Preparing for a pump/injection test in a coastal area in the Netherlands

determination background variations and local response of groudnwater heads to tides, precipitation, evaporation and surface water levels

Zaadnoordijk, Willem Jan; Booltink, Wim; Oudega, Mathijs; Gunnink, Jan; Bierkens, Marc F.P.

PREPARING FOR A PUMP/INJECTION TEST IN A COASTAL AREA IN THE NETHERLANDS

100 YEARS OF GEOLOGICAL MAPPING

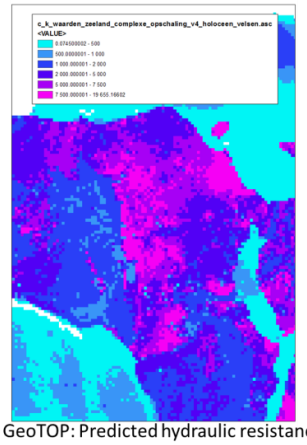
TNO innovation for life

DETERMINATION OF BACKGROUND VARIATIONS AND LOCAL RESPONSE OF GROUND-WATER HEADS TO TIDE, PRECIPITATION, EVAPORATION, AND SURFACE WATER LEVELS

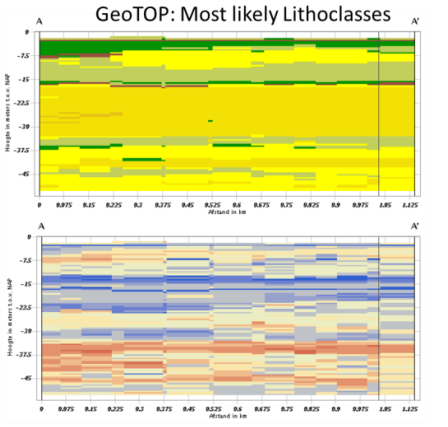
Willem J. Zaadnoordijk[1,2], Wim Booltink[1], Mathijs Oudega[3], Jan Gunnink[1], Marc Bierkens[4]
willem_jan.zaadnoordijk@tno.nl | +31 6 1180 3320 | ORCID: 0000-0001-9739-7582
[1] TNO Geological Survey of the Netherlands, Princetonlaan 6, Utrecht, The Netherlands
[2] Water Resources Section, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Stevinweg 1, Delft, Netherlands
[3] Wiertsema & Partners, Feithspark 6, Tolbert, the Netherlands
[4] Hydrology group, Faculty of Geosciences, Utrecht University, Princetonlaan 8a, Utrecht, the Netherlands

Introduction

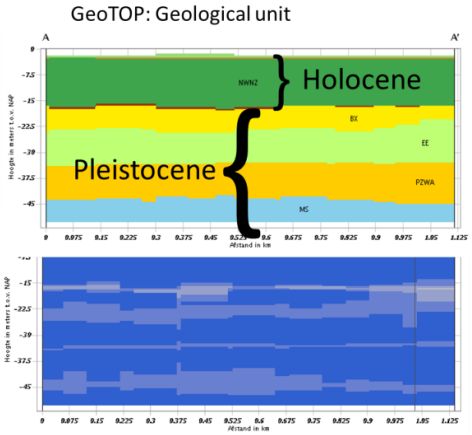
The Geological Survey of the Netherlands (TNO-GSN) provides public subsurface information (http://www.dinoloket.nl), a.o. GeoTOP – a (hydro)geological voxel model of the upper 50 meters. The voxels of 100m x 100m x 0.5m are assigned hydraulic conductivities based on a large collection of laboratory measurements of samples from undisturbed cores. The values are upscaled from laboratory to voxel scale for each combination of geological unit and lithoclass.
The hydraulic parametrization of GeoTOP for the province of Zeeland (TNO-GSN, 2016) resulted in very high resistances of the confining layer covering the main regional aquifer. A pump test has been carried out to validate the high resistance because of its importance for the salinization risk for the shallow groundwater and the increase of this risk due to sea level rise.



GeoTOP: Predicted hydraulic resistance basal Holocene clay layer in days



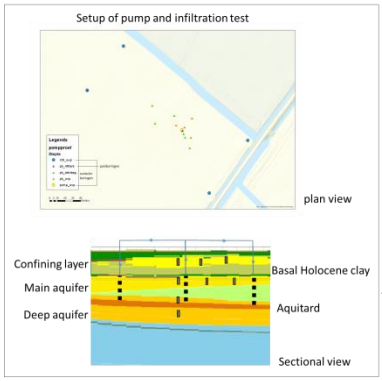
GeoTOP: Reliability of predicted lithoclasses



GeoTOP: reliability of geological unit

Design of pumping test and injection

The field test focussed on the resistance of a basal Holocene clay layer. It consisted of pumping from the aquifer below the clay layer combined with infiltration in various infiltration wells. Due to the injection, the saline pumped water did not need to be discharged on the surface water in the polder. By using 4 infiltration wells the flow patterns could be varied to assess the spatial variability of the hydraulic resistance of the clay layer.



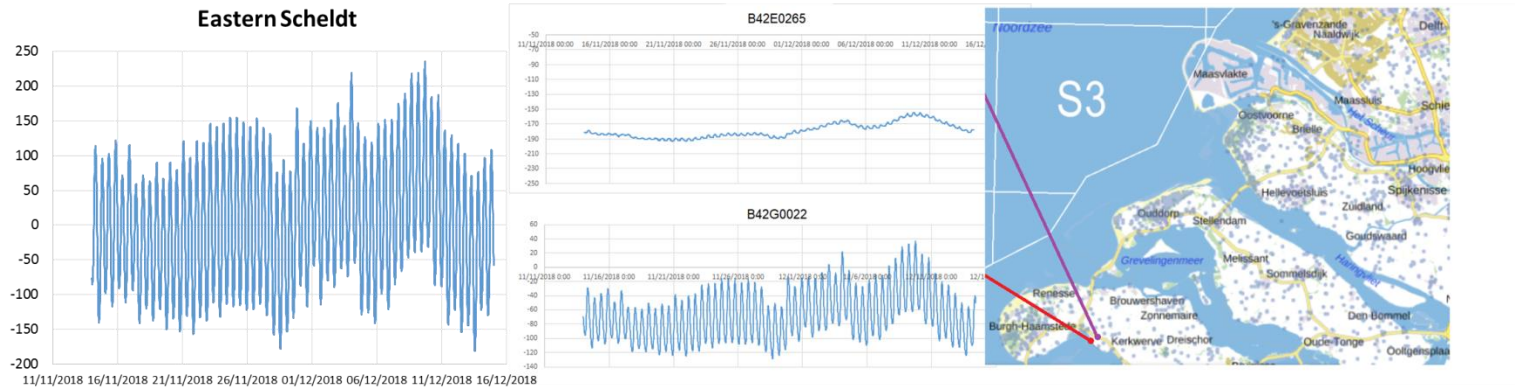
Exploratory model simulations have shown that 1) drawdown above the clay layer is needed for a reliable estimate of the resistance, and 2) only a small drawdown will develop above the clay layer even though the pumping will run for several months. This means that a small drawdown due to the pumping has to be separated from the background influences.

Background monitoring

The main background influences on the groundwater head are precipitation and evapotranspiration and the tide in the Eastern Scheldt. Existing piezometers near the site selected for the pomp test have been equipped with automatic pressure transducers half a year before the start of the test.

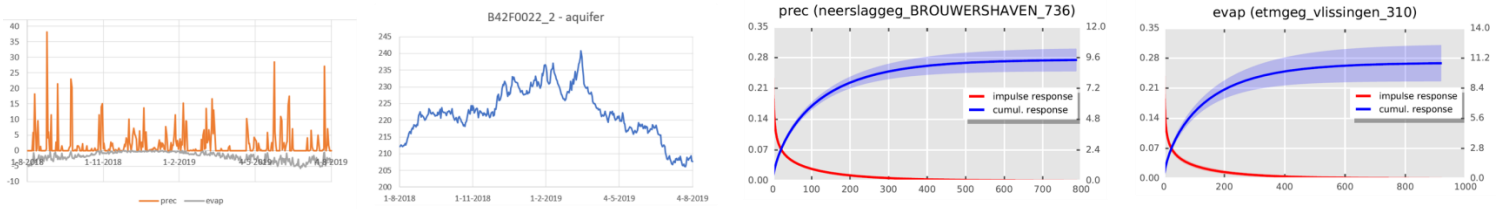
Tidal Influence

The tide in the Eastern Scheldt seems to be completely damped within a few kilometers, so that it can be neglected for the interpretation of the pump test. The damping can be used to give an independent assessment of the properties of the aquifer system (Bakker, 2019).



Influence precipitation and evapotranspiration

Transfer-noise time series modelling of the background heads with external influences is valuable because data from a longer period than the pumping test can be used to establish the relation between external influences and the groundwater heads.



The spread in the background monitoring wells gives information for a larger area than just the test field which is expected to aid the definition of appropriate boundary conditions for the groundwater modeling for the simulation of the pump and injection test and the accurate determination of the hydraulic resisance and its spatial variation.

Conclusions

TNO-GSN and Wiertsema carried out a combined pump and infiltration test which will be used to validate the high resistance predicted in the GeoTOP model for a basal Holocene clay layer in the Southeast of the Netherlands. Due to the small drawdown expected above this layer, it is important to filter out background influences. For this purpose, a South-North transect of existing monitoring wells between the main surface waters (Easter Scheldt estuary and Lake Grevelingen) and two existing monitoring wells East and West of the test site have been equipped with automatic pressure transduces set an a 15 minute interval to detect groundwater head variations due to tide and lake level variations as well as precipitation and evapotranspiration.

The pump test lasted 4 months, and the background monitoring has been started 8 months in advance and is still continued. This improves the assessment of the background variations and thereby the accuracy of the hydraulic resistance of the basal Holocene clay and its variation at the scale of the site.

References

Bakker, M. (2019). Analytic solutions for tidal propagation in multilayer coastal aquifers. Water Resources Research, 55. https://doi.org/10.1029/2019WR024757

TNO-GSN (2019) https://www.grondwatertools.nl/grondwatertools-viewer (in Dutch) TNO Geological Survey of the Netherlands (accessed 15 September 2019).

TNO-GSN (2016) hydraulic parametrization of GeoTOP Zeeland, TNO Geological Survey of the Netherlands, Utrecht, Netherlands.

Zaadnoordijk, W.J., and M. Bakker (2013) Application of Spatial Time-Series Analysis to Determine Calibration Targets for Transient Groundwater Models, MODFLOW & More 2013, IGWMC., Golden, Colorado, USA.

Zaadnoordijk, Willem J., Stefanie A.R. Bus, Aris Lourens, and Wilbert L. Berendrecht (2018) Automated Time Series Modeling for Piezometers in the National Database of the Netherlands, Groundwater, https://onlinelibrary.wiley.com/doi/epdf/10.1111/gwat.12819

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 731166