



## **Spatial and seasonal variations of groundwater upwelling zones in Stream Elverdamsåen using Distributed Temperature Sensing (DTS)**

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Spatial and seasonal variations in groundwater upwelling zones form a vital component of hydrological pathways influencing the temperature regimes of a riverine ecosystem necessitating observations at scales finer than the conventional point based measurements over wide array of hydrological conditions.

This study presents the dynamic behavior of groundwater fluxes entering within a study reach of a Danish lowland stream in three distinct hydrological settings using Distributed Temperature Sensing (DTS) system. High resolution DTS data have been used to identify and map the spatial and seasonal variability of groundwater upwelling zones in a Danish lowland stream 'Elverdamsåen'. An Agilent DTS unit (N4386A) was established in a 1.8 km study reach of Stream Elverdamsåen, Denmark with the fiber optic cable installed along the sediment - water interface to locate groundwater upwelling zones over three distinct hydrological settings comprising August 2010, November 2010 and May 2011.

The resultant stream bed temperature data revealed presence of 16 colder anomalies in August 2010, 16 warmer anomalies in November 2010 and 19 colder anomalies in May 2011 dataset within the study reach indicating locations of groundwater upwelling from the stream bed. Of all the identified interactions, two interactions identified at 1093 m and 1201 m were present in all three hydrological settings from August 2010 to May 2011 and two interactions identified at 1412 m and 1515 m were known to contribute throughout the study period in spite of being observed only in May 2011. These four perennial interactions were considered to be a part of regional scale interactions with contributions from glacial outwash sand deposits through fissures and fractures underlying the unconfined glacial moraine clay.

This study examined the capability of the DTS system to detect signals of inflow sources based on the variable hydrological settings encountered over three seasons from August 2010 to May 2011 and summarized the possible limiting factors comprising the ratio of groundwater inflow to the stream flow and thereby strength of the signal measured by the DTS system, width of the stream and location of the cable across the stream bed, local hydraulic conditions (pools and riffles) determining the dispersion of colder/warmer signals further downstream. With larger flows in a wide section of the stream channel dominated by gravel and boulders causing rapid dispersion of groundwater signal, proximity of cable to the inflow source is deemed to be a crucial factor in identifying the inflow source location as found to be the case in the groundwater spring at 1515 m. In addition, the choice of data collection period plays a crucial role in locating the inflow source.

Use of DTS system to investigate the exchange of groundwater fluxes in Elverdamsåen under variable hydrologic conditions provided insights into the spatial and seasonal variations of locations of groundwater upwelling zones and the physical settings controlling these dynamic processes.