# Hydrogeology of Wales: Ordovician and Silurian aquifers - groundwater occurrences

From Earthwise



**This page is part of a category of pages that provides an updated review of the occurrence of groundwater throughout Wales.**

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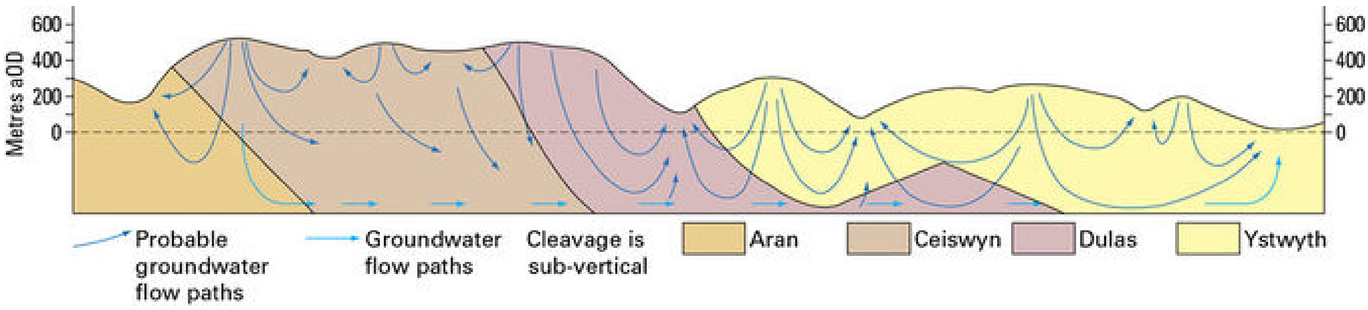
The diverse lithologies that are present in the Ordovician and Silurian strata in Wales support a range of hydraulic properties. This diversity contrasts with the Southern Upland massif of southern Scotland and south-east Northern Ireland where the dominant lithologies are sandstone, siltstone and mudstone. These areas offer more uniform hydraulic conditions, and the strata are described as weakly permeable and capable only of short and shallow flow paths supporting isolated springs and shallow wells (**Robins, 1999**). In Wales, some of the Ordovician and Silurian strata are also weakly permeable and cannot be considered as useful aquifers. However, there are other areas in which the strata are relatively productive and useable quantities of groundwater are available, for example from the Silurian sandstones, from which there is usually sufficient groundwater to support domestic and small-scale agricultural uses.

A weathered, frost-shattered and soliflucted horizon is well preserved in Wales. This is because the removal of the weathered zone by the ice sheets was less effective than it was in much of glaciated England and Scotland so that the weathered and fractured uppermost layer of rock is largely preserved in Wales south of Snowdonia. In some areas the effects of periglacial frost shattering enhance the near surface permeability of the rock. Tectonic activity has induced discontinuities throughout much of the Welsh succession where bedding plane fractures and subvertical breaks are commonplace. The boundaries between sedimentary lithologies and interbedded volcanic strata tend also to be marked by joints sufficiently dilated to allow groundwater transport. Significant groundwater storage, however, tends to be limited to coarser arenaceous deposits.

In general, the water table tends to be shallow where aquifer storage is not capable of receiving recharge from the available effective precipitation, a phenomenon known as rejected recharge. Flow boundaries may be defined by fracture orientation and the relationship between bulk-rock and fracture hydraulic conductivity. Dominant fracture orientation may also control groundwater flow direction (**Robins, 2005**).

Although awareness of the importance of groundwater in the Ordovician and Silurian strata is relatively new (e.g. **Haria and Shand, 2004**), its role in supporting low flow in upland streams has long been recognised. One of the earliest investigations into groundwater occurrence in the Ordovician and Silurian strata was a reconnaissance study of the Afon Dulas subcatchment of the Dyfi north of Machynlleth (**Glendining, 1981)**. The catchment comprises a series of folded, well-cleaved and fractured turbiditic mudstones and slates with a north-easterly strike, younging towards the south-east. There are volcanic rocks in the north-west corner of the catchment. The superficial cover includes head and scree deposits, peat and valley alluvium. The cleavage planes trend north-easterly and are subvertical to 60° in dip, the main joints are normally vertical and are orientated between 120° and 140°, the faults also are subvertical. Surface drainage is strongly influenced by this structure, with the Tal-y-Llyn and Dyfi valleys following major fault lines and many first order streams following the 120° joint directions; groundwater flow is mainly constrained by the structure and jointing (**Figure P859264**).

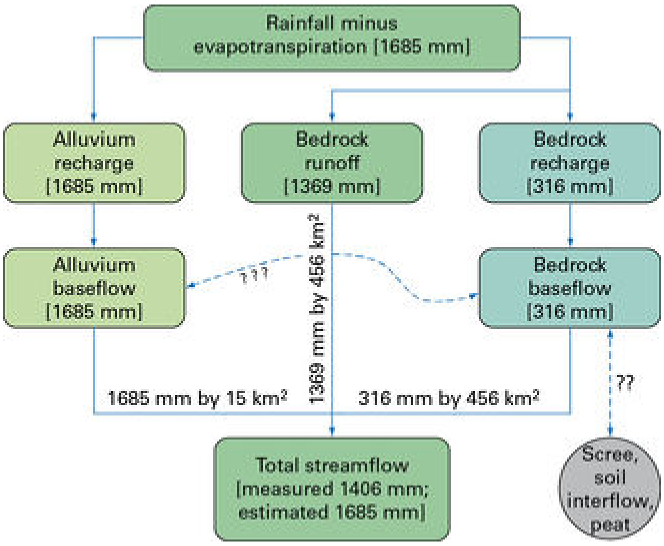



Schematic flow system for the Afon Dulas catchment controlled by topography, fracture orientation and fracture permeability (after Glendining, 1981. P859264.

Effective infiltration (equal to base flow divided between alluvium and bedrock in the Afon Dulas catchment (after Glendining, 1981).

| Year | Total flow (mm) | Base flow (mm) | Effective rainfall (mm) | Alluvium (15 $km^2$) infiltration $m^3$ x $10^6$ | Bedrock infiltration (456 $km^2$) infiltration $m^3$ x $10^6$ | Bedrock infiltration (mm) |
|---|---|---|---|---|---|---|
| 1962–1963 | 1195 | 312 | 1393 | 21.0 | 126 | 276 |
| 1963–1964 | 1017 | 275 | 1201 | 18.0 | 111 | 244 |
| 1964–1965 | 1713 | 333 | 1842 | 27.6 | 129 | 283 |
| 1965–1966 | 1679 | 314 | 1909 | 28.6 | 119 | 261 |
| 1966–1967 | - | - | 1715 | 25.7 | - | - |
| 1967–1968 | 1656 | 444 | 2131 | 32.0 | 177 | 388 |
| 1968–1969 | 1224 | 399 | 1453 | 21.8 | 166 | 364 |
| 1969–1970 | 1410 | 417 | 1774 | 26.6 | 170 | 372 |
| 1970–1971 | 1355 | 382 | 1750 | 26.2 | 154 | 337 |
| Mean | 1406 | 396 | 1685 | | | 316 |

The bulk catchment properties suggest that total river flow equates to total effective rainfall. This assumes that changes in storage and soil moisture deficit are negligible over the long term and that underflow from the catchment is small. Base flow separation of the catchment run-off was calculated, and divided between alluvium (15 $km^2$ in area in the catchment) and bedrock (456 $km^2$). Infiltration into the alluvium was assumed to be equal to total effective rainfall (**Figure P859265**). The effective rainfall over bedrock was divided between the amount needed to make up the overall base flow (estimated from the base flow separation calculation minus base flow from or effective rainfall into the alluvium) and run-off (see **the effective infiltration table** ). This shows that the average annual infiltration to the bedrock is about 316 mm or 19 per cent of the effective rainfall (compared with 1685 mm or 100 per cent to the alluvium). This is likely to be an overestimate as it disregards soil and scree interflow, short flow-path discharge through the near valley-bottom weathered zone and the capacity of the rock to accept recharge.




Analysis of throughflow volumes in the Afon Dulas catchment (after Glendining, 1981). P859265.

**Glendining (1981)** assigned percentage flow to shallow, intermediate and deep flow paths using estimates of hydraulic gradients for each flow path. This enabled the overall hydraulic conductivity for the rock mass to be calculated. The value is of the order $10^{-3}$ m $d^{-1}$, however, this has little bearing on the majority of groundwater flow which takes place in the near-surface weathered zone and which may be of the order 1 m $d^{-1}$.

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