EXPERIENCE IN INVESTIGATIONS OF GROUNDWATER AND ITS USE FOR WATER SUPPLY ABROAD

UŽSIENIO ŠALIŲ POŽEMINIO VANDENS TYRIMO IR NAUDOJIMO VANDENS TIEKIMUI PATIRTIS

III

MODELLING PROSPECTIVE WELL FIELDS FOR THE WATER SUPPLY OF RIGA

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Introduction

This paper contains a brief information based mainly upon the book [2] prepared jointly by the Environment Modelling Centre (EMC) of the Riga Technical University and the State Geological Survey of Latvia (SGSL) within the Project "Potential of Groundwater as a Source of Drinking Water for Riga" which was managed by the Geological Survey of Denmark and Greenland.

The research targets of the modelling were as follows: ✶ modelling new well fields as a potential source of high quality drinking water for Riga which may minimise water intakes from contamination exposed *Quaternary* groundwater, rivers and lakes; ✶ assessment of the risk of an anthropogenic contamination provoked by the proposed well field groundwater withdrawal.

No contaminant transport modelling and no investigations of available reserves for existing well fields were planned by the reported research.

Modelling tools and methodology

The job was performed by applying the REgional hydrogeological MOdel (REMO) "Large Riga", which has been jointly designed and developed since 1993 by EMC and SGSL [1]. Special software tools developed by SGSL specialists were used for modelling on detailed local subregions.

The results of modelling new well fields were obtained by the combined efforts of the EMC and SGSL teams as follows: ✶ EMC transferred all the REMO information needed for modelling to the SGSL data base. Thus, the SGSL team was able to apply the REMO calibrated data for creating detailed local models of well fields proposed; ✶ optimised characteristics of well fields were obtained by the SGSL team; ✶ data of optimised well fields were applied on REMO in order to create regional maps and tables of parameters regarding the new well fields.

A brief information about new well fields

Seven prospective new well fields were modelled. Their location are shown (excl. M1) in Fig. 1. The following well field codes are used in this paper: R1 - Riga 1; A1, A2 - Adazi 1, 2; V1, V2 - Vangazi 1, 2; M1, M2 - Malpils 1, 2. All new well fields make use of the upper *Devonian* D_3gj_2 *(Gauja upper)* and D_3gj_1 (*Gauja lower*) confined aquifers having rather high iron (Fe) content. Therefore, iron removal is a problem for all proposed well fields. The R1 well field was suggested by SGSL specialists. The other six well fields: A1, A2, V1, V2, M1, M2 were offered by hydrogeologist Mr. Y.Tolstov.

The following timetable for the future use of the well fields has been proposed initially: the fields R1, A1, A2, V1 should be the first ones to be investigated and utilised; V2, M1 or M2 must be investigated as a reserve for the further time perspective. The fields M1 and M2 were alternative (M2 was selected as slightly preferable).

Modelling results

The modelling has been done with respect to 1987 conditions because they represent a relatively normal

Table 1. The water consumption in Riga, 1987 and 1994 conditions

Type of water source	Withdrawal [thousand m³/day]		Vulnerability to surface pollutants
	1987	1994	
Surface (rivers, lakes)	194	125	very high
Quaternary	222	167	high
Devonian	75	29	medium
Total:	491	321	

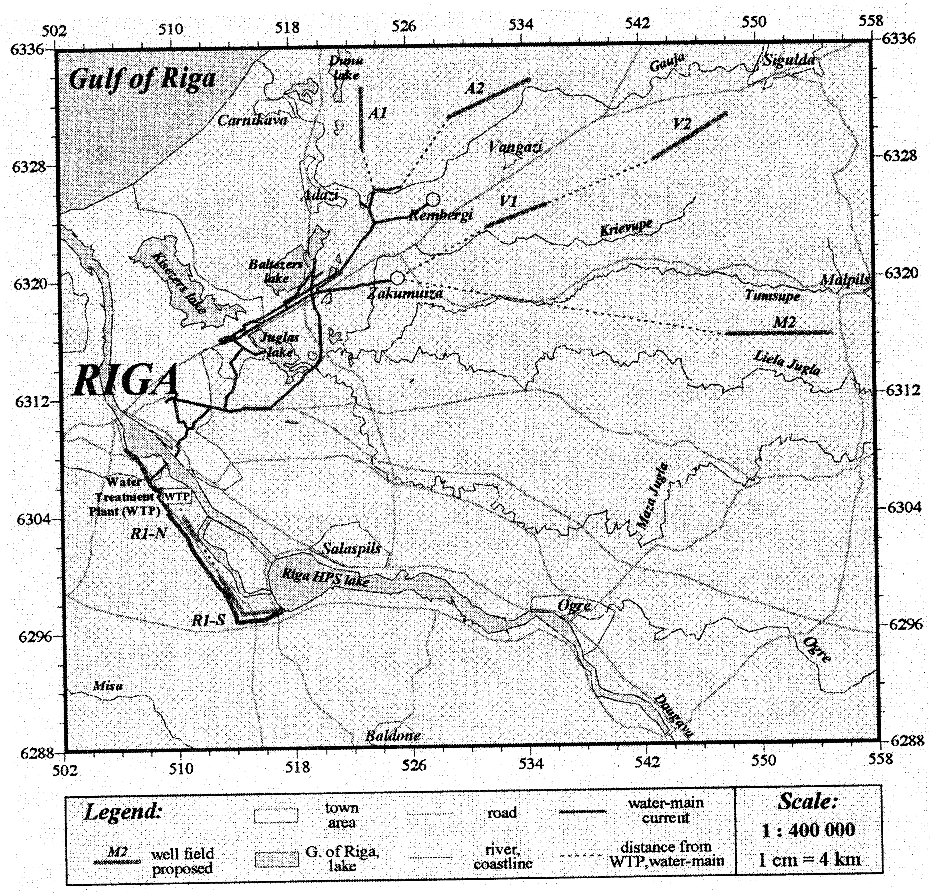
state of the Riga water consumption. Table 1 is a summary of the 1987 and 1994 conditions where types of water intake, the withdrawal and the water source contamination vulnerability are accounted for [3].

The 1994 conditions show the effect of an extraordinary drop of the groundwater withdrawal as a symptom of the economic crisis in Latvia. For example, the yield in Riga from *Devonian* aquifers has decreased from 75 to about 29 thousand m³/day.

Modelling shows that only weak interaction exists between six selected well fields. Therefore, they may be modelled in the regime when all fields are being utilised (max.Q = 305 thousand m³/day).

At the reported stage of research only a rough optimisation of the proposed well fields has been performed. During more detailed investigations the characteristics and the locations of these well fields may change considerably.

The characteristics: yields, lengths and positions of the well fields were used on REMO for obtaining regional maps and parameters of selected new well fields. It was found out that the R1 well field has a considerable influence on the existing Katlakalns and Salaspils well fields. The influence of



Proposed wellfield code name	Yield, thousand m³/day	Modelled drawdown, m	Typical depth of well, m	Distance from WTP, water-main, m
R1-N,S – Riga 1	60	55	85-150	1.0-6.0
A1 – Adazi 1	65	37	70-95	2.8
A2 – Adazi 2	30	21	60-90	5.4
V1 – Vangazi 1	30	32	70-115	6.9
V2 – Vangazi 2	60	56	95-135	19.4
M2 – Malpils 2	60	62	120-150	23.0
Total:	305 thousand m³/day			

Fig. 1. A summary of the modelling results.

the well fields A1, A2, V1, V2, M2 on the existing ones is slight. The SGSL team obtained data about the modelled drawdown in the area of the Riga hydroelectric power station caused by the R1 well field. The data may be useful for a more detailed future investigation of this problem.

Groundwater contamination problems

At present, the groundwater quality of all new well fields is good. Nevertheless, the quality may worsen if those well fields will be utilised.

Some of the problems regarding the influence of an additional groundwater withdrawal on leakage flow changes which may provoke the contamination of the D_3gj_1, D_3gj_2 aquifers have been investigated by modelling: ✶ the leakage down from the unconfined groundwater table surface *relh*; ✶ the leakage flow up from the D_2pr (*Parnu*) aquifer.

The amount of leakage between two aquifers is proportional to the head difference between them. Two variants were investigated: Q = 0, 1987 conditions; Q = 305 thou.cu.m/day (all six well fields utilised). Two kinds of the head difference D^a, D^b were computed (using the D_3gj_1 aquifer as an example): $D^a = p_{relh} - p_{D3gj1}$; $D^b = p_{D3gj1} - p_{D2pr}$ which represent principal parameters determining the leakage flow above and below the D_3gj_1 aquifer, respectively. If the head differences D^a, D^b are positive, then the groundwater recharge (infiltration) takes place with respect to the D_3gj_1, D_2pr aquifers, accordingly. The corresponding regional head difference maps for the D_3gj_1 aquifer with recharge areas shown were obtained. These head difference distribution maps may be rather useful in the course of more detailed future investigations of the leakance flow characteristics.

Some additional knowledge may be gained from applying the computed head difference distributions for 1939. These maps in REMO represent hypothetical undisturbed conditions when practically no groundwater withdrawal exists. By comparing 1939 and 1987 head difference distribution maps, it was concluded that in 1987 the corresponding leakage flows have changed drastically under the influence of groundwater withdrawal. However, up to 1996 no facts of significant contamination of the D_3gj_1 and D_3gj_2 aquifers have been recorded there. Nevertheless, it does not mean that no contamination danger exists. A careful hydrochemical regional analysis of risky areas of existing well fields may definitely help to understand better possible pollution processes if new well fields will be utilised.

In the areas of the A1, A2, V1, V2, M2 well fields, the 1987 groundwater withdrawal has caused practically no changes with respect to the 1939 conditions. Therefore, for these well fields, a theoretically maximal possible productivity can be achieved, affecting the existing well fields only slightly.

Conclusions

The principal results of modelling [1] are given in Fig. 1 including the summary Table of the following parameters of the new well fields: the yield [thousand m^3 /day], the modelled drawdown [m], the typical depth of the wells [m], the distance from existing Water Treatment Plants (WTP) or water-mains [km]. The following conclusions may be drawn:

♦ all six well fields selected are acceptable regarding the expected drawdown and the typical depth of the wells; their modelled total yield is 305 thou.cu.m/day which enables in the future to minimize water intakes from contamination vulnerable surface and *Quaternary* sources (see Table 1);

♦ the shortest distance from the existing WTP and water-mains holdsare landthe R1, A1, A2, V1 well fields and, therefore, the ones are the first candidates to be explored more carefully regarding their possible utilisation in the near future; in Fig. 1 the R1 ("Riga 1") well fields are connected via a new raw water-main with the existing WTP "Daugava";

♦ for the "Riga 1" well field special investigations are needed to explore thoroughly its groundwater withdrawal influence on the Riga hydroelectric power station and the risk of intensifying karst processes in the D_3sl layer there.

In [3], the expected total capital costs of constructing the new well fields for Riga are estimated to be about 166 mill USD. Anyway, the unit price of drinking water obtained from groundwater is competitive if compared to the one of surface water.

References

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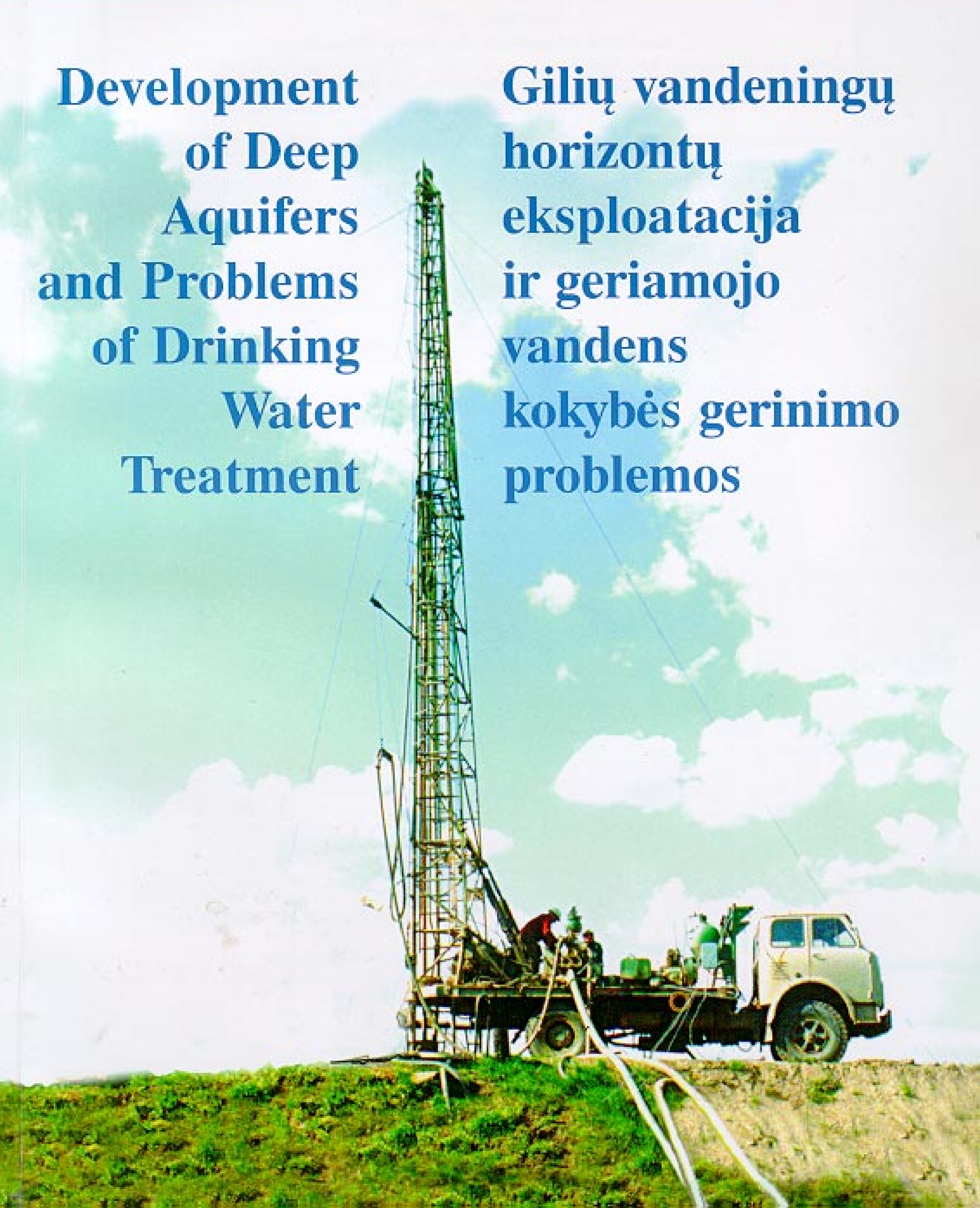
Development of Deep Aquifers and Problems of Drinking Water Treatment

Gilių vandeningų horizontų eksploatacija ir geriamojo vandens kokybės gerinimo problemos



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