## Integrated River Evaluation for Management (IREM): A novel approach to understanding the role and impact of groundwater-surface water interactions on in-stream water quality

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## Integrated River Evaluation for Management (IREM)

- IREM is a novel approach to integrate factors affecting surface water (SW) and groundwater (GW) connections to better inform management
  - interventions of local water resources impacted by multi-threats. This approach has been established to better manage water resources to meet standards (e.g. Water Framework) Directive (WFD; 2000/60/EC); a holistic assessment of the system behaviour and connections is required to deal with contemporary fluvial challenges (Brunner et al., 2017).
- IREM is an analytical tool that utilises desk- and field-based techniques to compile existing and empirical data in a Geographic Information (GIS) framework (Table 1).
- Here, we present the findings from a pilot test of IREM on the Herrington Burn (NE England).

## **Pilot Test**

Durham

University

- The Herrington Burn (catchment area: 13 km<sup>2</sup>) is a heavily modified tributary of the Lumley Park Burn which flows into the River Wear (Figure 1). It is currently failing to achieve 'good' WFD status (Environment Agency, 2018).
- There are concerns regarding elevated nitrate concentrations in GW abstractions at the borehole marked on Figure 2. It was initially hypothesised that the nitrate source was attributable to the downwelling of poor-quality SW. Applying the IREM approach has shifted focus from the surface to the subsurface, facilitating a first-order, holistic assessment across the systems.

Table L. Example data sources used in IREM.	
Surface	Subsurface
SW network, flow	Geology
Pollution sources – point and diffuse	Lithology, including superficial deposit thickness and composition
Land use – historic and contemporary	Worked mineral deposits, e.g. coal mining
Historical channel changes	GW quality





Table1: Example data sources used in IREM



The Herrington flows downstream through former open-cast coal mining workings towards redeveloped residential areas (Figure 2), coinciding with metal-rich and effluent-rich discharges respectively.

However, nitrate concentrations were notably low relative to those of the GW abstractions (>80 mg/l). Thus, despite the agricultural and effluent releases, the source was unlikely pointing towards the channel inflows.

reserved. [1853-1995].).

Herrington Burn Outfalls Abstraction Borehole Mine Entries Combined Sewer Overflows /// Mining spoil

High : 141.27 (m)

Low : 35.72 (m)

Figure 2: SW network, showing mining and effluent threats, with elevation (Data sourced from: Northumbrian Water; LiDAR Digimap © Crown copyright).



Stream-subsurface connections are likely on the basis of the shallow thickness of superficial deposits (Figure 3). Nitrate sourcing from the area marked A was thought to be flowing towards fault B, from which it thought that the SW was was downwelling and flowing towards the borehole (Figure 3).

The A-B SW connection was found to be a historical path of the Herrington (Figure 4). Now culverted, water drains from agricultural fields into the drainage system. Thus, a possible nitrate source. Subsequent surveying of the drains suggested that no leaks were likely, thus leading to question GW sources.



Figure 4: Historical Vs. contemporary path of the Herrington Burn (©

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Figure 3: Superficial deposit thickness with inferred geological faults (Geological Map Data BGS © NERC 2018) and SW connection (A to B). Rectangle shows the hypothesised SW nitrate source zone.

## What does this mean for management?

- IREM has proven an insightful and useful tool to link evidence to the management interventions of practitioners, considering the pathways and links, within, and between the GW and SW systems, bringing freely available data together using GIS.
- Composite mapping has facilitated a first-order approximation of the role of the surface and subsurface connections and interactions, allowing for the elevation of nitrates. Using IREM, likely contributions from the SW and shallow subsurface (including the drainage network) have been assessed, shifting the focus of investigation towards the deeper GW.

IREM is to be applied in other streams of the Wear catchment	<b>References:</b> Brunner, P., Therrian, R., Renard, P., Simmons, C.T. and Franssen, H-J. H. (2017). Advances in understanding river-groundwater interactions. <i>River-Groundwater Interactions</i> . 55: 818-854. Environment Agency (2018). <i>Catchment Data Explorer</i> . Available at: http://environment.data.gov.uk/catchment-planning/OperationalCatchment/3520 (Accessed on: 15th March 2018).
of IREM beyond the Herrington pilot test.	<b>Acknowledgements:</b> Thanks to the partners of the TOPSOIL Group – the Wear Rivers Trust, Northumbrian Water, Environment Agency and Durham University.