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# An integrated approach to understanding groundwater flow in a prospective shale gas basin

Miles Wilson (1), Fred Worrall (1), Richard Davies (2), and Alwyn Hart (3)

(1) Department of Earth Sciences, Durham University, Durham, DH1 3LE, UK (miles.wilson@durham.ac.uk), (2) School of Natural and Environmental Sciences, Newcastle University, Newcastle, NE1 7RU, UK, (3) Environment Agency, Research Assessment and Evaluation, Sapphire East, Streetsbrook Road, Solihull, B91 1QT, UK

The potential subsurface migration of hydraulic fracturing-related fluids from deep shales to shallow aquifers along natural geological pathways is an environmental concern shared by the public, governments, and regulatory bodies. An integrated approach is critical for better understanding groundwater systems in prospective shale basins so that potential pathways, receptors, and migration timescales can be identified and built into environmental risk assessments. This study integrates historic groundwater quality data from the Environment Agency of England; dedicated surface water sampling and laboratory analysis; seismic reflection interpretation; and numerical modelling to improve conceptual and numerical groundwater models of the Bowland Basin, northwest England. The Bowland Basin is a shale gas exploration focus in England but little is known about the deep groundwater system (>500 m) and how it interacts with the shallow and surface water systems. Initial numerical modelling results show that increased induced fracture extent, absence of deep high hydraulic conductivity strata, increased overpressure, and relatively low fault hydraulic conductivity (i.e. compartmentalising faults) are all statistically significant factors in reducing particle travel times to the shallow aquifer. The importance of compartmentalising faults is particularly evident and groundwater quality data from the Bowland Basin show that this effect exists, as well as stratigraphic compartmentalisation. Furthermore, surface water data suggest that bedrock is a key control on surface water composition, despite the widespread presence of overlying superficial deposits. These findings are now being combined with interpreted seismic reflection data to produce three-dimensional groundwater models of the Bowland Basin. These models may help identify areas of the principal aquifer which may be more, or less, vulnerable to contamination from the subsurface migration of hydraulic fracturing-related fluids.