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Transboundary aquifers

title: **Hydrogeological study of a Hungarian-Ukrainian transboundary aquifer**

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In the framework of an EEA Norway grants project involving industrial and scientific partners, complex hydrogeological investigation and groundwater modeling of a regional transboundary aquifer between Hungary and Ukraine were carried out in 2009. This challenging cooperation work was completed by an EU country (Hungary) and a non-EU country (Ukraine). This pilot project demonstrated how the EU Water Framework Directive can be applied for a regional scale transboundary aquifer between Hungary and Ukraine. The transboundary aquifers play significant role in Hungary because the country land is mainly located in a deep and closed basin called Carpathian. 40 from the total 185 groundwater bodies are classified as transboundary in Hungary. The authors of this work were lucky to participate in an earlier NATO Science for Peace Project (Lenart et al., 2003), which investigated a transboundary aquifer between Hungary and Romania some years ago. The experience gained in that project (Dassargues et al., 2004) was utilized by the researchers to conduct the present complex hydrogeological study in a well-organized and efficient way.

In order to achieve the sustainable water management of the investigated internationally shared aquifer (Lenart et al., 2003), the main tasks of the present international project were: a) development of a common hydrogeological data-base; b) additional field measurements; c) interpretation of the geology for a common conceptual hydrogeological approach; d) creating the conceptual flow model of the investigated transboundary aquifer; e) regional scale groundwater modeling; f) model simulation of different scenarios for groundwater management purposes; g) review of the main results obtained from the transboundary approach in the view of the European Water Framework Directive. As one of the main output, a common regional groundwater flow numerical model has been built and calibrated on historical measured field data. It is already and will be in the future very useful for a possible joint management of groundwater resources between Hungary and Ukraine. The derived results allow a better evaluation of groundwater resources and a sustainable management of these resources.

The targeted aquifer, which extends on both sides of the Ukrainian-Hungarian border on 550 km^2 area (see Fig. 1.), supplies drinking water to a population of about 100000 inhabitants in Ukraine and in Hungary.

Figure 1. The area of the investigated transboundary aquifer between Hungary and Ukraine.

The project focused on improving the previous understanding of the groundwater conditions including flow and pollutant transport across many scales, using data acquisition techniques and computer simulation models. On the basis of analysis of the available data (Gogu et al., 2001), new campaigns of field measurements were carried out focusing on the following aspects: piezometric levels or hydraulic heads; pumping tests for hydrodynamic parameters. The priority was given to measurements in areas with low density of observation wells, in order to prepare ideally all the needed data allowing a reliable groundwater modeling.

One of the most important steps in the mathematical modeling was the choice of the conceptual model of the aquifer. By keeping the essential features of the system, a reasonable compromise between the complexity of the multi-layered aquifer and the available reliable data concerning the actual structure and hydrogeological parameters was proposed. The Hungarian and Ukrainian experts agreed on a conceptual model consisting of three Pleistocene aquifer layers. The groundwater flow simulations were carried out with the Processing MOFFLOW Pro program package. As a first step, a steady-state flow model reflecting average conditions were created and calibrated. The calibration results and the simulated heads (see Figure 2.) confirmed the reliability of the conceptual model and the accuracy of the flow model (Szucs et al., 2006).

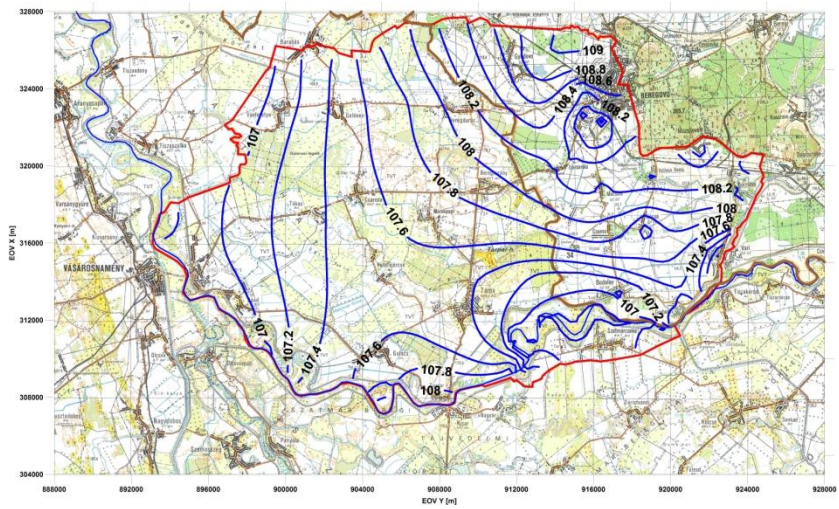

Figure 2. The calibrated hydraulic head map for the transboundary aquifer in case of the steady-state regional groundwater model.

The thickness of the Pleistocene transboundary aquifer is increasing from the Ukraine to Hungary (see Figure 3.). The total thickness of the targeted aquifer can exceed 130 m. A MODFLOW grid system was generated to simulate the hydrodynamic behavior of the groundwater flow systems. Then the boundary conditions were determined for the modeling activity using mainly natural geological and rivers conditions (see Figure 4.). The calibration results of the regional scale flow model were satisfactory. The RMSE value was 0.32 meter. As a next step, different future production scenarios were investigated. The expected future Ukrainian groundwater production increase is much more significant than the Hungarian one. As a result, groundwater level depressions are expected larger on Ukrainian side.

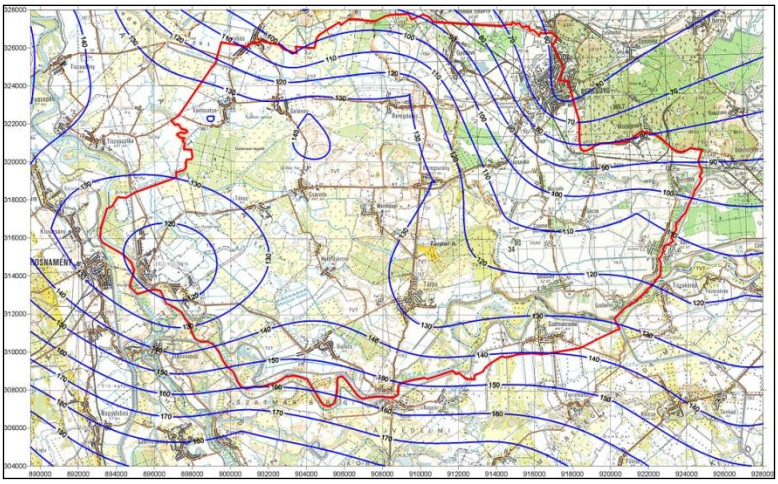

Figure 3. The thickness of the investigated Pleistocene aquifer between Hungary and Ukraine.

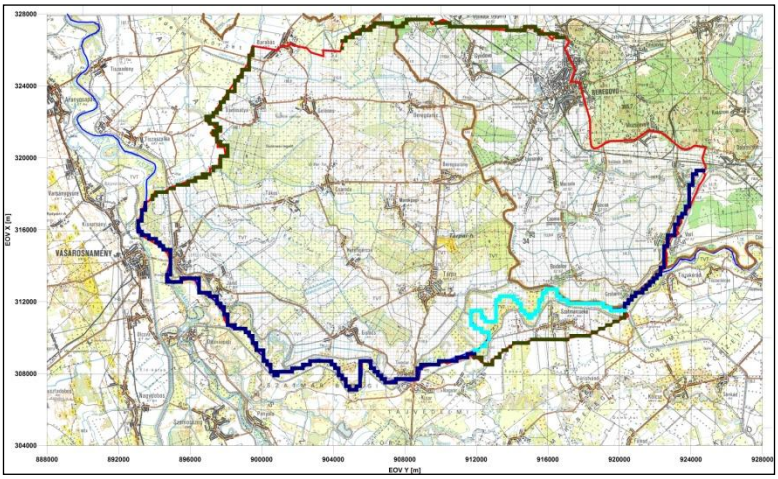

Figure 4. The grid system and the boundary conditions in the MODFLOW based flow model.

Figure 5. demonstrates that in some places the simulated shallow groundwater level decrease can exceed significantly the 0.5 meter. That means that harmful effects can occur in those areas if the given production scenario is realized. In order to avoid the harmful consequences, some future common measures between Hungary and Ukraine should be introduced.

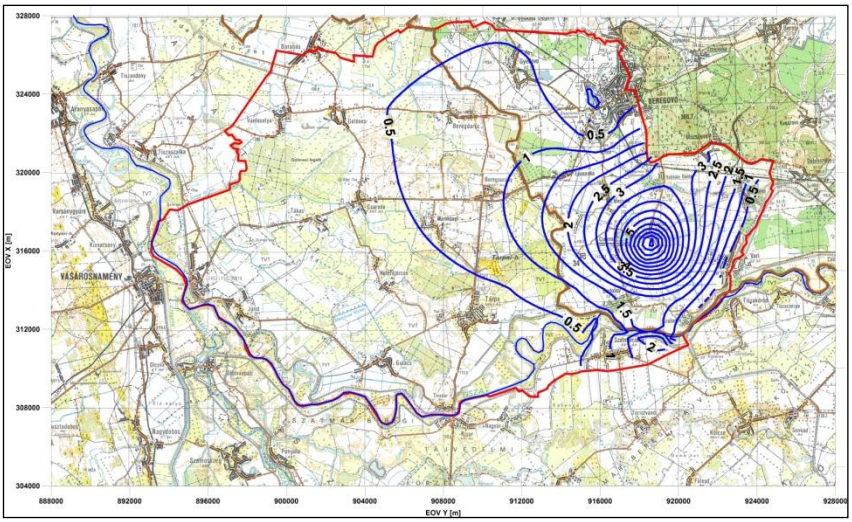

Figure 5. The expected shallow groundwater level decrease in case of a future production scenario.

The collaboration between the Hungarian and Ukrainian experts was outstanding. Some of the obtained results have already been involved into the water management policy of this transboundary region. The monitoring activity (see Figure 6.), the data exchange, and modeling activity will be continued in the future to get more detailed knowledge of the targeted internationally shared aquifer.

Figure 6. Field measurement will be continued in the future in the framework of the common monitoring activity.

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