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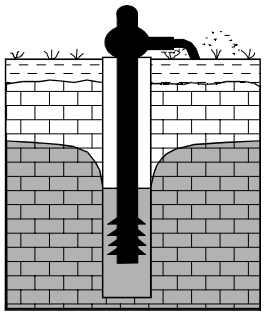
THE GSI GROUNDWATER NEWSLETTER

- Exploration
- Management
- Pollution
- News from abroad
- Development
- Quality
- Reviews
- Opinion Forum



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No. 30 November 1996

IN THIS ISSUE

The pollution of the public supply at Nenagh emphasises the need for sensible well location relative to both the natural vulnerability of the groundwater and the potential hazards in the zone of contribution of the well. This incident should not put people off groundwater (the most commonly used source of drinking water in the EU), but rather provide a lesson that while groundwater is usually a cheaper source of supply than surface water, it requires understanding and protection. The **value of groundwater as a successful source of supply** is well illustrated by Kevin Cullen on page 2.

One of the hazards posing a risk to groundwater (and surface water) is **oil**; a difficult substance in the geological environment. Matthew Hudson summarises a useful lecture by Paul Ashley at a recent IAH Technical Discussion which provided an up-date on **oil pollution and remediation** (page 3); while John Balco outlines a **practical approach to remediation taken in Massachusetts** on page 5.

The **disappearance of Lough Funshinagh** made the GB Show (on RTE Radio 1) during the summer; why does it disappear and where does the water go to? David Drew and Morgan Burke provide some answers on page 9.

Should groundwater development projects be undertaken without geophysics?; the article by Michael Hanrahan (page 10) illustrates the benefits of using geophysics to get the optimum locations for drilling. Similarily, on page 13, Kevin Cullen points out the value of retaining well information in a **groundwater database.**

Other items include details on an **international groundwater E-mail group** (page 12) from Catherine Coxon; **IAH News** (page 11); **News from Abroad** (page 13); and a review (page 2) of the **Agroclimatic Atlas of Ireland** by Geoff Wright.

Editor

GROUNDWATER DEVELOPMENT SUCCESSES IN 1996

Groundwater development has progressed in 1996 on a number of fronts reflecting the general buoyancy in our economy, increased water consumption and water charges, and the ever rising demand for clean water. The number of hydrogeologists employed in the country continues to rise a result of the increased demand for groundwater. An even better gauge of the increased groundwater abstraction is the volume of work being undertaken by water well drilling contractors. Most companies are fully employed. Some even have two or more rigs operating and for the first time, contractors have declined to tender for sizeable contracts!

Groundwater continues to be developed as an important source of public water supply. While groundwater will never attain the status of surface water abstractions due to our low population and the abundance of relatively clean rivers and lakes, it has a key role to play in the context of town supplies and large industrial demands. In this regard, 1996 witnessed important developments and studies at Roscommon, Ennis, Wexford, Kingscourt, Donegal and Monaghan to name a few. Also, strategic industrial sites were identified where future industries could develop large groundwater supplies free of charge, so to speak.

The demand for mineral water supplies continues to grow for home consumption and for export. With flavoured mineral waters becoming even more popular, many Irish plants are running a number of shifts to meet the demand. The availability of clean groundwater in Ireland is the backbone of this industry and as it, and the cooler industry grow, so will the demand for sustainable groundwater supplies.

1996 has been a good year for groundwater development and for hydrogeologists generally. The Nenagh incident has heightened awareness as to the vulnerability of this natural renewable resource and hopefully, this increased level of attention will be translated into protective measures to secure this tremendous resource for future generations.

Kevin Cullen, K.T. Cullen & Co. Ltd.

REVIEWS

Agroclimatic Atlas of Ireland (the 'AGMET Atlas')

Edited by James F. Collins & Thomas Cummins
ISBN 0 9511551 4 8

The Agroclimatic Atlas of Ireland was launched by the Minister for the Environment, Brendan Howlin TD, on AGMET Day, February 29th, 1996, at a two-day conference on "Climate, Weather and Environment - Key factors in Irish Agriculture" at Johnstown Castle, Wexford. Those readers of the GSI Groundwater Newsletter who missed the conference may not be aware of the Atlas and the wealth of information it contains within its 190 A4 pages.

Agroclimatology aims to put the results of long term weather information and a range of data from a host of other scientific activities into a form that can be used by farmers and other land managers. It also has implications for how we manage our wastes and how we protect our water resources. The Atlas provides a compact digest of published information relevant to Agroclimatology in map form. Most are 'all-Ireland' maps, but there is also a selection of larger-scale maps to indicate the availability of more detailed information.

As you might expect, climatological maps are well represented (e.g. distribution of meteorological instruments, annual precipitation, number of wet days, extreme rainfall events, duration of bright

sunshine, potential evapotranspiration, water deficits, etc). But there is much else besides: maps of agricultural land use, length of the grass-growing season, susceptibility to liver fluke and potato blight, winter rainfall acceptance potential, plus a number of maps of more direct interest to the hydrogeological community: geology, glacial geomorphology, rock aquifers, soils, land drainage problems, and much more. Each map or graph has an explanatory page of text. The hydrogeological maps themselves (aquifers, vulnerability) may well be familiar to many readers and are already somewhat out of date, having been compiled in 1979-82. Admire them by all means, but come to us for the more up-to-date (and larger-scale) picture!

The Editors must be congratulated on a very fine job - the Atlas is very well produced, with a colourful cover, good quality paper and a clear, crisp format. The Atlas is an absolute snip at £12.00 (+p. & p.) from Dr. J.F. Collins, Faculty of Agriculture, UCD, Belfield, Dublin 4. It is also available at some major bookshops and at the GSI.

AGMET ("Joint Working Group on Applied Agricultural Meteorology") is an informal group of people interested in agrometeorology, including members from MET Eireann, Teagasc, GSI, OPW, Universities, Colleges and private consultants, and began in 1984. Membership is open to all those interested in and willing to promote the uses of agrometeorology in Ireland. For further details contact Jim Collins at the above address, or Tom Keane at MET Eireann, Glasnevin Hill, Dublin 9.

Geoff Wright, Geological Survey of Ireland.

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IAH Annual Lecture "Oil Pollution and Remediation"

By: Dr Paul Ashley, Parsons Engineering Science

The IAH annual lecture this year was given by Dr Paul Ashley who is the contaminated land manager for Parsons Engineering Science in Cambridge, England.

Mineral oils are one of the most common pollutants of groundwater (and the unsaturated zone), and their behaviour, fate and remediation have been the subject of detailed research for some two decades. Nevertheless, contamination by oil remains particularly difficult to control and clean up. In his lecture Dr Ashley briefly reviewed the factors peculiar to oil pollution and he described in detail some of the available methods for its remediation. The main techniques that were described have been summarised in this review.

Once an oil spill has taken place the pollution can take one of three forms: as a free phase (where the oil is separated out from water), as a dissolved phase, and pollution in the unsaturated zone. The remediation methods discussed covered pollution in all these forms, although methods for the remediation of free phase oil and pollution of the unsaturated zone were covered in more detail. Dissolved phase contaminants can usually be removed by normal groundwater pumping and treatment techniques.

Dual pump oil recovery systems have been used in the past when dealing with free phase oil recovery. In this process a cone of depression is induced in the water table by pumping groundwater below the oil zone. The cone of depression encourages the movement of the oil to a second pumping well, which is open at the oil horizon. In practice the movement of oil is restricted by capillary forces and as a result of thinning (pinching out) of the oil horizon near the well.

Skimming is a simpler process which involves one pumping well which is open only in the oil horizon. A cone of depression is not induced in the water table and problems of the oil horizon pinching out are avoided.

Bioslurping is a process which involves drawing a mixture of air, water and oil through a suction system at the oil/water interface. As pressure is decreased in the unsaturated zone as well as below the water table the oil horizon remains relatively thick, avoiding the problems of the dual pump method. The driving force for this process is pressure rather than gravity, so there is a limiting depth to the application of this process (approximately 10 m). A by-product of this process is that some air is drawn through the contaminated zone above the water table, aiding in the remediation of the unsaturated zone. The discharge of these gases may, however, need treatment before release to the atmosphere. The bioslurping process was compared to the skimming and dual pumping techniques in remediation work carried out on air force bases in the US. Bioslurping was significantly more efficient in the

removal of free phase oil in most of these remediation sites.

Vacuum extraction is a remediation technique which is designed to remove hydrocarbons from the unsaturated zone. Wells are designed to pump large volumes of air out of the unsaturated zone; this process can be aided by venting wells which allow air to be drawn back into the ground. As air is drawn through the unsaturated zone hydrocarbons are volatilised; these vapours often need treatment at the surface before they can be released. Vacuum extraction is used mainly in the remediation of BTEX compounds (a group of soluble aromatic hydrocarbons which includes benzene, toluene, ethylbenzene and xylenes); these compounds are commonly associated with petrol spills.

Air sparging is another technique which uses air to volatilise hydrocarbons, both above and below the water table. Air is pumped downhole into the saturated zone and as air bubbles rise contaminant volatilisation occurs. Another pump is used to draw air out of the unsaturated zone. More air is pumped out of the unsaturated zone than is pumped below the water table so that a negative pressure gradient is created. This process is not always successful, as horizontal seepage of contaminants can occur along narrow zones, particularly if the local geology is complex. In some circumstances air pumped into the injection well can take narrow preferred pathways, directly to the extraction well, greatly reducing the remediation process.

Bioventing is a remediation process which uses biological degradation. Organic contaminants are used as an energy source by bacteria which can produce simple compounds like CO_2 and water from these complex organic molecules. Biological degradation is limited by the amount of available oxygen, therefore air is pumped into the unsaturated zone (at very slow rates) to aid the bacteria. Bioventing has the advantages that it works for a wide range of contaminants including BTEX compounds, diesel and kerosenes. Air flow rates are low, hydrocarbons are not volatilised and there is little or no release of vapour to the atmosphere. According to Dr Ashley, bioventing is a relatively cheap process when compared to other methods such as soil vapour extraction. Bioventing is however less successful in: fine grained subsoils, subsoils with a high moisture content, and where contamination occurs at very shallow depths.

Intrinsic remediation is a risk management strategy which exploits the natural attenuation processes in the unsaturated zone and in the groundwater. The natural degradation processes, including the consumption of nutrients, oxygen and other electron acceptors are closely monitored and controlled. Natural reactions which occur in the breakdown of hydrocarbons include the reduction of O_2 , NO_3, and SO_4, and the generation of methane. This strategy often represents the lowest cost solution where there is no immediate likelihood that oil will migrate off-site as a free phase.

The lecture by Dr Ashley shows that there have been considerable advances in recent years in the remediation of groundwater contamination by oil. The case studies described suggest that developments of the vapour-phase extraction process, particularly air sparging, bioventing and bioslurping, can be effective remediation techniques.

Dr Ashley's presentation was clear and efficient, and the remediation techniques discussed were covered in considerable detail, bearing in mind the short length of time available.

A comprehensive discussion on contaminated land remediation techniques is given in Physical and Chemical Hydrogeology by Domenico, P. A. and Schwartz, F. W., (1990); John Wiley and Sons, USA, pp. 711-750.

Matthew Hudson*, Geological Survey of Ireland

** Matthew is leaving the GSI and returning to England - we wish him success; Colette Cronin, a UCC graduate and University College London postgraduate, has joined the GSI in Matthew's place.*

A NEW MODEL FOR EXPEDITED CLEANUP

Introduction

Fairly or unfairly, environmental cleanup programs have been criticised for a wide range of deficiencies: study with no action, high cost of investigation and cleanup, cleanup standards unrelated to societal benefits, uncertainty about future liabilities limiting property use for productive economic purposes, and landowners being forced into a complex regulatory web for contamination over which they had no responsibility or control.

After three years of deliberation among industry, regulators and public interest groups, the State of Massachusetts has embarked on a radical departure from the traditional site investigation and cleanup model aimed at remedying the foregoing and achieving faster, and more cost effective, cleanup.

A New Beginning - Overview of the Expedited Cleanup Process

Among the major elements of the expedited cleanup program are:

- Keeping small problems out of the system entirely by reporting soil and groundwater contamination based on site specific risks to health and the environment.
- Encouraging prompt action to remove or contain contamination under appropriate circumstances with limited study or government oversight.
- Focusing government resources on the most serious sites while allowing and encouraging private parties to proceed independently by professionals specifically licensed to do so.
- Establishing risk-based cleanup standards based on contamination levels, media and potential threats and realistic site use, with controls to ensure future uses are compatible with residual contamination levels.
- Limiting liability of landowners whose property has been contaminated by off-site sources.

Reporting Contamination – Keep Small Problems Small

Under the new expedited cleanup model, risk-based soil and/or groundwater concentrations are established to determine if a detected contaminant needs to be reported in the first place. It recognises that materials found in older industrial areas may not represent a significant threat, while the same materials may be of major concern in an area contributing to a public drinking water supply. By eliminating the minimum sites from regulatory oversight, resources will be focused on more significant sites.

Examples of Reportable Concentrations (RCs) are:

Contaminant	Reportable Concentration (ppm) for Soil (RCS) and Groundwater (RCGW)			
	RCS-1	RCS-2	RCGW-1	RCGW-2
Benzene	10.0	20.0	0.005	2.0
Toluene	90	500	1.0	6.0
Lead	300.0	600.0	0.02	0.03
Total Petroleum Hydrocarbon	500	2,500	1.0	50.0
Chrysene	0.7	0.7	0.002	0.003

A Bias Toward Action

To encourage prompt action, notification time and response actions vary. A risk-based reporting standard has been adopted. The same contaminant which could impact an existing drinking water supply would be reported sooner than that contaminant in a less environmentally sensitive area.

Responsible parties are encouraged to take prompt action to reduce or eliminate contamination. For example, if the RC was triggered by contaminated soil which can be treated or properly removed before the notification deadline, RCs would not be exceeded. No RCs, no report, no site entering the investigation and cleanup system, limited site investigation, and rapid remediation achieved.

When a report is made, responsible parties are required in some cases (two hour and seventy-two hour releases) and encouraged in others, to take

prompt response action without state oversight. Examples are: "Immediate Response Actions", such as removal of contaminated soil and "Release Abatement Measures", such as pump and treat.

If the threat can be reduced or removed, it may not be necessary to conduct extensive site investigation and remedial alternative analysis. Prompt action reduces long term cost and regulatory oversight depending on the severity of site conditions.

Sorting Priorities - Tier Classification System

A tier classification system has been devised to determine which sites represent the most significant threats and merit state oversight vs. actions allowed without oversight. Tier classification must be completed within one year of release reporting. When a site is classified a permit system is evoked with yearly fees, as well as determining if state oversight is required.

A numerical ranking score is composed of the following components:

- Soil, groundwater, surface water and air exposure pathways
- Toxicity, mobility and persistence of oil and hazardous materials
- Disposal site hydrogeology
- Land use
- Groundwater use and potential use
- Surface water use and potential use
- Ecological populations of concern relative to site location

Only sites with scores above the highest numerical ranking threshold, estimated to be 10 percent of all reported sites, will be subject to state oversight.

Risk-based Cleanup Standards

Rather than a single numerical goal (e.g. drinking water standards), the remedial action objective is to reach a level reasonably necessary to achieve "no significant risk". This goal is implemented via risk-based criteria considering the contaminants, concentrations, location, and reasonably anticipated exposure scenarios.

Three methods have been established to assess acceptable risk-based cleanup standards:

- Method 1: A numerical standard for soil and groundwater cleanup based on defined exposure and fate and transport scenarios.
- Method 2: Using modified models to account for site specific conditions.
- Method 3: Developing risk-based cleanup targets by other approved methodologies.

Each has trade offs of simplicity, applicability to site-specific conditions, time and cost.

Risk-based cleanup standards are applied based on defined site conditions. Three groundwater classifications and three soil classifications are applied to each site situation.

Examples of each are :

Method 1 - Groundwater Standards (ppb)

	Groundwater Classification		
Contaminant	**GW-1**	**GW-2**	**GW-3**
Benzene	5	2,000	7,000
Toluene	1,000	6,000	50,000
Lead	15	N/A	30
Chrysene	0.2	N/A	3
Total Petroleum Hydrocarbons	1,000	N/A	50,000

Method 1 - Soil Standards (ppb)

	Soil Classification (differs by GW classification)		
	S-1	**S-2**	**S-3**

Contaminant	GW-1	GW-2	GW-3	GW-1	GW-2	GW-3	GW-1	GW-2	GW-3
Benzene	10	10	10	30	60	100	30	60	200
Toluene	90	90	90	500	500	500	500	1000	2500
Lead	300	600	600	300	600	600	300	600	600
Chrysene	O.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Total Petroleum Hydrocarbons	500	2500	5000	500	2500	5000	500	2500	5000

Cleanup for Today - Protect Tomorrow

A major issue associated with site remediation is cleanup standards for sites which do not pose a threat under today's conditions - especially in old, urban, industrial areas. The prospects of spending millions of dollars to treat groundwater to drinking water standards in areas that are unlikely to be used for drinking water has resulted in technical and legal confrontations, high transaction costs, and no action.

The MCP correlates cleanup standards to today's site use. A restriction can be placed on a property limiting use appropriate to the cleanup standards applied, Activity and Use Limitations (AULs). AULs apply to contaminated soils only. Possible changes in land use are acknowledged. Should the owner wish to change the use of the property in the future, the remedial goal will be re-evaluated, almost as a "permit reopener".

Cleaning Up Someone Else's Problem

As with the federal CERCLA program, the Massachusetts 21E statute provides for strict, joint and several liability. Prospective property owners or operators have been reluctant to commit to use or buy a contaminated site for fear of being brought into the large liability net. Thus, redevelopment of such sites has faltered, especially in urban areas where contamination could be widespread.

Requiring a property owner cleanup a problem which was not of their making creates hostility, distrust, anger, stonewalling and law suits. Plenty of heat, lots of interesting discussion and fighting about cleanup policies, a good deal of money on legal and administrative matters - but no site cleanup!

To remedy the inequity and avoid the associated transaction costs and delays, the regulations give significant added protection to "downgradient" landowners. Based on a comprehensive demonstration that the contamination did not come from the subject property, does not represent a threat to human health or the environment, and other factors (e.g. protection against sham "downgradient" property owners as, for example, carving out the source from a larger parcel), the subject property is put into a "holding pattern". As long as no threat exists, assessment and remediation deadlines are waived, as are compliance fees.

The option is not free. There must be a thorough investigation regarding source(s) and risks. But it may well be better than the alternative.

Keeping the System Honest

The linchpin of the revised site restoration model is the ability of the private sector to make decisions required without state oversight. This is accomplished by state licensing of individuals to perform the function, a Licensed Site Professional (LSP).

LSPs provide decisions such as: 1) implementing short-term risk reduction measures; 2) determining the scope of investigation and the need for remedial action; 3) tier scoring; 4) evaluating remedial alternatives; 5) assessing and selecting remediation actions; and 6) determining when site remediation goals have been achieved.

Licensing is the responsibility of a new Board of Registration of Hazardous Waste Site Cleanup Professionals. Licensing requirements are rigorous: for a standard track they include eight years of professional experience and five years of relevant experience in rendering waste site cleanup opinions; professional and personal references; and demonstrating experience by specific project examples. An exam is required, as well as significant continuing education requirements to maintain proficiency.

With much authority now in the hands of individual LSPs, some tension is created. A sceptical public may be concerned about objectivity, after all, the LSP is being paid by a

private party whose intent may be saving as much money as possible. A client may be concerned that studies will be "gold-plated" to protect the professional from law suits that will surely come in the uncertain world of investigating and remediating contaminated sites. Although far from settled, two aspects of the program attempt to deal with these concerns. An LSP is subject to severe penalties and sanctions if defined standards and a code of ethics are not followed. Further, the state will conduct independent audits of LSP activities; the goal is to audit 20 percent of all sites annually.

Summary

There are many uncertainties in the new Massachusetts approach to site remediation. It is not without pitfalls. However, there is a commitment on the part of state regulators, private parties, the legal and investment communities, and LSPs to work toward achieving the goals of the program. Its success will be measured by contaminated sites cleaned; legal and remedial costs saved; and progress in site reuse. It may well be a useful template to assist other state and federal program managers in finding a more efficient mode of operation.

It is not the only approach. Alternatives should be based on the legislative and regulatory environment in a given state, full recognition to some of the difficulties and uncertainties of the Massachusetts approach and acknowledge that any system will have advantages and disadvantages.

Site investigation and cleanup is a difficult problem. Many smart people have been grappling with the problem for decades. If it were an easy problem, it would have been solved by now.

Acknowledgement: This article was first published in the Proceedings of the American Defense Preparedness Association 21st Environmental Symposium "Environmental protection and a Changing Defense Mission– A Mid-Decade View" and is republished here with permission.

John J. Balco, GZA GeoEnvironmental, Inc., Massachusetts, USA.

THE PAUL ROCHE FUND.

The parents and friends of Paul Roche wish to thank all those who contributed towards the effort to initiate a search for Paul's whereabouts. A total of £13,000 was donated, over £5,000 of which was contributed by the Geological Community. This overwhelming response to the appeal enabled Paul's family to proceed with the search in mid August. Two of Paul's sisters and a close friend travelled in northern India for a period of three weeks and were able to considerably narrow down the search area. They then hired a professional search and rescue team to carry out a detailed ground search of the routes that Paul was thought to be following. No evidence of his whereabouts has been found to date, but the search is still ongoing, as are efforts by Paul's family to follow up on one or two leads which they uncovered during their trip.

Conor Walsh, K. T. Cullen & Co. Ltd.

THE DISAPPEARANCE OF LOUGH FUNSHINAGH, CO. ROSCOMMON, SEPTEMBER 1996

Lough Funshinagh is located to the west of Lough Ree, some 11km north-west of Athlone. The lake when full, is some 2.5km^2 in area with a maximum length (north-south) of some 3.2km. Normal water level is 70m O.D.

Lough Funshinagh is an intermittent turlough, the lake becoming nearly dry every three or four years. At longer intervals the lake dries completely with the exception of a few pools, the last expanse of water commonly disappearing within a short time period. J.C. Coleman (1965) remarks:

" In November 1955, the tenth time in the last fifty years, the waters of the lake vanished down a swallow hole, leaving hundreds of fish stranded on its muddy bottom. In July 1964 I visited the site and grass was growing over most of the lake bed. Like Lough Nasool in south Co. Sligo it appears that collapse of the plugged material in swallow holes causes these sudden disappearances"

In 1984 the lake vanished for six months and in late August of 1996 the lake again completely emptied, refilling only with the heavy rains of mid and late October.

The opportunity was taken to visit the site and the surrounding area on several occasions between early September and early November 1996 and the report that follows is based on these visits and conversation with local Wildlife Rangers.

The lake is flat floored and shallow (2m maximum depth) and is filled by two small streams, little more than drainage ditches, entering from the north-west. The lake has no surface outflow, the only outlet being a sinkhole, considerably enlarged by man, in the extreme southeastern corner. During the early part of the summer of 1996 water levels remained high in the lake but levels began to drop rapidly after August 19th and by September 1st only a small body of water some 30cm deep remained in the southern part of the lake, the water draining into the sinkhole. A few days later the only water remaining in the lake was in isolated pools, some of them old peat cuttings, into which those fish that were rescued in time were placed. The large numbers of fish that were left stranded on the dry lake bed emphasises the relative infrequency of the complete loss of water compared with the annual drying out of normal turloughs.

Locally it is considered that the turlough drains to Lough Ree to the east and Coleman (1965) also states that this is the case. However, Lough Funshinagh is separated from Lough Ree by a limestone ridge with an elevation some 70m higher than the lake and it seems improbable that a direct underground flow route through the ridge exists given the generally shallow nature of karstic groundwater flow in the western lowlands. To the south of the lake is an extensive area of hummocky till, kame-like in places, drained by the Cross River. Although the Cross River rises to the west of Lough Funshinagh, at the watershed with the River Suck drainage a series of strong springs augment flow in the Cross River near Milltown Pass some 5km south of Lake Funshinagh. A water tracing experiment using optical brightener proved a connection between the sink at Lough Funshinagh and the spring at Atteagh Corn Mill (Td Mullagh). The spring had a discharge of c. 10 litres/sec when the test was undertaken. All other sites monitored in the Milltown Pass area gave negative results. The height difference between the input and output sites is 15m (compared with 25m between Lough Funshinagh and Lough Ree) and the tracer reached the spring within 72 hours, a minimum flow rate of 70m/hour.

The emptying of Lough Funshinagh does not seem to have been as dramatic as indicated in the media, though the disappearance of the last extensive sheet of water was very rapid. The reason for the complete drying out is far from clear, but the regularity of the five to ten year recurrence interval is remarkable. It does not seem as though a plug hole in the sink ruptured as Coleman (op cit.) suggests happens; neither was the late summer especially dry. However, further west in north-east and south Galway water levels in several lakes-cum-turloughs were reported to have fallen to the lowest levels on record during the late summer - significantly lower than those achieved in the preceding exceptionally dry summer of 1995.

Reference: Coleman, J.C. 1965 The Caves of Ireland p. 68, Anvil books, Tralee

David Drew and Morgan Burke, Department of Geography, TCD.

GEOPHYSICAL SURVEYING - A VALUABLE PART OF GROUNDWATER RESOURCE DEVELOPMENT

In the past, the role of geophysics in groundwater resource development, in particular for domestic supply, has often been considered to be an expensive and non-definitive method of locating suitable drill targets. Certainly, in some geological situations geophysics will not always guarantee the identification of water bearing zones. However, a carefully planned and well designed survey, combined with an appreciation of all existing local hydrogeological knowledge, assists in choosing the optimum site thus providing a more cost effective method of groundwater investigation.

A recent extensive geophysical survey carried out at Letterkenny, Co. Donegal successfully identified and delineated a gravel rich palaeochannel, which had no surface expression. Vertical Electrical Soundings (VES) were carried out along the Swilly Valley between New Mills and Letterkenny Town, a distance of approximately 5km. This method measures the variation in apparent resistivity with depth between different layers within the ground by using an electrode array, where the spacing between the electrodes is systematically increased about a fixed central, or measurement, point. As the spacing is increased, the fraction of total current flowing at depth, and hence the depth of investigation, is also increased, thus allowing the identification of stratigraphic units. The work resulted in the delineation of a resistivity anomaly, approximately 50m wide, in the survey area. In areas where clay cover was thin (<4m) the existence of the anomaly was corroborated using VLF-R, a crude, but nonetheless effective, surveying method. When the anomaly was drilled, relatively clean, water bearing gravels of up to 7m in thickness were encountered with well yields of up to 10,500 gal/hr (47.7m^3/hr). The drilling of monitoring boreholes away from the anomaly intersected a sequence of silts and clays with occasional thin and silty gravel units. To attempt to drill in this area without a pre-drilling geophysical survey would to say the least have been haphazard and certainly not cost effective.

More recent surveys to locate drill targets for domestic, light industrial and agricultural groundwater supplies have been successful in identifying water bearing bedrock structures, such as faults and fracture zones, in the Lower Carboniferous Limestone successions of Counties Kilkenny and Tipperary. Since these surveys were for low yielding supplies, a quick and cost effective method was required. Hence, Very Low Frequency (VLF) surveying using the WADI® equipment was employed. This method detects the distortion of electromagnetic waves, from distant VLF transmitters, resulting from the presence of underground conductive bodies, such as faults, fracture zones and ore bodies orientated parallel to the direction of wave propagation. The WADI®, which is operated by one person, offers the capability of rapid coverage, enabling as many as three sites to be surveyed in one day. In each of the sites surveyed no surface features existed to indicate the presence of bedrock discontinuities and so geological knowledge was limited to published work. However, linear anomalous zones, which proved to be productive, were identified in each site using this method. Had drilling taken place without the geophysical survey it is doubtful whether just as high a success rate would have been achieved.

In conclusion:-

- Groundwater bearing zones in areas with extensive drift cover are more numerous than any map can indicate. Geophysical surveys should not be carried out in isolation, rather a well designed pre-drilling geophysical survey, where the results are closely integrated with all existing hydrogeological knowledge, offers the best possibility for the location and development of sustainable groundwater supplies.
- The cost of a pre-drilling geophysical survey is in the region of 10-20% of the total cost of a drilling programme and therefore should play a valuable part of groundwater resource development schemes.

Michael Hanrahan, Minerex Environmental Limited.

THE IMPORTANCE OF GROUNDWATER DATABASES

The value of groundwater databases became evident during the year when it was necessary to drill water wells in response to a water shortage and a pollution incident.

In Donegal, attempts to augment a lake abstraction with groundwater were unsuccessful due to the natural impermeability of the strata underlying the preferred sites. Reference to past drilling results in adjoining areas allowed the drilling programme to then locate a successful well that could be developed to meet the shortfall. As the earlier information followed from work carried out in **1980,** the availability of this data was crucial in the re-direction of the groundwater development programme.

The response to the pollution incident at Nenagh required the replacement of a spring source with an alternative supply that could be developed quickly and tied into the existing distribution network. Groundwater offered the only solution and accordingly wells were located in the general vicinity of the town. The trial well sites were based primarily on the results of previous groundwater investigations carried out in the general Nenagh area on behalf of a variety of companies over a period of 15 years. Access to this information provided a sufficient level of confidence to proceed with the drilling programme with a reasonable expectation of a sucessful outcome.

In both the Fanad and Nenagh cases the relevant past well drilling results were available at the Geological Survey for inspection. This data had been submitted to the GSI as part of their ongoing groundwater database management programme.

Kevin Cullen, K.T. Cullen & Co. Ltd.

(Editors comment: K.T. Cullen & Co. have, over many years, led the way in giving their well records for entry in the GSI's national groundwater database; this has added substantially to the database and has benefited not only the GSI but all who use the database.)

NEWS FROM ABROAD

California: MTBE Causes Well Closure

Santa Monica may be the first city in the U.S. to be shut down due to contamination by the petrol additive MTBE. Three of the five wells supplying 40% of the city's drinking water are badly affected, with concentrations rising to 600 ppb. The contamination is blamed on leaking underground petrol tanks nearby.
Source: Geraghty and Miller's Groundwater Newsletter, Vol. 25, No. 16.

U.S.: Regulations Retard UST Market, Aid ASTs

Although larger-capacity underground storage tanks (USTs) are being built, demand for USTs has been flat for the past six years, largely because of the regulatory situation, while demand for aboveground storage tanks (ASTs) has increased. Large non-retail tank facilities are removing their USTs and/or replacing them with ASTs, especially new jacketed and composite tanks, according to the vice president of the Steel Tank Institute.
Source: *Source: Geraghty and Miller's Groundwater Newsletter, Vol. 25, No. 19.*

US: Lawns – A Potential Source of Pollution!

It has been estimated that homeowners in the US use 10 times more chemicals per acre to grow attractive lawns than farmers use to grow crops.
Source: Geraghty and Miller's Groundwater Newsletter, Vol. 25, No. 17.
Is the situation similar here in Ireland, even if not to the same degree?

Compiled by the Editor

AN INTERNATIONAL GROUNDWATER E-MAIL GROUP

Users of electronic mail may be interested to know of an international groundwater listserver or e-mail group which has been running since December 1995. Anyone who joins the listing (free of charge) can post a message on any groundwater-related topic. Subscribers include hydrogeological consultants, people working for public bodies (e.g. U.S.G.S., U.S.EPA), academics and interested amateurs. Although many postings are from the U.S. (where the listserver is based), there appears to be a good global spread of messages from both the developed and the developing world.

Typically there are about 10-15 messages per day (which can be received amalgamated into two e-mail messages - see below). These range from technical questions on input parameters to groundwater models, and exchanges of information on remediation technologies, to queries from concerned members of the general public about the groundwater impact of planning proposals in their neighbourhood. Messages also include postings from new hydrogeology graduates seeking employment, and details of groundwater conferences, training courses etc. Replies to queries can either be sent directly to the e-mail address of the person who posted the query, or if the reply is of general interest, it can be posted on the listing.

- To subscribe to the listing, send a message to majordomo@ias.champlain.edu with the command "subscribe groundwater-digest" (no need for social niceties - you're speaking to a computer). Groundwater-digest provides the messages amalgamated on a daily basis into two messages. (You can also receive each message separately but this tends to completely clutter up your mailbox).
- To post a message, send to groundwater@ias.champlain.edu
- If you are getting buried under a pile of unwanted messages, you can unsubscribe by sending a message to majordomo@ias.champlain.edu with the command "unsubscribe groundwater-digest".

Catherine Coxon, Environmental Sciences Unit, TCD.

IAH NEWS

Future IAH Technical Discussion Meetings

3rd December **Reliable Outputs of Water Wells and Springs** by Bruce Misstear, Department of Civil and Environmental Engineering, TCD; followed by contributions from other speakers.

7th January **Hydrogeological Research in Irish Universities**, with contributions from Catherine Coxon (TCD), David Drew (TCD), Tiernan Henry (UCG), Bob Kalin (QUB), Paul Johnston (TCD) and Bruce Misstear (TCD).

4th February **The David Burdon Lecture**. Speaker to be arranged.

4th March **A Forum for Younger Hydrogeologists**.

Further details from Kevin Cullen ☎ 01-2697082 or Donal Daly ☎ 01-6041490

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IAH NEWS

Members of IAH (Irish Group) Visit St. Petersburg

During the last week of August a group of eight, organised by the IAH (Irish Group), visited St. Petersburg at the invitation of their Russian colleagues. The members of the delegation were:

Robert Aldwell (Geological Survey of Ireland)
David Ball (Consultant and Secretary of Irish Group of IAH)
David Drew (Geography Department, TCD)
Bruce Misstear (Civil Engineering Department, TCD)
Shane O'Neill (Ballygowan Spring Water Co Ltd)
Simon Pow (ESB International)
Olga Aslibekian (University of Limerick)
Geoffrey Wright (Geological Survey of Ireland)

This was the first time for the Irish IAH to send such a delegation abroad. It came about as a result of my ongoing contacts with Russian hydrogeologists and which has seen three of them from St. Petersburg visit Ireland in recent years.

Objectives of visit

- Establish good personal contacts between hydrogeologists in Ireland and Northwest Russia.
- Exchange of information on current hydrogeological topics - activities, procedures, problems.
- Based on firsthand information, to attempt to identify areas of mutual interest which could lead to future co-operation beneficial to both sides.

The two main items of the visit were a seminar held in the University and a two day field workshop in the area surrounding St. Petersburg. The seminar was entitled "Environmental Aspects of the efficient use of Groundwater Resources" and was sponsored by three Russian organisations:

- The St. Petersburg Section of the International Academy of Mineral Resources
- The St. Petersburg Group of the International Association of Hydrogeologists
- The Hydrogeology Department of St. Petersburg State University.

There were some twenty participants with about twice as many present at the opening by the President of the City Council (Duma). The papers were presented in English or Russian followed by translation into the other language. Olga Aslibekian (University of Limerick), who is a hydrogeology graduate of Moscow State University, had prepared Russian abstracts of the Irish papers and assisted with the translation. Some of the Russian hydrogeologists have quite good English. There were particularly interesting Russian presentations on attenuation of tailings (Mironenko), modelling of radioactive leachates (Oziabkin) and vulnerability mapping (Bezroukov). It is hoped to publish the abstracts at a later date.

The field workshop consisted of a visit to the Izorskoye limestone plateau to the southwest of St. Petersburg and to the Karelian Isthmus to the northwest. The plateau is of Ordovician age and is of strategic importance as a source of water supply to the city and to the famous fountains at Petrodvorets. The Izorskoye limestone is not highly karstified and appears more like the English Jurassic oolites than the Irish karst. There was a stop to visit the Krasnoye Selo waterworks which pumps 15000 m^3/d of relatively good quality groundwater from the limestone. We also saw some of the limestone springs near Novaya Burya serving the Petrodvorets fountains. The two technical stops in the Karelian Isthmus were at the huge estuarine barrage across the mouth of the river Neva at Kronstad and to the famous spa at Sestroretsk. This spa specialises in the treatment of gastro-intestinal complaints and can cater for 2000 people. The spa water comes from Cambrian sandstone and is rich in sodium chloride and bromine. It has a

temperature of 10.8°C which is about 3°C above the regional groundwater temperature.

A half day was spent visiting the University. It was founded by Peter the Great and has some 20,000 students, half of whom today are housed at a new campus at Peterhof, some 35km from the city. Among its best known alumni is Mendeleyev and several Nobel Prize winners. We had discussions on future co-operation with the Department of Hydrogeology and also met with the Dean of the Faculty of Geology - Prof Buldakov and the Head of the office for International Relations - Mrs. Nosova. Prof Buldakov, who has a minerals background, mentioned we were the first geologists from Ireland that he had met. Mrs. Nosova said that most previous contracts with Ireland had been in linguistics.

There was a one hour press conference on the last day at the palatial city hall in the presence of press, radio and television. There is a serious problem about the quality of the local water supply which in part explains the high profile our visit received. In the circumstances most of the questions were directed towards our Russian hosts. One of the first was why Ireland? Prof. Voronov replied that there were considerable similarities in climate and geology between Ireland and northwest Russia. He followed on by stressing that Irish hydrogeologists were held in very high regard internationally. We were told that our visit was reported on Russian TV and were sent one of the subsequent newspaper articles.

As a result of the visit a number of follow up proposals are being considered:

- Five young Russian hydrogeologists to have their membership sponsored by Irish Group of IAH.
- Eight Russian hydrogeologists to be invited to make a return visit to Ireland for one week.
- Two young Russian hydrogeologists to come to Ireland for up to 3 months work experience.
- Irish hydrogeologists to lecture at St. Petersburg University.
- Possibility of setting up joint ventures in applied areas of hydrogeology.
- Irish assistance with setting up English language courses in hydrogeology at St. Petersburg University.
- Input to English-Russian hydrogeological dictionary.

A subcommittee of the Irish IAH has been set up to deal with these issues. Any suggestions or queries are welcome.

Bob Aldwell, Geological Survey of Ireland

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Fieldtrip to Gort-Kinvara Area

A local businessman in Gort was quoted in the newspaper during the winter 1994/1995 floods with "All I can say is that the Gort River should be drained."

The recent annual IAH fieldtrip showed that the Gort-Kinvara karst system is very complex and possible solutions to the flooding problem are likely to require creative and intuitive thinking. The timing of the visit was perfect with all hydrological features in a state of flux after the summer dry conditions. Even the weather was excellent for the weekend.

The study, being led by Southern Water Global and Jennings O'Donovan & Partners, is currently halfway through. Denis Peach of Southern Water Global initiated the weekend with a briefing on the work to date before the party visited some of the important hydrological features of the area.

The broad experience of all those on the fieldtrip; Karst-, Hydro-, Hard-Rock- and Quarternary Geologists, provoked some interesting discussions at each site and I'm sure some new thoughts for the project.

Saturday morning was spent visiting the catchment system upstream from Coole Lough from where it drains off the Slieve Aughty Mountains onto the limestone and down

through the karstic system as far as Ballylee. In the afternoon the system was continued downstream and the importance of Garrylands and Coole Lough as a collection point in the system was identified. The day ended perfectly at Kinvara close to low tide where the impressive resurgent springs discharge into Galway Bay.

After an enjoyable dinner and a late night for some, Sunday was spent observing the impact and style of the southern catchment on the system. This commenced at Lough Bunny, close to the watershed with the Fergus Catchment, and reasons were given here for the existence of the lake and the importance of the glacial clays at rockhead. The course of the stream flowing from Lough Bunny was followed northward past the dry stream bed at Skaerdean up to the marsh and bog area south of Hawkhill. Here it was indicated that improved drainage of the marsh area may have increased the flood impact in the Coole Lough area. The field trip finished with a view of the epikarst in the west of the area.

The weekend gave hydrogeologists the opportunity to meet in an informal environment and learn a little about an interesting and unique groundwater system. The whole area is incredibly beautiful and many of the features must be of major conservation value. It must have been felt by most there that the system should not be destroyed by large-scale human impact on the natural drainage system.

The members of the IAH would like to thank Denis Peach, Sally Watson & Clive Gardner from Southern Water Global and David Ball, Paul Johnston & Conor MacDermot for leading us through their work in the area in addition to Cecil Shine of Minerex Environmental for organising the event.

Richard Church, Minerex Environmental Ltd.

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1997 IAH Portlaoise Seminar

The annual IAH (Irish Group) seminar will be held in the Killeshin Hotel, Portlaoise on Tuesday and Wednesday 22nd and 23rd April 1997. The theme of the seminar is "**Soil and Groundwater Contamination and Remediation".** Speakers will include Ted Nealon, Paul Johnston, Teri Hayes, Jer Keohane, Andrew Moag, Donal O'Suilleabhain, Marcus Forde, Richard Church, Shane Bennet and Geoff Wright

Further details will be circulated in early 1997 and are available from Donal Daly, IAH Seminar Secretary, c/o Geological Survey of Ireland

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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 each year.

Your contribution to the dialogue would be welcome. **Contributions should arrive before 1st February 1997** to:

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The GSI Groundwater Newsletter,
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