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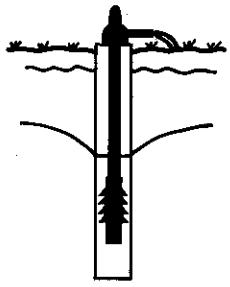
THE GSI GROUNDWATER NEWSLETTER



NUACHTÁN SCREAMHUISCE SGÉ

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GROUNDWATER EXPLORATION AND DEVELOPMENT

Groundwater for Development in Eritrea.

Earlier this year the aid agency War on Want asked me to visit the war-torn and famine-stricken country of Eritrea in northeast Africa. Accompanied by a British irrigation engineer and an Eritrean hydrogeologist, I spent three weeks monitoring water development projects carried out by the Eritrean Relief Association, aided by an international consortium of agencies, including Trocaire.

Until recently, water development in this arid region mainly comprised shallow well-digging and building small dams and cisterns. The wells, up to 20m deep and sometimes over 5m across, are mainly in dry river beds, and painstakingly excavated in weathered metamorphic rocks. They provide water both for drinking and for irrigating vegetable plots. Older wells are stone-lined, but the more recent are lined with Armco galvanised steel rings, 1.5m across, supplied by the consortium.

We also saw larger spate irrigation schemes, which divert flash flows from the rivers into bunded basins where the staple grain crop, Durrah, is grown.

Two drilling rigs recently provided by the consortium have now transformed the water programme. A lightweight Dando Gofer 110 is used, along with resistivity surveys, to investigate sites for dug wells, and an Ingersoll-Rand T4W to drill larger, deeper wells by DTH or rotary methods. The speed and power of the T4W is especially valuable in the Eritrean war situation. To avoid aerial attacks, drilling can only take place at night, the rig being hidden away in daylight. Within a few weeks of delivery the rig was already successfully exploiting water deep in the fractured metamorphic rocks. The Eritrean crew is supervised by a very experienced Eritrean drilling manager.

During our stay we saw many hopeful signs of recovery from the terrible famine of 1984-85, not only water schemes but also schools, health care and agricultural development - terracing, irrigation, and crop trials. Most impressive of all were the new roads which, in spite of the mountainous terrain, enabled the trucks to bring in the food aid which alleviated the worst of the famine.

The Eritreans are remarkable people, striving in very difficult circumstances to rebuild their country. It was a privilege to visit them and, in a small way, to help out.

Geoff Wright, Geological Survey.

North Monaghan Limestone Aquifer

A recent trial well drilling programme in North Monaghan has confirmed the presence of a major aquifer, as previously indicated by the joint An Foras Forbartha/Geological Survey Report and by a local group scheme well.

Monaghan UDC commissioned the trial well drilling and testing programme to establish whether the north Monaghan aquifer could be developed to supply Monaghan Town's immediate and long term fresh water requirements.

The hydrogeological investigation consisted of 3 trial wells located in the foothills of the Brogan Mountains at elevations of 150-180 m. The drilling sites were chosen on geological consideration only as the thick overburden (40m+) and drumlin topography precluded the use of geophysical surveys.

The first two wells at Knockatallan encountered some 40-50m of boulder clay overlying a black micritic limestone and were completed to depths of 61 m and 91m. Both wells encountered significant groundwater inflows and subsequent pumping tests gave yields of 1,200 and 1,960 m3/day with specific capacities of 65 and 280 m3/d/m respectively. The 3rd well, 4 km to the east near Tydavnet,encountered 50m of boulder clay overlying an interbedded succession of light coloured limestones and sandstones to a depth of 114m. This well gave a relatively disappointing yield of 491 m3/day with a specific capacity of 12.5 m3/d/m.

The north Monaghan groundwater is of excellent bacteriological quality and is characterised by a hardness level in the range of 172 - 264 mg/l $CaCO_3$. Monaghan U.D.C. are reviewing the results of the groundwater exploration

programme in terms of the projected water demands for the town and its environs.

Fergus Coyle, Monaghan County Council and Kevin Cullen, Consulting Hydrogeologist.

The Testing of Large Diameter Hand-Dug Wells.

Hand-dug, shallow wells of large diameter are rarely constructed now in Ireland although many old hand-pumped public wells still exist on roadsides throughout the country. However, many developing countries, particularly in Africa, are still building this type of well for village water supply and only in recent years has any attempt been made to devise a satisfactory method for pump-testing such wells. A reliable pumping test is required both for evaluating local hydrogeological conditions (e.g. determining hydraulic conductivity) and for assessing the performance of existing wells (i.e. the need for rehabilitation).

A typical village well is approximately 1.5m in diameter and less than 15m deep, usually penetrating less than 2m below the prevailing water table. Such wells contain significant storage, a characteristic which violates one of the principal assumptions of conventional pumping test analysis. For this reason, the Department of Engineering Hydrology at University College, Galway, as part of its involvement with water resources problems in developing countries, has been developing a theory and a practical pumping test for flow to hand-dug wells. The test is based on a numerical model which simulates the flow to a large diameter well and which runs on a standard microcomputer. The method involves a short period of pumping, using a petrol-driven suction pump or a submersible pump, followed by a recovery. Water levels are monitored during both phases and the data is typed into a microcomputer as input to the programmed model which is then used to indicate any need for rehabilitation of the well and/or to determine the hydraulic conductivity of the aquifer. In cooperation with Cork County Council, the method has been tested successfully in the investigation of some roadside wells in East Cork. The development of the technique is currently aimed at making the computer program as "user-friendly" as possible so that it can be used in routine fashion by engineers in the field.

Paul Johnston, Dept. of Engineering Hydrology, U.C.G.

Groundwater Resource Assessment in Lesotho.

A contract for the design of improved water supply schemes for four major towns in the Kingdom of Lesotho was awarded to Nicholas O'Dwyer and Partners (International). All water sources were to be investigated and Minerex were engaged to assess, and give recommendations on, the potential for groundwater development.

Rainfall is seasonal and river flows in winter are maintained only by groundwater discharge. Earlier studies of baseflow showed however that groundwater recharge is slight and maximum estimates of infiltration were only 30mm per year.

The geology of the country is simple, comprising a succession of horizontally bedded sedimentary formations (mudstones, siltstones and sandstones) overlain by large thicknesses of basalts. The latter crop-out over most of the land area, with the sedimentary formations outcropping only in the western lowlands. Alluvial deposits are limited in extent. The most important feature from a hydrogeological viewpoint are numerous dykes and sills that are intruded into all solid formations. These intrusives, and associated metamorphosed country rocks, are extensively fractured and, with river alluvium, are the only recognised aquifers worth developing.

Photogeology, magnetic surveying and resistivity traverse and sounding techniques have been used successfully to locate dykes and many boreholes have been drilled with varying success. Borehole depths do not exceed 100 metres and well screen and casing are unnecessary. Yields of 1 to 3 l/s are typical but a proportion of boreholes are dry in all rocks.

The intersections of dykes and surface watercourses were recommended as drilling sites, mostly on the upstream side of dykes where the fractured rocks might be recharged from superficial deposits throughout the year. Drilling sites were recommended adjacent to dykes close to the four project towns, and the investigation of alluvial deposits was recommended at some locations on the larger rivers to determine sub-surface flow. Methods of abstracting such flows were also proposed.

Stephen Peel, Minerex Limited.

Groundwater Development in North Louth

Following the successful completion of the initial phase of the Cooley Regional Water Supply Scheme, Louth County Council requested N. O'Dwyer & Partners, Consulting Engineers, to locate an additional groundwater source to supply the proposed western extension to the scheme. Six trial wells were drilled during the groundwater exploration programme in three separate areas, with the individual drilling sites chosen on a combination of geological, geophysical and physical considerations.

The existing groundwater source of Cooley is at Ardtully Beg and abstracts from a glacial outwash aquifer in the eastern part of the peninsula. These deposits were further investigated to the west at the Bush and Loughanmore. The glacial sediments at the Bush were found to be much less permeable than at Ardtully Beg while the Loughanmore site was found to be underlain by 24m of permeable sand and gravel. The trial well at Loughanmore gave a yield of 1036 m3/day with a specific capacity of 262 m3/d/m.

The second area investigated lies 3 km to the north of Dundalk at New Inn. This area is underlain by Lower Palaeozoic sandstones and the two trial wells completed here were drilled to a depth of 37m and encountered a sequence of very broken green sandstones or grits. A pumping test carried out on one of the trial wells at New Inn recorded a yield of 1091 m3/day with a specific capacity of 1267 m3/day/m.

The third area investigated was at Ballygoly in the valley of the Big River. The trial well completed here encountered a succession of igneous rocks and had a disappointing yield of 200 m3/day.

The identification of two major groundwater sources in the area has major implications for the design of the water scheme and N. O'Dwyer & Partners are reviewing the distribution network in light of the trial well drilling results.

Pat Hallahan, Nicholas O'Dwyer & Partners and Kevin Cullen, Consulting Hydrogeologist.

Development of a Marginal Aquifer at Ballydesmond, Co. Cork.

With increasing demand for water and the escalating cost of treating surface water, the development of marginal aquifers is becoming more important. Marginal aquifers can be classified as aquifers with low permeability or with water quality problems. While there are many examples of development of such aquifers overseas, a notable development of a marginal aquifer has recently been carried out for the village of Ballydesmond by Cork County Council.

The water source for Ballydesmond was for many years the River Blackwater. This source required treatment by coagulation with alum and pressure filter. The quality of the river water was a major problem as the colour and suspended solids varied considerably. This treatment plant required continuous monitoring and even then it was almost impossible to maintain a good quality water.

An investigation of the potential of developing a groundwater source to replace the existing river source was carried out in 1983. It was decided that the existing and future demands would be met by a source yielding 50,000 gpd. The investigations of the Upper Carboniferous Namurian Sandstone and Shale Aquifer indicated that it was capable of producing water in excess of the required quantity from a bored well of 60m depth However, excessive levels of iron and manganese were anticipated. A 200mm diameter well was drilled to a depth of 60m near the existing treatment plant. Pumping tests indicated that the well yielded 3,300 gph for 18m of drawdown. Chemical analyses of the aquifer water showed an iron level of 6.4 p.p.m. and 0.6 p.p.m. manganese. pH was 7.1. This water required treatment to bring the iron and manganese to acceptable levels.

In Stage 1 development to produce 30,000 gpd, the treatment plant was altered, the well water being dosed with chlorine and potassium permanganate and then passing through the original pressure chamber. The plant was installed by Mahon and McPhillips, Kilkenny. This treatment reduced the iron and manganese levels to within E.E.C. limits. The supervision of the plant was reduced to 1 hour per day for backwashing filters. Future development will extend the capacity to 50,000 gpd.

Brian Connor, Geoex Limited and Paul Walsh, Cork County Council.

Bunnadober Spring, Headford, Co. Galway

A salmon hatchery is being established at the above site using water from the large limestone spring that formerly fed a mill. It is essential that the water supply remain above a minimum quantity at all times and that it remain unpolluted (especially by iron and organic matter). A short investigation was undertaken in order to estimate probable low flows and to determine the approximate catchment area for the spring. Only one pollution source was located that was at all likely to affect the springs (proved by water tracing) but as this pollution source only became active under very high flows the dilution factor was sufficient to make the chances of significant pollution at the spring negligible.

David Drew, Department of Geography, T.C.D.

Septic Tanks and Groundwater: An Introduction.

Septic tank systems in the U.S. rank highest in the total volume of wastewater discharged directly into groundwater systems and are the most frequently reported source of groundwater contamination. One-third of all water borne disease outbreaks in the U.S. from 1971-76 were traced to the consumption of water from untreated groundwater sources. It has also been estimated that only 32% of the total land area in the U.S. has the geological and hydrogeological conditions which are required for the safe disposal of septic tank effluent.

Is the situation similar in Ireland ? There is increasing evidence to suggest that septic tanks are one of the main sources of groundwater pollution in Ireland. In Roscommon a survey by the local authority Environment Section showed that out of a total of 41 group schemes 22 (54%) contained E.coli. In another county examined by the Geological Survey, it was found that out of a total of 146 groundwater sources, 84 (58%) contained E.coli. Similar results were reported from Sligo by Richard Thorn in the last newsletter. The two principal sources of E.coli are septic tanks and farmyards. E.coli is an indicator of the possible presence of pathogenic microbes which can cause diarrhoea, gastroenteritis, hepatitis, dysentry and typhoid fever.

To highlight septic tanks as a source of groundwater pollution, this contribution is the first of a series I will be writing on different aspects of septic tank systems. I hope that they will not only increase awareness of septic tanks but will generate discussion and contributions. So if you disagree with my comments or have points to make, write in to the Newsletter.

Donal Daly, Geological Survey.

Septic Tanks : A Survey.

A survey by the School of Science, Sligo R.T.C., of the siting, design, operation and maintenance of 42 randomly selected septic tanks revealed some worrying facts. The most disturbing of these were:

(i) None of the tanks used a pipe distribution filter field, as recommended by the I.I.R.S. (1975)*, for the disposal of the tank supernatant.

(ii) 47% of the tanks, which were mainly between five and twenty years old, had never been desludged. This is in contrast to the I.I.R.S. recommendation that tanks be desludged once a year.

(iii) 50% of the tanks were situated in areas where the density was more than one tank per acre (0.4 ha). Numerous authors have shown that septic tank density is a major factor determining the extent to which groundwater becomes contaminated and health risks develop.

Other causes for concern revealed by the survey were: a high proportion of tanks giving odour problems; a high proportion located in areas susceptible to flooding; a significant number of tanks located near to groundwater sources and many tanks in areas where the water table or bedrock was close to ground level.

The findings of the survey have obvious implications for groundwater quality and health matters and point to an urgent need to tighten up the planning controls for septic tank siting, design and maintenance.

*I.I.R.S. (1975) Recommendation for septic tank drainage systems for single houses. I.I.R.S. SR. 6., 28pp.

Marie Doyle, Hubert Henry and Richard Thorn, Sligo R.T.C.

Disinfecting Small Water Supplies - Is UV Treatment the Answer ?

Many private and small group scheme groundwater supplies are polluted, as indicated by the presence of E.coli. Health Board analysts usually recommend that group scheme supplies should be chlorinated. The chlorination systems are installed but in my experience they are often not used after the first few months. The reasons for this are understandable :

(i) Group scheme organisers seldom realise the significance of the pollution - after all the water usually looks and tastes good.

(ii) Chlorination systems are fairly complicated to use.

(iii) Group schemes are run voluntarily.

Ultra-Violet (UV) sterilizers have a number of advantages :
(This information was supplied by Jer Keohane, Water Research Centre, U.K.).

(i) cheaper equipment;

(ii) no bother with chemicals;

(iii) equipment has no moving parts needing maintenance;

(iv) it is impossible to overdose;

(v) no effect on the taste.

However they have disadvantages relative to chlorine :

(i) it is harder to tell by inspection whether they are working correctly;

(ii) they do not have a residual downstream effect.

Because of their convenience and simplicity - all that is required is that the UV bulb should be changed regularly - I believe that they should be considered seriously for small group schemes and also for domestic supplies with occasional problems. However I cannot comment on their effectiveness and perhaps there are disadvantages I am not aware of. Can anyone help ? Are there any comments ?

Donal Daly, Geological Survey.

INFORMATION SOURCES

Groundwater Books and Journals in the G.S.I. Library.

In recent years the G.S.I. Library has steadily built up a collection of works on groundwater which are available for reference.

Among the journals, we have GROUNDWATER and GROUNDWATER MONITORING REVIEW, both from the National Water Well Association in America, and devoted entirely to groundwater. Other journals including papers on groundwater are the QUARTERLY JOURNAL of ENGINEERING GEOLOGY, the JOURNAL of HYDROLOGY and WATER RESOURCES RESEARCH. The journal of the British Drilling Association, GEODRILLING, often has interesting articles on well drilling, and is very readable.

We have a number of up-to-date basic textbooks on hydrogeology, including D.K. Todd's classic GROUNDWATER HYDROLOGY (2nd Edn. 1980) and H. Bouwer's useful paperback of the same name (original titles seem hard to find !) GROUNDWATER, by R.A. Freeze and J.A. Cherry (1979), C.W. Fetter's APPLIED HYDROGEOLOGY (1980) and the slightly older GROUNDWATER RESOURCE EVALUATION by W.C. Walton (1970) are other excellent books in this area.

Books specialising in groundwater chemistry, quality and pollution have proliferated recently, and our collection includes CHEMICAL HYDROGEOLOGY by W. Back and R.A. Freeze (1983), INORGANIC HYDROCHEMISTRY IN RELATION TO GROUNDWATER by J.W. Lloyd and J. Heathcote (1985), THE PROPERTIES OF GROUNDWATER by G. Matthess (1982), GROUNDWATER POLLUTION MICROBIOLOGY by G. Bitton and C.P. Gerba (1984), WASTE DISPOSAL EFFECTS ON GROUNDWATER CONTAMINATION (1984) from the U.S. National Research Council.

Books on well drilling and testing include WATER WELL TECHNOLOGY by M.D. Campbell and J.H. Lehr (1973) and the invaluable ANALYSIS AND EVALUATION OF PUMPING TEST DATA by G.P. Krusemann and N.A. De Ridder (1976).

At a simpler level we have INTRODUCTION TO GROUNDWATER HYDROLOGY by R.C. Heath and F.W. Trainer (1968), a useful self-instruction type of textbook, MANUAL OF APPLIED GEOLOGY FOR ENGINEERS (1976) from the Institution of Civil Engineers, INTRODUCING GROUNDWATER by M. Price (1985), and FINDING WATER (A GUIDE TO THE CONSTRUCTION AND MAINTENANCE OF PRIVATE WATER SUPPLIES) by R. Brassington (1983).

Finally, for those interested in Water Divining, the standard work on the subject is WATER WITCHING U.S.A. by E.Z. Vogt and Ray Hyman (2nd Edn 1979).

The G.S.I. Library is an information resource not only for Survey staff but also for the public, so come and make us of it. For further information, contact one of the Survey hydrogeologists or our library assistant, David Ivers.

Geoff Wright, Geological Survey.

NEWS FROM ABROAD

Britain - Environmental Protection Ministry Promised by Labour Party.

The Labour Party in Britain plan to create a new environmental ministry if it wins the next election. (Source: New Scientist 28th August 1986). The new ministry would have two enforcement agencies. One would be responsible for public health, monitoring pollution and ensuring purity of food. It would be known as the environmental protection service which would not only centralise environmental and monitoring responsibilities in one organisation but would also separate them from bodies who carry out potentially polluting activities (i.e. separate gamekeepers from poachers). Labour is promising tighter pollution controls and says it will bring farming and forestry under planning control for the first time.

Donal Daly, Geological Survey.

Denmark Tackles Groundwater Protection. (Notes on a visit to attend IAH Groundwater Protection Commission meeting).

Denmark takes 98% of its water supplies from groundwater. As a result the Danes are among the leaders in Europe in the study and protection of groundwater.

Due to the low topography of Denmark and the permeable nature of the bedrock and surficial deposits, groundwater quantity poses few problems for most purposes. Groundwater quality however is a major preoccupation. Denmark's famed meat and dairy products result from high yielding intensive farming. Among the environmental costs of this factory farming are increased levels of nitrogen in the water, derived from fertilisers and large quantities of hard to manage animal slurries. It is believed that up to 10% of Danes, all dependent on small local supplies, drink water with nitrogen above the EEC maximum allowable concentrations. This year draconian new measures have been introduced by the Government to counter groundwater pollution from agriculture. The main points are:

1. Regulation of all manure storage.
2. A farm must have storage facilities adequate to hold six months slurry.
3. No silage may be ensiled in a field without an adequate concrete base.
4. After the harvest, slurry can only be spread on fields with a growing crop.

5. Large farms must provide environmental harmony between animals and crops.

Industrial wastes are also being tackled. After major scares at Copenhagen and Aalborg a general investigation of all known tip heaps, used and disused, is underway. A 1982 national investigation of 3115 registered landfills showed 501 containing toxic chemicals with 1327 providing doubtful results. Two major clean-ups cost IR£1 million. There is increasing world-wide evidence that good design of waste disposal sites saves a lot of money.

Bob Aldwell, Geological Survey.

United States - Microchips and Groundwater Pollution.

The microchip industry, often regarded as a modern "clean" industry, is one of the dirtiest industries in the U.S. from a groundwater viewpoint. For instance in "Silicon Valley" in California the groundwater is extensively polluted by organic solvents - trichloroethylene (TCE), 1,1,1 - trichloroethane (TCA) and dichloroethylene. It is claimed that above-average levels of birth defects, miscarriages and heart problems among children have been caused by the pollution. Now a referendum is being organised in California for a proposal called the Safe Drinking Water and Toxic Enforcement Act which if passed would prohibit the discharge of toxic chemicals into drinking water supplies if they exceeded "safe levels" and would ensure that workers and consumers would have to be advised if they are exposed to unsafe levels of the chemicals at work or in food and other consumer products. The microchip companies are alarmed at this and are campaigning against the proposed Act.

(Source: New Scientist 25th September 1986). Donal Daly, Geological Survey.

I.A.H. NEWS

Field Excursion to South Munster, 4/5 October.

The excursion, led by Geoff Wright, visited several warm springs and three public groundwater supply schemes. Twelve people attended.

The first stop was at Mallow where an ambitious project is being undertaken by Cork County Council with the aid of an E.C. grant, to use warm water and heat

pumps to heat a swimming pool and a school. Two boreholes have been drilled recently by Dunnes Wellboring (Mallow) with yields of 15,000 gph and over 20,000 gph and with temperatures of 19.5°C and 13°C respectively. Further details on the scheme can be obtained from Peter Brück, David Burdon or Bob Aldwell. The initiative of the local authority engineers - Michael O'Brien and Paul Walsh - was appreciated by the group.

Several warm springs in north Cork, east Kerry and south Limerick, with temperatures varying from 13°C to 20°C, were visited. The geology and geochemistry of these springs are described by Brück et al. (1986) in IR. J. Earth. Sci. Vol 7, pp169-194.

The first day ended at the Rathluirc water supply scheme which consists of 3 boreholes in the Old Red Sandstone with a "safe yield" of about 2 mgd. The computer control system and the general layout and upkeep of the scheme set a good example for other groundwater developments.

On Sunday, the Cloyne-Aghada groundwater scheme was visited. This consists of 5 production boreholes in "reef" limestone with a "design-yield" of about 1.5 mgd, although a larger quantity is available.

The excursion ended at the Dower spring, Castlemartyr, which is one of the largest limestone springs in the region with a minimum flow of 1.5 mgd and a current abstraction rate of 1.1 mgd.

Donal Daly, Geological Survey.

REVIEW

Paper: Pumping Tests. A guide to the testing of water wells for public, industrial and farm supplies.

Author: Geoff Wright

Journal: Information Circular 85/2, Geological Survey of Ireland
26 pages; IR£2.00 per copy.

In his publication on pumping tests Mr. Wright has provided a clear and practical guide enabling anyone even remotely interested in developing a groundwater source to execute a satisfactory pumping test; a feat that regularly eludes most of us who are daily engaged in groundwater development. The advice given in the G.S.I. circular has been obviously collated from the many personal experiences of Mr. Wright and his colleagues and the purchase price of £2.00 will be recouped many times over in time saved by following closely the recommended procedures.

The circular stresses the need for careful planning of all aspects of a pumping test and recommends that any testing programme should consist of three separate phases; a preliminary test of short duration to be followed by a step test and a constant yield test. By carefully measuring the pumping rate, the water level in the well and the time during each of the separate phases it is possible to answer most queries regarding the capacity and character of a water well. The circular describes in detail the various methods for measuring these parameters and provides a useful form for recording the data and outlines how the data can be graphed and analysed.

I can only agree with Mr. Wright when he highlights the need to ensure that the pump chosen for the pumping test is either capable of testing the well to its maximum capacity or at least is capable of delivering 2 or 3 times the intended permanent pumping rate. Failure to use the correct test pump will leave gaps in the understanding of the relationship between output and drawdown which is so important in the fissure flow aquifers that predominate in Ireland.

Kevin T. Cullen, Consulting Hydrogeologist.

CONTRIBUTIONS FOR NEXT ISSUE OF THE NEWSLETTER

The **GSI Groundwater Newsletter** aims to improve communication among the many scientists and engineers involved with groundwater. It will include news, developments, reviews and opinions on all aspects of groundwater-exploration, development, management, water quality and pollution. It will be published at three-monthly intervals.

Your contribution to the dialogue would be welcome. It should reach the Geological Survey before 1st January, 1987. All items should be as short (maximum 300 words, but preferably less than 200 words), interesting and newsworthy as possible.