

MANAGEMENT AND PROTECTION OF QUALITY OF GROUNDWATER RESOURCES IN THE ENGLISH MIDLANDS

K.H. SELBY and A.C. SKINNER

Severn-Trent Water Authority, Birmingham (U.K.)

ABSTRACT

The aquifers of the Severn-Trent region of the U.K. are important sources of public water supply. They are threatened by a variety of local and diffuse quality problems and significant contamination of these aquifers has occurred in some locations. This paper outlines some of these problems and describes the groundwater quality management and resource protection strategy adopted for the Severn-Trent area.

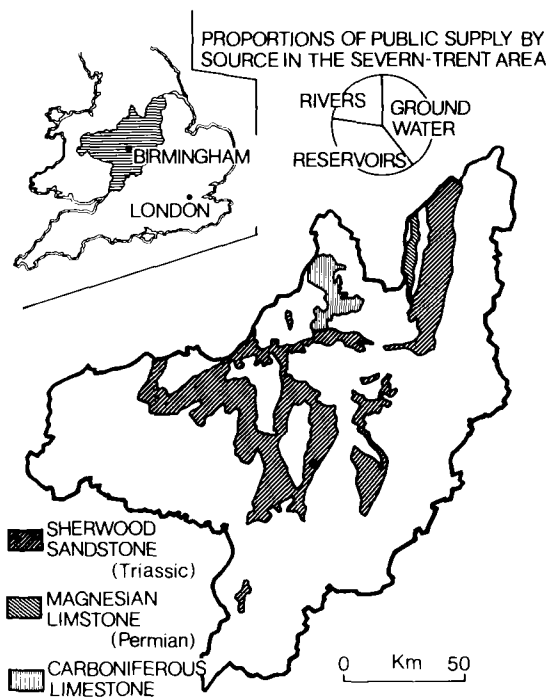


Fig.1. The Severn-Trent Water Authority area, showing major aquifers and proportions of public water supply by source.

INTRODUCTION

In England and Wales water authorities are responsible for the management and operation of the whole water cycle. The Severn-Trent Water Authority is one of ten such authorities, responsible for much of the Midlands (Fig.1). The Authority's area covers over 20,000 km² and it serves a population of more than 8 million people. About 40% of all public water supplies in the region come from groundwater. The importance of groundwater in the water supply system requires that there is an integrated approach to the development and management of groundwater resources and its protection from increasingly diverse threats to water quality. This approach is facilitated by the multifunctional catchment-based structure of the industry in the United Kingdom. The principal aquifer of the area is the Sherwood Sandstone formation (Triassic), a fluviially deposited sequence of sandstones with subsidiary conglomerates and mudstones. Other aquifers of importance are the Magnesian (Permian) Limestone and the Carboniferous Limestone. The total volume of groundwater abstracted for public supply in 1980 was 340Mm³/a and this is expected to rise by 25% to 425Mm³/a by the year 2000. The continued protection of the quality of this element of the water supply system is essential.

THREATS TO GROUNDWATER QUALITY

Natural Contamination

The area has no significant coastline and problems of migration of sea-water have not arisen. In a number of areas connate waters, usually associated with mudstones of Carboniferous, Permian or Triassic age, are in natural stratigraphic or faulted contact with the major aquifers, where the continued high quality of water might be placed at risk by indiscriminate pumping.

Pollution by human activity

Domestic Refuse Disposal. It is normal practice in the U.K. to dispose of domestic refuse and similar types of commercial waste to landfill sites. Incineration has proved as much as four times as expensive, and existing incineration plants are being closed with consequent greater pressure for landfill. Many suitable landfill sites are on aquifers, where mineral and aggregate quarrying has taken place, and thus pose a pollution threat.

Coal Mining. A substantial part of the Triassic aquifer overlies important coal fields. Coal waste with a high soluble mineral content is often tipped onto exposed aquifer. The run-off from these tips, together with highly mineralised mine drainage water, is discharged to surface streams. Many of these streams are influent to the aquifer due to the high level of groundwater abstraction, with the result that there has been both direct and indirect contamination of groundwater by colliery activities, and potable sources have been lost.

Coal Carbonisation. Policies to reduce atmospheric pollution have led to the establishment of low temperature carbonisation plants at some collieries to produce smokeless fuel. These plants often have tar distillation and chemical manufacturing facilities associated with them. The waste liquors have a high organic content and can give rise to organoleptic problems in water supplies at very low concentrations. One public supply has recently been abandoned because of taste problems stemming from phenolic effluent disposed of over 20 years previously.

Sewage and Sewage Sludge disposal. The water authorities are directly responsible for the treatment and disposal of domestic sewage. Normally treated sewage effluent is discharged to surface waters. However the practice of direct land disposal has not been completely phased out and problems of high nitrate groundwaters requiring blending still remain from previous more widespread activity of this nature. Sludge residues from conventional sewage treatment processes are normally disposed of to agricultural land. Agricultural utilisation of sewage sludge is an acceptable means of disposal without environmental risk provided that the rate of application is controlled, the treatment eliminates pathogens and the sludge is free from potentially toxic materials.

Agricultural activity. The most serious problem associated with agriculture is the increased use of nitrogenous fertilisers. A continuing steady increase in nitrate in groundwater has been observed over the last fifteen years and, on the basis of recent increases in amounts of fertiliser applied, this is expected to give rise to further water supply problems.

Industrial discharges direct to underground strata. In the past substantial volumes of industrial effluent including toxic chemicals, have been discharged directly into water-filled disused coal workings mainly in the West Midlands, resulting in local contamination of private groundwater supplies (ref. 1).

Oil Pollution. Leakages from oil storage tanks and associated pipework continue to cause oil pollution of groundwaters, and constitute a major proportion of all accidental groundwater pollution incidents. Major overland petroleum pipelines which cross the important aquifers constitute the greatest risk.

MANAGEMENT STRATEGY

The control policies and procedures adopted by water authorities are dependent upon the legislative and other control measures available. These include the legal controls which are directly enforceable by the Authority and powers enforced through the agency of the one hundred or so local public authorities in the area.

Legislative powers enforced directly by Water Authorities

Discharges of trade or sewage effluent or other polluting substances made into the underground strata are controlled by the issue and enforcement of consents by the Water Authority. The powers available have deficiencies; for example some saline minewater discharges and the surface disposal of certain sludges and effluents are not controllable under existing legislation. A significant feature of the U.K. legislative system is that there is no provision at present for the creation of water supply protection zones on the pattern commonly employed elsewhere in Europe.

Legislative powers enforced through the agency of Local Public Authorities

The majority of construction and development projects require permission under planning laws from the local public authority. Many of these activities include an element of risk to groundwater quality and a consultation procedure exists so that the local authority may be advised of this and on the measures necessary to minimise the problem. There is no statutory obligation for the water authorities' requirements to be accepted.

The position is different in respect to the disposal of wastes onto land. Waste disposal activities are regulated by a licence issued by the local public authorities but Water Authorities have powers to prevent their issue or may require the imposition of conditions designed to protect water interests.

POLICY

The absence of statutory protection zones has not proved to be a disadvantage and the legal and administrative control procedures described have a valuable degree of flexibility introduced by the necessary site by site consultation process. However statutory water protection zones do have the advantage that the priority areas for protection from pollution are clearly defined and that all other parties including public authorities are aware of the general constraints imposed and can take them into account in their own plans. It is not unreasonable that general guidelines should be established so that the water pollution hazard can be included in any multi-objective planning study. In order to meet this need and to preserve a uniformity of standards across a large and varied administrative area, the Severn-Trent Water Authority and some other U.K. Water Authorities have issued aquifer protection policies and supporting groundwater protection maps. These policies, although in some respects similar to groundwater protection zones, have no legal force and are not designed to effect prohibition. In Severn-Trent the basic approach has been to identify resource vulnerability in hydrogeological terms, to classify activities considered to present a risk to quality and to give an indication of the Authority's likely response (ref. 2).

GROUNDWATER QUALITY MANAGEMENT PROCEDURES

In order to deal with the wide range of problems which arise an integrated approach to groundwater quality management is necessary, the elements of which are summarised.

Monitoring

In formulating management procedures for pollution control, provision must be made for monitoring quality on a regular basis in order to (i) detect departures from natural background conditions; (ii) to provide a control against which possible cases of pollution may be revealed and compared and (iii) to enable proper exploitation of resources. Samples from a network of nearly 400 monitoring points are analysed on a regular basis. Water levels and other resource management data, for example flow data to identify influent rivers, are also recorded. This is a broad scale monitoring programme and is supplemented by more localised intensive investigations, which are often necessary when individual proposals are assessed. Analysis covers a full suite of mineral ions with less regular determination of metals and screening for organics by both conventional techniques and occasionally by gas chromatography/mass spectrometry.

Operational Procedures

Since the Authority's statutory functions include direct operational responsibility for the disposal of sewage effluent and sewage and water treatment plant sludges, this provides the opportunity to include measures to safeguard water quality in the Authority's operational procedures. These operational procedures provide an in-house pollution control system and is in considerable contrast to the control which Water Authorities are able to exercise over similar activities in agriculture.

Consultation procedures

Reference has already been made to the extensive inter-authority consultation made necessary by the legal framework. These consultations often take place initially on an informal basis and may be directed towards the resolution of areas of conflict, for example in the design of measures for leachate control at waste disposal sites. Parallel consultation procedures are necessary within the water authority to ensure that agreements reached are acceptable in terms of all the authority functions.

Investigation and research

Special field investigations also form part of the management process. There is often a need to obtain supplementary information in advance of granting licences for land disposal of waste. Studies of this sort are normally carried out by the applicant for the licence, although he frequently consults the water authority on its specification. Where more general issues arise the authority will take a more direct role in jointly funded studies, with the objective of establishing reference

information for use in similar relevant examples in the future. In situations, such as nitrate and coal waste pollution, because of the lack of legislative controls, the Water Authority has carried out the necessary studies itself, so that it can be reliably informed about pollution mechanisms and likely future trends (ref. 3).

RESOURCE MANAGEMENT OPTIONS

Although the number of pollution threats has increased in recent years and increasing demand for water has led to more extensive use of groundwater, these trends have been matched by the development of the legislative and management procedures described above with the result that the essential and reliable role of groundwater in public supply will remain secure provided that water authorities continue to exercise vigilance. Many of the existing pollution problems are localised, and although in some cases they have sterilised an aquifer for private use, the quality of supply to the consumer is protected, at extra cost, by development of new sources and by blending of supplies. The knowledge available from landfill research and recent and forthcoming legislation controlling waste and coal mining discharges should ensure that future developments of this type can be carried out with reduced threats to water quality. The most significant problem for the future is expected to be that of continuing nitrate pollution. Much of the aquifer area is agricultural and the diffuse pollution load will continue to affect many supply sources. The authors expect that any increase in nitrate levels will not reduce the contribution of groundwater to future public water supplies for the following reasons:-

- i) the process of nitrate build up will be slow giving time for the water authority to make changes in the supply system in anticipation of the developing problem. Modelling studies are helping to define the time scale.
- ii) in some areas significant parts of the aquifer are confined and at reduced risk from surface derived pollution. In future a greater proportion of the water could be abstracted from the confined aquifer, though at increased capital cost. This would enable the considerable available storage to be used to further delay the impact of high nitrates in supply.
- iii) the policy of increasing linking of groundwater and surface water systems in public supply will allow further opportunities for blending. This might be done either by conventional mixing in the distribution system or by using groundwater in river flow augmentation schemes (ref. 4).

REFERENCES

- 1 L.H. Dowse and K.H. Selby, Wat. Pollut. Control. 74(1975)526-543.
- 2 K.H. Selby and A.C. Skinner, Wat. Pollut. Control, 78(1979)254-269.
- 3 J.L. Lucas and G.M. Reeves, in Proc. Int. Assoc. Wat. Pollut. Res. Conference, Brighton, November 3-7, 1980.
- 4 A.C. Skinner, in Memoires, Volume XIII Int. Assoc. Hydrogeologists, Birmingham, July 24-30, 1977.