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Shallow Groundwater Temperatures and the Urban Heat Island Effect: the First U.K City-wide Geothermal Map to Support Development of Ground Source Heating Systems Strategy

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The first UK city-wide heat map is described based on measurements of groundwater from a shallow superficial aquifer in the coastal city of Cardiff, Wales, UK. The UK Government has a target of reducing greenhouse gas emissions by 80% by 2050 (Climate Change Act 2008) and low carbon technologies are key to achieving this. To support the use of ground source heating we characterised the shallow heat potential of an urban aquifer to produce a baseline dataset which is intended to be used as a tool to inform developers and to underpin planning and regulation.

We exploited an existing network of 168 groundwater monitoring boreholes across the city, recording the water temperature in each borehole at 1m depth intervals up to a depth of 20m. We recorded groundwater temperatures during the coldest part of 2014, and repeat profiling of the boreholes in different seasons has added a fourth dimension to our results and allowed us to characterise the maximum depth of seasonal temperature fluctuation.

The temperature profiles were used to create a 3D model of heat potential within the aquifer using GOCAD® and the average borehole temperatures were contoured using Surfer® 10 to generate a 2D thermal resource map to support future assessment of urban Ground Source Heat Pumps prospectively.

The average groundwater temperature in Cardiff was found to be above the average for England and Wales (11.3°C) with 90% of boreholes in excess of this figure by up to 4°C. The subsurface temperature profiles were also found to be higher than forecast by the predicted geothermal gradient for the area. Potential sources for heat include: conduction from buildings, basements and sub-surface infrastructure; insulation effects of the urban area and of the geology, and convection from leaking sewers. Other factors include recharge inhibition by drains, localised confinement and rock-water interaction in specific geology. It is likely to be a combination of multiple factors which we are hoping to make the focus of future study.

The next stage of this work will be to develop conceptual models of the thermal groundwater regime, and monitoring under abstraction conditions to confirm the sustainability of groundwater temperatures as a long-term thermal resource. We have also instrumented a non-infiltration Sustainable Urban Drainage System (SuDS) scheme, where we will characterise the effect upon the thermal groundwater resource as localised infiltration is reduced.