Measuring Groundwater

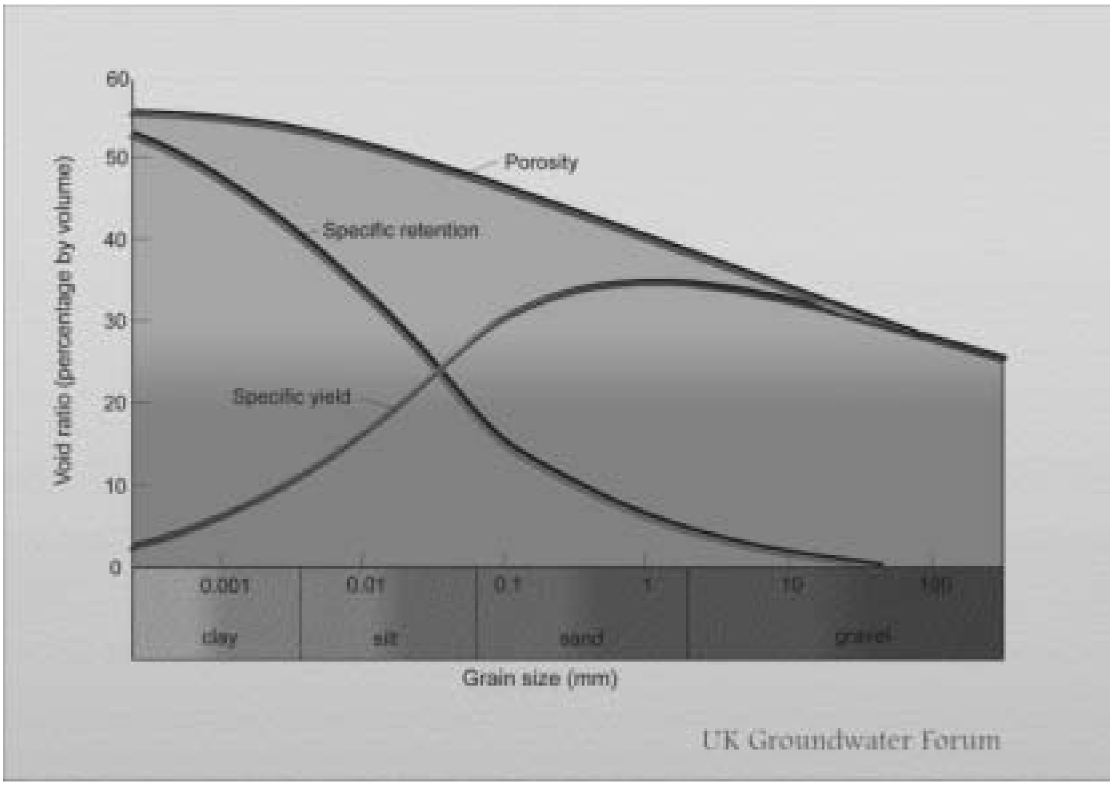
Groundwater is not found in all rocks. **Aquifers** are rocks that are able to store and transmit groundwater in sufficient quantities to be used for groundwater development. The following section covers the main properties of aquifers, which are often discussed by hydrogeologists:

Most groundwater is found in small spaces or holes in rocks, such as in cracks or fractures, or in the spaces between grains in a sandstone. The water in the rocks is usually spread over a wide area, a little like water soaked into a cloth or sponge, and it is very rare that groundwater is found as underground “rivers” or “lakes”. The proportion of spaces in a rock compared with the total volume of the rock is called **porosity**, and is often expressed as a percentage:

Porosity = (volume of voids ÷ bulk volume of the rock) x 100%

For example, river gravels may have a porosity of about 30%, whilst a fractured granite may only have a porosity of about 5%.

For the purposes of groundwater development, however, it is not enough that rocks are porous. Some rocks such as clays have a high porosity, but the pores are so small that water is trapped in them and cannot easily be taken out. The volume of water that drains naturally from a rock compared with the total volume of water in the rock is called the **specific yield**. In some cases, such as coarse gravels, most of the water held in the rock will drain out when the water table drops, and the specific yield and the porosity are therefore very similar. In other cases, such as clays, the rocks may have a high porosity but a low specific yield. For the purposes of groundwater development, it is really specific yield that is of interest rather than porosity.



Finally, we need some measurement of the rate at which water will move through a rock, for example towards a well or borehole. If the water will only move very slowly, then it may take too long for a well or borehole to fill up for practical purposes. GROUNDWATER ALWAYS MOVES IN THE DIRECTION OF THE SLOPE OF THE WATER TABLE. This slope is known as the **hydraulic gradient**.

The rate at which the groundwater moves is proportional to the hydraulic gradient and a property of the rock called the **hydraulic conductivity**. Hydraulic conductivity (K) is measured in units of metres per day (m/d), and it is different for different rocks. The relationship between groundwater velocity and hydraulic gradient is called **Darcy's Law**:

q = Ki	(**q** is the volume of flow per unit cross-sectional area (m/d), **i** is the hydraulic gradient and **K** is the hydraulic conductivity)

Rocks that look very similar may have very different hydraulic conductivities, since hydraulic conductivity is dependent not only on the size of the void spaces, but also whether the spaces in the rock are joined together (interconnectivity). Rocks that transmit water easily can have hydraulic conductivities of 30 m/d or higher, and these rocks are said to be **permeable**. Rocks with very low hydraulic conductivities are said to be **impermeable**. A good aquifer will be able to yield sufficient quantities of groundwater (specific yield) and transmit the groundwater at sufficient rates towards well or borehole intakes (hydraulic conductivity).

The saturated thickness of the aquifer times the hydraulic conductivity is called **Transmissivity (T)**. This is a measure of how well the whole aquifer conducts water.

T=Kb (**K** is the hydraulic conductivity and **b** is the saturated thickness)

Source: J Davies et al (2002) Development of a curriculum and training of supervision teams in borehole construction in Malawi. British Geological Survey Internal Report CR/02/219N