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MODEL OF THE INFLUENCE OF MEANDERS AND TIME VARYING STREAM LEVELS ON GROUNDWATER DISCHARGE TO STREAMS

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The EU Water Framework Directive and the new Danish law on contaminated sites assessment require the evaluation of contaminated site impact on streams. This is a challenge because little is known about how contaminant discharge to streams varies because of stream meandering and changes in water levels in streams. This means that it is difficult to design appropriate monitoring strategies to detect contaminant input to streams.

This study aimed to develop a model of groundwater discharge to streams incorporating stream geometry and the time varying water levels in streams. The model was used to determine the likely location of groundwater discharge to streams, and determine the origin of that groundwater. The model was also used to examine how time varying stream water levels can impact stream discharge. The model was developed for a field site at Grindsted Å and used to analyse groundwater discharge measurements obtained at the field site.

The model developed was a three-dimensional COMSOL Multiphysics model of groundwater flows entering Grindsted Å. The model was used to design field monitoring campaigns and then, once data was collected, was compared with Point Velocity Probe and stream temperature measurements which provided data on the location, magnitude and direction of groundwater discharge to the stream. The model was also compared with time series of head data at monitoring wells located next to the stream. Finally, the implications of the model results for monitoring design were discussed.

The model showed that groundwater discharge is concentrated at the extreme edges of stream meanders, and that groundwater can flow under the stream and then through the bank opposite its point of origin (see figure 1). Groundwater discharge varies greatly with time, with the largest groundwater discharge occurring during periods of low stream levels. The model was shown to reproduce field data very well, leading to confidence in results. The model showed that stream monitoring data must be interpreted very carefully to avoid mistakes in risk assessments.

Models are shown to be very useful for designing field campaigns and for interpreting monitoring results. Groundwater discharge to streams varied greatly with location, depth and time. It is important to carefully analyse contaminant discharge data to streams, for example it is easy to mistakenly assume that groundwater originates from the area on the same side as a given stream bank, while it may come from an area on the opposite side of the stream.

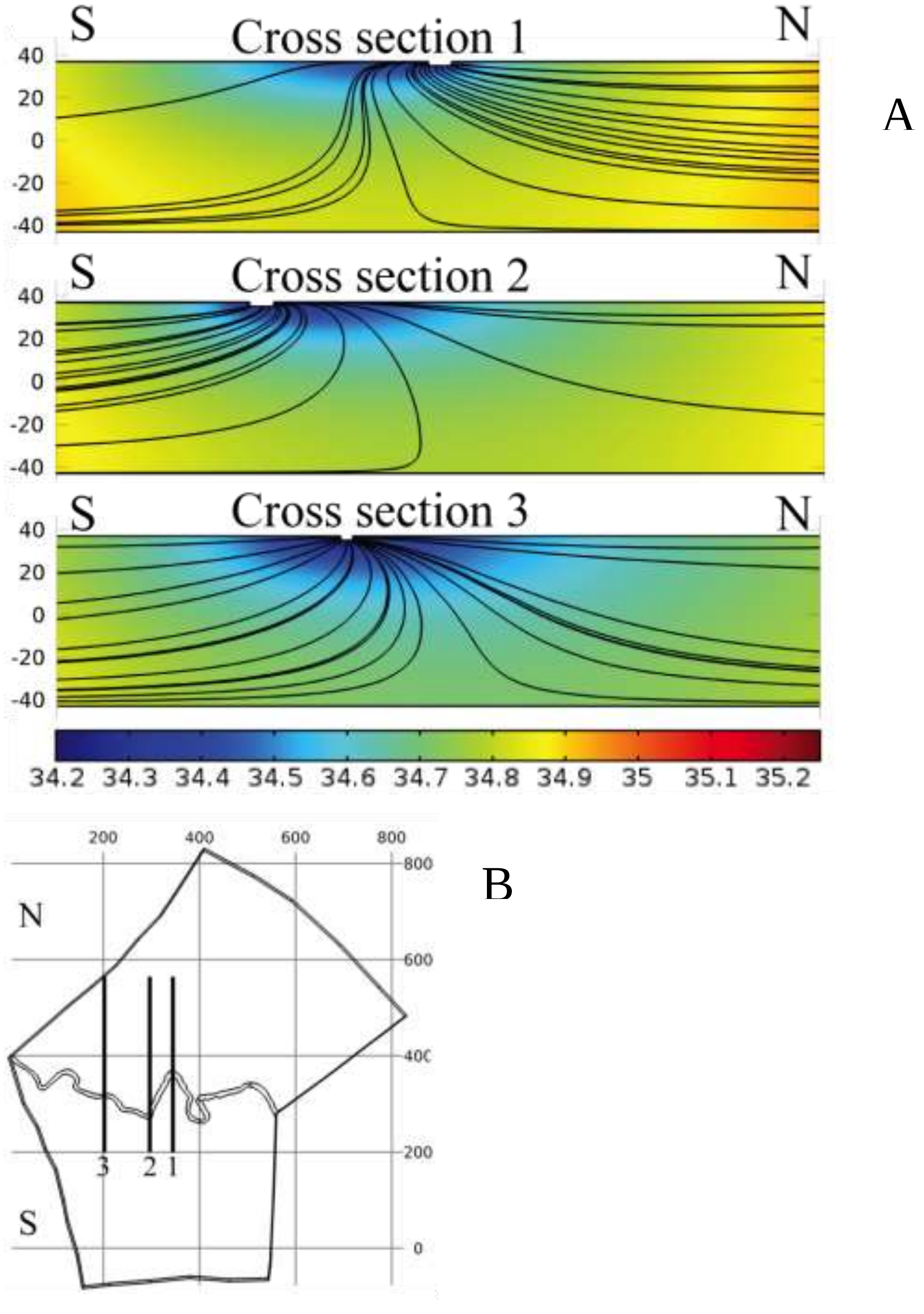

Figure 1: Cross sections of Grindsted Å (Panel A), showing modelled head (m) and groundwater streamlines toward the stream. Panel B shows the location of the cross sections. As can be seen in cross section 1, most of the water discharging to the stream comes from the area north of the stream. In contrast, groundwater water flowing to the stream at cross section 2 comes from the south.