Geophysical Research Abstracts
Vol. 16, EGU2014-1946, 2014
EGU General Assembly 2014

The validity of the linear-reservoir approximation for various aquifers.

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Aquifers discharging in streams are often modelled as linear reservoirs. A survey of existing solutions explored if this approach has support in groundwater theory. Literature reports based on numerical solutions show that sloping aquifers do not behave linearly. For horizontal aquifers, an analytical solution for the case with the stream water level close to the aquifer bottom can be shown to produce a second-order reservoir. A recent analytical solution for an aquifer of constant thickness (stream water close to the aquifer top) shows that such aquifers can behave like linear reservoirs when the recharge and the stream water level are constant long enough. If the aquifer is leaky, the exponential recession typical for a linear reservoir is superimposed on a constant baseflow.
Analytical expressions for the discharge-storage relationships are presented. They are used to demonstrate the consequences of incorrectly assuming recharge to be zero.
The characteristic time of the aquifer increases with the square of the aquifer size (distance between the water divide and the stream). Fields with drains or ditches spaced a few tens of meters have characteristic times in the order of a week. Aquifers drained by rivers spaced several kilometers apart can have characteristic times of decades or centuries. The analytical solution shows that the surface water level needs to be constant for about two characteristic times and recharge for about 8 characteristic times before the aquifer behaves like a linear reservoir. In conceptual catchment models, the excess outflow before that time is typically attributed to a separate fast-response reservoir.