Using chemistry to measure river bank storage

National Centre for Groundwater Research and Training

This publication introduces a new method for investigating whether, during floods, river water is pushed into the river bank, and if so, how far it travels into the adjacent aquifer. This has important implications for water management.

BANK STORAGE BACKGROUND

Bank storage occurs during flooding. As the water level in the river rises, it becomes higher than the surrounding water table. The river water then pushes into the river banks where it is temporarily stored.

This has a couple of implications. Firstly, it reduces the amount of water in the river during flooding, so it dampens flood peaks. Secondly, because floods are transient, when the river level subsides back below the water table, the water that was pushed into the banks slowly trickles back into the river. This slow release of water is often thought to maintain the flow of rivers over drier periods.

Traditionally, we have thought of surface water and groundwater as quite separate, and they have been managed as such. Sometimes this leads to water being measured twice, which can mean that water is allocated to users twice; this contributes to the overuse of our water resources.

This is the driver for much of the NCGRT's research; that is, how can we separate the ways that we are measuring these different types of water? One way of doing that is knowing things like how far river water travels into river banks during floods.

TRADITIONAL METHODS OF MEASURING BANK STORAGE

The simplest (and most common) way to work out if bank storage is occurring is to monitor the water level in the river, and the water level in the adjacent aquifer (i.e. the water table). When the river level is higher than the groundwater, you can assume that water is flowing through the river bank into the aquifer, and vice versa.

However, this doesn't provide any information on how far river water is actually moving into the aquifer. That is, if you monitor the water table level some distance from the river, and find that it is rising following a flood, this doesn't necessarily mean that river water is reaching that location. River water may well be pushing into the aquifer, but it may simply displace the existing groundwater close to the river, thereby forcing the water table to rise some distance away.

A NEW APPROACH

Currently, the NCGRT is looking for new and improved ways to measure the movement of water between the ground and the surface.

NCGRT researcher Chani Welch has been tackling this problem as part of her PhD. Her new approach involves measuring not just river and groundwater levels, but also measuring the changing chemical makeup of the water in aquifers during floods.

TESTING THE THEORY

The first step was testing the theory using a computer model (or simulation) of a homogenous aquifer system. This allowed researchers to estimate how far into the aquifer water would move in an ideal scenario.

Using a field site on the Cockburn River in northern New South Wales, researchers gathered information to further test this new approach.

They used a series of piezometers installed by the NSW Office of Water. In each of the piezometers and in the river they installed loggers which record both the level and the and the electrical conductivity of the water (an indicator of salt content) every 15 minutes. A drop in groundwater salinity indicates the time at which the river water actually reaches the piezometer, and dilutes the more saline groundwater. Movement

Want to know more?

The journal paper describing this research is:
Welch, C, Cook, PG, Harrington GA, Robinson, NI, in press, 'Propagation of solutes and pressure into aquifers following river stage rise', *Water Resources Research*. DOI: 10.1002/wrcr.20408

To learn more about bank storage in general, the USGS publication *Ground water and surface water: a single resource* may be useful, in particular pages 9–17. It may be viewed at http://pubs.usgs.gov/circ/circ1139/#pdf of river water into the river bank would be indicated by both a rise in the water table and a decrease in the groundwater salinity as river water is usually fresher than the groundwater around it.

Once the data was collected, they saw that, during floods, the water level in the river rises quickly, followed closely by a rise in the water table. However, it takes some time for the groundwater salt concentration to drop.

At the research site on the Cockburn River, it took around ten times longer for the salt concentrations to change than for the groundwater level alone to change.

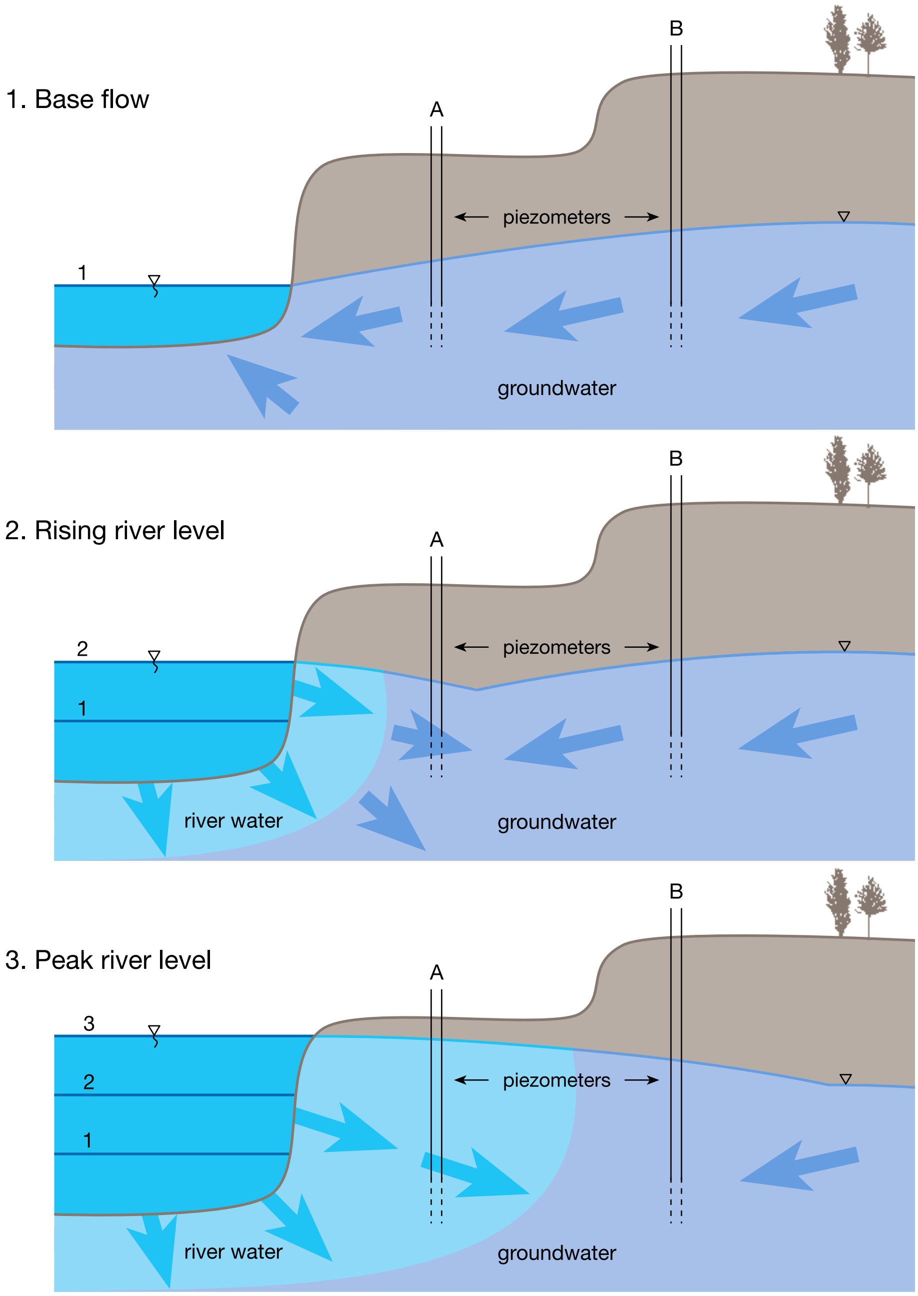
For the first time, theoretical relationships have been developed (in the form of mathematical equations) that relate the time it takes for river water to move into an aquifer to aquifer characteristics, changes in groundwater salinity, and the height of the flood wave. Knowing these relationships can help us find out how far the river water moves into the aquifer.

CONCLUSIONS

Monitoring river and groundwater chemistry provides more information on bank storage processes than just monitoring water levels alone. This work demonstrates that, in an aquifer system like that around the Cockburn River, the ground water level changes faster than the groundwater chemistry does.

This method could be applied to other locations. Moreover, how long it would take river water to reach a certain point in an aquifer could be calculated, if enough is known about local conditions.

This new method may be particularly useful in situations where there is concern about possible contamination between river and aquifer.



1. Under normal conditions, groundwater seeps into the river.
2. When the river level rises, the river water begins to push into the river bank. This pushes out the groundwater, and the water level in the bore marked A rises. However, the salinity at bore A has not changed because the river water has not moved this far.
3. When the river level is very high, and has been for a period of time, the water level in both bores A and B has risen, and the salinity measured in bore A has decreased as the river water has now travelled this far and is mixing with and diluting the groundwater at this location. The salinity level in bore B has not yet changed.

CONTACT US

Call: 08 8201 2193
Fax: 08 8201 7906
Email: enquiries@groundwater.com.au
Web: www.groundwater.com.au
Mail: NCGRT, Flinders University, GPO Box 2100, Adelaide SA 5001

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