Well, well – it's all in the design

Dr Phil Ham, principal hydrogeologist at Envireau Water, looks at some of the most important aspects of borehole design, the benefits of getting it right and the implications of getting it wrong

The trouble with water wells – or water supply boreholes – is that they can cost a lot of money. And as it's an asset that you can't see, convincing a client to spend money on upfront design work can be a challenge.

As with any other engineering challenge, there is much to be gained through careful design – such as ensuring boreholes deliver good quality-water in the most hydraulically efficient and cost-effective way. This approach guarantees that capital investment is made on the back of good science.

DESIGN STANDARDS

There is no single recognised standard for borehole design in the UK, but that is not to say that there are no standards. There is a British Standard for the specification for water-well casings, and there are guidance documents on borehole construction published by the Environment Agency and Scottish Environment Protection Agency (SEPA). The Water Research Centre has a Well Construction Specification that is aimed at public water supplies, and although it is a bit contract focused, it does specify minimum dimensions for annular spaces, grout mixes and so forth.

Perhaps the most comprehensive guide in the UK water-well industry is Banks, Misstear & Clark's *Water Wells and Boreholes*, which provides theoretical and practical guidance on the siting, design, construction, operation and maintenance of water wells. This is a key reference.

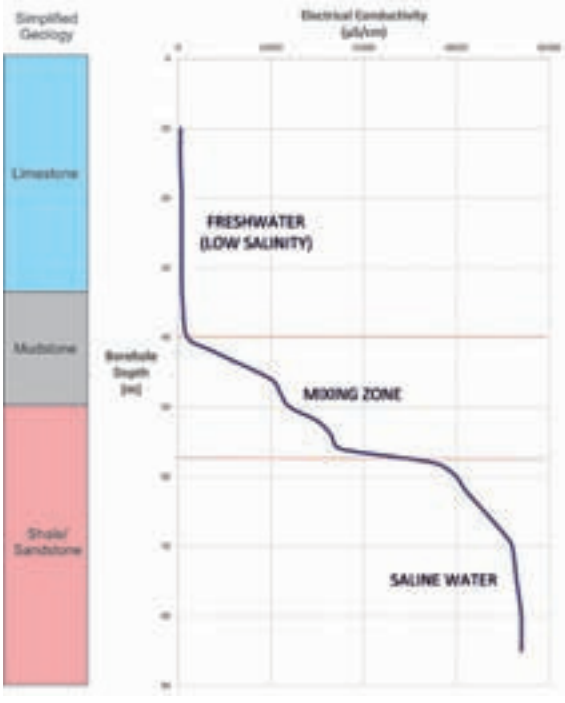

Figure 1: water quality can vary between formations over small distances

SIZE MATTERS

The depth and finished diameter of a borehole are critical design considerations. While both aspects have a direct impact on the scale of drilling costs, both also have a bearing on the final yield and water quality from a borehole.

Borehole depths need to be planned based on the depth and thickness of the target aquifer formation and the depths at which groundwater inflow is anticipated. The planned depth of a borehole also needs to account for the expected performance of the aquifer – that is, sufficient aquifer thickness is penetrated to allow the required yield to be delivered, with an allowance for drawdown during pumping and seasonal variations in water levels.

Where the geology is variable or boreholes are designed to target multiple formations, thought must be given to potential changes in water chemistry that might occur with depth or a change in strata. This is often overlooked and in some cases – as shown in Figure 1 – water chemistry can change dramatically within just a few metres.

Likewise, the finished diameter of a borehole is not only dependent on the size of pump required to deliver the required yield, it also needs to account for potential quality issues. For example, where formations are unstable or a high proportion of fines are expected in groundwater, allowance needs to be made to install a suitable well screen and a formation stabiliser or filter pack. The Water Research Centre recommends that the minimum annular space to allow a filter pack to be installed is 75mm. This needs to be accounted for prior to construction and will have a knock-on effect on drilled diameters and overall development costs.

CASINGS AND SEALS

Casings are used to provide structural integrity and to seal out unwanted groundwater. Casings can be used to prevent the ingress of poor-quality groundwater from shallow depths or groundwater originating from particular formations known to contain water with an undesirable chemistry. Casing depths should be planned based on a sound understanding of the hydrogeology prior to drilling, and the final depths and installation decided using information ascertained during drilling and, where warranted, geophysical logging.

Permanent casings should be grouted in place. Again, sufficient annular space needs to be allowed to ensure a good sanitary seal or unwanted formations are sealed out of the borehole.

SCREENS AND STABILISERS

The design of well screens and formation stabilisers often gets forgotten, or is never thought about in the first place. If properly designed, the screen and stabiliser will hold back unstable formations and fines, while

maintaining good borehole hydraulic efficiency and yield.

Conversely, poorly designed screens and stabilisers result in inefficiency and the possibility of boreholes being incapable of delivering the required yield. While the borehole may still function, in some cases, the implications of getting the screen and stabiliser wrong are much more severe.

For example, an oversized screen and pack will not prevent the mobilisation of fines; sand-pumping issues will ensue resulting in wear of pumping equipment and – in the worst cases – the potential of collapse. Similarly, an undersized screen and stabiliser can also lead to collapse where, under pumping conditions, physical clogging induces large head differentials inside and outside the borehole.

Getting the screen and stabiliser design right is not hard. The scientific techniques for selecting screen sizes and the grain distribution of formation stabilisers is well published, and if correctly applied, ensures sufficient water can enter the borehole to achieve the required yield while holding back fine material.

IMPLICATIONS OF POOR DESIGN

It is common to avoid the design stage and go straight to drilling contractors who can just get on with the job. This approach works. A drilling contractor will drill you a borehole. But that's not to say it will be the borehole your client wants or needs.

The apparent saving of just getting on with the job is soon lost when boreholes suffer from yield and quality issues that could have been avoided. The consequences of poor design may not be initially apparent and may manifest themselves over a number of years following construction.

Filter pack pumped from borehole due to failure

The starting point for any borehole construction project requires a good understanding of local geology and hydrogeology. The understanding need not be complicated but sufficient to allow plans to be made at the start of the project regarding drilling depths and diameters, and what allowances need to be made for the placement of casings, screens and formation stabilisers.

Envireau Water is a water resources consultancy specialising in the development, management and regulation of independent water supplies