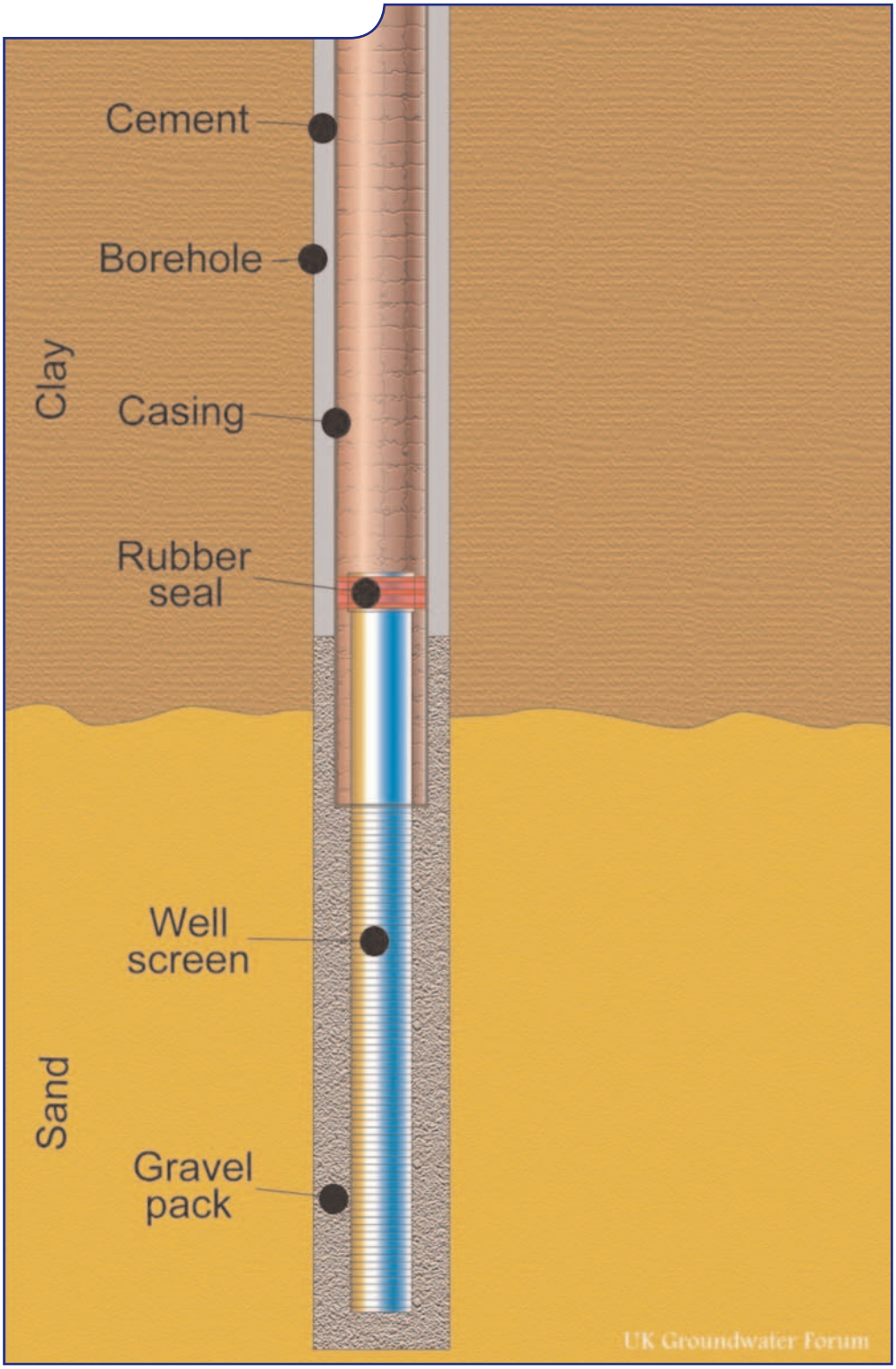
SEPA
Scottish Environment Protection Agency

Decommissioning Redundant Boreholes and Wells



Decommissioning Redundant Boreholes and Wells to Protect Groundwater Resources

1. Scope

This booklet is intended to assist with the decommissioning of redundant boreholes or wells to protect groundwater. It suggests a number of best practice options. Other factors, for example ground and site conditions or health and safety issues, must be carefully considered before any final decisions are made and expert, site-specific advice should always be sought. Boreholes near landfills or other sources of soil gas may also require venting to prevent the build-up of noxious or explosive gas.

2. Legal Framework

The Scottish Environment Protection Agency (SEPA) has a duty under the Water Environment and Water Services (Scotland) Act 2003 to promote the efficient use of water. SEPA also aims to ensure that there is a progressive reduction of groundwater pollution and that further pollution of groundwater is prevented.

SEPA is responsible for the protection of 'controlled waters' from pollution under the Control of Pollution Act, 1974 (as amended). Similar controls are in place in England and Wales. It is an offence to cause pollution of controlled waters either deliberately or accidentally.

'Controlled waters' includes all watercourses and groundwater contained in underground strata (or aquifers).

SEPA also has a specific duty to prevent groundwater pollution by certain listed substances under the Groundwater Regulations, 1998. These regulations complete the transposition of the EC Groundwater Directive (80/68/EEC) into UK law. Discharge into groundwater of substances in List I of the Directive is prohibited, and discharges of substances in List II must be minimised to prevent pollution.

3. Introduction

Boreholes and wells are constructed for a variety of purposes: to abstract water; to collect geological information; to investigate and sample soils and groundwater etc. Often, old wells are found on properties that are now connected to a mains water supply, and, therefore, boreholes and wells may become redundant.

Improperly abandoned boreholes and wells may act as preferential pathways for groundwater or contaminant movement. This may result in the contamination of groundwater, the mixing of groundwaters of variable quality from different aquifers or contribute to the loss of aquifer yield and water pressure (potentiometric head) as groundwater flows out of the system. They may also present a physical hazard.

Artesian boreholes are those where groundwater in a confined aquifer is at sufficient pressure to cause water to discharge either at the ground surface or into another overlying aquifer without any pumping. These present different problems and require special attention to prevent wastage of groundwater resources either by the flow of water from one aquifer unit into another poor quality unit, or mixing of clean and polluted groundwaters.

Boreholes and wells that are no longer required need to be made safe and structurally stable. They should also be backfilled or sealed to prevent groundwater pollution and flow of water between different aquifer units. However, in certain circumstances they may be adapted for use as a groundwater monitoring facility. Wells and boreholes should not be used as soakaways for foul and contaminated surface water drainage because this constitutes a direct discharge into groundwater and, as such, poses a high risk of groundwater pollution. Such discharges must be authorised and are allowed in only very limited circumstances.

4. Borehole or well construction

When considering how best to backfill and seal a borehole or well, or whether it can be put to an alternative use, for example as a groundwater monitoring facility, it is necessary to obtain information on the geological strata encountered by the borehole and its completion details. These will include the depth of the borehole, its diameter(s) and construction details (casing, screen and pack). These details may be obtained from site records, the original driller's log(s), or the British Geological Survey. Once all available information has been collated and assessed, the most appropriate course of action can be determined.

5. Conversion to groundwater monitoring points

Redundant boreholes have the potential for conversion into groundwater monitoring boreholes if the data collection exercise described in Section 4 (above) indicates that the boreholes intersect appropriate aquifer units (in terms of resource and quality), and are constructed so that representative groundwater samples may be collected or water levels measured.

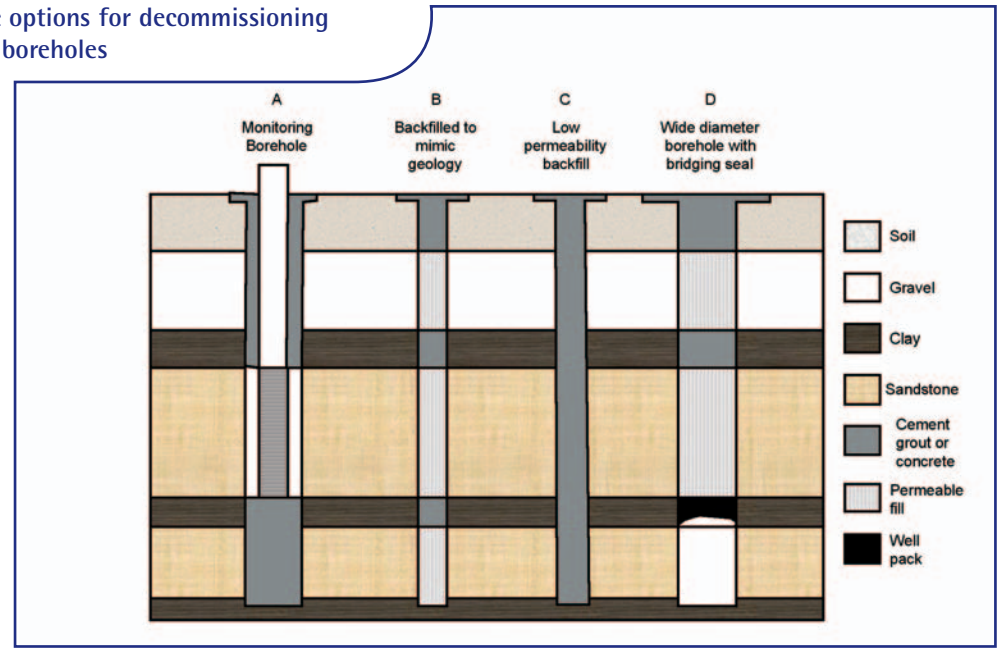
There are many good reasons for collecting groundwater samples or measuring groundwater levels. This information can, for example, validate the success of any remedial works being undertaken on the site or can contribute to comprehensive overview of groundwater in Scotland required by Water Environment and Water Services (Scotland) Act 2003.

Before decommissioning a borehole you should consider whether you wish to retain an interest in the borehole as a private monitoring facility. If not, contact SEPA to see if it is in a location where monitoring facilities are needed. If you wish to retain the borehole as a monitoring facility or if SEPA consider it to be in a location where a monitoring facility is required then an assessment as to whether the borehole can be modified to a groundwater monitoring facility should be carried out.

If the borehole is not to be converted to a monitoring facility then the borehole should be abandoned using the guidelines in Section 6. The British Geological Survey should be informed of this action.

The ideal borehole construction and completion is dictated by its intended use and the geological strata encountered. Boreholes that intersect a single aquifer unit may be cased through the unsaturated zone, but open hole (or screened) below the watertable. Boreholes in complex geologies are likely to require casing over most of the depth of borehole with the exception of the aquifer unit(s) of interest (see Fig. 1(A)) These details must be established when considering conversion of the borehole to a monitoring point along with the ultimate purpose that the monitoring facility will serve.

Figure 1 Schematic options for decommissioning wells and boreholes



6. Decommissioning redundant boreholes and wells

If conversion to a groundwater monitoring point is not possible or necessary, the following borehole abandonment procedures are recommended. However, every borehole and well is different and may require variation in the detail of the approach. For the best results, the employment of a proficient well contractor with a good knowledge of the local geology and well abandonment procedures is recommended.

a) Defining the objectives

Each site has its own particular characteristics that must be considered when planning how to decommission a borehole or well.

The following objectives may apply, although additional objectives may also be applicable.

- Remove the hazard of an open hole (safety issues);
- Prevent the borehole acting as a conduit for contamination to enter groundwater;
- Prevent the mixing of contaminated and uncontaminated groundwater from different aquifers;
- Prevent the flow of groundwater from one geological horizon to another;
- Prevent the wastage of groundwater from overflow from artesian boreholes.

The method of decommissioning should be capable of achieving each of the objectives that are applicable to a site.

b) Removing headworks and casing

Ensure that the borehole or well is free from all obstructions that may interfere with the sealing of the hole. In particular, the pump and pipework should be removed together with any other infrastructure (dip tubes etc.). The condition of any borehole casing and grout must be examined to ascertain whether its retention in the hole would prejudice any of the objectives of the abandonment. For many holes, examination of the casing from the ground surface will be adequate, however, deep boreholes may require the use of a down-hole Closed Circuit Television (CCTV) to examine the casing at depth. Where casing has corroded or broken, or the grouting has failed, it may be necessary to remove those materials in order to prevent flow of groundwater around the outside of the borehole. Care should be taken, however, to ensure that removal of the well casing does not result in the collapse of the borehole walls (particularly in unconsolidated materials) and possible subsidence at the ground surface. The advice of a specialist well contractor should be sought over these issues. If it is decided that the well casing needs to be removed, various techniques are available to do this and the well contractor can advise on the most appropriate technique for a given site.

c) Backfilling the hole

i) General information

For most purposes the ground should be restored as closely as possible to its pre-drilled condition. The borehole or well should be backfilled with clean (washed), uncontaminated, excavated materials such that the permeability of the selected materials are similar to the properties of the geological strata against which they are placed. The backfilled borehole will then mimic the surrounding natural strata and groundwater flow and quality will be protected.

Restoration will require a variety of materials to be used so that permeable aggregates (e.g. pea gravel, sand) are positioned adjacent to aquifer horizons, whilst low permeability materials (e.g. clay, bentonite or cement grout, concrete) are positioned adjacent to low permeability horizons (see Fig. 1(B)). Alternatively, the entire borehole or well can be backfilled with low permeability materials that will prevent significant vertical or horizontal movement of groundwater through or along the borehole (see Fig. 1(C)).

The materials used to backfill a borehole or well must be clean, inert and non-polluting. Suitable materials include pea-gravel, sand, shingle, concrete, bentonite or cement grout and uncontaminated rock.

UNDER NO CIRCUMSTANCES SHOULD POTENTIALLY POLLUTING MATERIALS BE USED AS INFILL.

Consideration should also be given to the geochemical environment into which these materials will be placed, as under different environmental conditions the behaviour of materials may change (e.g. phenol contamination may prevent bentonite grouts curing).

Aggregates (pea-gravel, shingle, sand etc.) should be selected such that they have a grain size that allows easy delivery into the borehole and should be introduced in a controlled manner to ensure that accidental 'bridging' does not occur within the borehole. Concrete and grouts that are introduced in a liquid form should be introduced through an appropriate delivery pipe (e.g. tremmie pipe), to ensure that voids do not form. Boreholes that penetrate highly fissured aquifers, such as chalk and some limestones, present additional problems. Liquid grouts (particularly those injected under pressure), or fine-grained aggregates (e.g. fine sand) may be transported out of the borehole into the body of the aquifer through fissures. Careful monitoring of the process is required if these techniques are used, and in these cases it may be more appropriate to use coarser aggregate (e.g. gravel) as a backfill against fissured aquifers.

Where the site is in a very sensitive location (e.g within 50 metres of a potable abstraction) consideration should be given to disinfecting the materials prior to its use as infill. Care must be taken, however, to ensure that the disinfectant does not, in itself, present a groundwater pollution risk. The advice of SEPA and disinfectant manufacturers should be sought in such circumstances.

ii) Deep and wide boreholes/wells

In the case of very deep boreholes and wells with wide diameters, the volume of material needed to backfill the hole may be very large. In such circumstances it may be appropriate to adopt an alternative strategy, as long as this will not prejudice any of the original objectives.

Provided that the long-term structural stability of the borehole can be demonstrated, it is acceptable to place a permanent bridging seal, or plug, within the borehole and then to infill above this level using the approach given in Section 6c) (see Fig. 1(D)). The bridging seal should ideally be positioned below the lowest aquifer horizon. However, where this is not possible, it is important that the open borehole beneath the bridging seal penetrates no more than a single aquifer unit thereby preventing the flow of groundwater between different aquifers.

The material commonly used as a bridging seal is cement, although a combination of a mechanical plug and cement is acceptable. Cement seals must be allowed to set (cure) in place before backfilling is continued and completed. The advice of a specialist well contractor should be sought for the most appropriate technique.

iii) Artesian boreholes

For artesian boreholes, the de-commissioning process should aim to confine the groundwater to the aquifer from which it came in order to prevent loss of confining pressure, and the loss of water resources to the surface or other formations. The first step is to control the artesian flow.

There are a number of ways to accomplish this depending, in part, on the water pressure in the confined aquifer and the depth to which the water level must be lowered, for instance:

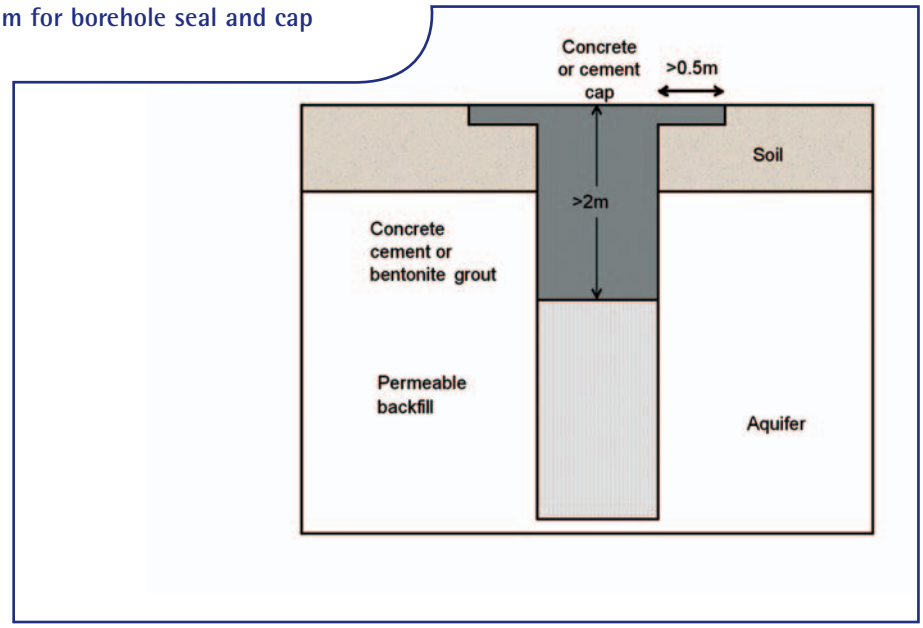
- Pumping the borehole to produce the necessary drawdown;
- Pumping nearby boreholes;
- Extending the casing above ground level beyond the elevation to which water will rise in the borehole (potentiometric surface);
- Introduce dense, non-polluting, fluids into the borehole;
- Introduce a pre-cast plug at an appropriate level within the hole;
- Using an inflatable packer, pressure grout the void space below the packer.

Decommissioning of artesian boreholes is likely to be easiest in late summer, when groundwater levels and artesian flows are at their lowest. Decommissioning artesian boreholes is a specialist job and requires expert advice.

d) Sealing the top of the borehole

In order to prevent potentially contaminated surface run-off or other liquids entering the backfilled borehole, it is necessary to complete the backfilling of all boreholes with an impermeable plug and cap. The final 2 metres (from ground level down) should be filled with cement, concrete or bentonite grout and a concrete or cement cap of suitable strength should then be installed over the top of the borehole and surrounding ground, such that its diameter is at least one metre greater than the diameter of the backfilled borehole (see Fig. 2).

Figure 2 Schematic diagram for borehole seal and cap



e) Recording details on site plan

Complete and accurate records should be kept of the abandonment procedures for future reference.

These records should include the following:

- The reasons for abandonment (e.g. water quality problems);
- Measurement of groundwater level prior to backfilling;
- The depth and position of each layer of backfilling and sealing materials;
- The type and quantity of backfilling and sealing materials used;
- Any changes made to the borehole/well during the abandonment (e.g. casing removal);
- Any problems encountered during the abandonment procedure.

Abandoned borehole and well locations should be marked on site records and, if possible, on the ground. Details of any decommissioning or modifications to borehole construction should also be forwarded to the British Geological Survey.

7. Conversion to soakaways

Redundant wells and boreholes have historically been used for the disposal of surface water, foul effluent and other waste liquids. Such activities can allow the direct discharge of contaminants to groundwater without any potential for attenuation. In many instances this practice has resulted in groundwater pollution.

Under the Water Framework Directive, which will be transposed into regulations to control point source pollution and abstractions in 2005, there is a prohibition of direct discharges of pollutants into groundwater subject to certain provisions.

It is also a criminal offence under Section 30F of the Control of Pollution Act 1974 to 'cause or knowingly permit any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled waters'. The definition of 'controlled waters' includes all groundwater.

The Discharge of pollutants to groundwater via a borehole is not normally permitted .

8. Specialist Advice

It is recommended that the advice of a specialist well contractor and local SEPA staff should always be sought, and the site-specific characteristics of a site given full consideration when determining the best borehole abandonment solution. Details of specialist drilling contractors can be obtained from The British Drilling Association.

Further advice can be obtained from your local SEPA office.

9. Further Guidance and References

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EPA – 570/9-75-001.

British Geological Survey.
National Geosciences Information Centre (NGIC), Keyworth, Nottingham, NG2 5ED.
Tel: (0115) 9363100.

British Drilling Association,
P.O. Box 113, Brentwood, Essex, UK, CM15 9DS.
Tel: (01277) 373456.

10. Acknowledgements

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