Deltas in Depth scientific sessions		
Deltas in Depth 3. Governance of adaptation		
DD 3.3 Groundwater, salinity intrusion		
Chair	Prof.dr. Shah Alam Khan, Bangladesh University of Engineering and Technology, Bangladesh	
Presentations	•	PhD Perry de Louw, Deltares, the Netherlands
	•	PhD Holly Michael, University of Delaware, USA
	•	MSc Marloes van Ginkel, Delft University of Technology & Royal HaskoningDHV, the Netherlands
	•	MSc Koen Zuurbier, KWR Watercycle Research Institute, the Netherlands

Saline Seepage in deltaic areas: from problem to solution, PhD Perry de Louw, Deltares, The Netherlands

Groundwater seepage is a problem in many coastal areas. It leads to the salinization of surface water, shallow groundwater and sometimes the root zone. Seepage comes in three forms: paleochannel seepage, diffuse seepage, and boil seepage. Boils are the dominant salinization sources in deep polders. It is due to "upconing" of the salt groundwater; salt water being pushed up from a low-lying aquifer, into the land or water surface, creating the effect of boiling water.

By mapping the boils, salinization can be monitored and protective actions can be taken as increasing the water level to minimize head difference and/or operational salt water management.

Questions:

Would horizontal wells be a solution for water boiling?

Not really, we are thinking about possible solutions but it is complicated to find one.

Vulnerability of groundwater to salinization and the case of the Bengal Delta, dr. Holly Micheal, University of Delaware, United States of America

Three major mechanisms that cause groundwater salinization are: Reduced groundwater recharge, sea level rise (vertical and lateral intrusion), and storm surges (increased frequency and intensity). Various factors determine the vulnerability of a system, how these factors interact and affect the vulnerability is the main research question, followed by a possible classification of these factors to determine the vulnerability of coastal systems.

Two coastal systems can be classified: topography-limited and recharge-limited. These classes form a first indicator of coastal vulnerability. Deltas are generally topography-limited, and highly populated. The Bengal delta is a good example of a topography limited system; it does not have a nice layered ground build up. This geology determines the pattern of lateral intrusion. Human influences accelerate lateral salinization but according to the 2D models used for this study, it does not dominate. Vertical infiltration is of large impact for the vertical infiltration.

The effects of these local system characteristics and developed indicators can be used by the managers working on the assessment of vulnerability of a system to create site-scale impact assessments and the management of pumping to minimize the effects of salinization.

Questions and discussion:

Are you stating that climate change and sea level rise is not as important for salt intrusion in the delta?

For the lateral groundwater intrusion this might be the case, but the frequency of storm surges might increase as well with climate change, leading to more vertical intrusion.

Guiding principles for fresh water lens development: Exploitation and maintenance in artificial islands, MSc Marloes van Ginkel, Delft University of Technology & Royal HaskoningDHV

Underground water storage as ASR (aquifer storage recovery) and MAR (Managed Aquifer Recharge) are coming more in use in the past decades worldwide. It requires minimal land surface, does not attract mosquitos and does not come in contact with sunlight or algae. Artificial islands can profit from the idea; they are constructed of sand, designed from scratch and have low fresh water availability. Designing the perfect conditions for water storage might solve fresh water issues on artificial islands. Two systems were analysed; a closed system and a partly open system, each with respective cons and pros. Artificial islands provide opportunities for water storage.

Questions and discussion:

What would be the option when there are limited resources to construct the island (e.g. remote situations)?

A good assessment can be done by using a cost benefit analyses.

Is this system tested in a real case?

The system is in use for decades, but its practical application and optimization for artificial islands is not tested yet.

Did you consider modelling the layering construction?

Not yet, but this presentation was mainly to show that this is a system that might work, optimization is still an important part of further research.

Sophisticated well configurations to enable aquifer storage and recovery in coastal aquifers, MSc Koen Zuurbier, KWR Watercycle Research Institute

One of the problems with ASR is that fresh water floats on salt water. When recovering the water from the aquifer, the borders will be mixed with the salt water, and the freshwater lens will have moved towards the surface. Horizontal drilling can prove a solution but never will a 100% recovery be reached due to buoyancy and mixing. The Freshmaker is a system of two horizontal drilled wells; a shallow well for infiltration and recovery of freshwater surpluses and a deeper well to remove salt water and prevent upconing. Other ways to increase fresh water recovery is the ASR coastal system that uses wells at different depths. The future of these systems depends on further valorisation, optimization, replication, automation, regulation, and sharing knowledge.

Questions:

Multiple vertical wells; Can you install them in one borehole?

Yes, this was an important constraint during the design of this system.

Vertical wells; how important is regional flow?

Regional flow is very important. When choosing for such a system you should always aim for stagnant flow areas. Lateral drift will be of large influence.

What are you injecting?

In green house areas it will be rain water from the rooftops. The Freshmaker uses winter flush of the system.

Infiltration via the deeper filters; how much do the impermeable clay layers affect the system?

You can prevent a lot with installing two or three wells. It is important no not loose the flexibility of the system.

Discussion:

In regard to the last presentation; do you think any clogging like chemical clogging can be a problem?

In both systems there is no source for mechanical clogging due to filters. The ASR coastal has no microbial clogging because the rain water is relatively fresh.
In case of the Freshmaker surface water is used; containing more organic carbon and microbial contents which could lead to more contamination.
Is storing water on the surface an option?
Any farmer would much rather keep it in the ground and use the free space to build more green houses (Zuurbier).
In regard to the presentation of Holly Micheal;
Which deltas would have a higher vulnerability?
It was not meant to say that lateral intrusion is not important. In Bangladesh the head of the lower aquifer is high enough to make hand wells possible. A motivator was the question how long people can be drinking the deep tube freshwater. Which delta is more vulnerable than the other is something that cannot be concluded from this research.

Holly Micheal: Human impacts might be big. The shrimp farming is increasing regional salinity and introducing salt water into the groundwater, which could look a lot like vertical salt intrusion due to storm surges.