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Characterising the role of heterogeneity on surface water-groundwater interaction in the Permo-Triassic Sandstone aquifers of the Eden Valley, NW England

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The Permo-Triassic Sandstone aquifers of the Eden Valley, Cumbria UK, are a key water resource for public water supply in NW England as well as local agriculture and industries. Permo-Triassic Sandstone aquifers are characterised as having large storage capacities and moderate transmissivities, however, in the Eden Valley these characteristics vary greatly on a range of scales i.e. granulation seams (deformation bands) that are millimetres thick but have been shown to extend for hundreds of metres on analogous sandstones; silicified layers that are several metres thick and extending 10s to 100s of metres laterally; and lithological variation and faulting have been shown to juxtapose hydrogeological units with different hydraulic properties. Complex heterogeneous superficial deposits overlay 75% of the Permo-Triassic Sandstone aquifers and comprise glacial till, glacio-fluvial outwash deposits, river terrace deposits and alluvium. The lateral and vertical continuity of these superficial deposits is highly uncertain.

The complex geological and superficial deposits in the Eden Valley impose a control on flow processes and impact sub-surface runoff. Specifically, lenses of high conductivity sands and gravels within low conductivity clay till deposits coupled with the presence of low conductivity strata at ground level suggests that indirect recharge is an important sub-surface runoff component. Therefore, the magnitude and location of recharge to the Permo-Triassic Sandstone aquifers is highly uncertain. Published recharge estimates rely on baseflow separation techniques and thus do not distinguish between indirect and direct recharge. This highlights the uncertainty regarding the sub-surface flow processes active in the Eden Valley.

A methodology for characterizing the surface water – groundwater interaction spatially and temporally in an ungauged upland sub-catchment is presented.

A non-invasive approach has been implemented to investigate the relationship between the surface water and groundwater systems in the Eden Valley. This involved the design and installation of low-cost ultrasonic sensors that measure stream stage. The sensors have been installed at key locations within sub-catchments that incorporate limestone pavements, geological contacts and along fault trends in the headwaters of the Eden Valley. Flow gauging has been conducted along the reach of these streams to investigate the spatial variation in discharge. Data from the low-cost sensors and flow gauging have been used to estimate the magnitude of volumetric water exchange between the surface water and groundwater systems, as well as characterise this relationship spatially and temporally.

The thickness and composition of the superficial deposits along these stream reaches will be investigated via passive seismic survey. The superficial investigation and the volumetric water balance will be used to estimate indirect recharge in the upper Eden catchment. The results of which will be compared to localised recharge estimates calculated from groundwater level timeseries. This comparison will indicate the importance of indirect recharge within sub-surface runoff processes.

This ongoing research is a vital step in quantifying the relationship between the surface water and groundwater systems in a complex upland catchment. A knowledge of the active sub-surface runoff processes highlighted are key for reliably assessing the long-term security of groundwater resources in the Eden Valley.