Investigating the hydraulic disconnection of leaky pipes from the groundwater

A leaky sewer pipe infrastructure in an urban environment is connected to a range of problems, such as soil and groundwater contamination (DeSilva et al., 2005) or significant changes in urban hydrology (Lerner, 1986). A general understanding of the sewer leakage process is required to mitigate those problems.

It was recently found that leaky sewer pipes hydraulically disconnect from groundwater (Peche et al., 2017; Nguyen et al., 2021), leading to a convergence of the exfiltration rate towards a constant value with decreasing groundwater levels. This is due to a significant decrease in relative hydraulic conductivity, which, from a certain distance of pipe defect to groundwater table, is dominating the flow rates. That distance (it may be called disconnection depth) is not well studied in literature. Knowledge about that depth may simplify the calculation of exfiltration rates significantly, because subsurface conditions are irrelevant to flow and exfiltration rates merely depend on pipe water level (assuming colmation layer properties (see Ellis et al., 2009) are constant).

The present Master thesis will study the above described disconnection depth numerically using a simulator such as HYDRUS (Šimůnek et al., 2016) or OpenGeoSys (Kolditz et al., 2012). The candidate will set up a simplified model of a single defect sewer embedded within a variably saturated subsurface. The candidate will then determine disconnection depths for a range of model cases, varying a set of parameters which is still to be determined (e.g. distance of groundwater to leaky pipe, different properties of the subsurface/different soils, different pipe water levels, different colmation layer properties). Goal of the present study is a lookup table/mathematical criterion providing disconnection depths for different soil types, colmation layer properties and pipe water levels.

We are looking for a motivated candidate with experience in numerical modelling and with basic knowledge about water flow in the (saturated & unsaturated) underground. A basic knowledge in programming (Python) would be of help. We offer the candidate a collaboration with a Federal Institute and the supervision by motivated, experienced personnel.

Supervisors (BGR): Fritz Kalwa, Aaron Peche (Kontakt: aaron.peche@bgr.de)

Examiner (ISU, LUH): Thomas Graf

Literature (used above and additional topic related literature):

DeSilva, D., Burn, S., Tjandraatmadja, G., Moglia, M., Davis, P., Wolf, L., ... & Hafskjold, L. (2005). Sustainable management of leakage from wastewater pipelines. *Water science and technology*, *52*(12), 189-198.

Karpf, C., Traenckner, J., & Krebs, P. (2009). Hydraulic modelling of sewage exfiltration. *Water Science and Technology*, *59*(8), 1559-1565.

Kolditz, O., Bauer, S., Bilke, L., Böttcher, N., Delfs, J. O., Fischer, T., ... & Zehner, B. (2012). OpenGeoSys: an open-source initiative for numerical simulation of thermo-hydro-mechanical/chemical (THM/C) processes in porous media. *Environmental Earth Sciences*, *67*, 589-599.

Lerner, D. N. (1986). Leaking pipes recharge ground water. *Groundwater*, *24*(5), 654-662.
Nguyen, H. H., Peche, A., & Venohr, M. (2021). Modelling of sewer exfiltration to groundwater in urban wastewater systems: A critical review. *Journal of Hydrology*, *596*, 126130.
Peche, A., Graf, T., Fuchs, L., & Neuweiler, I. (2017). A coupled approach for the three-dimensional simulation of pipe leakage in variably saturated soil. *Journal of Hydrology*, *555*, 569-585.
Peche, A. (2019). *Numerical modeling of pipe leakage in variably saturated soil*. Hannover: Institut für Strömungsmechanik und Umweltphysik im Bauwesen der Leibniz Universität Hannover.
Šimůnek, J., Van Genuchten, M. T., & Šejna, M. (2016). Recent developments and applications of the HYDRUS computer software packages. *Vadose Zone Journal*, *15*(7).