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Anisotropy of streambed sediments of contrasting geomorphological environments and its relation to groundwater discharge

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As a main factor controlling surface water-groundwater exchange, spatial variability in streambed hydraulic conductivity and anisotropy is a key to understand groundwater discharge patterns to streams. Here we report on a field investigation in a soft-bedded stream, where horizontal and vertical streambed hydraulic conductivities were determined in order to, (i) detect spatial and seasonal variability in streambed hydraulic conductivity and anisotropy, (ii) relate this variability to channel morphology and different streambed sediments.
The study was carried out at a field site located along Holtum stream in Western Denmark. The 5 m wide stream has a soft sandy streambed, an average discharge of 1000 l/s and an average depth of 0.7 m. Hydraulic tests were carried out in 8 transects across the stream with 5 test locations in each transect to study the spatial variability and streambed hydraulic anisotropy across the stream. Different geomorphological environments were compared by having two transects in a straight channel and six transects across a channel bend with a depositional and an erosional bank. Streambed horizontal hydraulic conductivity (Kh) 0.5 meters below the streambed was determined with slugtests in piezometers. At the same locations falling head tests were conducted in standpipes to calculate vertical hydraulic conductivity (Kv) on a 0.5 m long streambed material column some of which were later removed for grain size analysis. In order to account for any seasonal changes in the temperature-related fluid properties the falling head tests and slugtests were carried out in December 2011 and August 2012.
Both the Kh and Kv values show greater variability in the summer dataset. During both seasons the shallow, depositional streambank displays the highest Kh values, while the erosional bank at the thalweg is characterised by lower Kh. Vertical streambed hydraulic conductivities do not show any spatial trend across the stream. Streambed anisotropy values of several orders of magnitude, between 0.5 and 1655 were observed with the least variability close to the streambanks. Kv values show greater changes between measurement seasons than Kh, possibly due to changes in the streambed surface sediments.
Based on the correlation between streambed hydraulic conductivity, anisotropy and geomorphological characteristics, results were also related to different streambed sediments, thus giving a comprehensive survey of the main factors affecting groundwater discharge to streams and hyporheic flow, some of the major issues in contamination of gaining rivers.