WATER SUPPLY FOR THE CITY OF ST PETERSBURG

Client: the municipality of St Petersburg

Issue: Plan sustainable water supply from the Vendian Aquifer, the main source of water for the city of St Petersburg

Solution: the AMWELLS module of ANSDIMAT was used to model production in the borefield since 1946 (start of production) and determine the effective parameters of the aquifer. The parameters were used for planning groundwater supply over the next decades.

Well field location and history

The Leningrad water supply well field is located in the St-Petersburg region, on the Karelian Isthmus (Fig. 1). Presently the borefield consists of several hundred production wells that can be grouped in six clusters. Each cluster of production wells has been pumping groundwater at rates from less than 5,000 m^3/d to more 45,000 m^3/d. Production started in 1946 providing drinking, household and industrial water for the city of (Leningrad) St-Petersburg. Total annual production rate has increased from 5,000 to 75,000 m^3/day between 1946 and 1979 (Fig. 2) and since then has been continuously declining down to 35,000 m^3/d.

The well field is exploiting the 80 m thick sand units of the Vendian aquifer system in the northwestern part of the Leningrad Artesian Basin. The aquifer is confined a**nd located at depths of 100–120 m** in the study area. The conceptual hydrogeological sketch is presented in Fig. 1. T**he aquifer top is 20–50 m below the bottom** of the Gulf of Finland and it is disconnected from this surface water body by the thick horizon of the Vendian Clay.

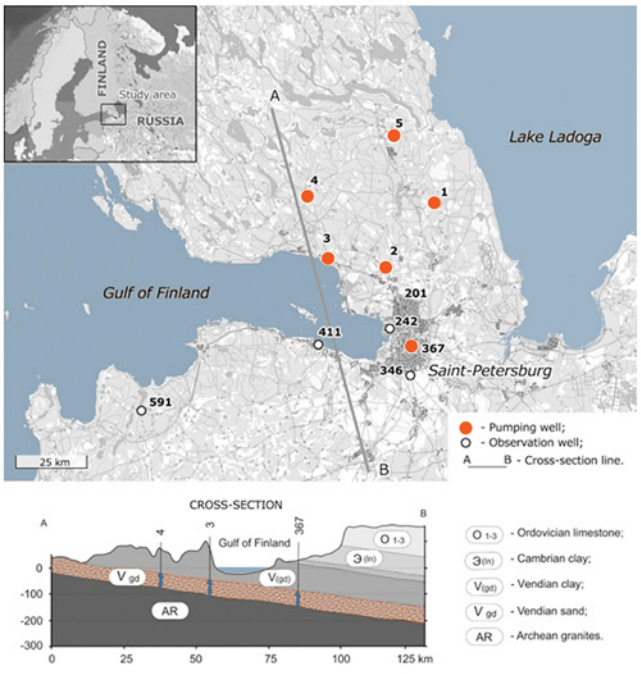

Fig. 1. Location map of the Saint-Petersburg borefield (top) and the conceptual hydrogeological profile (bottom).

Well field operations over the last 70 years resulted in the development of a large depression cone, occupying an area of 20,000 km^2. Aquifer drawdowns were monitored in numerous monitoring wells over various periods of observations. The most complete records were available from five wells, where water levels were regularly monitored at quarterly intervals between 1946 and 2000. These five monitoring wells were used for AMWELLS model calibration.

Model set up, calibration and results

The preliminary analysis of borehole hydrographs and production rates indicates that the aquifer response to pumping corresponds to that of an infinite confined aquifer, which can be reliably and quickly interpreted by AMWELLS $s/Q - \lg(t'/r'^2)$ plots can be approximated by a straight line for each observation well (Fig. 3), suggesting that borehole drawdowns are not impacted by areal boundaries or complex heterogeneity zones. In these conditions, predicting borefield productivity does not require the use of a numerical model.

Initial (prior to calibration) aquifer properties were obtained using ANSDIMAT aquifer test interpretation module using borehole construction details, time-variable production rates and well hydrographs. The interpreted hydraulic properties were input in the AMWELLS module to simulate the entire period of the borefield production in the confined, homogeneous and unlimited Vendian aquifer (Fig. 4).

The model was calibrated to the borehole hydrographs in observation wells. Fig. 5 present borehole hydrographs and the scatter diagram that demonstrate a good match between modelled and observed piezometric heads.

The calibrated aquifer transmissivity (T = 264 m²/d) and specific storage (1.3·10-4 1/m) were considered representative for the Vendian sand aquifer in the area of the borefield operation.

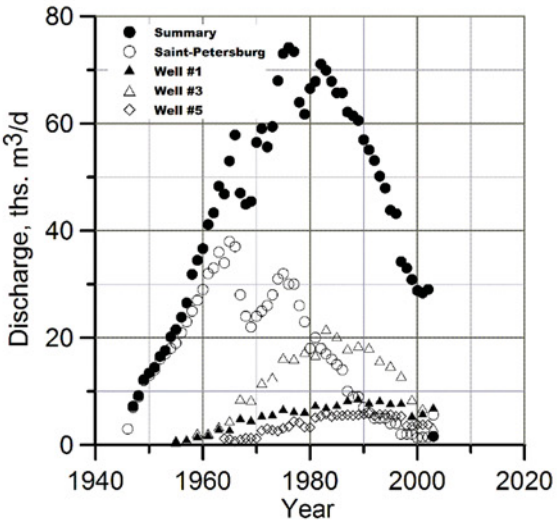

Fig. 2. Pumping rates for four clusters of production wells.

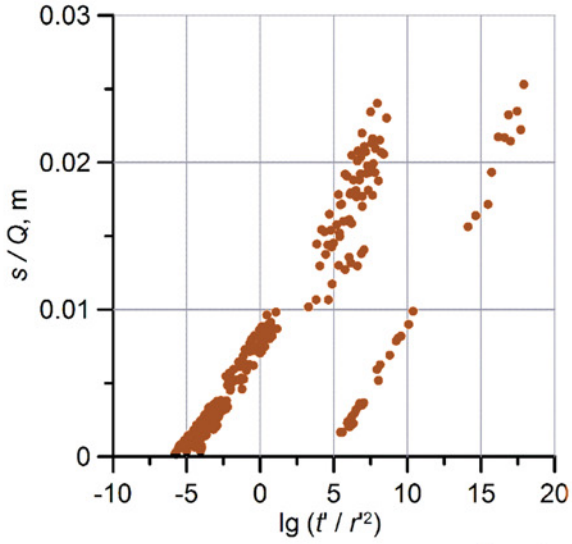

Fig. 3. Linearization of drawdown: $s/Q - \lg(t'/r'^2)$ plots for observation wells

Conclusion and value added

The AMWELLS module of the ANSDIMAT software was used to simulate the production history of the Leningrad borefield between 1946 and 2000 considering appropriate analytical equations for a confined, homogeneous and unlimited aquifer. A good match was obtained between simulation and production data, allowing to accurately determine the aquifer properties over the borefield area. These properties can now be used to predict the productivity of the borefield depending on selected pumping schemes and allowing for production optimization. ANSDIMAT allowed to obtain quickly accurate results without the need to develop, calibrate and run a complex numerical model, saving time and budget to the municipality of St Petersburg while delivering the critical information for the management of the city main resource in water.

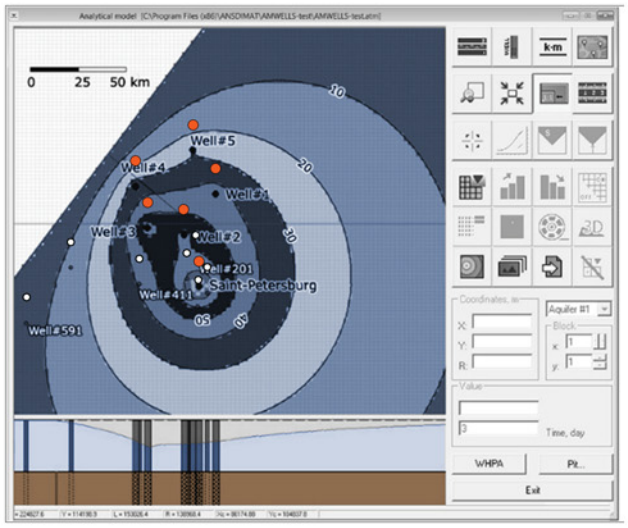

Fig. 4. Modelled drawdown map for simulation time 36 years.

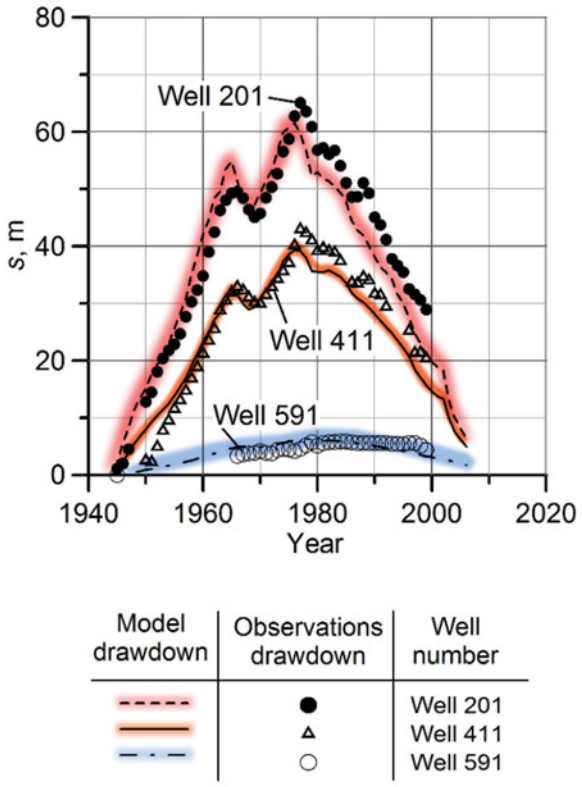

Fig. 5. Observed and simulated observation well hydrographs.