

United Kingdom

Capital city: London
Inhabitants: 66.7 Million



INSTITUTIONAL SETTING AND PURPOSE

The regulatory environment agencies are responsible for managing and protecting groundwater in the UK. As the UK comprises four devolved nations, each has an agency: Environment Agency (England), Scottish Environment Protection Agency (SEPA), Natural Resources Wales (NRW) and Northern Ireland Environment Agency (NIEA).

Groundwater monitoring is one of the statutory activities carried out by the agencies to comply with the EU Water Framework Directive (WFD), EU Groundwater Directive (GD) and EU

Nitrates Directive (ND) and UK legislation relating to water resource management and protection, e.g. status and trend assessment for the WFD and GD, nitrate vulnerable zone delineation (ND) and abstraction licencing.

In particular, the British Geological Survey (BGS) has a role to collate data for a sub-set of sites that are part of the environment agencies water level monitoring network. These data are used as is described in the following sections, for instance, to produce the Hydrological Summary (see below).

CHARACTERISTICS OF THE NETWORK

The groundwater monitoring network is comprised by 181 sites, from which 166 are in England, 3 in Northern Ireland and 1 in Scotland, figure 1. Data from 28 stations chosen as index wells are compiled every month to provide continually updated regional trends and variations in groundwater resources, in the Hydrological Summary for the UK.

Groundwater levels are measured manually using a dipper, or automatically using a pressure transducer. Automatic readings are either stored in a data logger (the site is visited periodically to retrieve the measurements) or sent automatically over the phone network to a database through telemetry.

It is important to notice that the monitoring networks operated by the national agencies comprise many more monitoring sites than are used for the Hydrological Summary. For instance, there are around 3500 groundwater quality (chemical) monitoring sites, possibly double this number for groundwater level.



Figure 1 - Groundwater situation map as of 21.11.2019. Source: NAQUA National Groundwater Monitoring

PROCESSING AND DISSEMINATION

This section focuses only in the processing and dissemination of data by BGS, although it is noteworthy that each national agency process and disseminate data and information from their own managed groundwater monitoring networks as well.

BGS hosts the National Groundwater Level Archive. It is the national repository for groundwater level data, and it also collects groundwater level data from their research projects.

The WellMaster database is another data storage (in addition to the National Groundwater Level Archive), where currently water level data from 60,000 boreholes are available. These data come from logs of boreholes drilled for water supply, and most of them are a single historical reading of the water level after drilling or when the borehole was surveyed.

The Hydrological Summary is produced monthly by the National Hydrological Monitoring Programme. The Programme is a collaboration between the Centre for Ecology and Hydrology (CEH) and the British Geological Survey (BGS). The Hydrological Summary includes information from rainfall, river flows, reservoirs and groundwater.

The data used for the Hydrological Summary are a small sub-set of the Environment Agency's monitoring network. The sub-set is the collection of data that is operated for water resource management purposes including EU Water Framework Directive status assessment and River Basin Management Plans (RBMP) reporting. Of the index boreholes on the BGS map, some of these are telemetered (all Environment Agency boreholes) and the data can be obtained directly by API, while others are dipped manually.

Normalisation methods are applied to display data in the Hydrological Summary. A spot map is created based on the end of month levels, figure 3.

For a given month, all measurements of that month in the pe-

riod of record of each borehole are ranked. The map displays the rank of the current month with respect to all historical measurements of that month, figure 2. Then, the point is coloured according to the rank's ratio (total number of month/rank of current months), in seven possible categories, table below.

Category	Ratio
Exceptionally high levels	0.950000 – 1.100000
Notably high levels	0.870000 – 0.949999
Above normal	0.720000 – 0.869999
Normal range	0.280002 – 0.719999
Below normal	0.130002 – 0.280001
Notably low levels	0.050002 – 0.130001
Exceptionally low levels	0.000000 – 0.050001

Figure 2 - Categories applied to ratio of the rank

When a new high or low level is established for a given month/period, the spot is circled with arrows.

ArcMap documents and output image/PDF files are produced from spreadsheet files containing level ranking and ratios using a Python script.

Groundwater monitoring stations are used in the analysis only if they have high hydrometric data quality and long records of at least 30 years. The data collected for monitoring is used for modelling. Their objective is to simulate fluctuations in ground-

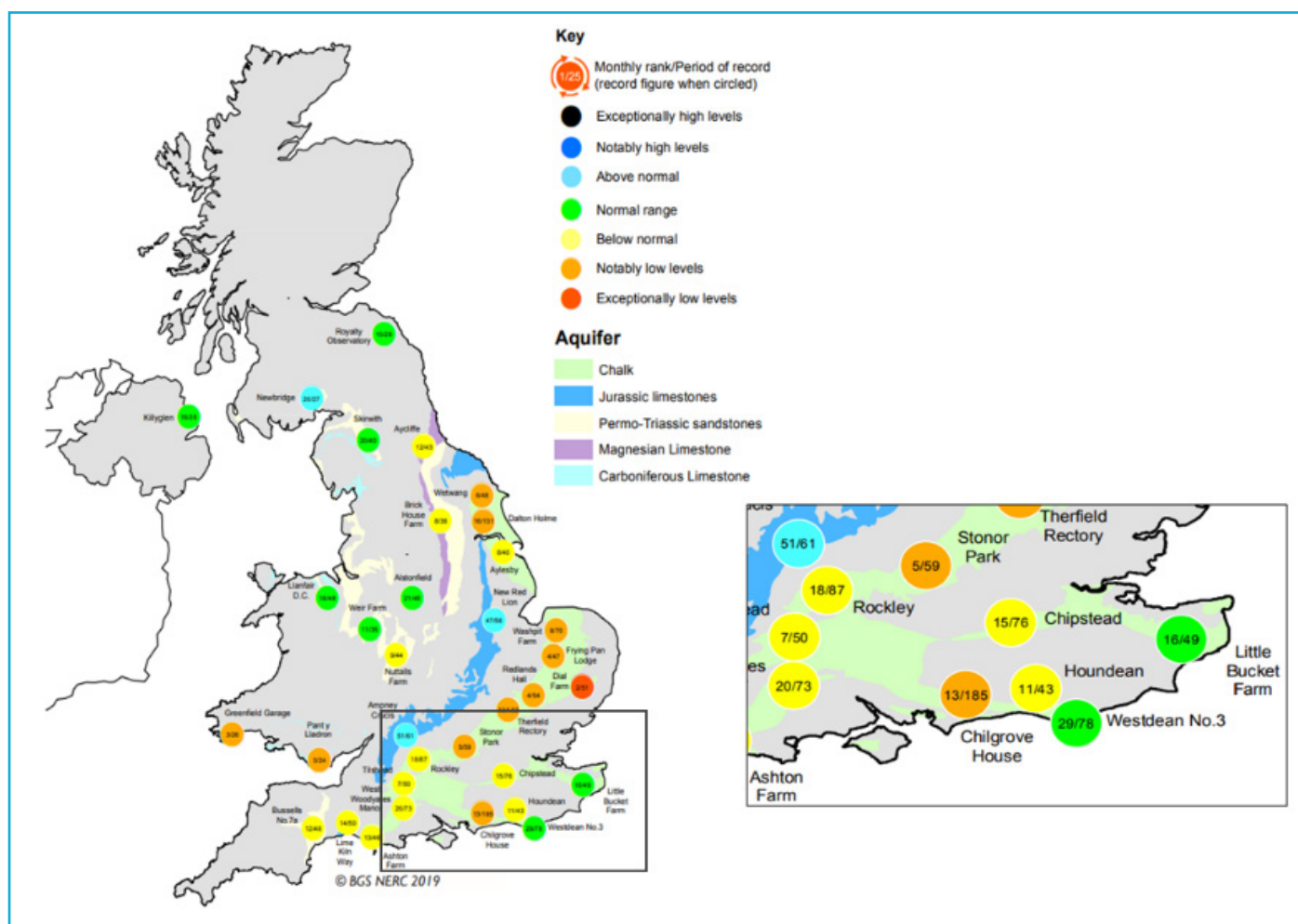


Figure 3 - Spot map for Groundwater levels July 2019 in the UK (left) and zoomed view with boreholes ranking (right). Source: BGS 2019

water level at 25 sites across the UK to forecast groundwater levels. Each of these models is driven by rainfall and evaporation time-series and has been calibrated against past observations of groundwater level. To forecast the change in groundwater level at a site over the coming one and three months, BGS uses 1 and 3-month ahead climate forecasts produced by a Met Office climate probabilistic model. Each of these two climate forecasts consists of an ensemble of up to 42 members and each member provides a projection of rainfall and temperature into

the future. Each member of the two climate forecast ensembles is run through each groundwater model. Thus, a probabilistic groundwater level forecast is produced for each site.

BGS produces forecasts at sites located in most of the principal aquifers of the UK where groundwater abstraction has significantly modified the observed groundwater level, and a hydrograph have not been modelled yet.



Figure 4 - Fresh spring water at St Ann's Well, Buxton, by: Tom Parnell

Sources

- **British Geological Survey. Groundwater level information** - <https://www.bgs.ac.uk/research/groundwater/datainfo/levels/home.html>;
- **British Geological Survey. National Groundwater Level Archive** - <https://www.bgs.ac.uk/research/groundwater/datainfo/levels/ngla.html>;
- **Feedback from British Geological Survey** - received on 28-09-2020;
- **UK Centre for Ecology & Hydrology. Hydrological Outlook UK – Groundwater** - <http://www.hydoutuk.net/methods/groundwater/>;
- **UK CEH Water Resources Portal** - <https://eip.ceh.ac.uk/hydrology/water-resources/>;
- **UK Centre for Ecology & Hydrology. National River Flow Archive** - <https://nrfa.ceh.ac.uk/monthly-hydrological-summary-uk/>; and
- **World Meteorological Organization. Information provided internally through HydroSOS Project** - <https://www.wmo.int/pages/prog/hwrp/chy/hydrosos/index.php>.