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## **Groundwater Abstraction**

This module is designed for users proposing to drill a water borehole for the abstraction of groundwater supplies and/or to inject water into an aquifer.

It contains an evaluation of the geological formations beneath the site in terms of aquifer potential including groundwater yields, water levels and groundwater quality. It also contains recommendations on the design of the proposed water borehole and information on the legal requirements.

Proposed yield is 20 m<sup>3</sup>/d (metres cubed per day)  
Proposed use is for a potable supply for an office block

### **Groundwater Potential**

The required yield of 20 m<sup>3</sup>/d is equivalent to 0.6 l/s (2 m<sup>3</sup>/hr) for a 10 hour/day pumping regime.

Till is present on the eastern edge of the site. This comprises stiff, grey clay, weathered to yellow-brown in the upper 2 m, with pebbles and cobbles of flint and rare limestone and chalk. Boreholes in the area show the Oadby Till to be locally underlain by a thin sand which is water bearing. This is unlikely to form a sustainable water resource. The groundwater is likely to be of the calcium-bicarbonate type with a total dissolved solids content of less than 500 mg/l; water derived from glacial deposits is often ferruginous.

The Mercia Mudstone Group is generally of low permeability and transmits groundwater mainly through fractures in the occasional thin, impersistent siltstones and sandstones that are present (referred to as skerries). These skerries commonly possess only a very small outcrop area and consequently recharge is often limited. They tend to vary in thickness and may not be laterally persistent, making it difficult to identify their presence and thickness without drilling. The success of a borehole will depend on the number and thickness of these beds penetrated, with failure to penetrate a skerry or intersecting one that is only poorly fractured, resulting in a dry or low-yielding borehole. Yields are generally less than 0.5 l/s and can decline significantly with time as pumping depletes groundwater storage within the water-bearing horizons. If no skerries are encountered, supplies are rarely obtained from below the weathered zone.

It is anticipated that the rest water level beneath the site is likely to be about 48 m above OD. However this could differ by as much as 5 m, as there are significant differences in water levels across the whole BGS site from 57 m above OD in the east to 43 m above OD in the west from boreholes penetrating to the Arden Sandstone. This equates to a steep hydraulic gradient of about 1 in 27 westwards, assuming that the same skerries contribute in both boreholes. In addition seasonal water level fluctuations may occur.

There are some records of boreholes abstracting from the Mercia Mudstone Group in the surrounding area. A 50.3 m deep borehole at Burton-on-the-Wolds (SK 5781 2022) into the Branscombe Mudstone Formation was tested at 0.9 l/s. A 26.2 m deep borehole in Plumtree (SK 6139 3309) only yielded 0.4 l/s. A 61.3 m deep borehole at Keyworth (SK 6132 3168) supplied up to 45 m<sup>3</sup>/d, but was unable to pump for more than 3 or 4 hours at a time, before having to stop and allow the water level to recover for an hour. A 24 m deep borehole at Ruddington (SK 5872 3316), drilled into marl with skerries (Arden Sandstone Member) yielded 0.44 l/s for a drawdown of 0.8 m after an 8 hour pumping test.

Water quality from the Mercia Mudstone Group is very hard with the total dissolved solids content likely to be in excess of 2000 mg/l, of which the predominant ions are calcium and sulphate, derived from gypsum in the rocks. A 42.6 m deep borehole sited near the top of the Mercia Mudstone Group at Bunny Lane, Keyworth (SK 6090 3085) recorded a small yield of water 'unsuitable for drinking and with a similar effect to Epsom Salts' from a 2.1 m thick bed which was described as limestone and is likely to have been dolomitic sandstone, encountered at a depth of 11 m below ground level. Borehole logging of existing boreholes on the site indicated that the Windmill Hill Sandstone within the Branscombe Mudstone Formation contained groundwater under pressure with a total dissolved solids content of between 2000 and 2300 mg/l. Beneath this the water becomes more mineralised with the water from the Arden Sandstone at the top of the Edwalton Formation probably having a total dissolved solids content of around 5000 mg/l. Water with this level of mineralisation can be corrosive.

The Sherwood Sandstone Group forms an excellent aquifer in the East Midlands, however in this area it occurs at a depth in excess of 200 m, although it is anticipated that the rest water level will rise to within 30 to 40 m of the ground surface. At this depth, it is likely that the water quality would be poor. A 251 m deep and 200 mm diameter borehole at East Leake (SK 5530 2775) yielded 17.7 l/s during a 15 day test for a drawdown of 16.4 m from 58.8 m of saturated Sherwood Sandstone. The rest water level was 167 m above the top of the sandstone (27 m above OD). A nearby 152 mm borehole of similar depth (SK 5534 2774) yielded only 4.2 l/s for a drawdown of 14.6 m. The water was of the calcium sulphate type and brackish with a total dissolved solids content of 1690 mg/l and a sulphate ion concentration of 865 mg/l. Another borehole at Edwalton Nurseries, West Bridgford (SK 5872 3437) was 228.6 m deep and yielded 15 l/s for a 26.5 m drawdown from the Sherwood Sandstone during a 3 day pumping test; the main yielding horizons being in the Nottingham Castle Sandstone Formation between a depth of 213.4 m and the bottom of the borehole. The water contained high concentrations of sodium (890 mg/l), calcium (268 mg/l), chloride (1410 mg/l) and sulphate (680 mg/l). A borehole at Ruddington (SK 5650 3243) which penetrated Sherwood Sandstone between depths of 142.3 and 209.5 m, encountered water 'so hard as to be unusable' and a depth sample from the Sherwood Sandstone in the Plungar borehole (SK 7720 3347) showed it to have a total dissolved solids content of over 4000 mg/l, of which 2646 mg/l were sulphate.



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### **Groundwater Vulnerability**

The mudstones of the Mercia Mudstone Group may provide some protection from contamination occurring at the ground surface to groundwater in the skerry horizons. However, the predominance of fracture flow can lead to the rapid transport of contaminants both to, and through, the saturated horizons.

### **Conclusion**

In conclusion, the site is not a good one for developing a potable groundwater supply. A borehole penetrating to the base of the Arden Sandstone Formation (about 50 m deep) may provide the required volume, however this cannot be guaranteed as the size of the supply will depend on the number of the water-bearing horizons intersected. However, the quality of the water will not be suitable for a potable supply without reverse osmosis treatment. Any gypsiferous horizons should definitely be cased out but the borehole will probably require support throughout, with perforated casing installed against the contributing horizons. A borehole to obtain a supply from the Sherwood Sandstone will need to be about 215 m deep, to penetrate at least 10 m of this aquifer. Groundwater from this aquifer is likely to be of better quality than that from the Mercia Mudstone, but still likely to be slightly brackish. If this aquifer is developed, the whole of the Mercia Mudstone should be lined out and if friable horizons are encountered in the Sherwood Sandstone these will require perforated casing, possibly with a sand screen and filter pack.



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## **Borehole Location, Construction, Testing and Legal Obligations**

### **Location:**

It is good practice to site a borehole as far away as possible, and preferably upslope, from any potential sources of pollution, including septic or fuel tanks, soakaways, slurry pits and areas of intensive grazing. A minimum distance of 50 m between a water borehole and any potentially polluting activity is recommended.

### **Construction:**

For boreholes abstracting from the superficial deposits, the top few metres should be cased out (the depth of plain casing depending on the aquifer thickness at the specific site). A borehole abstracting water from a bedrock aquifer should be sealed off through the superficial deposits by installing a length of plain casing to at least 5 m below the upper surface of the bedrock. The casing should be grouted effectively in order to minimise the risk of poor quality surface or shallow groundwater entering the borehole.

### **Testing:**

Any new borehole should be subject to a pumping test to determine the yield and drawdown of the water level. For a borehole designed for a single domestic property, it is recommended that a pumping test of at least 3 hours duration, or at least as long as the anticipated daily pumping period, is carried out, during which both the pumping rate and water level are monitored. For domestic supplies for more than one property, a longer pumping test of at least 6 to 12 hours is more appropriate. For larger supplies the Environment Agency are likely to require a test of several days duration, as well as the monitoring of nearby water sources before, during and after test pumping.

### **Water quality:**

It is recommended that a water sample, taken during the final stages of the pumping test, is sent for full analysis to a reputable laboratory. They, or if a potable private supply is envisaged the Environmental Health Officer of the local council, should be able to advise on the range of analyses to be undertaken, which would normally include pathogenic indicator bacteria, iron, manganese and nitrate. An adequate and well-maintained disinfection treatment would be considered advisable for any supply intended for potable use.

### **Legal requirements:**

While BGS may assess the groundwater potential at this site, the prerogative of granting a licence rests with the Environment Agency, < add relevant > Region. Currently all sources abstracting 20 m<sup>3</sup>/d or more require an abstraction licence. A 'Consent to Investigate Groundwater' must be obtained prior to a licensable borehole being drilled. This consent permits drilling and pump testing. If a borehole to more than 15 m depth is drilled, there is a statutory requirement (Water Resources Act, 1991) for the driller to supply full information to the Wallingford office of the BGS for inclusion in the National Well Record Archive. A form for supplying the required information is enclosed.



**Maximum admissible concentrations and values for selected parameters in drinking water\***

Parameter	Concentration or value
<b>Physical characteristics</b>	
pH	≥6.5 and ≤9.5
Electrical conductivity (SEC) @ 20°C (µS/cm)	2500
<b>Inorganic parameters</b>	
Aluminium (µg/l)	200
Ammonium (mg/l)	0.5
Chloride (mg/l)	250
Fluoride (mg/l)	1.5
Iron (µg/l)	200
Manganese (µg/l)	50
Nitrate (as mg/l NO <sub>3</sub> )	50
Sodium (mg/l)	200
Sulphate (mg/l)	250
Arsenic (µg/l)	10
Bromate (µg/l)	10
<b>Organic parameters</b>	
Benzene (µg/l)	10
Pesticides-individual (µg/l)**	0.1
Pesticides-total (µg/l)	0.5
Polycyclic aromatic hydrocarbons (µg/l)	0.1
Tetrachloromethane (carbon tetrachloride) (µg/l)	3
Trichloroethene and tetrachloroethene (perchloroethylene) (µg/l)	10
<b>Microbiological parameters</b>	
Coliform bacteria (number/100 ml)	0
Enterococci (number/100 ml)	0
<i>Escherichia coli</i> ( <i>E. coli</i> ) (number/100 ml)	0
<i>Clostridium perfringens</i> (including spores) (number/100 ml)	0

\* under the Water Supply (Water Quality) Regulations, England & Wales 2000 and Scotland 2001

\*\* except aldrin, dieldrin, heptachlor and heptachlor epoxide where the limit is 0.03 µg/l