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Review of article

Anonymous Referee #2

Referee comment on "The influence of hyporheic fluxes on regional groundwater discharge zones" by Brian Babak Mojarrad et al., Hydrol. Earth Syst. Sci. Discuss., <https://doi.org/10.5194/hess-2021-148-RC2>, 2021

Review Hess hyporheic fluxes

General discussion of the content of the paper **"The influence of hyporheic fluxes on regional groundwater discharge zones"**

The paper "The influence of hyporheic fluxes on regional groundwater discharge zones" submitted to HESS by Mojarrad et al. investigates different scale flow systems by means of topographically induced groundwater circulation and the role of hyporheic flow on groundwater circulation in the river valleys. The flow systems are discussed in relation to possible accumulation of radioactive waste originating from deeper aquifer regions within the Quaternary deposits; by differentiating between re- and discharge zones.

I think that the approach, of the influence of topography on the distribution of hydraulic potential in different scales is interesting. The extent to which the link of deep groundwater circulation with the potential field of the hyporheic interstitial can be easily connected would have to be discussed in more depth, especially by delving into the processes that can also influence the potential fields at different scales.

The concept underlying the work is not new and it is surprising that the authors do not mention the fundamental work of J. Toth.

The authors cite the work of W. Zijl, who, through a Fourier analysis and consideration of the anisotropy of the geologic sequences, or important boundaries, such as the topography of the bedrock surface, or different structural properties of the bedrock, determine a series of flow cells. A reduction to two or three as proposed in this paper is probably too simplified. Thus, I would find it justified for the authors to emphasize the

conceptual aspect of the work and to discuss the role of influence of topography of the river bed (i.e., the river corridor concept of Stanford and Ward), the influence of heterogeneity of the geological sequence, the role of the relative water flux contributions etc.).

Based on the work (concept) of Toth, it is not surprising that the drainage system can correspond to the exfiltration zones.

However, there are other aspects to be considered:

The River corridor concept of Stanford and Ward, shows that the topography of the riverbed and the topography of an impounding layer (can be e.g. glacial deposits, bedrock surface or discontinuities of the gradient of the riverbed along a river course) produce infiltration and exfiltration zones within the hyporheic interstitial, which can be very dominant with respect to water fluxes.

I do not know the glacial sediments of the area, but I suspect that because of the diversity of processes, heterogeneities in these deposits also lead to vertical hydraulic gradients that could significantly affect the simple potential distribution.

The structural heterogeneity of the bedrock and the character of the hydraulically relevant structures of the subsurface (shear zones, fracture patterns, etc.) can also significantly affect the anisotropy of the hydraulic conductivities, so that over long geologic times the pattern of the exfiltration zones is also not necessarily uniformly distributed along the drainage system.

The concept depth decaying hydraulic conductivity has to be approved by regional specific data. Other, more complex heterogeneity development with depth could have a strong influence on the Potential distribution.

A much more important point influencing the regional flow systems over longer times periods (transport of radionuclides from certain depths of the bedrock) is the dynamics of the development of the topography. Please discuss, how topography was shaped during the last 15'000 years. Over long time periods, topography cannot be assumed to constant.

I think the paper could benefit from a more in-depth discussion. In its current form, the argumentation is a bit too simplistic.

Some general comments:

- Although the character of the model is mostly conceptual the authors state that results from intense field investigations exist. Nevertheless, nearly none of these existing data are specified or used for calibration and/or validation of the model (i.e. character of the hyporheic zone, heterogeneity character of the glacial deposits).

-For seven different soil types in the Krycklan catchment hydraulic conductivity was obtained. A sensitivity analysis for hydraulic conductivity of streambed sediment would be interesting.

- Provide a more quantitative of visualization of discharge locations (Fig. 1), e.g. by means of point densities. Likewise, an illustration with the "pinholes" of groundwater discharge and/or "nested" flow cells (maybe for a zoom) would also help to understand the different flow processes.

- How was the catchment area delineated (surface?). And is this approach appropriate when evaluating the deep aquifer, when the shape of the topography changed over the last 15'000 years? A 3D visualization would help to better understand the geological settings in relation to the topography.

- Some repetitions could be avoided, like e.g. Software use.

Some specific comments:

- 29: Definition of "long-term"
- 54: This strongly depends on the geology which means that without a regional geological model a detailed statement due to deep groundwater discharge zones remain fragmentary
- 66: please add References of S. Todd
- 84: the history of the hydrology at different time scales will also influence the contribution of water from different flow systems in the exfiltration zones.
- 82: I cannot find information on geological heterogeneity

- 86: Darcy's law should be known to the readership?
- 103: Missing specific information on the time scale and the rates of considered processes
- 118: There should be drillings for geological information's. A corresponding map and a stratigraphic-lithologic overview, allowing to evaluate the degree of vertical variability of hydraulic properties is missing.
- 122: a sedimentological description of the glacial sediments would allow a better info on heterogeneity, till comprises a lot of different glacial sediment types
- 134: There is no information about the geometric extension of the model and why was Comsol chosen for such a simple model of the geological setting and not modflow, feflow or any groundwater affine software?
- 137: The presented material does not allow this simplification, which project data support the statements of the cited publications?

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l.158: The information of the mesh sizes should be expanded with the number and delaunay quality of elements

- 175: DT has not been introduced
- 178: give a reference to the particle tracing routine used

l 181: One of the described aims in the introduction is the influence of radionuclide spreading for humans and biota. With a residence time of 320 million years it would be hard to make any predictions at all? A cumulative curve from particles reaching the surface over time could be more detailed.

At the long time scale the topography has changed and as a result the flow field also would have changed,

- 219-220: Specify "other models and statistical uncertainties"
- 239: Correct "Monte Carla"
- 335: Can you better explain the role of the Froude number on the dynamic head component?
- 348-350: Why you mention this? Is it not expected?
- 495: In the long time, changes of the Surface and streambed morphology is expected, therefore it is not clear how these changes interfere with the flow field in the deeper deposits (Quaternary and bedrock).

L 510 and following lines: Do you take into account structural aspects of the

heterogeneity in the bedrock, such as heterogeneity due to shear zones , mylonites etc.

Figures:

Integrate Figures 1 & 2

4: Up-date: Northing? Points instead of stars?

Figure 9: Correct catchemnt