Seawater intrusion

NATIONAL CENTRE FOR GROUNDWATER RESEARCH AND TRAINING

This resource introduces the concept of seawater intrusion, which is a natural process, but one that can be exacerbated by human activitiy. Seawater intrusion can cause salty seawater to contaminate coastal or inland bores, rendering them unusable. This factsheet also describes some of the research that NCGRT scientists are doing in this area.

'NATURAL' SEAWATER INTRUSION

Aquifers near the coast are normally partially filled with seawater. It is very common to find that seawater intrudes in a 'wedge' shape along the bottom of a coastal aquifer. We can think of this as 'natural' seawater intrusion. This happens primarily because seawater is denser than freshwater, and so a column of seawater exerts a higher pressure than a column of freshwater of the same height.

Under natural conditions, seawater intrusion is also affected by the tides. The tides change the shape of the wedge and can also cause a wider mixing zone between the intruded seawater and the freshwater. In many coastal aquifers the wedge is not in equilibrium with the present coastline position but is still responding to past sea-level change.

This natural process is shown in the first diagram overleaf.

THINGS CHANGE...

In the modern world, human activity often causes major changes. Seawater intrusion is usually caused (or exacerbated) by pumping groundwater from aquifers along the coastline.

In Australia, the majority of the population is spread along the coastline. Bores are drilled to provide residents, farmers and industries with freshwater, but in pumping from an aquifer near the coast, fresh groundwater is sometimes partially replaced by seawater which is drawn into the aquifer, usually by a drop in pressure caused by pumping.

Human-induced seawater intrusion is depicted on the second diagram overleaf.

...CREATING PROBLEMS

Seawater intrusion is a major problem in many parts of the world, and indeed Australia.

If the seawater intrudes far enough inland, it can reach bores, making the water too salty to be usable. Bores are usually very expensive to drill – abandoning them to seawater intrusion is a major problem, particularly if there are lots of people in the area relying on fresh groundwater. Remediation of aquifers affected by seawater intrusion is extremely difficult and costly, or can take decades to centuries.

OUR RESEARCH

Seawater intrusion processes are extremely complex – affected by many factors, including the geology of the aquifer, the tides, sea-level change, weather, land-use change, and the rate of pumping from bores – and are difficult and expensive to measure or predict.

Seawater intrusion is a research focus at the National Centre for Groundwater Research and Training. A number of our researchers, primarily based at Flinders University in Adelaide, South Australia, are working on a variety of projects. Two of these projects are described as follows.

PROJECT 1

The NCGRT explored seawater intrusion in the Willunga Basin, South Australia's McLaren Vale wine region. This work showed how real-life seawater intrusion is often much more complicated than in theory.

Many coastal aquifers respond slowly to changes in the environment, and some aquifers are still adjusting to the rise in sea level that started 20,000 years ago, when sea levels were approximately 120

Want to know more?

The National Water Commission report described in Project 2 overleaf, National-scale vulnerability assessment of seawater intrusion: summary report, may be found at: http://www.nwc.gov.au/__data/assets/pdf_file/0014/23162/85-Seawater-intrusion.pdf

Werner AD, Jacobsen PE, Morgan LK, 2013, Understanding seawater intrusion. [Poster]. Earth Sciences collection, http://hdl.handle.net/2328/26647. Flinders Academic Commons, Adelaide, South Australia.

m lower than they are today.

In South Australia that means that the coastline was much further out, and where the beach is today, there might have been an outback-like landscape as far as the eye could see.

By drilling a series of bores, NCGRT researchers were able to get a very accurate idea of the below-ground salinity distribution in the area. They were amazed to find that the water in the very bottom of the Port Willunga formation – an 80 m thick aquifer – is twice as sality as seawater, right at the coast!

While they do not know for sure how this could be, they hypothesise that this could be the legacy of a salt lake that once existed in the area, or as a result of native vegetation using a lot of the rain and groundwater, and leaving the remaining salt behind in higher concentrations, just like what is happening in the heart of Australia today.

Research is continuing to discover whether this finding is isolated or occurs across the South Australian coastline. This is important information, as it shows that drawing saline water from a bore may not necessarily indicate that seawater intrusion from modern seawater is currently occurring.

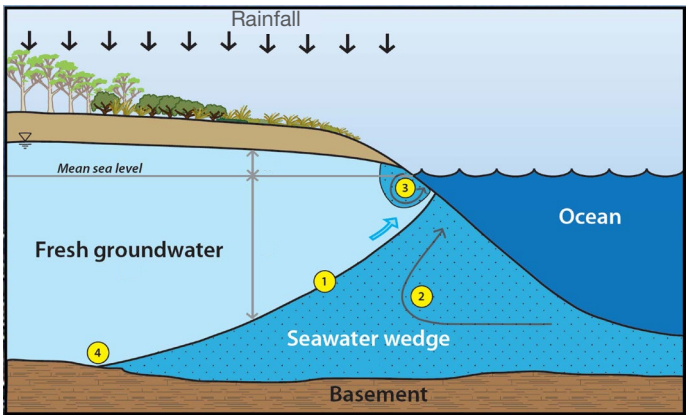
PROJECT 2

Researchers from NCGRT and Geoscience Australia undertook a major project mapping the vulnerability of Australia's coastal aquifers to seawater intrusion.

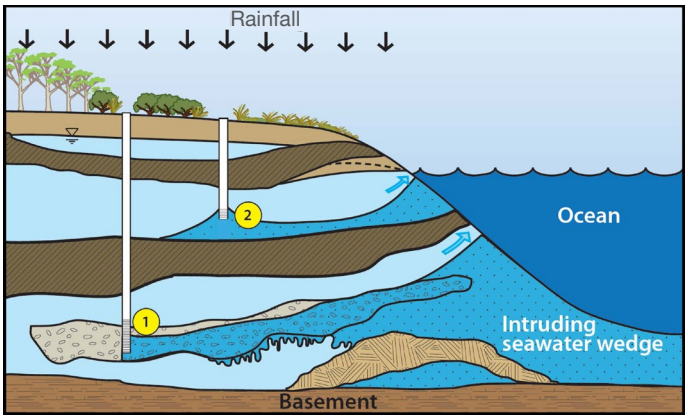
The group developed a new, low-cost and easy way to calculate if a coastal aquifer is at risk of seawater intrusion. This approach can give a useful early indication of aquifer vulnerability, and may help coastal communities to implement monitoring programs, or to adjust their groundwater pumping regimes to minimise the risk of seawater intrusion occurring.

The group also found that coastline aquifer vulnerability in general is likely to increase due to the sea-level rises and increase in storm surges anticipated under climate change.

Among the communities found to be highly vulnerable to seawater intrusion were areas of Perth and Adelaide, as well as regional towns such as Exmouth, Derby, Bunbury and Esperance in WA, the Eyre Pensinsula in SA, Port Phillip Bay in Victoria, and the Burdekin and Bowen areas of Queensland.



The image above shows the natural equilibrium of seawater and groundwater in an undisturbed system. Figure (1) marks the interface between seawater and groundwater; (2) shows movement of water affected by density, while (3) is movement driven by the tide. Figure (4) shows the furthest extent of seawater intrusion.



The image above shows seawater intrusion occurring in a more complex aquifer with human activity contributing. The image shows (1) seawater moving preferentially through high-permeability layers in the ground, and (2) excessive pumping drawing seawater upwards, causing the bore to become contaminated.

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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