Impact of shale gas production on water resources in Noord Brabant, the Netherlands

Topic category: Water Resources

B.W. Raterman, MSc & D.G. Cirkel, PhD[1]
[1] KWR Watercycle Research Institute, Postbus 1072, 3430 BB Nieuwegein, The Netherlands,
bernard.raterman@kwrwater.nl

Abstract
The possible future exploration and production of shale gas in the province of Noord Brabant may have a considerable effect on water resources and therefore has to be studied. This study shows that the yearly water demand for drilling and fracking ranges from 0.58 to 1.35 Mm3/y. This is comparable to a major industrial water extraction. This amount cannot be supplied by local water distribution networks unless major adaptations are done. Also local surface water resources are insufficient, especially in the summer months. The vast amount of wastewater which is produced during the drilling and fracking will probably have a high salinity. Assuming a high salinity, the wastewater cannot be treated by the existing municipal wastewater treatment plants (WWTP) in the area or discharged in local surface waters. According to current Dutch mining regulations it is also not possible to inject the waste water in the deep subsurface. The only option is therefore special wastewater treatment and extensive water reuse. Eventually rest products (brine) will have to be transported and, if possible from an ecological standpoint, discharged into the sea.

Introduction
In order to guarantee the availability of safe drinking water in the Netherlands, groundwater sources need to be protected. New activities in the subsurface need careful consideration because of the possible impact on the groundwater quality and availability. The possible future exploration and production of shale gas in the province of Noord Brabant may have a considerable effect on water resources and therefore has to be studied. The main purpose of this study is to assess both the water demand during drilling and fracking stages and wastewater production during shale gas production from the Posidonia Shale Formation (Lower Jurassic) in Noord Brabant. An inventory of water resources has been carried out. Also the main options for the disposal or treatment of wastewater have been outlined.

Methods
Because only limited information from deep (> 2000 m) boreholes are available the assessment is based on scenarios developed in a previous stage by the Dutch Ministry of Economic Affairs.
Based on the spatial distribution of so called ‘sweet spots’ within mature shale layers (see Figure 1), geological fault patterns and estimations of development rates, a long term 49-years forecast of water demand and wastewater production can be made. To achieve this, a geodatabase is designed to hold the spatial and temporal data. Using ArcGIS 10.1, Spatial Analyst and the ModelBuilder functionality a set of tools is designed to model the spatial and temporal distribution of well fields for the production of shale gas in Noord Brabant. Using index numbers from literature, the water demand and wastewater production can be determined.

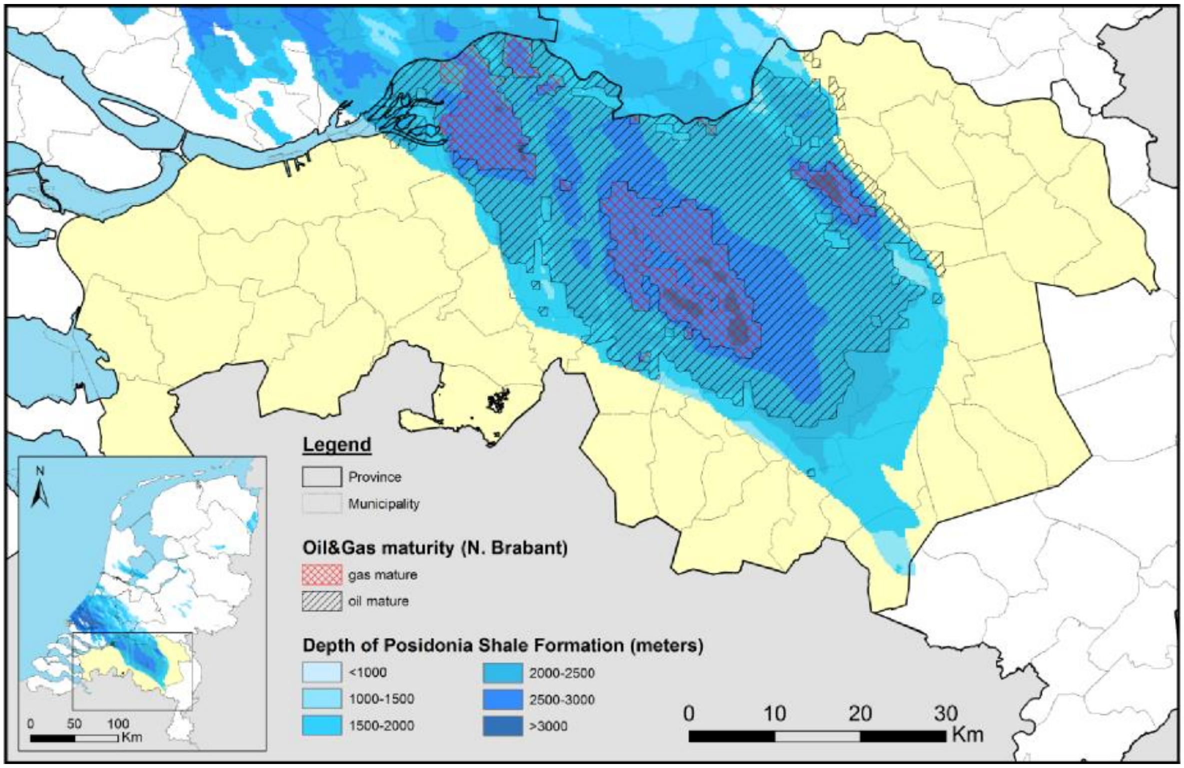

Figure 1 Maturity and depth of the Posidonia Shale Formation in the Province of Noord Brabant in The Netherlands (van Bergen et.al. 2013).

The inventory of water resources is based on recent information from both the local water company Brabant Water, local water boards and the province of Noord Brabant. Options for wastewater disposal or treatment are drawn from literature.

Results

The results are clearly presented in the form of maps, graphs and video animations in ArcGIS showing the development on a yearly basis over a period of 49 years. The results of the study show that the water demand is only a small portion (0.39%) of the total yearly drinking water production in the study area and is comparable to the yearly abstraction of a large industrial water user.

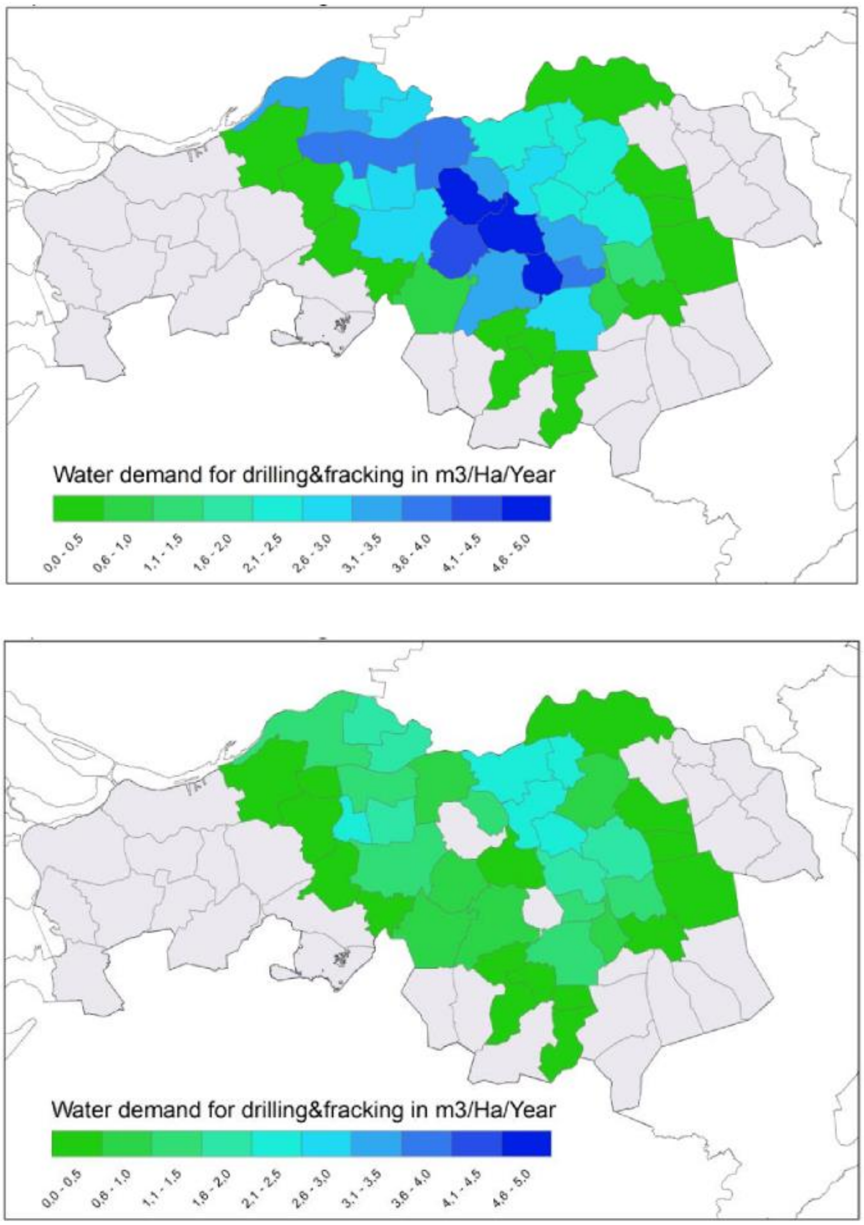

Figure 2 Water demand during the development of production sites of shale gas in the first period (top, year 0 – 16) and second period (bottom, year 17-33).

The 49-years forecast for water demand is based on the up scaling of earlier studies by Halliburton (2011) and Godderij et al. (2014). In the first 33 years, shale gas production sites will be developed by drilling and fracking. From year 1 through 16 the water demand is approximately 1.35Mm^3 per year. From year 17 through 33 the water demand will be less, 0.58 Mm^3 per year (see Figure 2). The water demand has been compared to the regional water resources, i.e. drinking water from groundwater sources, surface water and WWTP effluent (Figure 3). During winter surface water is available but in the summer this will be insufficient. Due to the effects of climate change it is projected that there will even be more frequent and intensive shortages of surface water in the future. Because of the dense drinking water distribution network, this water source may be appealing to oil and gas companies. However, this study shows that drinking water supply cannot be guaranteed during high peak demands. Also in most of the foreseen shale gas production areas the sustainable capacity of the groundwater abstraction plants is insufficient.

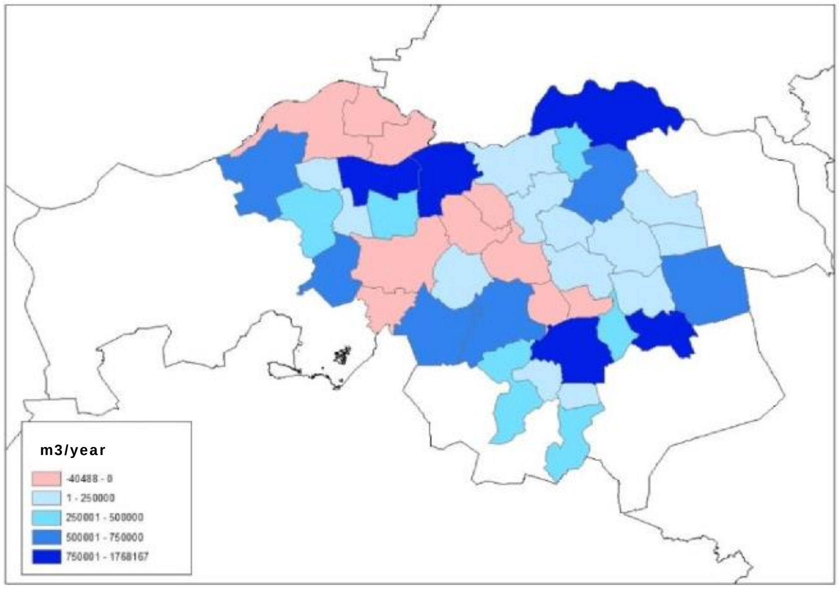

Figure 3 Potential water shortages (light red) per municipality in m^3/year during the first development period (year 0-16)

During and after development of the production sites solid and liquid waste will be produced. The total amount of drill cuttings is estimated at 340.000 to 460.000 m3. This solid waste needs to be transported, treated and reused if possible. However, some of the cuttings may contain radioactive material or heavy metals limiting the possibilities of reuse.

After fracking a part of the used water flows back to the surface (Lutz et al., 2013). This part is estimated at 15% which amounts to 1.45 Mm^3 during the total construction period in the first 33 years. Depending on the type of fracking technique this amount may be higher, 4.35 Mm^3 in case of a 'slick water' fluid instead of a viscous fluid. Along with the produced gas or oil so called formation water will be produced from the shale. Based on assumptions made by the Dutch Ministry of Economic Affairs (Godderij et al., 2014 and Halliburton, 2011) we estimate a total of 3.6 Mm^3 of formation water during the whole production period of 49 years, see figures 4 and 5 (Cirkel et al., 2014). However, a comparison with actual figures from Pennsylvania shale gas wells (Lutz et al., 2013) indicates that this amount may be higher, up to 34.2 Mm^3 in the same period.

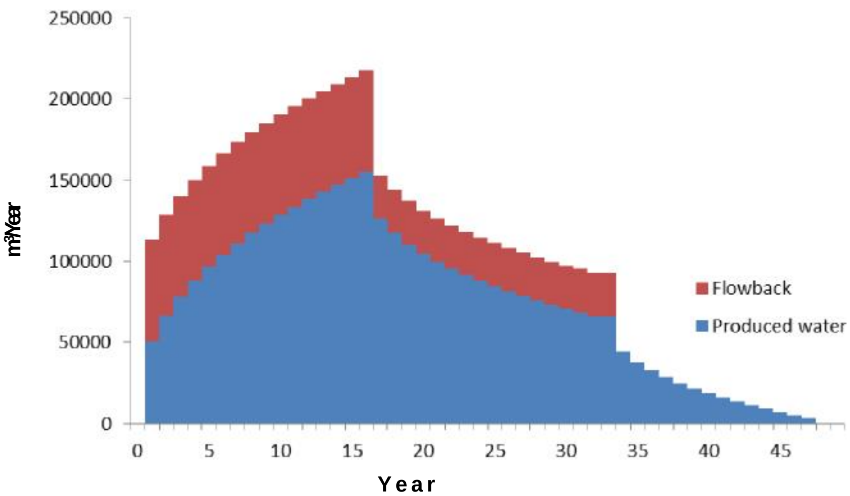

Figure 4 Waste water production at full scale shale gas production in Noord Brabant.

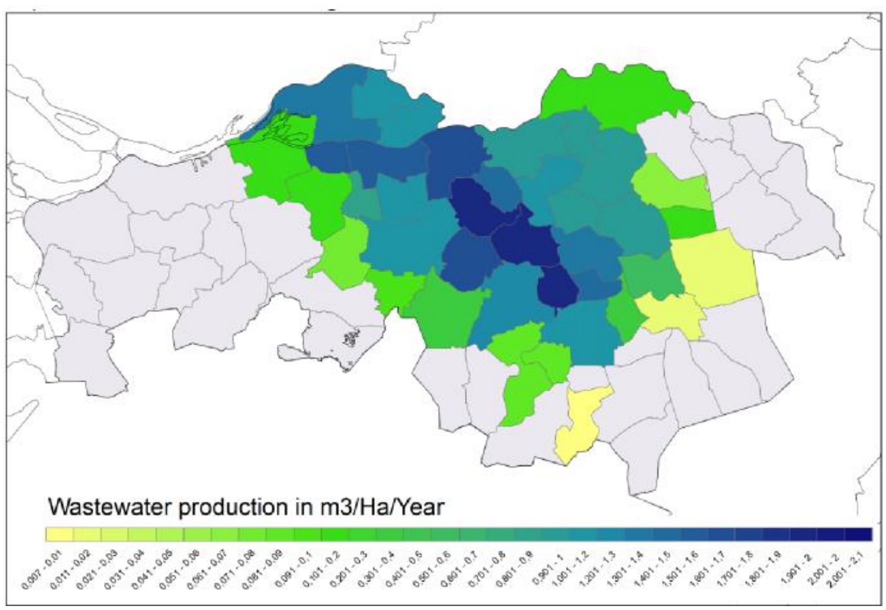

Figure 5 Waste water production (flowback + produced formation water) during year 15 of shale gas development.

The discharge of flowback and formation water in surface waters or treatment by WWTP's is not feasible from an ecological perspective and due to management regulations of the WWTP's. The main concern is the high salinity which is estimated at 55-70 g/l (Verweij, 2003). Deep injection in the subsurface is also not possible due to regulations and possible risks of induced seismicity and leakage. Through new treatment techniques the saline water may be reused for fracking purposes. However, supply and demand will not be equal over time. Eventually rest products (brine) will remain which has to be transported, treated extensively and, if even possible from an ecological standpoint, eventually discharged in the sea.

Conclusions

Using ArcGIS it was possible to model the spatial and temporal distribution of water demand and waste water production related to the possible production of shale gas in Noord Brabant. The possible future exploration and production of shale gas in the province of Noord Brabant may have a considerable effect on water resources. The produced wastewater (with diluted salts, metals, natural radioactive compounds and hydrocarbons) is a potential threat to the environment. Also ground and surface water sources which are used for drinking water production may be at risk. The management of the waste water from possible shale gas production in the future needs to be scrutinized.

References

Cirkel, D.G., Raterman, B.W., Leunk, I. 2014. Waterverbruik en afvalwaterproductie schaliegaswinning Noord Brabant, KWR Water Cycle Research Institute, BTO 2014.033, Nieuwegein.

Godderij, R. et al., 2014. A Conceptual Shale Gas Field Development Plan for the Lower Jurassic Posidonia Shale in The Netherlands. SPE 167796, SPE/EAGE European Unconventional Conference and Exhibition, Vienna, Austria.

Halliburton, 2011. EBN Notional Field Development Plan, final report.

Lutz, B.D., Lewis, A.N., Doyle, M.W., 2013. Generation, transport, and disposal of wastewater associated with Marcellus Shale gas development. Water Resources Research, 49(2): 647-656.

van Bergen, F., Zijp, M., Nelskamp, S., Kombrink, H., 2013. Shale gas evaluation of the Early Jurassic Posidonia Shale Formation and the Carboniferous Epen Formation in the Netherlands. In: Chatellier, J., Jarvie, D. (Eds.), Critical assessment of shale resource plays: AAPG Memoir 103, pp. 1-24.

Verweij, J.M., 2003. Fluid Flow Systems Analysis on Geological Timescales in Onshore and Offshore Netherlands: With Special Reference to the Broad Fourteens Basin. Netherlands Institute of Applied Geoscience TNO, National Geological Survey.