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THE GSI GROUNDWATER NEWSLETTER

NUACHTÁN SCREAMHUISCE SGÉ

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IN THIS ISSUE

It is inevitable that most private wells used for domestic supplies are located relatively close (30-60m) to potential contamination sources, such as septic tank systems and farmyards. There is now sufficient information to show that, in some areas, many of these wells (up to and more than 50%) are contaminated, at least intermittently and thus are posing a health risk. Although the main reason for this contamination is improper location, construction and maintenance of contamination sources, there can be little doubt but that **poor well construction** is either allowing or exacerbating contamination in situations where natural protection is provided by the geological deposits above the groundwater. As a solution to this problem, Geoff Wright argues (on page 2) that **well construction** should be included under **planning conditions** and that **national guidelines** should be established. The second article (page 3) by Aidan Briody provides details on how **proper well construction can protect well water.**

The **hydrogeological significance of faults in Ireland** is outlined by Geoff Wright on page 5. This is followed by an article which compares the hydrogeology of Irish geological deposits with those of other European countries, particularly Britain.

A summary of the **quality of effluent from Irish septic tank systems** is provided by Nick Gray on page 8. **Packaged effluent treatment plants** are increasingly being proposed in rural areas as a means of dealing with sewage from developments with population equivalents less than 200. Siobhan Crinion-Shiels has surveyed 83 such plants in the west of Ireland and she summarises her findings on page 9.

Is the **rate of solution of limestones** in Ireland significant at human time scales? The answer is 'yes' according to David Drew (page 12), because while average 'global' rates are low – 0.015-0.055mm/yr – solution rates in certain situations are as high as 3mm/yr. The karst limestone theme is continued by Istvan Sarvary on page 12, who describes some of the problems that have arisen in Hungary from **mining operations**.

Editor

WELL CONSTRUCTION STANDARDS

Following David Ball's paper at the recent IAH annual seminar at Portlaoise, calling for Irish national standards or guidelines for well construction, this article is intended to stimulate further discussion.

Most hydrogeologists are probably convinced of the desirability of national standards for well construction. However, It could be argued that the absence of such standards has caused few serious problems, that the quality of well construction is solely a matter for the well owner and is of no public concern, and that we are seeking to impose further unnecessary bureaucracy on the (mainly rural) population. We must therefore be clear about what we want and why we want it.

1. Groundwater needs protection from wells!

The need for groundwater protection is now fairly universally agreed, and is required by EU policy. The protection of groundwater depends largely on the integrity of the protective covering layers (mainly subsoils) above the aquifer. Any breach of that cover is a potential pathway for contaminants. Such breaches may be natural (exposed rock, swallow hole, etc.) or artificial (mine, quarry, gravel pit, road cutting, or WATER WELL). An improperly sited or constructed well is an excellent pathway for contaminants to reach the aquifer.

Normally, of course, the only potential victim of such contamination is the owner or user of the well, and the contamination will spread no further. However, for various reasons, a significant number of wells are not in regular use - for instance, a property may be occupied only occasionally (eg as a holiday home), or may be completely empty for long periods. In other cases, a well may be abandoned (perhaps because it is polluted, or because a mains supply becomes available) or retained only as a standby. In all such cases, pollutants entering the well can move into the aquifer and travel down-gradient to pollute other wells. Out of the tens of thousands of wells in Ireland, we must assume that several thousand are not in regular use and therefore constitute a potential threat to groundwater quality. As a matter of public policy, it is essential that all new wells should be properly constructed and that abandoned wells should be sealed.

2. Water well buyers need reassurance.

Water wells are normally traded along with the property which they serve. A modern house requires planning permission and must be built in accordance with detailed Building Regulations which ensure that certain minimum standards are observed. Mains services - electricity, gas, water and sewerage - are all constructed to national standards by certified installers, and septic tanks, where required, must also conform to planning conditions and usually to the guidelines of SR.6. However, if a property has its own private well, this is covered by no standards, no regulations and no planning conditions. There is therefore a strong argument that well construction should be included under planning legislation and that national guidelines should be established.

3. Well registration.

Even if arrangements, such as outlined above, were brought about immediately, there would still be the question of the tens of thousands of wells already existing. One possibility would be that all well owners could be required to register their existing wells (as exempt from planning permission) over a period of time - say three years - and to identify the well as being in use or not. This would enable the local authority to consider if the well needed to be sealed to protect the aquifer, and would greatly assist the future planning of groundwater management (which will probably be required under the upcoming EU Groundwater Action Programme).

The Next Step

I think there is a fairly general consensus that water well standards, however they are to be implemented, are needed. Groundwater professionals should take the initiative and begin work on drafting guidelines on water well construction. This could be started by a small working group, which would then convene larger discussion groups including drillers, local authority and DoE engineers, before producing specific recommendations.

Geoff Wright, Geological Survey of Ireland.

PROTECTING PRIVATE DOMESTIC BOREHOLES

Domestic water well drilling normally comprises an opening diameter hole in overburden greater than the diameter of the mild steel casing subsequently installed. This drilling method can in turn lead to some potential for surface water and/or shallow groundwater to migrate downwards along the annulus of the casing installed to a deeper aquifer or possibly to the producing zone of the well.

Assuming the Drilling Contractor has the necessary drilling capabilities and appropriate drilling and welding experience there are three steps, in the order set out below, that can be taken to maximise protection of the producing section of the well from potential migrating contaminating surface/shallow groundwater. It is important to note that well disinfection, on completion of drilling, is merely treating a symptom of the problem, i.e. treating contaminated water, at that point in time, but not altering the problem itself, if the well is poorly constructed in the first instance.

Step 1. Importance of High Specification Steel Liner in Well Protection

It is critical that only certified and approved Grade 1 mild steel casing is used at the well lining stage. Grade 1 casing ideally would comply with the following specification:

DIN S9411 ST 44.3	Structural Cold Formed Hollow Section
BS 6363 GR 34/26	Welded Cold Formed Structural Hollow Section
BS 4360 43	Structural Hollow Section Cold Formed

This high specification mild steel casing while more expensive than light, thin walled casing, ensures the following:

- factory cut ends forming flush joints between casings for ideal welding conditions;
- welding will not perforate i.e. burn through the casing;
- high specification casing will withstand hammering into position and thereby not cause narrowing/damage of the casing's internal diameter.

Step 2. Importance of Grouting in Well Protection

There are a variety of grouting techniques adopted at present when attempts to grout a domestic borehole are undertaken. One method for example comprises the following: plugging the butt of the liner prior to installation in the borehole, pouring grout into the open borehole and thereafter installing casing. This approach has limitations including; on retrieval of the drill string prior to grouting, the open borehole is likely to infill as the overburden is likely to be unconsolidated and liable to collapse. Also this grouting method is unlikely to disperse grout evenly around the annulus of the liner of its installation.

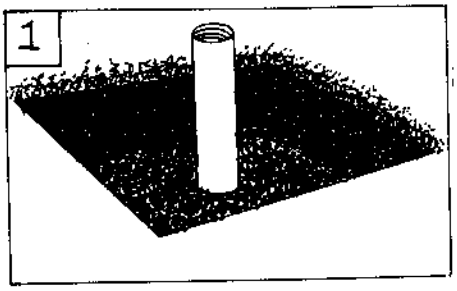
The method we would like to put forward, which for identification purposes will be referred to hereafter as the Briody Domestic Borehole Grouting Method, is a realistic attempt to minimise costs while effectively grouting the annulus of the installed casing. This method would need to be adapted where certain drilling conditions are encountered.

1. Open borehole at not less than 10" diameter 1 metre into bedrock.
2. Install 8" diameter (Inside Diameter) liner 1 metre into bedrock.
3. Drill 8" diameter from 1 meter into rock to say 4 metres into bedrock.
4. Drill @ 6" diameter from 4 metres into bedrock to completed depth securing adequate water supply.
5. Carry out well development and retrieve drill string and drilling hammer.
6. Install whatever required length of 5" casing to extend from the top of the well to the depth where the borehole narrows from 8" to 6" (i.e. at 4 metres into bedrock level). Prior to installation, weld a wedge on outside of base of 5" casing to anchor it on top of 6" diameter borehole wall (see Figure 1). Note that the drilling machinery can now be moved to next site.
7. Backfill the annulus of 5" casing with 1 metre of sand at base and thereafter ordinary portland cement at a ratio of 1 bag cement to 6 gallons of water to top of borehole (yielding cement grout with specific gravity circa 1.8).

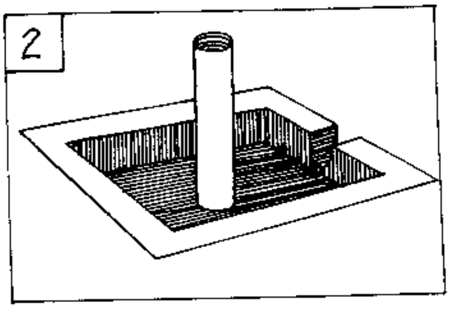
Step 3. Importance of Well Head Completion in Well Protection

The immediate area around the liner protruding above ground level is too often left carelessly unfinished. For example the liner is often cut flush with the ground level and a plastic bag is pushed into the liner. Quite obviously the well is vulnerable to run-off water navigating towards the well head, also clay and other debris is liable to fall into the well. It is advisable to adopt the following steps to ensure a satisfactory well head completion.

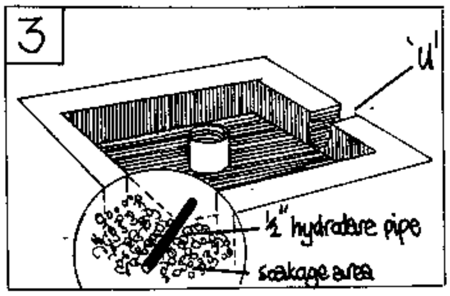
1 Dig an area 3 ft square around the liner and 2ft in depth.



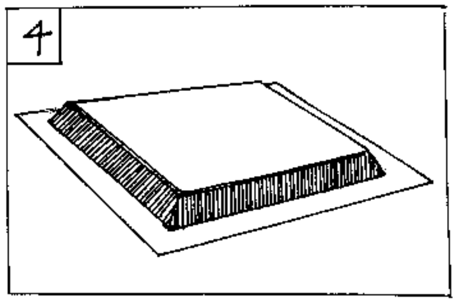
2. Pour concrete or use 4" solid blocks to construct a manhole with a "U" on one side to allow pipe and cable passage to pressure vessel and electrics.



3 Concrete floor inside manhole at a slope with corner piece in lower corner funnelled through with ½"drainage pipe feeding into soakage area thereby preventing water lodging in the manhole. Leave mild steel liner 4" above concrete floor.



4. Consider placing a secure lock and a concrete/reinforced steel cover over the manhole.



The cost of carrying out the above three steps is by no means prohibitive and it could be that critical extra small investment to protect your natural fresh water supply from surface water/shallow groundwater contamination.

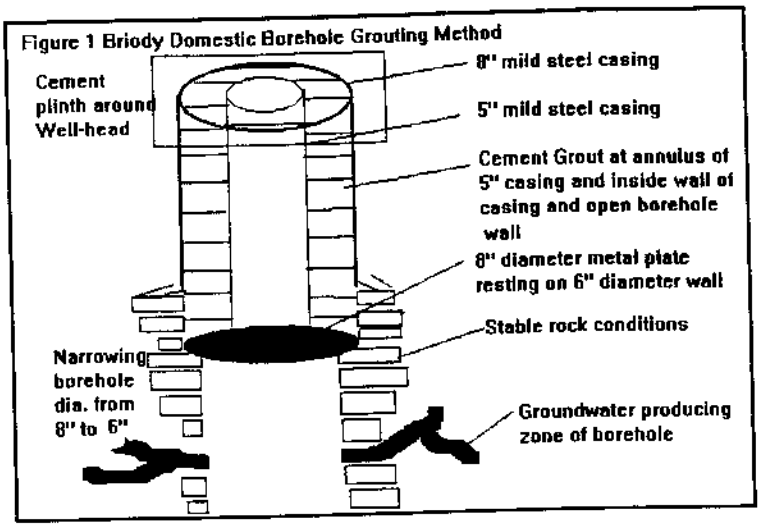


Figure 1 Briody Domestic Borehole Grouting Method

Aidan Briody, Patrick Briody & Sons - Aquadril Services.

THE HYDROGEOLOGICAL SIGNIFICANCE OF FAULTS IN IRELAND

Non-hydrogeologists have some misconceptions about the hydrogeological significance of faults. A number of points need to be made under two headings: (1) the actual role that faults play in the hydrogeological regime, and (2) the way that faults are identified, inferred, and mapped by geologists. (to put it another way, the significance of faults *in reality*, and their significance *on geological maps*).

The significance of faults in the hydrogeological regime.

Geological significance:

Faults are important in determining geological structures, i.e. the geometrical relationships of the various formations underground. For instance, the horizontal or vertical boundaries of an aquifer may often be formed by faults.

Hydrological significance:

Faults can be zones of water movement or can be barriers to water movement, depending on a number of factors:

- The nature of the faulted rock: in strong, competent rocks, faulting will tend to create zones of higher permeability, whereas in weak, incompetent rocks, the fault will tend to be filled with broken or crushed material (fault gouge) which impedes water movement.

- The structural environment: where rocks are under tension, a fault will tend to be open and allow water movement; where rocks are under compression, a fault will tend to be tight and not allow water movement.

- The age of the faulting: very old faults will tend to be closed, more recent faults (or old faults which have been subsequently re-activated) are more likely to be open.

Three other points should be made on the hydrogeological significance of faults:

- Fault zones: single faults, even if open, are unlikely to be very significant in terms of mass water movement, unless karstified. Faulting which has affected a wider zone of rock (perhaps several hundred metres wide) is more likely to be significant.
- Accompanying joint sets: faulting is often accompanied by a parallel set of joints (i.e. fractures in the rock along which no significant movement has occurred) which may permeate the whole formation and be much more significant hydrogeologically.

In conducting hydrogeological investigations, theoretical considerations of the significance of faults need to be tested, e.g. by field examination of exposures of faults (if possible - is there evidence of fault gouge, of water movement, seepages, springs, etc.) - by geophysical methods, or by drilling.

The significance of faults on geological maps

Geological maps in Ireland indicate many faults. It is important to understand that most of these faults have not been mapped directly, i.e. cannot be seen in rock outcrops, but have been inferred from the pattern of rock exposures and/or borehole evidence. Therefore, in most cases the mapped location of these faults is subject to some uncertainty – +/- a few hundred metres could be typical. In some cases, the very existence of the fault could be in doubt. Equally, it is likely that many other faults exist which are not indicated on geological maps. For example, where a particular outcrop pattern could be accounted for by the existence of one major fault, or by two or more smaller faults, the mapping geologist will probably opt for the simplest explanation, but other alternatives may be equally likely.

It follows from the above that it is impossible to make any general statement about the general significance of faulting in Irish hydrogeology, except to say that it is probably more significant than, say, in southern England, because our rocks are harder and more brittle. The significance of faulting and associated jointing is normally taken into account when considering the aquifer status of any given formation, e.g. in respect of the existence or otherwise of localised zones of higher permeability.

When considering the suitability of any given site for a given development, the presence of mapped faults may or may not be significant, and this will need to be studied at the site investigation stage.

The absence of mapped faults should not be taken as an assurance that faults are absent from the site.

Also, note that the terms 'major' and 'minor' fault are only relative and have no absolute significance, and in any case have no particular *hydrogeological* significance, i.e. a major fault may be very tight, while minor faults may be water-bearing.

The Editor would welcome accounts of readers' experiences of faults in hydrogeology.

Geoff Wright, Geological Survey of Ireland.

COMPARISON OF THE HYDROGEOLOGY OF IRISH GEOLOGICAL DEPOSITS AND THOSE OF OTHER EUROPEAN COUNTRIES, PARTICULARLY BRITAIN

Introduction

The age and tectonic history of geological deposits are critical factors in dictating the hydrogeology and, in particular, the type and degree of permeability. This article draws attention to the importance of the type of permeability in considering groundwater flow, contaminant attenuation and groundwater vulnerability to contamination. It also summarises differences with other European countries.

Influence of Permeability Type

Permeability, which is a measure of the capacity of a rock to transmit water, can be subdivided into two types. Firstly, where water moves between the grains, it is called primary or intergranular permeability. Secondly, where the water moves through fractures or fissures or joints and along bedding planes, it is called secondary or fissure permeability.

Intergranular flow is slower than fissure flow in rocks under most conditions, void or pore spaces are usually smaller and flow paths are more irregular. Also the amount of water stored in granular rocks is generally greater than in fissured rocks. These factors have an important bearing on contaminant attenuation. In contrast to rocks in which fissure flow is dominant, the slow flow rate in rocks with an intergranular permeability delays the entry of contaminants into groundwater and, particularly in the unsaturated zone, allows time and opportunities for interactions between contaminants and rock grains. Also, the relatively small pore sizes allow filtration and absorption of bacteria and viruses. The irregular flow paths within a porous matrix cause hydrodynamic dispersion, which decreases contaminant concentration. For contaminants that reach the water table and enter groundwater, dilution is much greater in rocks with an intergranular permeability and thus the resultant contaminant concentrations are much less. The worst situation is in karst limestone areas where flow rates are very high - over 100 m/hr in some instances - due to widening of fissures by solution and there is little scope for attenuation other than by limited dilution. **Consequently, there is generally far greater degradation and purification of contaminants in rocks with an intergranular permeability than in those with a fissure permeability.**

Flow paths in fissured rocks are less predictable than in granular rocks due to anisotropy. Also, vertical permeability is usually greater than horizontal (Kv > Kh) in fissured rocks, whereas the opposite (Kh > Kv) is usually the case in granular aquifers.

The presence of an intergranular permeability in rocks is related to the geological history. In general, the greater the age and the more forceful the tectonic history the greater the degree of fracturing, fissuring and infilling of intergranular pore spaces. So rocks of pre-Permian age seldom have an intergranular permeability whereas Quaternary sediments seldom have a fissure permeability. Rocks of intermediate age may have both, although fracturing is less common in the clayey rocks.

Situation in Ireland

In the Republic of Ireland, apart from a small area of Permo-Triassic sandstones at Kingscourt, all bedrock types are older than 290 million years and all have a fissure permeability only. The bedrock at Kingscourt has a dual permeability - intergranular and fissure. The only rocks with an intergranular permeability alone are the Quaternary deposits, i.e. sands/gravels, tills, silts, clays, peats.

One of the consequences of this is that in areas where the subsoils are thin or absent, the groundwater in the bedrock is extremely vulnerable to contamination. Also, it is advisable to assume that once contaminants enter groundwater in bedrock there is, owing to the fissure permeability that characterises Irish bedrock, little attenuation other than by (usually relatively limited) dilution, and secondly that an unsaturated zone in bedrock is not a significant factor. Consequently, the GSI guidelines on groundwater vulnerability assume that, with the exception of karst morphological features that indicate rapid recharge (swallow holes, for instance), the only factor determining the vulnerability of groundwater in bedrock in Ireland is the nature (type, permeability and thickness) of overlying subsoils or Quaternary deposits.

Comparison with other Countries

In Britain, the situation is very different. The south-east of Britain (SE of a line from Exeter to Newcastle) and the areas around Liverpool and Carlisle are underlain by rocks that are post-Carboniferous in age (younger than 290 million years). These younger rocks include two major aquifers - Sherwood Sandstone and Chalk - together with low permeability clayey rocks e.g. Keuper Marl, Lias clays. These aquifers are far more productive than the best limestone aquifers here in Ireland. As a consequence of this and the fact that these areas coincide with high population densities and industrial development, a high proportion of hydrogeological research and interest in Britain has focussed on the post-Permian rocks. This has influenced, for example, groundwater protection, groundwater vulnerability mapping, landfill site selection policy, etc., in Britain.

The Sherwood Sandstone and the Chalk have a dual permeability - intergranular and fissure. This means that there is far greater attenuation in these bedrock types than, for instance, in the Carboniferous limestones in Ireland. It was this fact that led to the "dilute and disperse" philosophy being used as the basis for landfill site selection in Britain. These rocks were found to provide good attenuation of trace substances such as cyanide, arsenic, etc., while at the same time leachate collection was not thought necessary. It was only when monitoring for trace organics started in the early 1980s that doubts were cast on "dilute and disperse" sites, and it was only in the early 1990s that such sites were no longer approved. (In contrast here in Ireland, the GSI, while initially influenced by the established views in Britain, changed their philosophy in 1984 from being willing to consider dilute and disperse sites to saying that they were not suitable in the context of Irish hydrogeology. Since that time the GSI have advocated the use of containment sites.)

Even some of the rocks of pre-Permian age are different in Britain. For instance recent work by the British Geological Survey has shown that Devonian and Carboniferous sandstones in Scotland have both an intergranular and fissure permeability, whereas those in Northern Ireland have a fissure permeability only.

Examination of the geology of other EU countries shows that much of the area, with exceptions such as Scandinavia, is underlain by rocks of post-Permian age, i.e. rocks with dual permeability or intergranular permeability only. There are some areas of karst limestones where the groundwater is highly vulnerable, mainly in mountainous areas.

Conclusion

Hydrogeological research carried out in Britain, the experiences of British hydrogeologists and the education of hydrogeologists working in Ireland by British universities have been very beneficial to Irish hydrogeology. However, in view of the significant differences between the hydrogeology of Irish aquifers and those of other EU countries, particularly Britain, it is important that we form our own views and not accept the established views without full consideration of whether they are suitable for Ireland.

Donal Daly, Geological Survey of Ireland.

COMPOSITION OF SEPTIC TANK EFFLUENT

During a recent court case a dispute emerged concerning the strength of the effluent emanating from a septic tank. The problem arose from the data presented in the GSI report RS 93/1 (Groundwater), and in particular Table 3 which gives the physico-chemical composition of septic tank effluents (Daly *et al.*, 1993).

In terms of chemical quality, the effluent from a septic tank can be assumed to be very similar to normal settled sewage (Gray, 1992). The major differences appear to be slightly lower organic strength, as measured by the BOD and COD tests, and elevated nutrients conditions. These differences can be explained by the restricted input of organic matter, and the comparatively low dilution that urea and phosphorus compounds receive within such small systems compared to a sewered wastewater treated centrally. Septic tank systems should not receive any surface water from paved areas or roofs, and no infiltration water. Table 1 summarises the physico-chemical quality of 28 septic tanks monitored in Co. Meath (Gray and Keenan, 1993a,b), and it can be seen that these values are significantly higher than those quoted in the GSI report.

Septic tank effluent strength is largely a function of water usage, and this is the main cause of the variability in effluent strength seen in Table 1. For example, families who install dishwashing machines may reduce the strength of their septic tank effluent by up to 35%, although the total waste load discharged (as kg/d) remains the same. Other factors are also important such as tank hydraulic retention time per capita, family residence time which controls the total loading to the tank as well as the variability of effluent concentration over time, and the disposal practices within the family.

Irish septic tank effluent is significantly stronger than similar effluents in the US, which is the source of the GSI effluent data. This is due to a number of factors, the most important being the lower water usage in Ireland compared to North America, and the larger size of the average family. Table 1 represents a more realistic characterisation of septic tank effluent in Ireland. Therefore, it appears that the data presented in GSI RS93/1 (Groundwater) describing the nature of septic tank effluents needs revision to avoid confusion in the future.

References:

Daly, D., Thorn, R. and Henry, H. (1993). *Septic tank systems and groundwater in Ireland.* RS 93/1 (Groundwater), Geological Survey of Ireland, Dublin.

Gray, N.F. (1992). *Biology of wastewater treatment.* Oxford University Press, Oxford.

Gray, N.F. and Keenan, T. (1993). Chemical characterisation of septic tank performance. *Fresenius Envir. Bull.*, 2, 49.

Gray, N.F. and Keenan, T. (1993). Physical characterisation of septic tank performance. *Fresenius Envir. Bull., 2, 114.*

Table 1. Performance characteristics in mg/l of 28 domestic septic tanks, regardless of tank configuration.

Variable	Mean	sd	n	Median	Min.	Max.
pH	7.0	0.24	84	7.0	6.3	7.5
BOD	264	94.1	84	240	110	510
COD	500	176	84	461	225	900
Suspended Solids	127	53.4	84	115	56	255
Ammonia	55.0	21.4	84	54.0	16.0	106
Total phosphorus	16.2	6.4	84	17.0	2.0	29.0
COD:BOD	1.9	0.21	84	1.9	1.3	2.4

N.F. Gray, Environmental Sciences Unit, TCD.

(Editor's Comment: All future copies of the GSI publication will have a copy of this article attached.)

THE USE OF PACKAGED DOMESTIC EFFLUENT TREATMENT PLANTS FOR ON-SITE TREATMENT OF DOMESTIC WASTES FROM DEVELOPMENTS WITH POPULATION EQUIVALENTS OF LESS THAN 200

Introduction

The purpose of all sewage treatment systems is the disposal of wastes without nuisance, the protection of health and the protection of the environment. Approximately 33% of the Irish population live in areas which are unsewered. On-site domestic waste water treatment in these areas mainly comprise of septic tanks with either soakaways or percolating areas. The NSAI SR6: 1991 "Recommendations for Domestic Effluent Treatment and Disposal from a single Dwelling House" now take into account "T" values which are too fast as well as values which are too slow and also recommend percolation areas in all cases as opposed to soakaways. This is a significant improvement on the SR6: 1975 Recommendations.

The use of "package plants" is also covered under SR6 1991 but no clear recommendations are given. Reference is only made to one type of package plant. In fact a survey in 1994 uncovered five different types of package plant, which are manufactured by nine different companies and all of which are available on the Irish Market. SR6 1991 recommends that package plants may be used on sites which would not pass either a trial hole test or percolation test and so would be unsuitable for a conventional septic tank system. The use of package plant domestic waste water treatment systems is now quite common on "sensitive sites" i.e. areas of high amenity sites with poor percolation, lake shore developments sites with high water tables etc. The 1993 GSI publication "Septic Tank Systems and Groundwater in Ireland" (Daly, Thorne and Henry) has provided more information on a wider variety of package plant systems than the SR6 1991; however, neither publication looks at the use of these treatment systems for developments larger than single dwellings.

Rural developments with population equivalents of under 200 are very common and comprise housing and tourism/leisure developments in particular. It is estimated that by the year 2000 tourism will be the biggest industry in the world. Bord Fáilte is expecting an annual increase of approximately 8% in tourism to the year 2000.

Holiday Developments - Particular Sewage Treatment Problems

Holiday/leisure developments such as hotels, clubs, pubs, camping/caravan sites etc. are very different from normal residential developments with regard to sewage treatment facilities.

The main problems are:

(1) Usually located in high amenity areas.

(2) Populations will fluctuate greatly from season to season.

(3) Most facilities will incorporate at least one commercial kitchen which produces particular effluent treatment problems, the most important of these being grease.

(4) Flow rates will fluctuate greatly from season to season.

(5) Organic strength of the waste will fluctuate possibly from day to day.

(6) Due to the requirement of high standards of hygiene in these commercial developments, a large amount of chemicals will be used in laundry, kitchen, toilet and general cleaning processes. The amount used will also fluctuate regularly depending on the type of tourist trade.

(7) Sewage treatment facilities may be required in some cases to be shut down for winter months or possibly for a six month period or more. This type of usage does not generally facilitate the smooth running of a package plant since "start-up" can produce low standard effluent for many days or possibly weeks.

(8) Most of these commercial facilities will not have professionally trained staff to operate and maintain a package plant. Only the more advanced types of developments will have a full-time maintenance/caretaker who will have several other jobs on site and will not have the time or the

experience to monitor a sewage treatment package plant.

All of these problems must be carefully considered when choosing a package plant for treating waste water from a tourist facility.

Package Plants available on the Irish Market

The package plants available on the Irish market can be broken down into five main treatment processes:

1. R.B.C.	- Rotating Biological
2. Filter Media	- Biofibrous Media/Soil Media
3. Activated Sludge	- Non-fixed Biological Digestion
4. Submerged Biological Aerated Filters	- Fixed biological digestion - (Plastic media)
5. Chemical Coagulation	- Use of chemicals to enhance primary settlement

A market survey identified approximately 23 separate companies (not including engineering consultancy firms) offering package domestic effluent treatment systems suitable for small flows (less than 200 P.E.) These companies tended to offer systems from a total of nine Irish/British manufacturing companies. These systems can be purchased from the manufacturing company itself or from the agents of the manufacturing company.

This survey also looked at the operation and performance of these package plants for counties Sligo, Mayo, Galway and Clare. A total of 83 package plants have been installed in these counties (surveyed mid-1994) and the table below outlines the types of development surveyed and the choice of package plant used.

Many of these package plants treat effluent from tourist related developments and do not always operate to the performance standards claimed by the manufacturer. Package plants which do operate successfully are well maintained, well sited and are operated correctly.

As with septic tanks/percolation areas, package plants require good site suitability which may require the plant purchaser to carry out detailed site investigations so that the correct choice of package plant is made.

Site preparation is also extremely important especially with regard to the provision of grease traps and percolation areas (where required). As with site preparation, maintenance of the package plant after installation is most important. Maintenance contracts may be arranged with all of the manufacturers/suppliers of package plants to this country. A maintenance contract should specify at least two visits per year and also an obligation to carry out further repairs and maintenance in the event of a malfunction or leak emergency.

Generally speaking all unserviced developments larger than a single dwelling are eligible for licensing under section 4 of the Local Government (Water Pollution) Acts, 1977-90 and monitoring of such developments will depend on licence conditions (and the resources of the local authority).

Conclusions

The achievement of a consistently high standard of effluent quality from low flow waste water treatment package plants is dependent on:

1. Proper site investigation including suitability.

2. Correct choice of package plant to suit site and effluent characteristics.

3. Proper installation procedures, not only of the package plant, but all other ancillary works including pipe work, grease traps, septic tank percolation areas etc.

4. Weekly general maintenance of the plant by suitable informed personnel.

5. At least one annual maintenance check by a suitable qualified engineer. The inspection should be suitably detailed to ensure the long-term smooth running of the plant.

6. Regular effluent monitoring should be carried out, preferably by an independent authority such as the relevant local authority, to ensure compliance with all relevant water/effluent quality standards.

Table. Types of Development and Choice of Effluent Treatment Package Plant in the West of Ireland (Sligo, Mayo, Galway and Clare)

Type of Development	RBC	BAF	Act. Sludge	Chem. Coag.	Filter Media
Community Housing	12	2	17	-	5
Holiday Accommodation (Camping)	3	-	-	-	2
Hotels	4	-	-	-	3
Restaurants	1	-	-	-	4
Pubs	1	2	1	-	2
Interpretive Centres	2	4	-	-	4
Schools	-	-	-	-	3
Nursing Homes	2	-	-	-	-
Commercial Development (Domestic Waste)	1	1	-	-	2
Golf Clubs	2	2	-	-	1

Siobhan Crinion-Sheil, North-Western Region Fisheries Board.

WELL DRESSING - AN APPRECIATION OF THE GROUNDWATER RESOURCE

Throughout the summer, many visitors flock to Derbyshire in England to see the colourful well dressing ceremonies. It is thought that this began as a pagan tradition, as a sacrifice to the water gods. The early ceremonies involved hanging garlands of flowers above springs as thanksgiving for past and future supplies of water. Later well dressing also became a thanksgiving ritual in certain villages for deliverance from scourges such as cholera and plague; testimony to the purity of groundwater.

The worship of springs and wells was forbidden by the early Christian churches but despite its pagan origins the custom has strong religious connections today.

Well dressing involves creating pictures and designs from natural objects to decorate the wells or springs. Many villages believe that only living plants and flowers should be used to dress the wells, but there are no hard and fast rules. Flowers, plants, petals and herbs are used to create colourful tapestries and pictures.

Once the dressing is complete, a service is held to bless the wells and a week of festival is held for the whole village.

Could it be that devotion in Ireland at many of our 'holy' wells was adopted by the Christian churches from a similar pagan practice?

Jer Keohane, Geotechnical and Environmental Services Limited.

RATES OF SOLUTIONAL EROSION OF LIMESTONE IN IRELAND

Meaningful measurement of rates of landscape erosion are notoriously difficult to achieve. However, in the case of karstifiable limestones the problem is simplified by the fact that the great majority of erosion is via chemical dissolution by acidified rainwater with subsequent removal by the runoff. Also, very little unweathered or immobile material remains behind. Thus, there have been many attempts over the past century or so to quantify erosion rates in limestone regions.

Three main methods have been used to assess erosion:

- The measurement of the total solute load leaving a drainage basin over a particular time period (Spring discharge x mean concentration of dissolved $CaCO_3$). Estimates made using this method have given lowering values of c.55mm per 1000 years for western Ireland (0.055mm/year). Such methods are simply global estimates of limestone removal from a basin and cannot distinguish between calcium carbonate dissolved from till rather than bedrock nor differentiate zones of higher and lower erosion rates in the basin. Obviously measurements over a period of a few years cannot with any confidence be extrapolated for thousands of years.
- Measurement of the height of the rock pedestals (karrentische) that have developed where a limestone surface has been protected from solution erosion by a transported block of rock. The blocks are usually glacially transported in Ireland and the length of time for which the pedestal has been forming is taken to be the Holocene (<18,000 years). Thus erosion rates can be inferred, estimates of 0.015 to 0.05 mm/yr having been obtained for Ireland. Great differences in estimates arise depending on the area and pedestals sampled and on the presumed length of time for which solution has been active in post-glacial times.
- Site specific measurements using 'erosion studs' or indirect methods. An example of the latter is estimating the rate of downcutting of cave stream passages by dating calcite deposits at various heights above the passage floor. The calcite can only have begun to form when the stream had cut to a lower level. Dates from Pollnagollum cave in Co. Clare suggest a downcutting rate of 0.2mm/year over an 18,000 year period (probably an underestimate). More detailed analyses in Cullaun Cave in Clare gave rates of 3mm, 2mm and 0.7mm/year for the past several hundred years.

It may be that the 'global' rates are indeed indicators of average areal erosion but that at particular sites (for example with a continuous flux of highly aggressive water) erosion rates for limestones may be several orders of magnitude greater; sufficient to be necessary to take into account on a human time scale of activities.

David Drew, Department of Geography, TCD.

KARSTIC ENVIRONMENTAL PROBLEMS RELATED TO MINING OPERATIONS IN HUNGARY

In Hungary sizeable mineral reserves such as brown coal, manganese and bauxite are located in basin areas of karstic massifs. If these reserves are situated beneath the water-table as in the case with Transdanubian Mountain Range, security of mining operations requires that continuous mine dewatering is enforced.

After World War II three different methods of mine de-watering were applied in Hungary namely, the passive, preventive and active methods, depending on the degree of risk to mining operations. In the **passive case** only that amount of water is pumped out which flows spontaneously into the galleries. The **preventive case** is enforced when there is a pending danger of an unexpected water in-rush from surrounding networks of large cavities. Controllable pathways are opened by horizontal or oblique fore-drilling to divert the water away from the operation zone. When a really considerable depression is required the **active dewatering method** is used. In this case the water has to be removed prior to shaft sinking and uses large diameter (up to 5m) pumping wells which are drilled by special drilling equipment using a single core.

Between the mid-70's and mid-80's, approximately 860,000 m^3 per day ($600m^3$/min) of karst water is discharged from the mining operations in the Transdanubian Range. This, in addition to the existing water supply of the region ($200m^3$/min), produced a total groundwater demand of $800m^3$/min. However, the long term mean groundwater recharge for the region is estimated at $600m^3$/min. Therefore, significant depression in the karst water table occurred over a total aquifer region of 8,000 km^2. The average depression for this aquifer region was between 30 and 50m. In the vicinity of the mines, depressions of 100 - 150m were observed. By the end of this period, water supply schemes that had existed previously were completely dry. Moreover, the famous thermal springs which were used for centuries as health spas and in recent decades as important tourist attractions were significantly affected.

To substitute those damaged local provisions, new large-scale water supply schemes were installed utilising the existing mine de-watering structures. Unfortunately, within five to ten years after this the extraction of the underwater mineral deposits became less profitable. Combined with political considerations closing of the mines was decided under mutual agreement between the authorities and the mining companies.

Prior to decommissioning of the mines, the state authorities required the relevant companies to perform a clean-up operation. The clean-up operation involved bringing to the surface those substances which have harmful effects when mixed with the groundwater. However, only partial clean-up was accomplished before the companies conveniently declared bankruptcy. The security equipment (i.e. roof-supports, ventilation, light, pumps, transport facilities and related electrical network) had to be left in-situ as they could not be retrieved safely (due to risk of collapse and water intrusion). Consequently, several thousand tonnes of iron structures, 10 - 20 thousand cubic metres of wooden structures, 100's of tonnes of hydraulic oil, considerable volume of various chemical substances (i.e. fire extinguisher material, plastics for sealing etc.) and sewage effluent from the former work force were left behind.

Analysis of water samples taken from the subsequent pumpings which had been intended to purify the affected areas revealed that the rock material itself was source to a number of unexpected pollutants. The most prominent natural pollutant found was pyrite (a common mineral, containing iron and sulphur) which was dispersed throughout the mother-rock. Pyrite itself is quite harmless until it becomes oxidised and dissolved in water. During the mining operation pyrite was oxidised as a result of forced ventilation. The primary source of the available oxidised pyrite was in the broken rock-blocks throughout the mine cavities. Once inundated by the recovering water-table it dissolved in the form of sulphuric acid, which proceeded to fuse together with other material (e.g. iron) that remained in the mines.

Pollutants originating from the altered rock milieu such as pyrite are relatively inexhaustible as they occur naturally. Their overall contribution was found by analyses of the pumped water during the control period to be at least 1,000 times more polluting than the human-made pollutants. This control period lasted several months. These findings had serious implications for the water supply schemes which utilized the mine water. Numerous techniques were applied to protect the intake of water to these water-supply schemes against underground pollutant sources.

The following techniques were applied. **Artificial barriers** (injected concrete screens) were created to seal-up various mine cavities in order to reduce circulation creating dead areas of water. **Flushing-through methods** together with **forced pumping-up** of the dissolved materials were also applied but were found to be of limited success. Initially, results were promising but it was found that the pumping only created "short circuits" in the tunnels allowing uncontaminated water to discharge to the surface and more importantly found that the pollutants in the water regenerated themselves from the rock, once pumping had ceased. The most successful method was in **hydraulic defence** of water supply sources. This involved continuous long-term pumping to create local depressions in order to keep the contaminated water in place (i.e. away from the water supply area).

The costs of these remedial pumping operations which commenced in 1991 and which are still on-going at present had to be and are funded by the state (i.e. the tax-payers). It is anticipated that such pumping operations will have to be maintained for at least another decade if not two decades. The mining companies responsible for causing the above mentioned environmental effects could not be forced to cover the associated costs as they had dissolved without any legal successor.

The environmental impact from the mining operations and particularly from the decommissioning of the mines is significant and will be for many decades. The main lessons to be learnt from this experience are that adequate planning for mine decommissioning (which is a rather complicated procedure) must be formulated in detail and approved prior to the granting of license consent to a mining project. On-going reviews of, and up-dates to the decommissioning procedures should be carried out regularly throughout the life of the mine. This will allow a certain degree of flexibility in updating the decommissioning procedures in light of unexpected problems/changes in mining operation and new techniques/information. Furthermore, a budget for the mine decommissioning must be retained in the care of the licensing authority prior to commencement of mining and which is to be contributed to by the company on a regular basis.

Acknowledgement: I would like to thank Tony Cawley of the Engineering Hydrology Department, UCG, for his assistance in the preparation of this article.

Dr. Istvan Sarvary, Water Resources Research Centre, (VITUKI) Budapest, Hungary.

MAGNETIC PROFILING

I refer to the article by Gibson and Lyle in GSI Groundwater Newsletter, No. 26, which should read 'magnetic', not magnetometer, profiling.

Magnetic anomalies are caused by the combined effects of remanent magnetism and induced magnetism, where contrasts in these quantities exist. Induced magnetism is produced by the effect of the earth's magnetic field on the magnetic susceptibility of the geological materials in question. Both of these are vector quantities and the presence of an anomaly depends entirely on a contrast in magnitude and/or direction of these quantities. To measure small anomalies arising from small contrasts, it is <u>essential</u> that diurnal corrections be made to the field data.

A fracture zone does not necessarily produce a magnetic anomaly. Indeed there are many major faults and fracture zones which have no magnetic signature at all. For example, magnetic surveys carried out over faults and fracture zones in the Carboniferous limestones of Central Ireland do not show any anomalies as these limestones have negligible magnetic susceptibility. In addition, magnetic susceptibility variations in the soil can produce small anomalies which have nothing to do with the underlying formations.

On the other hand, metamorphic and basic volcanic rocks have minor magnetite content and significant susceptibility values, and it is not uncommon to observe anomalies over fault zones. A single profile is insufficient, however, as other variations in susceptibility, e.g. weathering, folding, re-magnetisation etc. can also produce anomalies. Only a grid survey and the presence of a linear magnetic feature can identify a fault zone. Finally, the presence of an anomaly means nothing as regards potential for groundwater.

While not disregarding magnetic profiling altogether, it is certainly an ill-advised approach in areas of sedimentary rocks. The electrical resistivity of earth materials depends upon their water content and water quality. Primary and fracture porosity have a great influence on the resistivity of a rock and the large contrasts in resistivity, or more correctly, the conductivity associated with a water-filled fracture zone can be detected by electrical and electromagnetic measurements. Electromagnetic surveys using high frequencies, using controlled source dipolar systems (EM-34, GENIE, Max-Min) or plane wave systems (EM-16, Wadi etc.) are very effective, provide quantitative information, and are comparable in terms of cost.

George Reynolds, GeoRho Ltd.

IAH NEWS

IAH (Irish Group) Committee

The membership of the Committee is as follows:

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The committee has focussed for the first six months on the preparations for the Portlaoise Seminar. Meetings during the summer will concentrate on the role of the IAH (Irish Group) in the 1990s and in particular on the question of professional registration for hydrogeologists.

David Ball, IAH (Irish Group) Secretary.

Proceedings of IAH Portlaoise Seminar 1995 "Groundwater in Sustainable Development and Planning"

The Proceedings of this Seminar include the following papers:

Our Geological Heritage is Worth Sustaining
Peadar McArdle, Geological Survey of Ireland
Integrating Environment and Development - the Use of Pricing and Other Incentives to Achieve Efficient Use of Environmental Assets
Frank Convery, Environmental Institute, UCD
The Principal Characteristics of the Flow Regime in Irish Aquifers
Eugene Daly, Eugene Daly Associates
Groundwater Protection in Ireland : A Policy for the Future
Donal Daly, Geological Survey of Ireland
The Role of Modelling in Groundwater Source Protection
Paul Johnston, Dept. of Civil and Environmental Engineering, TCD
EPA Landfill Manuals
Gerry Carty, Environmental Protection Agency
The Engineering of Landfill
Jonathan Derham, M.C.O'Sullivan & Co.
Landfill Studies : The Role of the Hydrogeologist
Suzanne O'Sullivan, Consultant Hydrogeologist
Trace Organics in Irish Groundwaters
Shane Bennet, K.T. Cullen & Co. Ltd.
Landspreading of Animal Wastes
Billy Moore, Tipperary (SR) Co. Co.
Occurrence and Distribution of Groundwater in Northern Ireland
Nick Robins, British Geological Survey
Implications of Sewer Development on Groundwater Quality
Bruce Misstear, Dept. of Civil and Environmental Engineering, TCD and Phillip Bishop, Mott MacDonald Group
Sustainable Groundwater Sources
David Ball, Consultant Hydrogeologist

The Proceedings can be purchased for £15 (plus postage £2) by contacting Philippa Finn, Groundwater Section, Geological Survey of Ireland; cheques payable to the Geological Survey.

NEWS FROM ABROAD

Britain: Doubts about Bioreactor Landfills.

In recent months, the bioreactor landfill has been promoted as a means of achieving sustainability in waste disposal. However, the Draft Management Paper 26B on landfill, prepared for the DOE by Aspinwall & Co, is highlighting technical difficulties with the bioreactor concept:

- the hydraulics of landfill are poorly understood;
- leachate recirculation may be difficult to achieve;
- the accelerating of decomposition cannot be predicted with confidence;
- lower in situ waste densities will be required, thus reducing the available void space;
- the rapid settlement of waste will result in strain on leachate and gas extraction systems;
- greater quantities of gas will be produced initially, with possible odour problems.

So although the concept is exciting, the practical realities cast doubts on its efficiency.

Source: The ENDS Report, No 242 March 1995.

US: Pollution Control Spending

Pollution control spending in the US rose from less than 1% Of GDP in 1972 to 2.1% in 1990 and is expected to reach 2.5% in 1995. Net employment may have increased slightly as a result of environmental protection laws. Companies have blamed environmental protection spending for less than 0.1% of all layoffs.

Source: Geraghty and Miller's Groundwater Newsletter, Vol 24, No. 2.

USA: Groundwater Clean-up on Contaminated Sites

A recent report of the National Research Council (NRC) has concluded that at the majority of contaminated sites in the USA existing remediation technologies are unable to restore groundwater to drinking water standards. The conventional clean-up method is to pump and treat. An assessment of 77 sites where sufficient information had been gathered to allow a reasonably full evaluation, showed that although remediation had been under way for between five and seven years, clean-up goals had been achieved at only 8 sites. The main problem with the pump and treat method was found to be the complexity of the subsurface, with difficulties arising particularly in the fractured rock situation. The worst pollution situations arise where non-aqeous phase liquids (NAPLs) are involved and, in particular, where there are leakages or spillages of DNAPLs, such as chlorinated solvents, where the liquid is denser than water and may therefore sink to considerable depths. In 1977, IBM was found to have contaminated a drinking water borehole with chlorinated solvents. The company installed a conventional "pump and treat" system in 1978 and by 1984, after $10 million had been spent, levels of solvent had fallen dramatically. Treatment was terminated; but within three years solvent concentrations in some monitoring wells were found to be higher than before the clean-up began. However, clean-up of pollution caused by petrol stations tends to be relatively successful, due to the relatively rapid biodegradation of petrol. As these constitute the majority of contaminated sites, and as the sites covered by the NRC review were not representative, the statistics given above reflect the difficulties where the site hydrogeology is complex and where LNAPLs and DNAPLs are the pollutants.

In spite of the disappointing performance of pump and treat systems in achieving full clean-up to drinking water standards, the NRC maintain that the technology can be very useful, as it reduces the size of the contaminated plume and prevents pollution from spreading away from the NAPL pools. The NRC committee assessed a variety of other methods such as air sparging, in situ bioremediation, in situ reactive barriers and intrinsic bioremediation. However they concluded that no known technology can ensure the achievement of health-based clean-up goals at complex sites.

Are there lessons in this for Ireland? In view of the complexity of Irish hydrogeology, it emphasises the need for prevention of pollution, with engineering measures that take account of both the vulnerability and the value of the groundwater.

Source: The ENDS Report, No. 235, August 1994.

England: Pollution by Blood

A company in Southampton was prosecuted by the National Rivers Authority and fined £4000, with costs of £750, after a stream was polluted by blood. The blood was injected into the topsoil but entered the stream from a field drain following heavy rain.

Source: The ENDS Report, No. 237, October 1994.

England and Wales: Water Polluters League

According to the National Rivers Authority (NRA) prosecution data, water companies are worst with 163 prosecutions between 1989 and 1994, followed by the food and drink industry with 150 convictions, with the construction and aggregate industry in third place with 114 pollution prosecutions. Contamination of watercourses by silt/suspended solids seems to be the main problem with the latter.

Source: The ENDS Report, No. 235 August 1994.

Britain: Controlling Pesticides by Protection Zones Cheaper than Treatment.

In 1992, the water industry spent £800 million removing pesticides so that the 0.1 μg/l pesticide limit set by the 1980 EC Directive on drinking water quality was complied with. The cost has since increased. The DOE commissioned a study from WRc to examine the economic case for restricting pesticide usage as an alternative way of meeting the EC limit. The scenarios considered included no curbs on pesticide use, a total ban, limitations on usage and water protection zones in which applications of key pesticides would be banned in certain areas.

Numerical models of two catchment areas were developed, the first to assess the impact on a surface water supply and the second on a groundwater supply. Under the no-restrictions scenario, isoproturon, chlortoluron, mecrocrop, simazine, diuron and flutriafol exceeded the EC limit in the surface water supply; whereas, isoproturon and chlortoluron were predicted to breach the limit in the groundwater supply. A restricted use scenario would require major reductions in pesticide usage; 96% of isoproturon and 85% of diuron and mecrocrop use to ensure compliance in the surface water supply, with 57% and 63% reductions in the use of isoproturon and chlortoluron in the vicinity of the groundwater source. For the surface water source, a 10-metre strip along both sides of major water courses, occupying 0.7% of the catchment, was required to attenuate isoproturon levels. For the groundwater source, at least 63% and possibly up to 90% of the catchment would have to be designated to protect against chlortoluron infiltration into the aquifer. The costs of the scenarios to farmers were calculated. In the surface water catchment, the protection zone scenario was cheapest. For the groundwater catchment, the restrictions on pesticide applications and the protection zone approach were both less than one-third of the treatment option. In both catchments the cost of a total pesticide ban was prohibitively expensive.

Source: The ENDS Report, No. 242 March 1995.

Compiled by the Editor

'WRITTEN IN STONE' – A NEW GSI PUBLICATION

Did you know that Ireland will be 100 miles further away from New York in 1 million years? Or that the red clay bricks that are a feature of many of our houses came from an Irish desert? Or, that Ireland once lay at the Equator where it could be described as a Bahaman Paradise? Imagine Africa and South America coming together in a great slow motion collision. It would be a big crunch - as was the collision that ended Iapetus, which was an Ocean that vanished from the face of the earth. Imagine ice everywhere about and hundreds of metres above your head. That was what the Ice Age brought for 2 million years. It only came to an end, as far as Ireland was concerned, about 10,000 years ago.

The T.V. Series "Written in Stone" was devised to tell the fascinating story of how Ireland has evolved.

The book, Written in Stone, which accompanies the series, will explain these and other phenomena and will cause people to reflect on the many ways we interact with the landscape of our scenic country.

The Booklet is an excellent read for the person who wishes to know more about Irish Geology. Many of the scenes from the highly successful T.V. series are reproduced in colour to compliment the text. It is 50 pages long and can be purchased from the GSI for £6.95 + postage £1.

CONTRIBUTIONS FOR THE NEXT ISSUE OF THE NEWSLETTER

The GSI Groundwater Newsletter aims to improve communication among scientists and engineers involved in groundwater. It includes news, developments, reviews and opinions on all aspects of groundwater - exploration, development, management, water quality, pollution and energy. It is published three times per year.

Your contribution to the dialogue would be welcome. Contributions should reach the GSI before 1st October 1995.

**The contributors are responsible for the content of the material in this newsletter.
The views expressed are not necessarily those of the
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