this is due to the fact that, as the US EPA reports, 25% of all US homes and over 33% of new developments use on-site wastewater systems as permanent components of the nation's infrastructure. A 1997 *"Response to Congress Report"* on the use of decentralised wastewater treatment systems identified the "Lack of Management Programs" as one of five barriers inhibiting the expanded use of decentralised systems.

In March 2003 the US EPA published "*Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems*". The guidelines were intended to help improve system performance by encouraging the institutionalising of the concept of management, raising the quality of state and local management programs and suggesting minimum levels of activity. The USEPA goes so far as to state that "adequately managed decentralised systems that protect the environment and public health can provide an alternative to centralised wastewater treatment systems". The term "adequate management" of the systems is the key element of the assertion.

In Ireland, the Department of Environment Heritage and Local Government issued a circular letter (SP5/03) last year in relation to planning matters, development and environmental protection. The Circular Letter included three issues, the third of which was "the need for planning authorities to put in place appropriate monitoring and enforcement mechanisms to ensure that those who carry out approved development meet their obligations to adhere to the terms of their planning permissions". The Letter expanded this later, referring to "an annual programme of testing and monitoring the performance of individual wastewater treatment and disposal systems." I understand also that the revised EPA Wastewater Treatment Manua, now being finalised, will contain guidelines on the maintenance of wastewater treatment systems.

As a result, it appears highly likely that the management and monitoring of onsite wastewater treatment systems including septic tank systems will become a welcome requirement in this country in the very near future.

Most people will be aware that the application for planning permission to construct a building in an unsewered area requires a site assessment. This assessment evaluates the capacity of the soil to adequately assimilate and renovate the effluent from the septic tank system so that the risk to the environment and public health is minimised. This process assumes a degree of treatment performance in both the septic tank and in the percolation area. This requires a quality of workmanship, understanding of the processes involved and attention to detail, from the design of the septic tank right through to the siting and installation of the percolation area, that has often been missing, resulting in many poorly performing treatment systems.

Professor Gray's article identified three critical areas in relation to septic tank systems:

1. The design of tanks (jointed, cracks and fractures, number of chambers and tank capacity);
2. Operation (scum formation and use);
3. The percolation area (effective flooding and treatment)

Based on my commercial experience with wastewater treatment systems, both in Ireland and in the US, there are a number of products in everyday use outside of this country which can assist us to improve in many of these areas.

Effluent Filter Screens

The escape of solids, especially toilet paper, was a particular problem identified by Professor Gray. Effluent screens are compulsory in all septic tanks in many of the US states. The table below from the US EPA 2002 Onsite Wastewater Treatment Systems Manual compares the level of treatment anticipated from filtered tanks to unfiltered tanks.

The anticipated reduction in TSS is particularly striking, reducing from 300 mg/l down to 80 mg/l or 73%. The US manual states "the use of a removable cleanable effluent screen connected to the outlet is strongly recommended". My first experience with these filters was in 1994 when I used a commercial version to try to restrict grease carryover as a result of hydraulic flush in poorly designed septic tanks onto peat filters in a demonstration project in Alabama. A subsequent visit after a few months showed a healthy scum layer on the septic tank and no evidence of grease on the treatment media. A decision was made by the company to use the filters on every system installed since then both in Ireland and in the US.

Chapter 3: Establishing Treatment System Performance Requirements

Table 3-27. Proposed onsite system treatment performance standards in various control zones

Standard	BOD (mg/L)	TSS (mg/L)	PO_4-P (mg/L)	NH_4-N (mg/L)	NO_3-N (mg/L)	Total N (% removed)[a]	Fecal coliforms (CFU/1000 mL)
TS1 - primary treatment							
TS1u – unfiltered	300	300	15	80	NA	NA	10,000,000
TS1f – filtered	200	80	15	80	NA	NA	10,000,000
TS2 - secondary treatment	30	30	15	10	NA	NA	50,000
TS3 - tertiary treatment	10	10	15	10	NA	NA	10,000
TS4 - nutrient reduction							
TS4n - nitrogen reduction	10	10	15	5	NA	50%	10,000
TS4p - phosphorus reduction	10	10	2	10	NA	25%	10,000
TS4np - N & P reduction	10	10	2	5	NA	50%	10,000
TS5 - bodily contact disinfection	10	10	15	10	NA	25%	200
TS6 - wastewater reuse	5	5	15	5	NA	50%	14
TS7 - near drinking water	5	5	1	5	10	75%	<1[b]

NA = not available.

[a] Minimum percentage reduction of total nitrogen (as nitrate-nitrogen plus ammonium nitrogen) concentration in the raw, untreated wastewater.

[b] Total coliform colony densities < 50 per 100 mL of effluent.

Source: Hoover et al., 1998.

Distribution Boxes with Adjustable Weirs

Professor Gray identified the need for watertight connections between distribution boxes and the percolation area trenches. In the recent presentation to the IAH technical discussion seminar at the GSI by Cormac O'Suilleabháin and Laurence Gill of Trinity College Dublin on the performance of percolation areas, difficulties were identified with distribution boxes in evenly distributing effluent to the percolation trenches.

Plastic distribution boxes with watertight seals to accommodate 110mm pipes and with adjustable weirs are available to assist in these situations. The adjustable weirs have a 50mm hole offset from the centre of the 110mm fitting which can be rotated by hand so that more or less water flows from each outlet in order to equalise flows. Flow adjustments can easily be made at a later date in the event of movement due to settlement as a result of soil movement, landscaping activity or other traffic nearby

Alternating Flow Devices

The following extracts are taken from US EPA Technology Fact Sheet 13 on the renovation and restoration of subsurface wastewater infiltration systems (SWIS)

Devices are commercially available in Ireland to split flows and allow the simple alternation of flows to drainfields. Many of the existing stock of septic tank systems could be improved significantly with relatively little cost by devices such as these and others, especially if there was an incentive such as grant funding.

> SWISs are occasionally unable to accept the total daily wastewater load they receive, leading to ponding and eventual hydraulic failure. This is typically caused by the accumulation of biomass and suspended solids in or near the biomat, which reduces the soil's porosity and hydraulic conductivity. If the system fails hydraulically, the first step is usually to pump the septic tank and clean and replace the effluent screen (also known as a filter).
>
> Restoring the hydraulic function of the infiltration system involves eliminating or reducing the flow restrictions. Various methods and products have been developed for restoring the infiltration capacity of SWISs. These include resting, additives, hydrogen peroxide, and soil fracturing.
>
> ***Periodic resting***
>
> Periodic resting is a passive method for restoring the hydraulic capacity of the SWIS. Infiltration surfaces are "rested" by removing them from service for an extended period of time, typically 6 to 12 months. To remove a portion of the SWIS from service requires that the SWIS be constructed with multiple cells that have a total hydraulic capacity of 100 to 200 percent of the design flow, or enough suitable reserve SWIS area. Resting may also be used in seasonal facilities that discharge no wastewater for extended periods of the year. The portion of the SWIS taken offline receives no wastewater during the resting period, which allows the infiltration surface to drain and dry out. The resulting aerobic biochemical oxidation of the biomat mass can restore the porosity of the biomat, helping to unclog the system.
>
> Several studies have shown resting to be an effective method to rejuvenate the hydraulic capacity of soil infiltration surfaces (Sharpe et al., 1984). Extended periods of resting at regular intervals is effective in preventing excessive soil clogging and restoring clogged infiltration surfaces. Seventy to eighty percent of the original infiltration capacity of the soil can be recovered by resting. The rate of restoration is proportional to grain size; that is, sand restores more quickly than silt and clay.

Other Useful Devices

Other useful devices include activated carbon vent odour filters, perspex sludge gauges that have a ball seal at the base of the tube which allows a core profile of the septic tank to be taken to view the depth of sludge and scum accumulations in septic tanks and larger municipal treatment systems.

Ease of access to the septic tank and all components is essential if inspection and maintenance is to become routine. Gaining access should not require more than one person to lift the covers otherwise two people are required which becomes too expensive and the inspection may be short-circuited or ignored.

Light, watertight covers can be pre-cast into the tanks with risers added as required in order to bring them to ground level. Alternatively, plastic handles can be pre-cast into concrete lids to facilitate lifting.

Other devices such as UV disinfection systems, electronic remote monitoring and wireless tank alarms are no longer expensive and can be discreetly added to any system. These are available from a variety of Irish manufacturers and suppliers.

In conclusion, it has been my experience that there are many devices and products available that would assist in the improvement of the much maligned septic tank treatment system. And while most manufacturers of septic tanks and proprietary treatment systems alike would welcome the opportunity to improve the performance and reliability of their products, they are prevented in doing so as long as lower quality products are acceptable and meet the customer's goal. However, in 99% of cases their goal is not care of the environment but achieving planning permission to construct their home. Unfortunately, the reality in most of the world is that environmental standards must be enforced by legislation.

I am optimistic that the climate exists in Ireland and in much of Europe now for a significant improvement in onsite wastewater standards. Industry will welcome it; the public will happily accept it as long as it is not too expensive and the various regulatory bodies appear to be more in tune now than for some time. Onsite treatment systems need not be the poor relation of centralised treatment.

With appropriate selection, design, installation and ongoing system management, on-site wastewater treatment can be a viable long-term means of managing our wastewater. *For more information on any of the contents please contact* joe.walsh@ashtecs.com

Joe Walsh, Ash Environmental Technologies

Bottled Water Quality - S.I. No. 6 of 2004

Statutory Instrument (SI) No.6 of 2004 came into Irish Law on 1st July 2004 and brings clarity to the permissible composition of bottled waters in Ireland. Interestingly, this SI in addition to defining 'Natural Mineral Waters' and 'Spring Waters' also introduces the concept of 'Other Waters'. This latter group would apparently include all waters, including surface waters, that go to make up every day mains or tap water.

In SI 6 of 2004, 'bottled waters' means:

- (a) natural mineral waters,
- (b) spring waters, and
- (c) other waters,

intended for human consumption and supplied in a bottle or containers, other than waters which are 'medicinal products'.

Natural Mineral Waters

Bottled Natural Mineral Waters must still derive from groundwater sources that have been formally recognised by a Member State and which satisfy Annex 1, Section 1 of the founding Council Directive 80/777/EEC.

However, an anomaly that existed previously where the chemical quality of Natural Mineral Waters was essentially uncontrolled has now been remedied as SI 6 of 2004 also gives effect to Council Directive 2003/40/EC. This recent directive established the list, concentration limits and labelling requirements for the constituents of natural mineral waters and the conditions for using ozone-enriched treatment for natural mineral waters and spring waters.

Table 1 shows the constituents naturally present in natural mineral waters and maximum limits which, if exceeded, may pose a risk to public health. This list allows for the continuing production of Natural Mineral Waters (i.e. spa waters) which contain constituents such as sulphate at levels above the drinking water standard but which are not considered a risk to human health at even these high concentrations.

The labelling of Natural Mineral Waters must indicate where the groundwater contains more than 1.5 mg/l fluoride or where the raw groundwater has been treated with ozone to remove certain constituents such as iron, manganese, sulphur and arsenic. The State must continue to regularly monitor the quality of Natural Mineral Waters exploited within its boundaries.

Spring Waters

While the groundwater sources providing Spring Waters have to satisfy the same inherent bacteriological status as that of sources supplying Natural Mineral Waters it is not necessary for the catchment of these sources to be formally investigated by the manufacturer or recognised by the State.

However, the chemical composition of bottled Spring Waters must comply with a much wider set of parameters which essentially matches the quality standard for drinking water. So for instance, a Natural Mineral Water can have a manganese level of 0.5mg/l while a bottled Spring Water or mains water would ideally only have a manganese concentration 1/10th of that level at 0.05mg/l.

The labelling of Spring Waters must indicate whether the raw groundwater has been treated with ozone to remove certain constituents such as iron, manganese, sulphur and arsenic. The labelling of Spring Waters must also avoid any confusion with natural mineral waters, in particular with the description ‘mineral water’.

SI 6 of 2004 allows for the comprehensive monitoring and sampling of the bottled Spring Waters by the State.

Other Waters in Bottles and Containers

SI 6 of 2004 allows for the bottling of waters that are wholesome, clean and which meet the same standards as Spring Waters (i.e. drinking water standards) at the point at which the waters are put into the bottles or containers.

The important difference between both bottled Natural Mineral Waters and Spring Waters and bottled Other Waters is that the latter can be disinfected to achieve the necessary level of bacteriological quality required. No disinfection is allowed in the manufacture of Natural Mineral Waters or Spring Waters.

Other Waters would seem to include sources from lakes and rivers in addition to groundwaters as long as such waters are ‘wholesome and clean’ and meet the necessary quality requirements, after treatment if necessary, at the point where the water is put into the bottles or containers.

Interestingly, there is no requirement to indicate on the labelling either the composition of bottled Other waters or whether ozone was used in the treatment process as in the case in both Natural Mineral Waters and Spring Waters. However, labels on bottled Other Waters must not cause confusion with natural mineral waters, in particular the description ‘mineral water’.

Table 1 Comparison of Bottled Water Quality with Drinking Water Standards.

		Drinking Water	Maximum Limits For Bottled Waters		
		Standards	Natural Mineral Waters*	Spring Waters	Other Waters
Parameter	Symbol	mg/l	mg/l	mg/l	
Antimony	Sb	0.005	0.005	0.005	0.005
Arsenic	As	0.01	0.01	0.01	0.01
Barium	Ba		1.0		
Boron	B	0.001		1.0	1.0
Cadmium	Cd	0.005	0.003	0.005	0.005
Chromium	Cr	0.05	0.05	0.05	0.05
Copper	Cu	2.0	1.0	2.0	2.0
Cyanide	CN	0.05	0.07	0.05	0.05
Fluoride	F	1.0***	5.0**	1.5	1.5
Lead	Pb	0.01	0.01	0.01	0.01
Manganese	Mn	0.05	0.5	0.05	0.05
Mercury	Hg	0.001	0.001	0.001	0.001
Nickel	Ni	0.02	0.02**	0.02	0.02
Nitrate	NO_3	50	50	50	50
Nitrite	NO_2	0.1	0.1	0.1	0.1
Selenium	Se	0.1	0.01	0.01	0.01

Note: *= 2006 **=2008 *** Fluoride can occur naturally up to 1.5mg/l

Karen-Lee Ibbottson, White Young Green, & Kevin Cullen P.Geo.

Uranium & Groundwater

Uranium is well known for its radioactivity but much less recognised for its chemical toxicity. In fact, the radioactive dose from naturally occurring uranium is considered to be safe while uranium in drinking water is potentially more damaging to human health through its chemical toxicity.

Exposure to high levels of uranium can cause kidney disease.

The EU Council Directive 98/83/EC does not set a recommended level of uranium in drinking water nor does the Statutory Instrument 439 of 2000 which brought the EU standards into Ireland in January, 2004.

The World Health Organisation (WHO) has set its recommended level for uranium in drinking water at 15 micro-grams per litre (µg/l). The United States and Canada have set their standards at 30 µg/l and 10 µg/l respectively for uranium in drinking water.

There is however a recommended level of radioactivity for drinking water set in both the EU Directive and enabling Irish Regulations, Statutory Instrument (SI) 439 of 2000.

SI 439 0f 2000 stipulates that the radiation dose arising from one year's consumption of drinking water should not exceed 0.1milliSieverts (mSv). For practical purposes, the SI 439 requirements are assessed using screening levels based on activity concentrations as proposed by the WHO. SI 6 of 2004 applies the same radiation dose limit for all bottled waters.

For practical purposes the recommended screening levels to comply with the dosage limit are 100 mBq/l for gross alpha and 1,000 mBq/l for gross beta activity. If the radioactivity concentrations of water supplies are below these screening values then the water is considered to be in compliance with the SI dosage limit. If they exceed these levels then individual radionuclide concentrations are determined and, if necessary the radioactive dose arising from each component calculated.

Drinking water supplies serving more than a population of 10,000 are tested regularly by the Radiological Protection Institute of Ireland. All of the waters tested for gross alpha and beta activities have been found to comply with the legal requirements and WHO guidelines for water quality from a radiological perspective.

The RPII does not test drinking water as a matter of course for uranium concentrations but checks for alpha and beta activity. Where the RPII does determine the level of individual radionuclides in drinking water supplies it would only consider the health implications relating to the potential radiation dose that would arise from any uranium present.

The Environmental Protection Agency (EPA) has tested for uranium in rivers and groundwaters used for water supply. Results from the south east show elevated uranium levels in streams draining the Leinster granite. A tributary of the River Slaney which contributes to a water supply recorded uranium levels in the range 30 – 60µg/l while a private well in the same general area recorded an uranium level close to 300µg/l.

The recent detection of uranium at high concentrations in a public water supply well and in private wells in County Wicklow has highlighted the potential for uranium to occur naturally in Irish groundwaters. The Wicklow results and the EPA monitoring agrees with regional groundwater studies carried out in other countries which show that in certain geological environments uranium can be mobilised in groundwater at levels that pose a health risk in drinking water.

Uranium concentrations of up to 700µg/l have been found in private groundwater supplies in Canada. The mean and median levels of naturally derived uranium in groundwater of 287 wells sampled in south eastern Manitoba were 58µg/l and 10µg/l; the maximum value was 2,020 µg/l. Uranium levels were highest in Precambrian rock aquifers (average 116µg/l) and lowest in Palaeozoic rock aquifers (average 3.5µg/l)

Surveys have indicated that 18% of private wells in south-western Dakota have uranium levels exceeding 20µg/l and 3.5% have levels potentially exceeding 100µg/l. Most of the wells were less than 45m deep and located in sandstones with some lignites and volcanic ash deposits.

Of the 778 private wells sampled in South Carolina some 80 wells exceeded the recommended standard for uranium while 7 of the 322 public supply wells exceeded the recommended limit.

In a study of private wells in Devon some 9% were found to have radon above 1,000 mBq/l and some 7% were found to have levels of uranium higher that the WHO standard.

Geological environments likely to contain uranium were investigated in Ireland by exploration companies operating here in the late 1970's and early '80s. This work was mostly concentrated in south Leinster, Donegal and Galway and involved car borne scintillometer surveys, trenching and drilling programmes.

The Lower Palaeozoic volcanics, sediments and granites of south Leinster were particularly productive with a number of prospects identified and tested leading one geologist to report; 'Whatever the origin, it has been established that concentrations of uranium do occur in the area and that uranium bearing fluids have migrated through all the geological environments present in the area.'

The reports of the exploration work carried out in Co. Donegal were equally positive with remarks such as 'drilling has revealed that economic grades *(i.e. of uranium)* can be achieved.' and 'Potential for an economic discovery *(of uranium*) remains high.'

With the exploration reports describing 100's of 'radioactive' boulders in the Blackstairs Mountains and the occurrence of pitchblende and other primary uranium minerals such as uraninite in the Donegal granite uranium appears to be widespread throughout these formations and therefore likely also to be present in the shallow groundwater. In fact one of the exploration reports describes locating radioactive springs through surface prospecting.

Considering the extent of granitic, sandstone and volcanic rocks Ireland it would be reasonable to expect that a significant percentage of the numerous private wells drilled throughout the island might contain elevated levels of uranium. Furthermore, as exposure to high levels of uranium can cause kidney disease it would be advisable to have wells deemed to be at risk tested for uranium.

The regulatory bodies with responsibility for water quality might usefully provide maps identifying those parts of the island where the geological environments would be favourable for uranium mineralization.

Householders in areas deemed to be likely to contain uranium bearing minerals should be advised to have their wells tested for uranium for comparison against the WHO, US and Canadian standards in the absence of an EU limit for uranium in drinking water.

Where uranium levels are high and deemed to pose a health risk householders should consider possible treatment alternatives or seek alternative water supplies.

Source: Abstract of paper presented at the IGI Geohazards Conference – Dublin Castle – 4th October, 2004

Kevin Cullen, P.Geo.

TRANSBOUNDARY GROUNDWATER LAW: EVOLUTION, ISSUES AND APPLICATIONS IN THE MIDDLE EAST CONTEXT

This article is based on the findings of the author's Ph.D. research which will be published by IWA Publishing in February 2005 (for more details visit http://www.environmental-expert.com/resulteachpublication.asp?codi=3147).

1. Introduction

Solutions to partly resolve the world's water crisis may lie hidden underground. More than half of the world's population already depends on groundwater that is pumped from the layers of rock or other geological strata, known as aquifers, which lie hidden below the Earth's surface. These formations can span thousands of kilometres and contain enough water to satisfy much of humanity's demands for water for many decades. Groundwater is the largest source of fresh water available in reserve on Earth. Of 37 million cubic kilometres of freshwater estimated to be present on this planet, about 22% occurs below the land surface in the form of groundwater resources. Excluding water locked in polar icecaps, this constitutes 97% of all freshwater potentially available for human use. Groundwater is in general a high-value resource and is especially important as a source for drinking water. In Europe for instance, 75% of drinking water supplies come from groundwater sources, with reliance up to 98% in Denmark and 100% in Lithuania. In arid or semi-arid regimes, groundwater is almost the sole source of water supply for human and other consumption. Human dependence on groundwater as a major source of water supply has been recently acknowledged and the risks associated with depleting this valuable resource are widely recognized.

Transboundary groundwater, sometimes referred to as international or cross-border groundwater, is used in virtually every continent of the world and is subject to the same competition for its use as indigenous water resources. Many transboundary aquifers are found in Africa, North America, Europe, and the Middle East. Because of the special problems that are present when more than one national jurisdiction is involved, extraordinary concern has been shown for waters that are international in character.

A water scarce situation coupled with political instability and inequality in power structures between two nations sharing the same fixed amounts of water is regarded as the most complex setting for resolving water conflicts. This is true in the region of the Middle East where the political factors inevitably play a decisive role in the settlement of an international water dispute. The hostilities and conflicts arising over the utilization and development of the Mountain Aquifer shared between Israel and Palestine, which has been selected as the case study of this research, are among the most contentious in the Middle East region. As of 1967 up to 1995, the Palestinian utilization of transboundary groundwater has been governed by Israeli legislation and military orders. The Palestinians' access to the only major international surface watercourse – the Jordan River - has been denied since 1967. Accordingly, groundwater in Palestine, most of which is transboundary with Israel, constitutes the major source of supply for all uses. For many years, and in the context of shared water resources between Israel and Palestine, it appears that there has been a violation of the rights of Palestinians to equitable and reasonable utilization of these resources. This fact, in the opinion of this research, has for a long time been one of the major obstacles to co-operation and the achievement of peace between the Palestinians and Israelis.

2. Transboundary Groundwater Law: the Need for Modern Development

The unique characteristics of a watercourse and the need to use its waters in a rational way require legal solutions that are different from those applicable in other branches of international law.

This explains the fact that international water law is widely recognised as a distinct branch of international law. Furthermore, the special requirements of optimal and sustainable development of international groundwater aquifers and the alarming rate at which water resources are being overexploited and polluted suggest that groundwater is increasingly becoming a high-value resource. This fact is recently prompting the development of more appropriate legal, economic, social and institutional frameworks. These frameworks are being supplemented by the establishment of co-operative arrangements and mechanisms for the utilization, development and protection of groundwater resources.

Whilst the international law relating to the use of international surface watercourses has recently been subjected to remarkable development, the law governing transboundary groundwater appears to remain rather uncertain. International law governing the non-navigational uses of international watercourses has been developing during the last 50 years. At present this body of law provides suitable guidance and adequate legal instruments to settle conflicts and prevent disputes over shared water resources. Hundreds of treaties are signed on major rivers of the world including the Niger, Nile, Danube and the Mekong. Only a few regulate both international surface water and groundwater and rarely deal with transboundary groundwater as a distinct subject of the law.

At the commencement of the 21st century water scarcity has the potential to end in conflict, especially in the Middle East, and these risks have a global dimension. The concern is becoming most evident in the arid and semi-arid areas of Africa where shortage of, and lack of access to, water form the main causes of poverty, dwindling public health and food insecurity. The scarcity and rapid depletion of water in one of the world's driest regions constitutes a major determinant of the domestic and external policies of the major actors in the Middle East. The large variations in rainfall and limited surface water resources have led to widespread scarcity of fresh water in the region, resulting in a heavy reliance on groundwater as the major source for various uses. The contribution of surface water to the overall water balance is limited and marginal. Finally, due to the increasing dependence on groundwater, conflicts over the use and development of transboundary groundwater aquifers are expected to grow in the coming few decades and there is an increasing need to achieve a more optimal, equitable and sustainable utilisation of these resources through better co-operation between those sharing the waters. In the view of this research, co-operation is considered essential for the maintenance of peace and the avoidance of conflicts.

3. National Regulations and Relevance in Transboundary Contexts

Modern trends in national groundwater regulation inspire the progressive development of transboundary groundwater law. What distinguishes international from national regulation of groundwater, are the legal and institutional management difficulties in the case of the latter. This is true as decisions at the international level require two or more States to agree, with possibly two or more legal and political regimes involved. Having said that, however, the scientific and technical requirements of groundwater at national and international levels are analogous.

An illustrative analysis, done by the author, of modern trends in national groundwater regulations demonstrates that there is an increasing awareness of the emerging water crises and the urgent need to preserve these resources. The analysis also finds that there are some common denominators in the relevant state practice at the national level in selected regions. These could be summarized as: (i) the adoption of the "River Basin" concept, as it has been employed in national regulations for more than 70 years, with the aim to achieve integrated water resources management, (ii) the permitting or licensing systems, (iii) the declaration of protection zones, (iv) economic and financial instruments and incentives, and (v) the development of monitoring, assessment and control systems.

4. Codification and Progressive Development of Transboundary Groundwater Law

Despite the efforts of governmental and non-governmental organizations and groups in addressing the topic of international watercourses, the law governing the utilization, development and management of transboundary groundwater remains uncertain. International instruments including the 1966 Helsinki Rules, the 1986 Seoul Rules, the 1989 Bellagio Draft Treaty and the 1997 UN Watercourses Convention, provide guidance for States in concluding agreements and cooperative arrangements over their international watercourses. Of the mentioned instruments, the 1997 UN Watercourse Convention, although not yet in force, presents the only formal legal framework that codifies and progressively develops the law of international watercourses. The Convention includes connected groundwaters within its scope, which implies that the rules and principles it embodies apply equally to surface and groundwater. This research finds that the equal treatment of surface and groundwater is justified as far as substantive rules are concerned. However, the Convention ignores the fact that transboundary, the protection and management of groundwater require the development of procedural rules that are unique and tailor-made. This is maybe justified given the framework nature of the Convention, which leaves it to the discretion of States to adapt, modify and adjust their existing and future treaties to suit the condition of a particular watercourse, provided that they follow principles embodied in the 1997 UN Watercourses Convention. Guidance on the development of such procedures can be sought in the 1989 Bellagio Draft Treaty, which embraces comprehensive mechanisms and procedures that respond directly to the needs of optimal and efficient regulation of transboundary groundwaters.

The regulation of confined transboundary groundwater is another issue that remains unresolved under the 1997 UN Watercourses Convention. Although this topic was not of particular relevance to the present thesis, a limited analysis of the status of development of international law concerning these resources has been undertaken. It was found that the "Resolution on Transboundary Confined Aquifers", which was submitted in conjunction with the International Low Commission (ILC) 1994 Draft set of Articles, was the compromise that the ILC could achieve on the matter. For many reasons, however, this Resolution was never adopted by the General Assembly. Guidance on this matter could as well be sought from the 1986 ILA Seoul Rules, the 1989 Bellagio Draft Treaty and from the informal cooperative frameworks recently developing particularly in Africa. Most recently, the issue of confined transboundary aquifers has returned to the agenda of the ILC. In the latest recommendation, the need to formulate rules regulating confined transboundary aquifers has been emphasized. An inventory of these resources worldwide and a breakdown of the different regional characteristics of these resources are accordingly very essential.

5. Rules and Principles Governing Transboundary Groundwater

The "equitable and reasonable utilization" principle was found to be the fundamental rule governing the utilization of transboundary groundwater. This rule includes the factor of "degree of harm" among other factors. The 1997 UN Watercourses Convention offers a compromised balance between the "equitable and reasonable utilization" and the "no significant harm" principle with respect to the utilization, development and management of international watercourses. The operationalization of the equitable and reasonable utilization principle requires that hydrologic, economic, social and legal factors are reflected and considered.

In the context of procedural rules, the 1997 UN Watercourses Convention provides a useful, though not comprehensive, procedural framework, as far as transboundary groundwaters are concerned. Co-operation is at the heart of these procedures, which derives from the general principles of States' equality and sovereign rights. The main pillars of cooperation are:

prior notification, exchange of information, consultation and negotiation.

In addition to the fundamental procedural rules embodied within the UN Convention, it was found that the Draft Bellagio Treaty offers appropriate detailed procedures and mechanisms including: (i) the establishment of joint institutions for the implementation of the Agreement, (ii) the establishment and maintenance of a joint database, (iii) the identification of critical areas for joint administration, (iv) the declaration of conservation areas for concentrated management, regulations and control, (v) the development of comprehensive management and development plans, (vi) provisions on public health emergencies, and (vii) planning for drought.

6. Transboundary Groundwater in State Practice

States have been appealing to formal and informal types of international co-operation, as far as their international watercourses are concerned. It was found that, despite the improved awareness of groundwater behaviour and special characteristics, States remain reluctant to conclude international agreements that specifically regulate transboundary groundwater aquifers. States' formal positions towards the regulation of transboundary groundwater have been reflected in the debate within the ILC and the UN Working Group of the Whole. Additionally, State practice has been examined through a treaty survey relating to international watercourses, in three selected regions: Africa, Europe and the Middle East. States' informal cooperation concerning their international watercourses was also reviewed. The main findings concerning State practice in relation to transboundary groundwater provide that: (i) driven by the fear over their territorial sovereignty, States continue to resist the conclusion of binding treaties over their transboundary groundwater aquifers; (ii) State treaty practice provides strong evidence that the inclusion of connected transboundary groundwater within the scope of an international watercourse treaty is generally accepted; (iii) States explicitly exclude confined transboundary groundwaters from the scope of binding legal arrangements. Such exclusion, however, does not apply to informal co-operation between States with respect to confined transboundary aquifers. The awareness of the importance of such resources has led to the development of programmes and schemes with significant net benefits to all States concerned. The exchange of hydrogeological and other data and the coordinated or joint construction and cooperation of projects has been the subject matter of numerous successful international arrangements.

7. Application of Transboundary Groundwater Law under Difficult Political Conditions

Politics plays a vital role in delaying the conclusion of a comprehensive formal agreement concerning the Mountain Aquifer in the Middle East. Accordingly, in addition to the factors that are mentioned in the 1997 UN Watercourses Convention, the impact of the political factor, in this particular case, has to be well reflected and considered.

Palestine's sovereignty over their natural resources has not been extinguished due to the Israeli occupation; more precisely it has not been practiced for a period of time. Accordingly, Palestine is entitled to an equitable and reasonable share of the beneficial uses from all international water resources, including those from the Mountain Aquifer. It is concluded that despite the marked disparity between the stages of development and the size and strengths of Israel and Palestine, the challenge is how to convert this into a solution of mutual benefits. The Parties, however, have failed so far to foresee the benefits of joint integrated action, as far as their shared groundwaters are concerned. The inability on the part of the politicians to accept the consequences of international co-operation is reflected in a lack of willingness to place confidence in joint institutions to manage the utilization and development of the Mountain Aquifer. Finally, this research confirms that in the absence of genuine intentions to co-operate, even legally binding treaties are not helpful in solving the current dispute. International law is envisioned to offer enough guidance for the Parties on the steps needed to initiate and implement cooperation. Such guidance has been reflected in the proposed approach for solving the conflict that was presented in Section Five.

8. The Need for a Modified Transboundary Groundwater Framework Agreement

It is strongly recommended that a transformation in the manner transboundary groundwater is treated takes place. The serious attention by NGOs, expert groups and the ILC highlighted the complexity and importance of this area of regulation. Further development and integration are still needed, in order to adopt multidisciplinary approaches for the progressive development of this particular area of the law. The additional challenge is the operationalization of the law, by offering mechanisms for its implementation and enforcement, under the specific watercourse socio-economic and political conditions.

A Framework Treaty is recommended to build on the strengths of the 1997 UN Convention relating specifically to transboundary groundwater, and the complementary role that the Bellagio Draft Treaty was found to play in that regard. Additionally, this Treaty may benefit from the modern trends in national groundwater regulation. Therefore, the strengths of the UN Convention on the substantive level, combined with the strengths of the Bellagio Draft Treaty in the procedural mechanisms, are expected to yield a Framework Treaty that responds to the special needs of transboundary groundwater. Additionally, major procedures and concepts can be adapted and modified from national practice. These include the enactment of a Joint Permitting/Licensing System for the transboundary aquifer that is under joint regulation, and the concept of integrated water resources management.

9. The Need for Third Party Intervention

Under the framework of the proposed "progressive approach", for solving the Israeli-Palestinian conflict over shared transboundary groundwater, the intervention of a "Third Party" was recommended. In particular, this intervention was encouraged at the initial stages of "identification of the problem" and for setting the stage for collaboration and cooperation. Additionally, at end stages - namely "the treaty formulation"- this requirement is also valid. The role of a "Third Party" must be designed to produce wise outcomes efficiently and amicably. This role must ensure the development of an integrative arrangement, of equal benefit to the Israelis and Palestinians.

10. The Progressive Approach

In light of the political sensitivities, it was found inappropriate to propose a long term binding agreement over the Mountain Aquifer. The proposal within this thesis is to follow and implement a progressive approach, which starts with the identification of the problems and agreeing on common objectives concerning the shared groundwater. Coordination expands into cooperation and collaboration, and ends up with the formulation of a binding long term sustainable agreement. The active participation of informed, top level political representatives, with solid political support within their respective countries, is crucial and important. Once the intention for cooperation has been expressed genuinely at the political level, the rest of the process can be placed in the hands of the middle management and technical people. The mobilization of joint technical experts including engineers, lawyers, economists etc. is expected to enhance and improve international co-operation, which constitutes the basis for long term legal arrangements.

11. Institutionalization of Cooperation

Cooperation normally requires an institutional home. It is proposed that since the parties already have a joint international institution, the Joint Water Committee (JWC), this co-operation could be achieved through the restructuring and reactivation of its work. Having said that, it is important to study the reasons for its failure, and agree on the new mode of work that ensures successful cooperation.

Fadia Daibes-Murad, Nordic Consulting Group (www.ncg.dk) **and International Water Law Research Institute** (www.dundee.ac.uk/law/iwlri)

Launch of the CSA Geothermal Resource Map of Ireland at SEI

The Geothermal Resource Map of Ireland was launched at Sustainable Energy Ireland (SEI) Glasnevin on the 19th October 2004, along with the Arsenal report on the Campaign for Take-Off for Heat Pumps (see Geothermal Association of Ireland (GAI) Newsletter no. 7).

This study was performed by the CSA Group in co-operation with Conodate Geology, Cork Institute of Technology and the Geological Survey of Ireland. It was a Public Good contract carried out on behalf of Sustainable Energy Ireland.

The goals of the study were to:

- Identify potential resources of geothermal energy in Ireland.
- Create geothermal models of Ireland and gather the necessary thermal, geological, structural and hydrodynamic data to facilitate modelling.
- Produce a GIS-linked geothermal database and using the models, create a series of geothermal maps of Ireland.
- Review the current status and utilisation of geothermal energy resources in Ireland.
- Present recommendations on the future potential exploitation of the geothermal resource in Ireland in the context of International Best Practice.

Outputs
The study surveyed/compiled data on warm springs and groundwater temperature trends. In order to map the subsurface temperatures, all available borehole data in the Republic of Ireland were gathered. Temperature data from 19 mineral and oil exploration holes ranging in depth from 300m to 2,500m (deepest borehole Drumkeeran (No. 1), Co Leitrim) were retrieved from previously monitored boreholes. In addition to this, CSA surveyed 32 existing open boreholes to obtain their temperature profiles. This survey examined holes ranging in depth from 40m to 810m (deepest borehole 01-541-03, Co. Galway). A preliminary review of data from Northern Ireland was also included.

All survey data were added to the existing temperature data compiled for earlier studies. These data are presented in the Final Report which can be accessed via the website link below. Geothermal maps have been produced for surface, 100m, 500m, 1,000m, 2,500m and 5,000m depths.

The maps may be viewed using MapInfo software. In this way temperature plots may be examined with the accompanying geological data overlaid. Individual borehole data points with references may be interrogated.

The results of this review indicate that Ireland is particularly well suited for the utilization of ground source heat pumps, due to its temperate climate and rainfall levels that ensure good conductivity and year round rain-fall recharge.

There are abundant marine and surface water geothermal resources which could be exploited in Ireland, but they need some encouragement for their development. The two main areas of warm spring development are in the north Leinster and Mallow regions.

Considering the Republic of Ireland and Northern Ireland together, this review has shown amongst other things:

- at 500m depth a regional increase in temperatures ranging from about 18ºC in the south to 26ºC in the north,
- at 2,500m temperatures range from 28ºC – 45ºC to the south to 64ºC – 97ºC to the north..

This indicates significant geothermal sources with the potential for commercial development. Definition of the exact profile and extent of the geothermal sources and quantification of the resources requires additional assessment in any area deemed to be of interest.

Accessing the Report
Both the CSA Geothermal report and appendices, plus the Arsenal Ground Source Heat Pump Strategy report, may be downloaded as pdf files from the SEI's website at: www.sei.ie

Go to "Funded Programme" then "RE RDD" and select "Projects Funded to Date". The Geothermal Resource Map is found in "Geothermal" and the CTO for Heat Pumps (Arsenal Study) is found under "Heat Pumps".

If you wish to work with the big temperature maps, they are very large files and it is better to ask SEI to send you a CD of the report, rather than to spend a long time downloading them on broadband.

Gareth Ll. Jones and Róisín Goodman, CSA Group

The Thermal Environment at the New County Council Offices at Tullamore, County Offaly

From the outset, two issues focussed the minds of the design team members on this important project. The first as stated by architects Ahrends Burton and Koralek was that the elements of the structure should be exposed and the second was the stated intention of the M & E engineers Homan O'Brien Associates (HOBA) that every effort would be made to ensure that the building, through careful design and analysis, would be a model of energy efficient design into the new millennium.

In order to achieve the above objectives, it was essential that the thermal properties of the building fabric be identified and maximised. To do this, a detailed dynamic computer model was developed, by HOBA, so that the thermal interplay between structural elements and options relating to heating installation could be accurately defined and analysed.

During the early design stages, much of this work was directed towards analysing various options in relation to choice of materials and also merits of the admission or rejection of incident solar radiation. In particular, options relating to external shading were examined in detail to maximise the advantages of winter solar gain while minimising the attendant risks of overheating during the summer months. Shadow profiles for both low and high altitude solar regimes were generated, which enabled informed decisions to be made in relation to an optimum level of external shading, thermal insulation and glass type for the building facade.

The essential goal of HOBA was to achieve a building which, even with a comparatively deep plan profile, would be thermally comfortable throughout the year, without the need for full air conditioning. To this end, two distinct fundamental issues required to be solved. The first was to produce winter heating thermal energy with minimal recourse to fossil fuels and the second was to identify an effective summer alternative to conventional air conditioning.

In this respect, HOBA outlined their aspiration to reproduce the unique sensation of thermal comfort which is experienced on entering a heavy building, such as a cathedral in France or Spain during the summer months, in which comfort is experienced even though the internal air temperature is essentially similar to that of the prevailing external ambient air. This pleasant sensation is mainly attributable to the cooling radiant interplay between the occupants and the building structure which, through time lag, attenuates the diurnal temperature extremes of the external atmosphere.

Although the structure at Offaly is comparatively light, the desired thermal effect was achieved by embedding pipe-work in the floor slab through which water is circulated, at a temperature related to the prevailing thermal requirement. Thus warm water is circulated during the heating season and cooled water is supplied during the summer. The HOBA computer simulation studies confirmed that, without air conditioning, the internal ambient temperature could be maintained, during the summer months, within the guidelines set out in prevailing DIN and EU standards.

At the initial stage of the project, the HOBA proposal was to utilise ground heat to provide the winter heat requirement for the building and this would be achieved by drilling vertical boreholes into which pipe loops would be inserted and backfilled to facilitate good heat transfer between ground mass and the borehole pipe-work. By utilising the borehole pipe-work as a heat pump evaporator, heat could be recovered through the condenser to provide an invaluable source of low grade winter heat for the embedded slab pipe-work

During drilling of the first borehole, an underground well was identified which under test established the availability of a substantial water source of acceptable quality. At this point, it was decided to revise the design to utilise this well water rather than the originally envisaged ground embedded pipes.

The completed ground installation comprises three boreholes, two of which accommodate pumps, which transfer water to the heat pump evaporator and the third is a common return line. Each borehole is 150mm Ø and extends 52m to the top of the underground well. The two suction boreholes are approximately 3m apart and 15m from the return line.

Table 1 summarises the principle operating parameters of the heat pump from which the considerable heat output of 105.2 kW and the overall operating COP of 3.06 can be readily noted.

The heat potential of the well water in conjunction with the heat pump, is considerable and is sufficient to heat the entire office area of the building, through the structural slab, on all days in which the external ambient air temperature is 7°C or higher. During periods in which the external ambient air temperature is less than this value, supplementary heat is provided at the building perimeter by convective heating elements, which are supplied with lphw from an oilfired boiler. In accordance with good design practice, the temperature of the ceiling slab is maintained within 5°C of the room air temperature throughout the year, with the actual value being determined by the prevailing cooling or heating requirement.

Well Water Flow	6.6 l/s
Well Water Temp in	10.0 C
Well Water Temp Out	7.0 C
Heating Water Flow	4.93 l/s
Heating Water Temp in	25.0 C
Heating Water Temp out	30.0 C
Heat pump power input	.9kW
Well Water Pump Power	6.5 kW
Heat Pump Output	105.2 kW
Overall COP	3.06

Table 1 Heat pump data

Table 2 summarises the thermal characteristics of the building floor slab as influenced by the embedded pipe-work.

	Winter	Summer
Room air temperature C	21	23
Slab surface temperature C	26	18
Convective heat transfer W/m2	6	20
Radiant heat transfer W/m2	17	27
Total heat transfer W/m2	23	47
Total floor area m2	4200	
Total heat transfer kW	96	197

Table 2 Floor slab design criteria

As the season progresses from spring to summer the heat pump is isolated and water extracted from the well is circulated through a heat exchanger, to provide a free cooling source for the embedded floor pipe-work. In addition, during warmer summer weather, partly chilled water, originating from an air cooled chiller at roof level is circulated through the structurally embedded pipe-work to maximise the static cooling potential of the building structure.

As the building is of deep plan, a supplementary under-floor ventilation system is utilised to provide fresh ventilation air, throughout the year, to the occupied zones. Although the amount of air, supplied by this system, is small, it provides a valuable supplement, during summertime, to the cooling effect of the structural elements. The atrium fulfils a vital working role in offering a path to atmosphere for the vitiated air.

The Offaly County Council building, which was completed just over two years ago, has received a number of notable awards and a considerable amount of favourable comment in the architectural and technical press. The objective of realising a building of comparatively deep plan form, without recourse to air-conditioning has been achieved and the ultimate accolade of occupant approval is very positive. A source of particular satisfaction for Homan O'Brien Associates is the fact that their in-house analytical and thermal modelling techniques have been successfully validated and the experience gained has been an invaluable foundation for other buildings, which can be reviewed on another occasion

Seamus Homan, Homan O'Brien Associates

Addendum

Stan McKeon, Offaly County Council, provided the following information on the two wells:

Depth:	70 m to top of a cavity; cavities were 5.5 and 2.2 m deep.
Water level:	3.0 m bgl.
Depth to bedock:	10 m.
Pumping test abstraction rate:	1440 m^3/d.
Drawdown:	No drop recorded over 48 hours.

Coran Kelly, Geological Survey of Ireland

New M.Sc. in Hydrogeology at Leeds University

Jenny Rush, formerly of the GSI, is currently attending the one year taught M.Sc. in Hydrogeology course at Leeds University. She sent us this short comment on the new course.

With an interest in following a career in hydrogeology, a place on the new course established in Leeds University has been a great opportunity. With only one other full-time M.Sc. in hydrogeology in the UK at Birmingham, the new course was set up in response to a skills shortage in hydrogeology within the Environment Agency in the UK, which without a doubt is also being felt in consultancies and the Environmental Protection Agency in Ireland.

The course is designed to give a thorough grounding in theoretical, physical and chemical aspects of groundwater. This is to be complemented by training in hydrogeological field techniques and in numerical modelling for prediction of flow and contaminant transport in aquifers. The course at Leeds includes, as a distinctive feature, geochemistry of pollutants, their interaction with groundwater and aquifer rocks and their remediation. Also, the course is set to cover flow and transport behaviour of fractured aquifers, representing a significant proportion of aquifers in the Ireland. Optional modules include geophysical methods, environmental management and hydrology, with the hydrology option providing a good skills base for surface catchment analysis.

The course at Leeds has already received positive publicity from a profile-raising article in The Guardian Education Supplement on 16th October 2004. The article recognised the current shortage of qualified hydrogeologists, maintaining that the water industry is *'an industry that is crying out for trained staff in the UK'* and confirmed the high level of interest noting that applications are being taken for autumn 2005.

There is an obvious graduate interest in hydrogeology in Ireland, as three Irish students, from a variety of different academic backgrounds (geology, geography and environmental science) are attending. The course, so far, is proving to be challenging and, despite a few teething problems associated with being a new course, is running very smoothly.

Jenny Rush, M.Sc. Student at Leeds University

IAH (Irish Group) News

The IAH (Irish Group) AGM on 2nd November 2004 elected/confirmed the Irish Committee for 2005:

D. Ball *(President)*
M. Doak, EPA-Office of Licensing *(Secretary)*
S. Herlihy, RPS Group Ltd *(Treasurer)*
F. Collins, RPS Group Ltd *(Field Trip Secretary)*
S. Masterson, Minerex Environmental Ltd. *(Education & PR Secretary)*
P. Laffly, Environment Ltd *(Seminar Secretary)*
O. Dwyer, Komex (Conference Sub-Committee)
T. Hunter-Williams, GSI (Conference Sub-Committee)
C. Kelly, GSI (Conference Sub-Committee)
M. Burke, TES Consulting Engineers (Burdon Representative to IAH)

Malcolm Doak, IAH Secretary (Irish Group)

PLEASE NOTE DATE FOR DIARY:

25th Silver Anniversary

GROUNDWATER SEMINAR

IAH (IRISH GROUP)

TULLAMORE COURT HOTEL

Tuesday 19th & Wednesday 20th April, 2005

IAH (Irish Group) Field Trip Secretary Report

ANNUAL FIELD TRIP - NORTH WEST MAYO

9TH –10TH OCTOBER 2004

Trip Lead by:
Dr. Alan Dykes, University of Huddersfield;
Dr. Paul Jennings, Geotechnical Engineer, AGEC;
Michael Gibbons, Archaeologist, Walkwest;
Noel Dunne, Archaeologist, National Roads Authority;
Professor Peter Coxon; Geography Dept. Trinity College Dublin.
David Ball, Consultant Hydrogeologist.

This years IAH fieldtrip was held jointly with the Irish Quaternary Association (IQUA). The fieldtrip was held on the weekend of the 8th-10th October and was based in Belmullet, Co. Mayo. A total of 32 delegates attended.

The fieldtrip departed Belmullet promptly at 9.30 am on a beautiful clear day. Commentary on archaeological heritage was provided by Michael Gibbons on the drive from Belmullet towards Pollatomish. In addition Paul Jennings pointed out an ancient scar of a bog failure which dated to sometime in the 19th century.

The group ascended Carnhill to the West of Pollatomish and on to Barnacuillew. These hills were the site of over 40 landslides which occurred on the evening of the 19th September 2003 causing devastation to the local community. From the summit it was possible to see for miles around into neighbouring counties. One feature of note is a peat delta which formed when local peat slides and streams deposited their load on entering Srawaddacan Bay. Belmullet was also visible as well as Achill and Clare Island to the south, the Ox mountains of Sligo and the Blue Stacks mountains of Donegal to the north east.

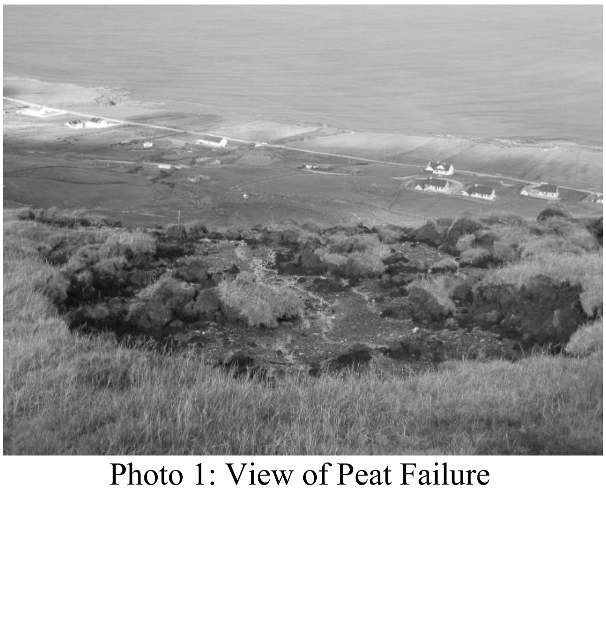

Photo 1: View of Peat Failure

Dr Alan Dykes pointed out the main failures. Within the first landslide viewed, the failure occurred within the till deposits underlying the peat and laid bare the weathered bedrock surface. There was a discussion about the cause of the landslides. They seem to have been the result of a prolonged dry summer followed by a heavy period of rainfall. During the dry period shrinkage cracks opened up in the peat and unconsolidated deposits. This allowed rainfall to infiltrate into the peat and till deposits and saturate them. The increased pore pressures at the base of the bog caused destabilisation of the sediments resulting in their movement along the relatively impermeable bedrock. Drainage channels (termed 'pipes') were visible at the base of the till and elsewhere at the base of the peat. The hillsides are reported to be heavily grazed by sheep. The influence of the vegetative cover on slope stability was discussed by Catherine Douglas, botanist with the NPWS. A positive aspect of combining the fieldtrip with IQUA was the contribution of multidisciplinary scientists to the discussion.

Local accounts of the event were that over the course of one and a half hours, 87mm of rain was recorded at the meteorological station at the radar tower on Barnachuillew. The rainfall was associated with an observed localised tornado that hovered but did not touch down. The rainfall was strictly localised and, remarkably, the shop at the base of Carnhill remained dry. The scene was witnessed by an American meteorological expert from there.

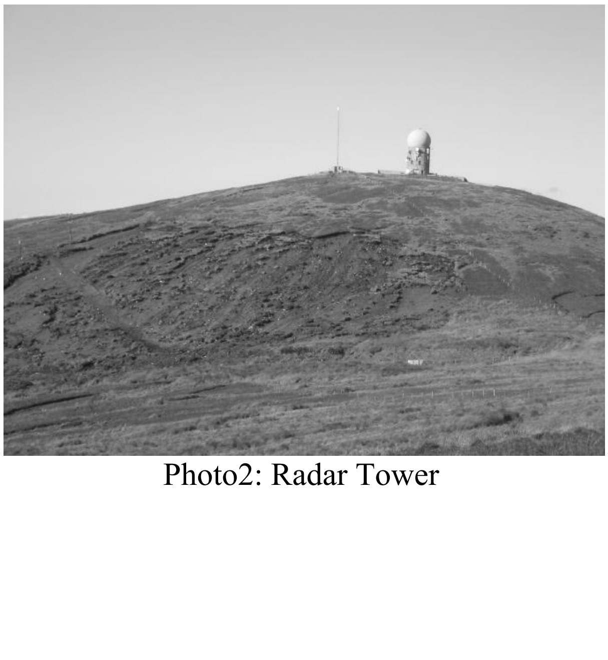

Photo2: Radar Tower

A horseshoe shaped scar was visible on the opposite hillside. The slide is the result of a failure in a zone where peat extraction machines had tunnelled and sliced to the base of the peat to drain it. The peat broke off in blocks or rafts which rode up on top of one another forming a barrier around which further landslide debris moved. The exposed bedrock had a blackened charred surface, the remains of a charcoal layer which underlies the peat. This layer was clearly visible within a further landslide on the western hillside. The charcoal is postulated to be the result of former forest clearing and would predate the blanket bog which developed from 3,000BC onwards. This impermeable layer would restrict downward movement of water, causing the upper layers to become waterlogged and favouring conditions for the growth of peat. It also forms a surface along which peat failure could occur.

The group had lunch at Pollatomish Dive Centre.

After lunch the group viewed a section of extremely weathered schistose PreCambrian bedrock in an excavated pit. It was directly overlain by peat deposits. Acids leaching out of the peat would have enhanced the weathering process.

The blanket bog which covers Ireland in places covers field systems, dwelling houses and tombs of the early Irish farmers. Michael Gibbons and Noel Dunne demonstrated a technique using bamboo stakes driven into the peat and allows pre-bog walled field systems to be located and mapped.

The group then returned to the coast to view an Iron Age (400 BC - 400 AD) promontory fort and Bronze Age (2000 BC – 400 BC) stone circle and Neolithic tomb. The discussions centred around the history of settlement and agriculture in the area in relation to the changes in climate and growth of the bog.

Sunday 10th October

The first stop was the originally proposed site for a peat repository for the proposed Gas Terminal at Bellanaboy. The site was viewed from the road. David Ball drew attention to the existence of extensive detailed data on peat and its hydrogeological and geotechnical characteristics at this site, in the several EISs and supplementary information presented during the planning process. This information is in the public domain.

The second stop was Belderg Harbour where Pete Coxon described the depositional process for marine muds which contain tell-tale shelly debris. These deposits are found elsewhere in the locality up to 18m above sea level, indicating isostatic rebound. The muds were deposited from a retreating ice sheet after the last ice age, 10,000 years ago. Modern day stratigraphic study and carbon 14 dating of shells within the muds allow ice sheet dynamics and sea level variability to be reconstructed. The patterns and timing of advances and retreats of the ice can give us clues as to how ocean currents affect this process. In this way it is hoped future climatological trends can be predicted.

Some spectacular geological formations were visible on the other side of the harbour: dolerite cones intruding into sedimentary rocks. The intrusions are estimated to be pre Devonian-Carboniferous, part of the Caledonian orogeny.

The final stop of the field trip was the Ceide Fields which overlooks the Atlantic Ocean and lies approximately half way between Belderg and Ballycastle. The remains of stone field walls and houses are preserved beneath a blanket of peat over several square miles. The Ceide Fields is reported to be the oldest (over 5,000 years) and most extensive Stone Age monument in the world. The rapid growth of peat bog preserved sites beneath the bog. It was discovered in the 1930's by a local schoolteacher who noted unnatural piles of stones at the base of the cut bog. Later his son, an archaeologist, discovered the true story of the Ceide Fields.

The field trip was a significant success and both IQUA and the IAH expressed a view that joint field trips, where a multidisciplinary approach would be attractive, should be considered for the future.

The IAH and IQUA would like to thank:

Dr. Alan Dykes, University of Huddersfield.
Dr. Paul Jennings, Geotechnical Engineer, AGEC.
Michael Gibbons, Archaeologist, Walk west.
Noel Dunne, Archaeologist, National Roads Authority.

The people of Pollatomish and Belmullet.
Staff at the Visitor Centre at the Ceide Fields.

Fionnuala Collins, IAH Fieldtrip Secretary.

CALL FOR PAPERS

TO HIGHLIGHT CURRENT IRISH ENVIRONMENTAL RESEARCH

A special edition of the Journal of Environmental Science and Health (Part A: Toxic/Hazardous Substances and Environmental Engineering) is planned for 2005 to highlight current Irish environmental research. The Journal invites researchers and practitioners from all environmental areas to contribute manuscripts for possible inclusion. This special edition will be edited by Nick Gray (nfgray@tcd.ie) who is one of the editorial board. If you would like to submit a paper or discuss the suitability of topics for the Journal then please contact Professor Nick Gray, Department of Civil, Structural and Environmental Engineering, Trinity College, Dublin 2, as soon as possible. Final manuscripts will be required to be submitted to Nick by the end of February 2005.

N.F. Gray,
Centre for the Environment,
Dept. of Civil, Structural and Environmental Engineering,
Trinity College, Dublin 2.

CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

Contributions for the next issue should arrive before 5th March 2005 to:

The Editor,
GSI Groundwater Newsletter,
Geological Survey of Ireland,
Beggars Bush,
Haddington Road,
Dublin 4.

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