*Geosciences and Engineering, Vol. 3, No. 5 (2014), pp. 93 – 97.*

# THE ARTIFICIAL RECHARGES OF GROUNDWATER – A CASE STUDY

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**ABSTRACT**

Nowadays, the importance of artificial recharge of groundwater – used for short or long term underground storage – is increasing due to the growing demand for groundwater and to the continuous assurance of advantageous or at least acceptable agricultural conditions *(Scanlon et al., 2010)*. In this study we focused on performance of the only Hungarian groundwater recharge system that is continuously working to reduce the effects of groundwater discharge in the surroundings of Borsodszirák village. At the site we analyzed the hydrodynamic effects on groundwater level of the artificial recharge of groundwater using finite difference method based numerical simulations, highlighted the potential advantages and disadvantages what are hidden in the methods. Four models - systems were built with the same geological structure. In the simulations the aim of the hydrodynamic calculations was to determine the effects of the recharge to the water levels in each model – variants and compare the results, which scenario has the less harmful effect for the vegetation *(Nagy et al., 2007)*.

## INTRODUCTION

In Hungary the main part of civil water supply is ensured from waterworks settled to subsurface water resources. The two– thirds of resources are in vulnerable geological environment, where the aquifers are not protected against surface contaminations. At sites of overexploitation the hydraulic heads in the aquifer are sinking endangering groundwater-related ecosystems. In this study we focused on the area of the Borsodszirák waterworks, which is using artificial groundwater recharge to improve the quality and quantity of existing groundwater through the modification of the groundwater flow potential field to modify the subsurface path lines of groundwater of high manganese, chloride and sulphate concentration and to enhance the groundwater resources. Four different scenarios of pumping/recharge rate were calculated and their effect to the groundwater-level was compared. Due to the fact that the agriculture needs balanced water budget to assure the acceptable conditions for the growing of the plants it can be possible to use artificial recharge in the future not only in groundwater production but also in plant or crop production *(Baser, 2004)*. We believe that all hydrogeological experiences gained from artificial groundwater recharge provide valuable information for agricultural engineers.

## THE INVESTIGATED AREA AND THE APPLIED NUMERICAL SIMULATIONS

The investigated area is at the North-East side of Hungary, in the valley of the rivers Sajó and Bódva. In the region the surface is flat, surrounding agricultural areas. The cover is Holocene flood plain clayey formation with 3 m average thickness. The waterworks was settled to the second layer – 4– 5 m thick Pleistocene gravely aquifer – with 40 shallow depth pumping wells and 25 infiltration basins. Unfortunately the hydraulic connection between the riverbed sediments and the gravelly aquifer is very poor; therefore water resources are supplied by the artificial recharge-system based on the surface water of the Bódva– river. The river drift is sedimented in a horseshoe-shaped basin before utilization, and in case of necessity an artificial filtering and cleaning is performed before the water is stored into two 400 $m^3$ clear water tanks. The pretreated water is pumped into the artificial recharge system where the water is infiltrated into the gravelly aquifer and after a natural purification the groundwater is exploited using the production wells.

For the numerical three-dimensional groundwater-flow simulations through porous medium we applied Processing MODFLOW software, which is based on finite difference method. The extent of model-grid is 3km x 5km *(Figure 1)*.

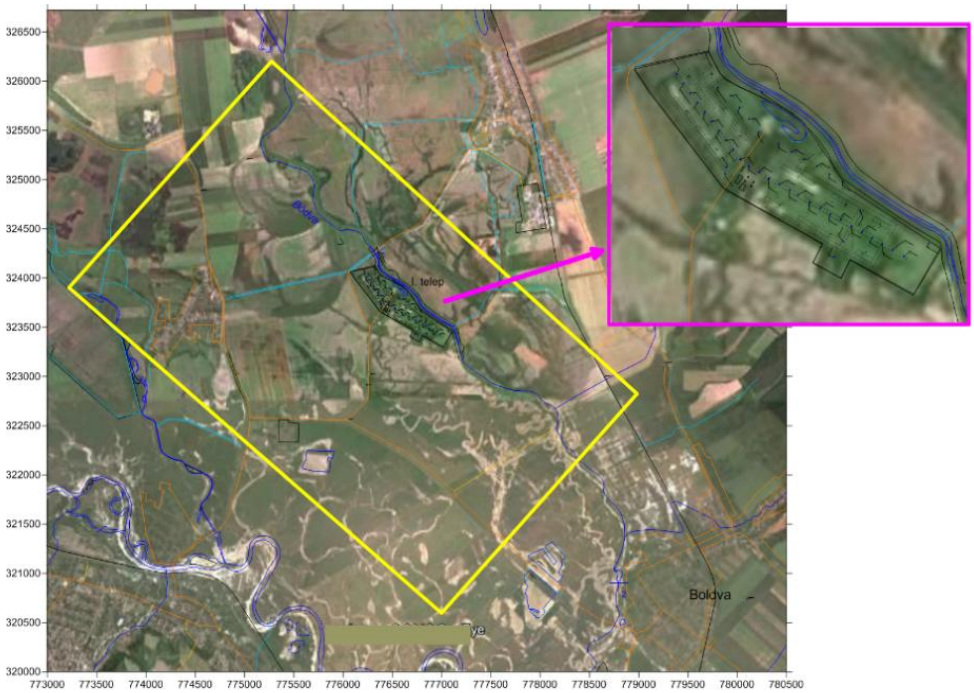


*Figure 1. The mesh and the investigated area*

The clayey cover formation's horizontal hydraulic conductivity is $8.5 \cdot 10^{-4}$ m/d *(Kovács et al., 2010)*. The aquifer is homogeneous and isotropic with a measured horizontal hydraulic conductivity of 90 m/d and an effective porosity of 0.2. The 25 infiltration basins are in direct hydraulic connection with the aquifer and treated as recharge cells *(Pedretti et al., 2012)*. The pumping wells and infiltration basins are shown in *Figure 2*.

*Figure 2. The infiltration basins and wells*

At all model variants the production of the pumping wells is 8730 $m^3$/d. In the 1st case there are no infiltration basins, in the 2nd case 50% of the production assured by artificial recharge. In the 3rd variant artificial recharge reaches the 120 % of the production (over-recharge). To determine the effects of the system a base model (4th variant) was calculated without any pumping wells.

## RESULTS AND DISCUSSION

The results of the numerical simulations - the calculated hydraulic heads – are plotted in *Figure 3*. The analysis of the different scenarios shows that the increase of artificial recharge reduces the drawdown on the well system and reduces the area of influence as well. Analyzing the water budget *(Table 1)* one can see that the river leakage is weak to compensate GW production, therefore the waterworks may only operate simultaneously to the artificial recharge system, otherwise regional sinking of the GW table will happen. Without artificial recharge the operation of the waterworks at the recent production rate became impossible. In case of the 3rd and 4th scenario the drainage effect of the river is dominant. The artificial recharge of 2280 $m^3$/d is possible even when no pumping is done, that causes maximum 2.7 m rise of the water table at the site center.

*Table 1*

*Water budget of the model varinats*

| **Model variants** | **Primer state** | | **1. scenario** | | **2. scenario** | | **3. scenario** | | **4. scenario** | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Flow term** | In | Out | In | Out | In | Out | In | Out | In | Out |
| | $m^3$/d | | $m^3$/d | | $m^3$/d | | $m^3$/d | | $m^3$/d | |
| **Wells** | No pumping | | - | 8733 | - | 8733 | - | 8733 | No pumping | |
| **Recharge** | No infiltration | | No infiltration | | 4282 | - | 10277 | - | 2282 | - |
| **River leakage** | 27 | 230 | 661 | 29 | 477 | 56 | 5 | 432 | - | 618 |
| **Head dep. Boud.** | 1598 | 1395 | 8519 | 418 | 4719 | 689 | 1156 | 2273 | 1016 | 2680 |
| **Sum** | 1625 | 1625 | 9180 | 9180 | 9478 | 9478 | 11438 | 11438 | 3298 | 3298 |

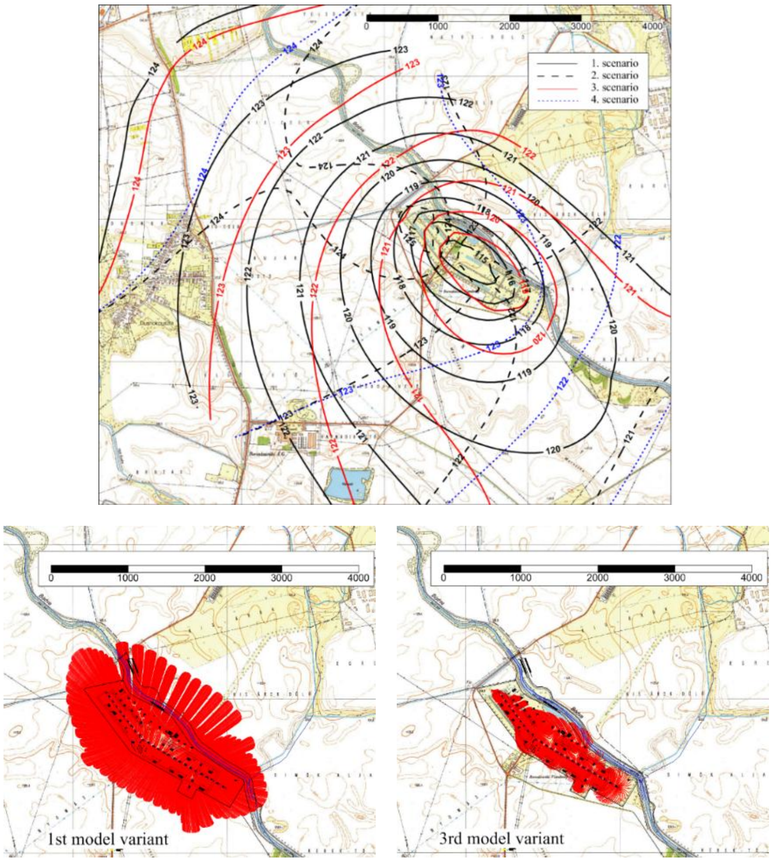


*Figure 3. The calculated hydraulic heads (flow potential field) and 90 d path lines to the wells (case 1 and 3)*

## CONCLUSIONS

The study proved that artificial recharge can be an important factor in keeping the groundwater budget even at large precipitation deficits. The groundwater model of the Borsodszirák area showed that there is a potential of rising GW table locally up to 2–3 meters and 0,2–1 m in a wider area even in gravelly aquifers. Considering the flow equation at sandy groundwater aquifers smaller artificial infiltration rates may lead to the same effects, therefore at dry periods due to climate changes the artificial recharge may compensate the overexploitation of subsurface aquifers. There is a need to test and apply artificial recharge on more sites to get more theoretical and experimental experiences *(Várallyay et al, 1989)* on the investigated topics in the future to assure the stability of groundwater related ecosystems in Hungary.

## ACKNOWLEDGEMENTS

The research was carried out in the framework of the Sustainable Resource Management Center of Excellence at the University of Miskolc as a part of the TÁMOP-4.2.2/A-11/1-KONV-2012-0049

"WELL aHEAD" project in the framework of the New Széchenyi Plan, funded by the European Union, co-financed by the European Social Fund.

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