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The contribution of geology and groundwater studies to city-scale ground heat network strategies: A case study from Cardiff, UK

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The development of integrated heat network strategies involving exploitation of the shallow subsurface requires knowledge of ground conditions at the feasibility stage, and throughout the life of the system. We describe an approach to the assessment of ground constraints and energy opportunities in data-rich urban areas.

Geological and hydrogeological investigations have formed a core component of the strategy development for sustainable thermal use of the subsurface in Cardiff, UK. We present findings from a 12 month project titled 'Ground Heat Network at a City Scale', which was co-funded by NERC/BGS and the UK Government through the InnovateUK Energy Catalyst grant in 2015-16. The project examined the technical feasibility of extracting low grade waste heat from a shallow gravel aquifer using a cluster of open loop ground source heat pumps. Heat demand mapping was carried out separately. The ground condition assessment approach involved the following steps: (1) city-wide baseline groundwater temperature mapping in 2014 with seasonal monitoring for at least 12 months prior to heat pump installation (Patton et al 2015); (2) desk top and field-based investigation of the aquifer system to determine groundwater levels, likely flow directions, sustainable pumping yields, water chemistry, and boundary conditions; (3) creation of a 3D geological framework model with physical property testing and model attribution; (4) use steps 1-3 to develop conceptual ground models and production of maps and GIS data layers to support scenario planning, and initial heat network concept designs; (5) heat flow modelling in FEFLOW software to analyse sustainability and predict potential thermal breakthrough in higher risk areas; (6) installation of a shallow open loop GSHP research observatory with real-time monitoring of groundwater bodies to provide data for heat flow model validation and feedback for system control.

In conclusion, early ground condition modelling and subsurface monitoring have provided an initial indication of ground constraints and opportunities supporting development of aquifer thermal energy systems in Cardiff. Ground models should consider the past and future anthropogenic processes that influence and modify the condition of the ground. These include heat losses from buildings, modification of the groundwater regime by artificial pumping, sewers, and other GSH schemes, and construction hazards such as buried infrastructure, old foundations, land contamination and un-exploded ordnance. This knowledge base forms the foundation for a 'whole life' approach for sustainable thermal use of the subsurface. Benefits of the approach include; timely and easy to understand information for land use and financial resource planning, reduced financial risk for developers and investors, clear evidence to help improve public perception of GSHP technology, and provision of independent environmental data to satisfy the needs of the regulator.

References:

Patton, A.M., Farr, G.J., Boon, D.P., James, D.R., Williams, B., Newell, A.J. 2015. 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. Geophysical Research Abstracts. EGU 2015 Vienna, Austria. (Poster)