GROUNDWATER RESOURCES
GOVERNANCE
in TRANSBOUNDARY AQUIFERS
(GGRETA Project)

Case study: The Pretashkent Aquifer in Central Asia:
Kazakhstan, Uzbekistan

Exchange of data and information in the study of the Pretashkent TBA

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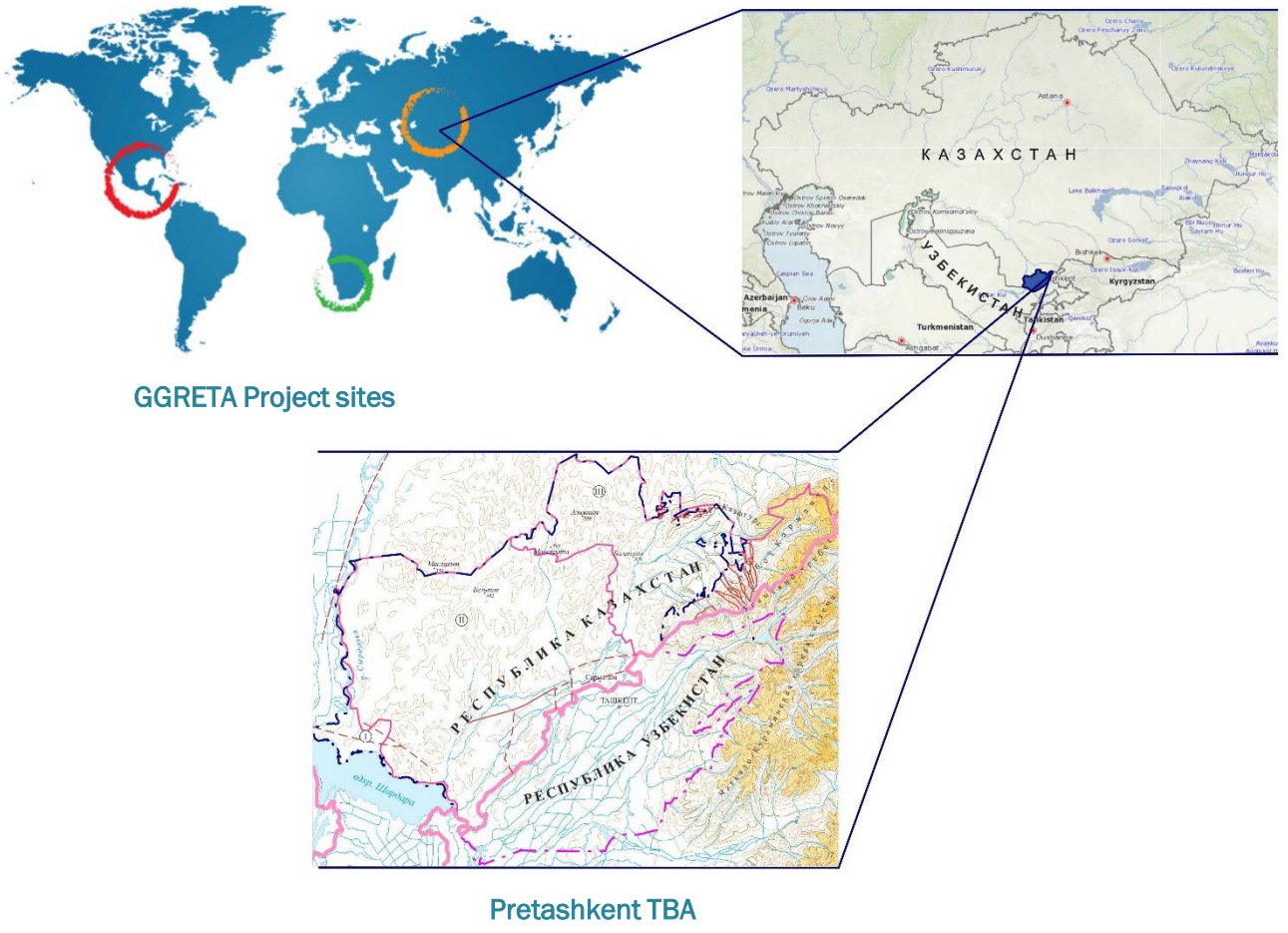
There are two main transboundary issues identified for the Pretashkent TBA as such. They are associated with a decrease in the groundwater level due to water abstraction:

1. Depletion of groundwater storage of the Pretashkent TBA;

2. Potential degradation of the groundwater quality of the Pretashkent TBA.



Key conclusions and recommendations of the GGRETA Project (Phase 1)

To ensure effective management of transboundary groundwater resources of the Pretashkent TBA, it is essential:

1. To build the capacity for international cooperation on joint management of groundwater resources of the aquifer and exchange of data of hydrogeological monitoring of the aquifer.

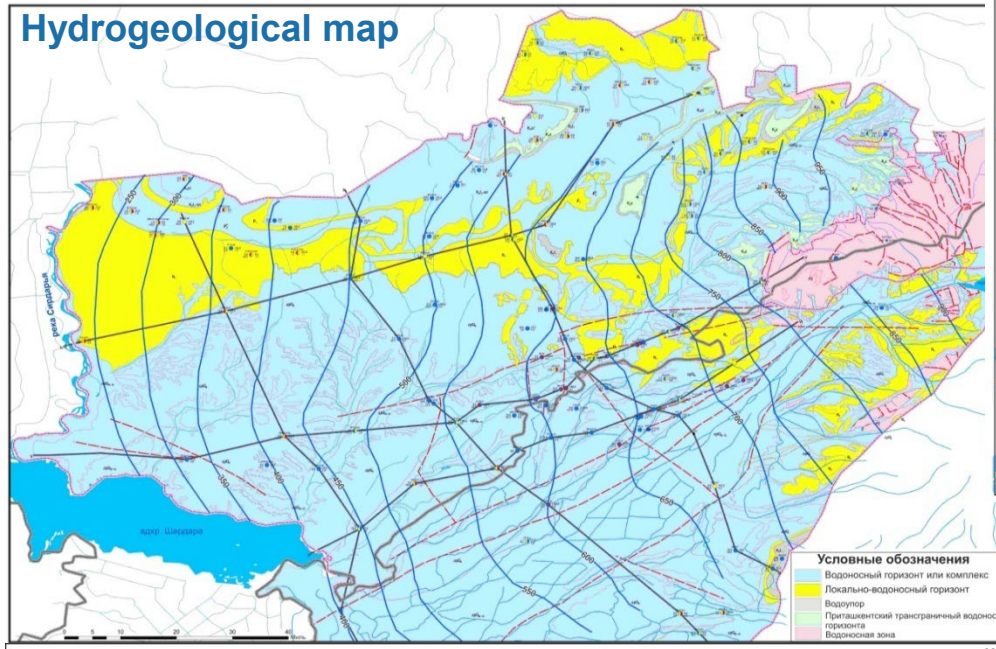
2. Joint (Kazakhstan – Uzbekistan) management of groundwater resources of the Pretashkent TBA should be based on the creation and operation of a mathematical simulation model of the aquifer.

3. To develop a consolidated strategy for managing the risk of degradation of the Pretashkent TBA (Kazakhstan–Uzbekistan), taking into account pressures.

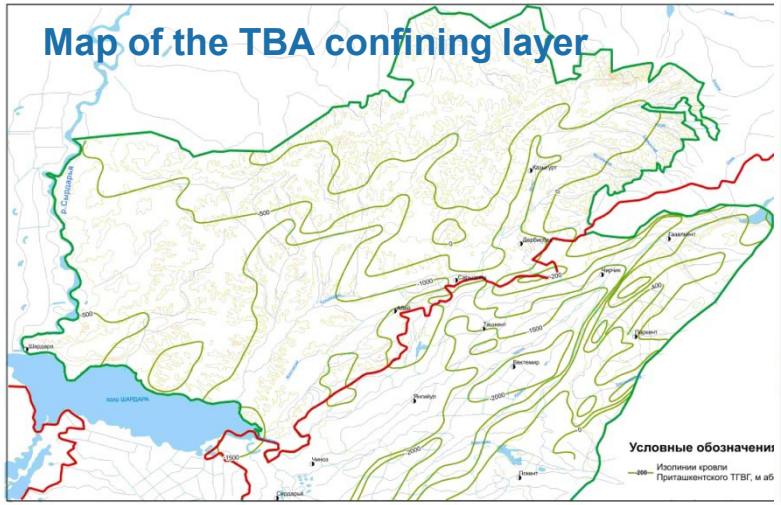
GGRETA Project (Phase 3)

1. Preparation, correction, and harmonisation of map documents
2. Database harmonisation
3. Conceptual numerical model
4. Stationary model calibration
5. Non-stationary model calibration
6. Development of forecast scenarios
7. Predictive modelling
8. Conclusions and recommendations

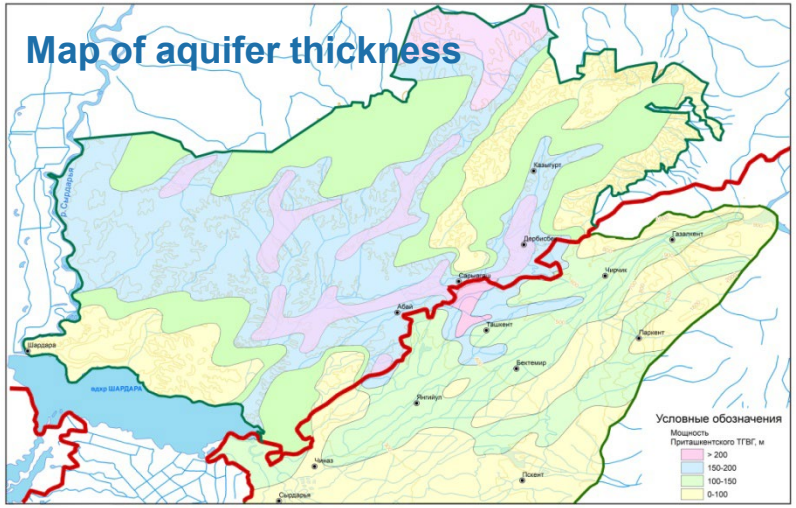
Hydrogeological map



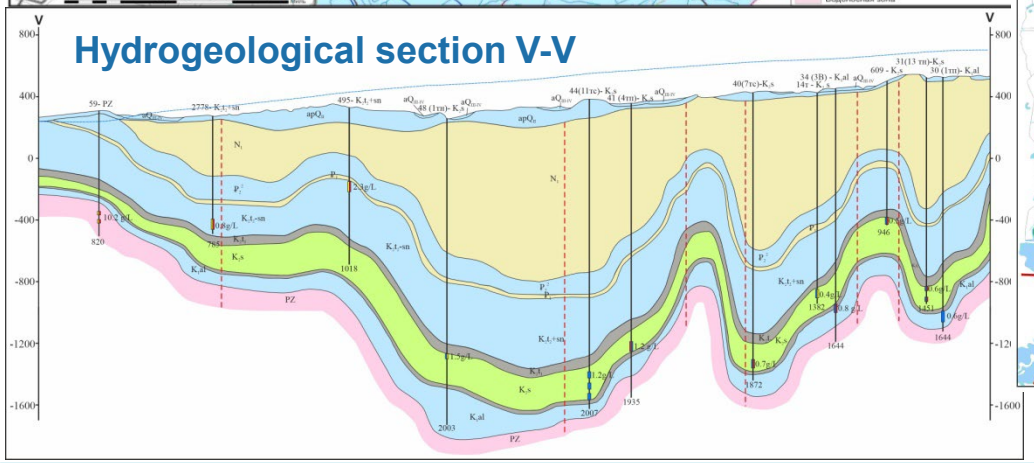
Map of the TBA confining layer



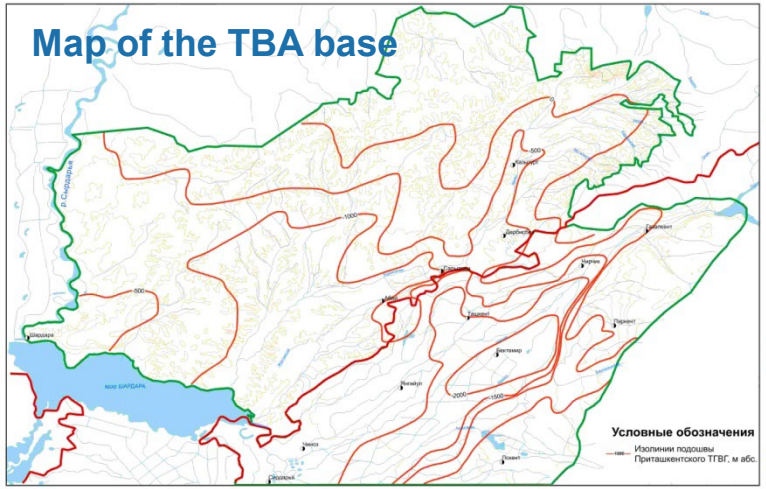
Map of aquifer thickness



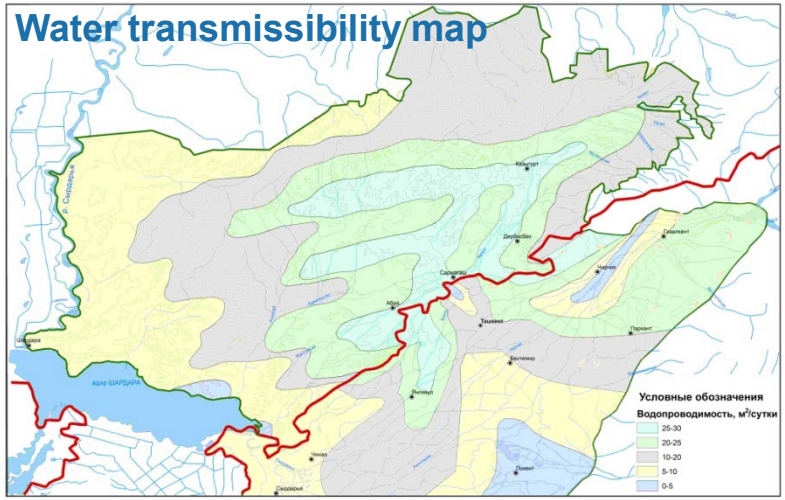
Hydrogeological section V-V



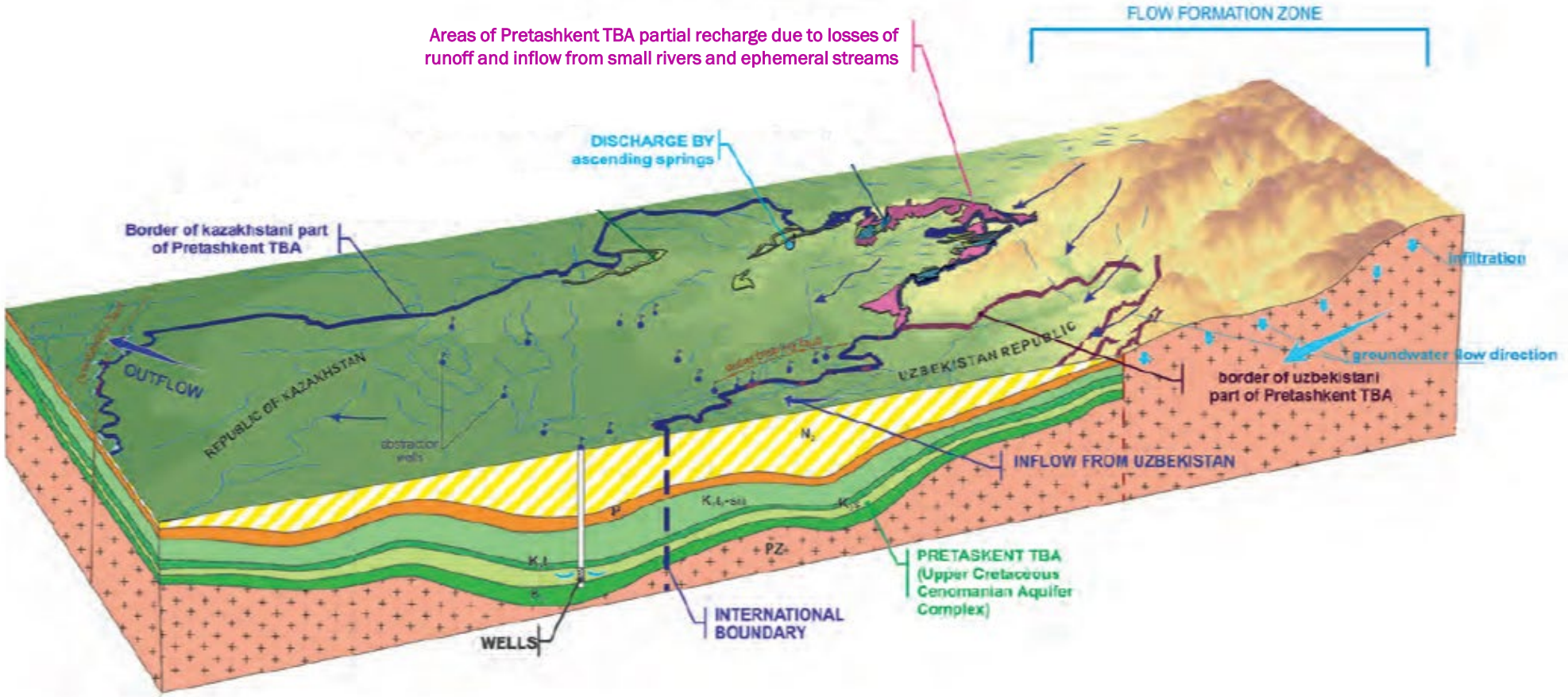
Map of the TBA base

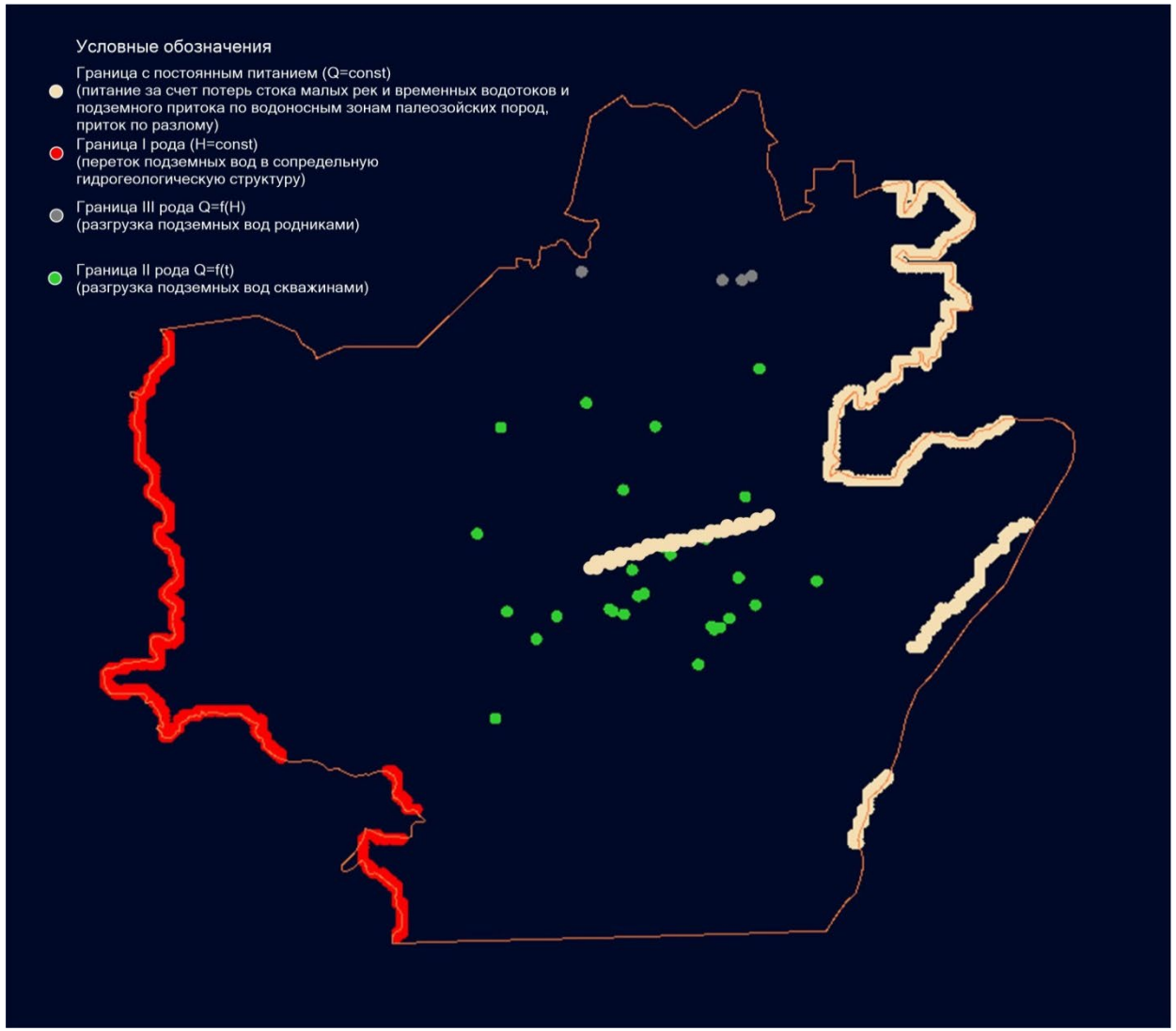


Water transmissibility map



Conceptual model of the Pretashkent TBA





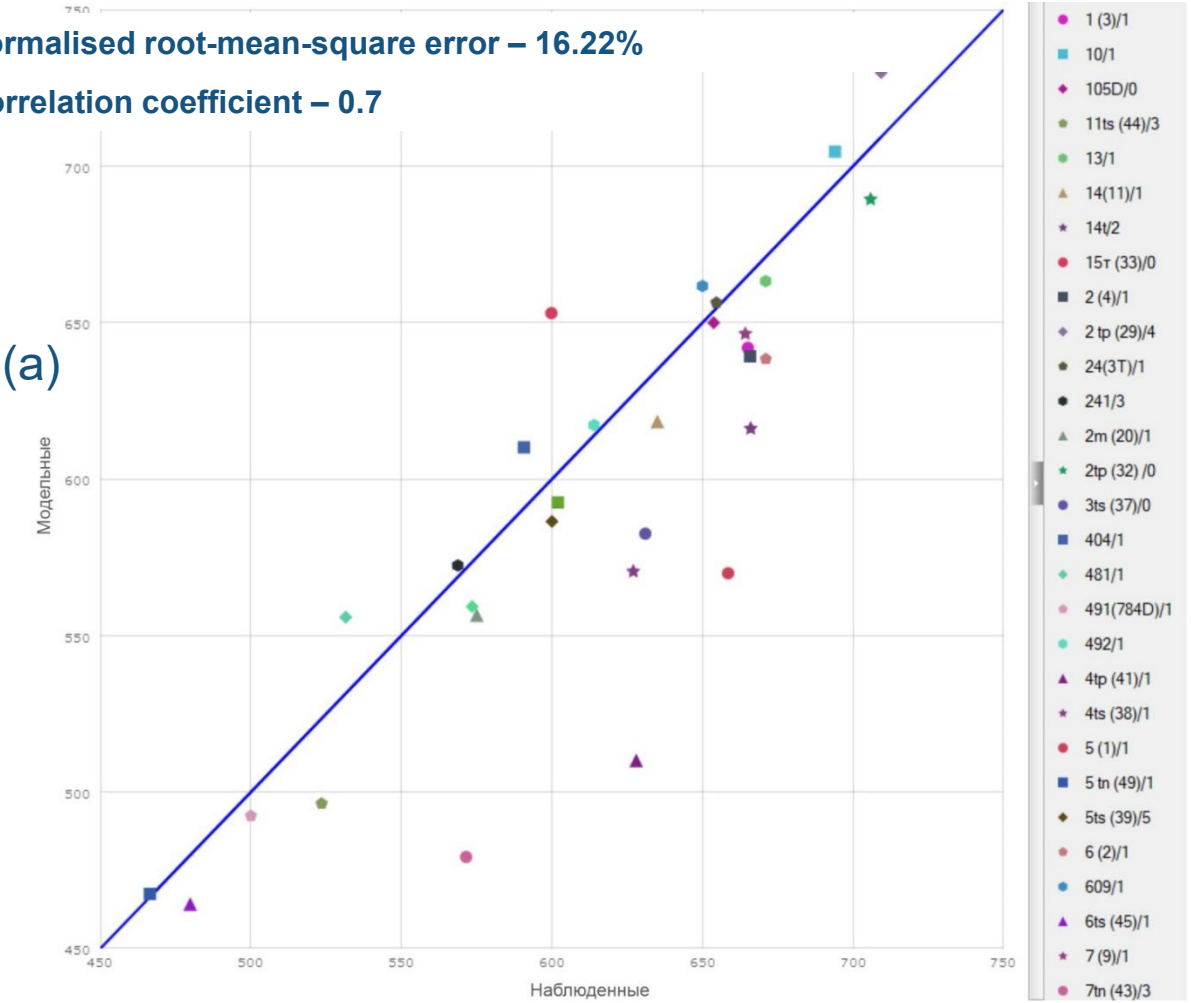
Conceptual numerical model

Boundary conditions

Normalised root-mean-square error – 16.22%

Correlation coefficient – 0.7

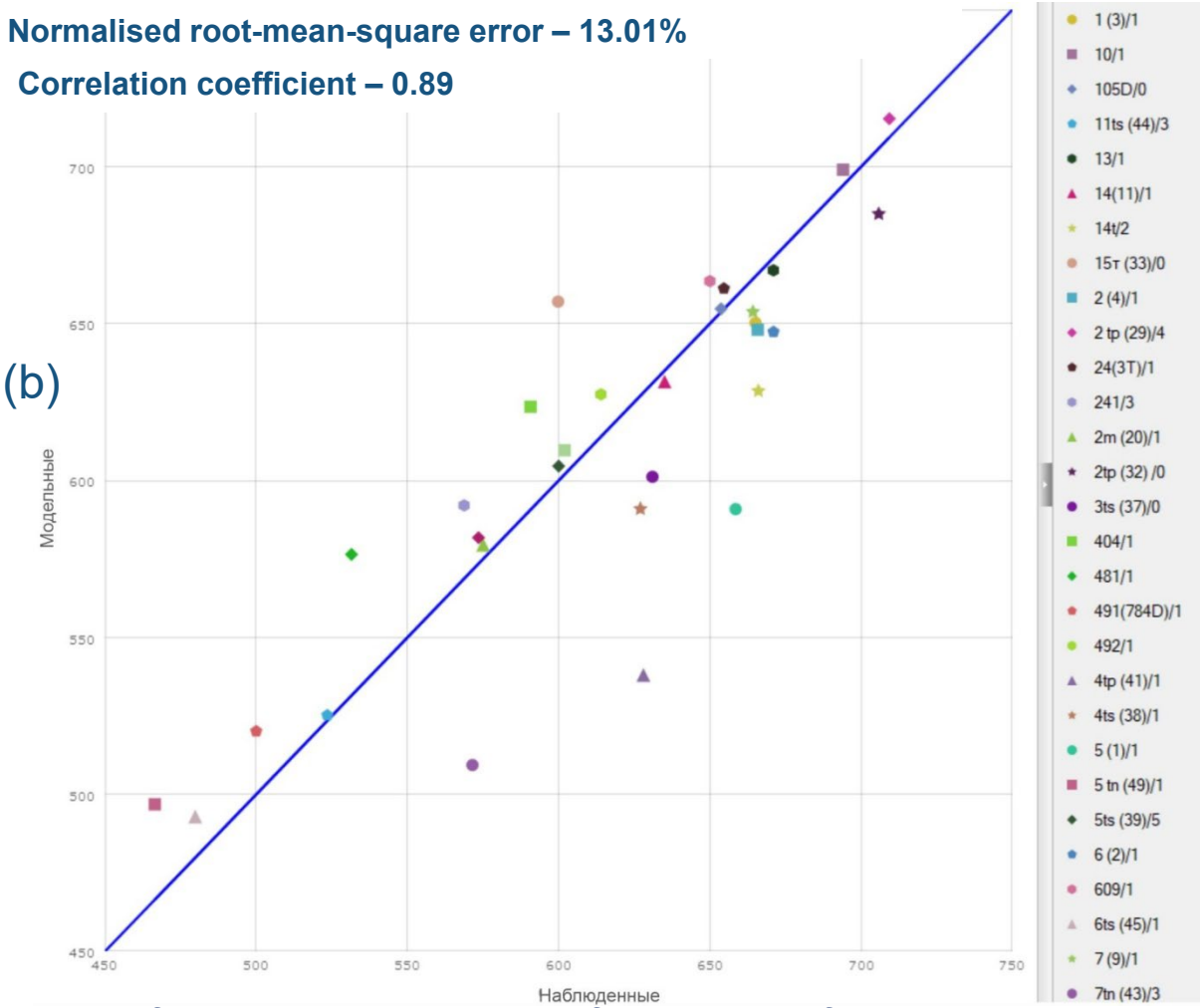
(a)



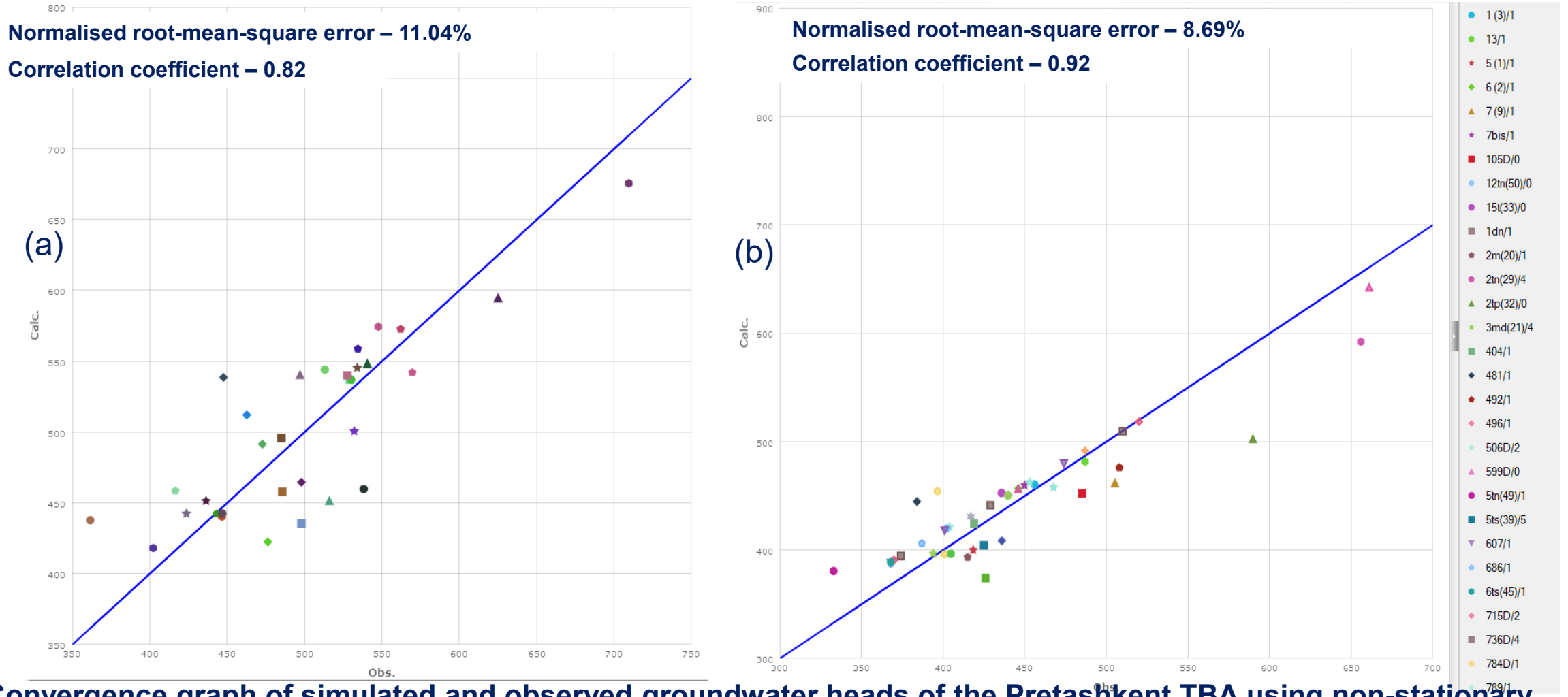
Normalised root-mean-square error – 13.01%

Correlation coefficient – 0.89

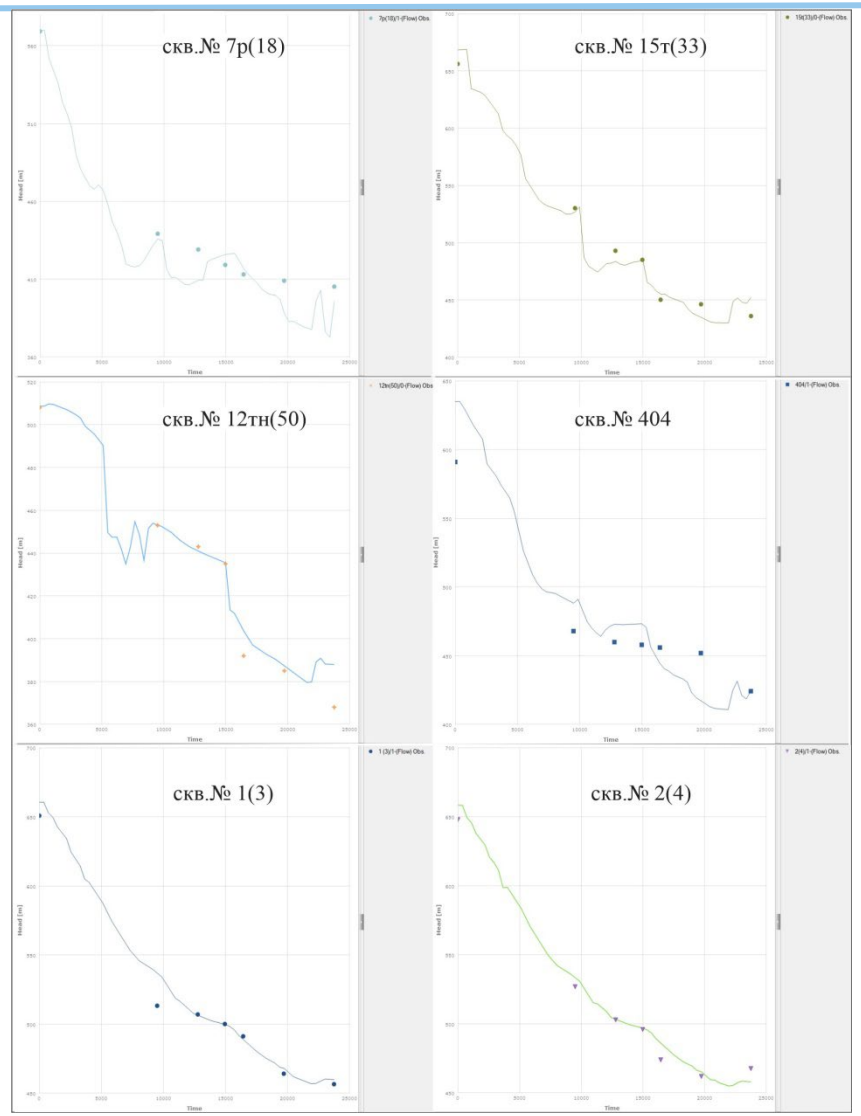
(b)



Convergence graph of simulated and observed groundwater heads of the Pretashkent TBA before (a) and after (b) stationary calibration



Convergence graph of simulated and observed groundwater heads of the Pretashkent TBA using non-stationary calibration for (a) 1981 and (b) 2020



Non-stationary calibration

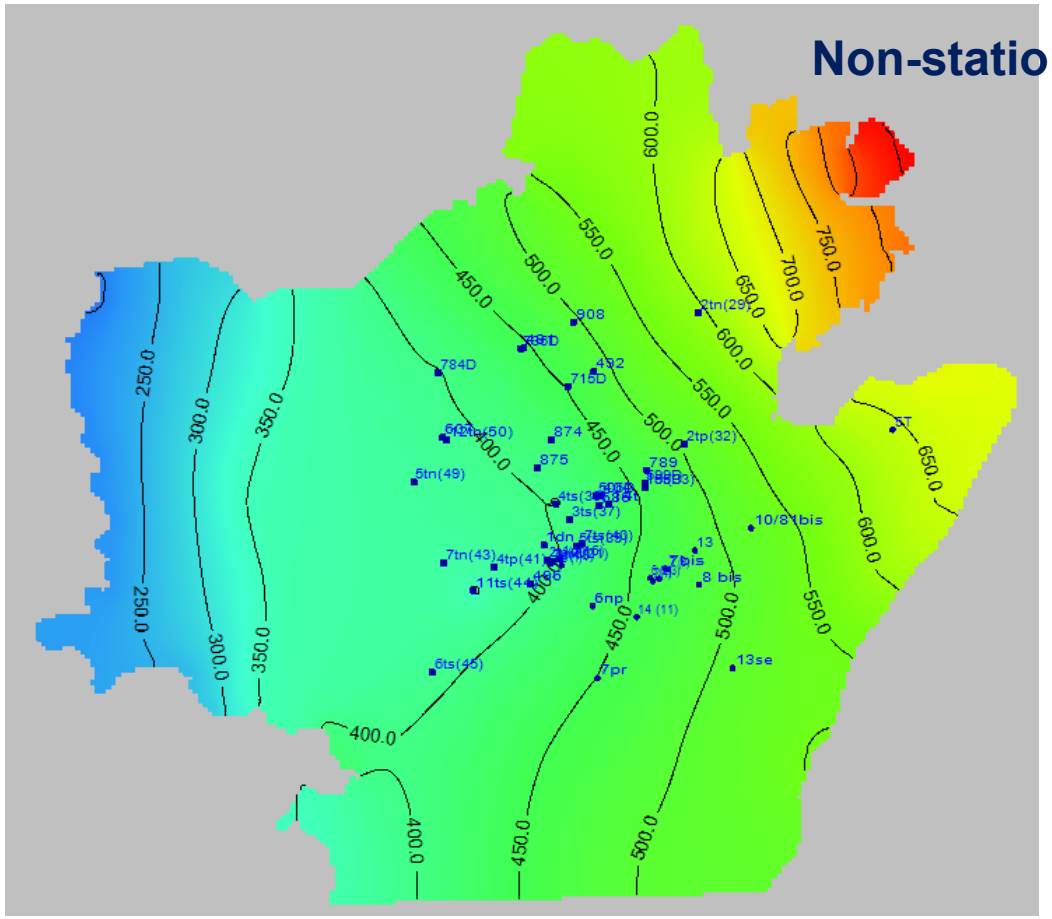
Graphs of groundwater head dynamics in wells of the Pretashkent TBA for the period of 1955–2020 based on the results of solving the non-stationary problem

(dots on the graph represent observed heads)

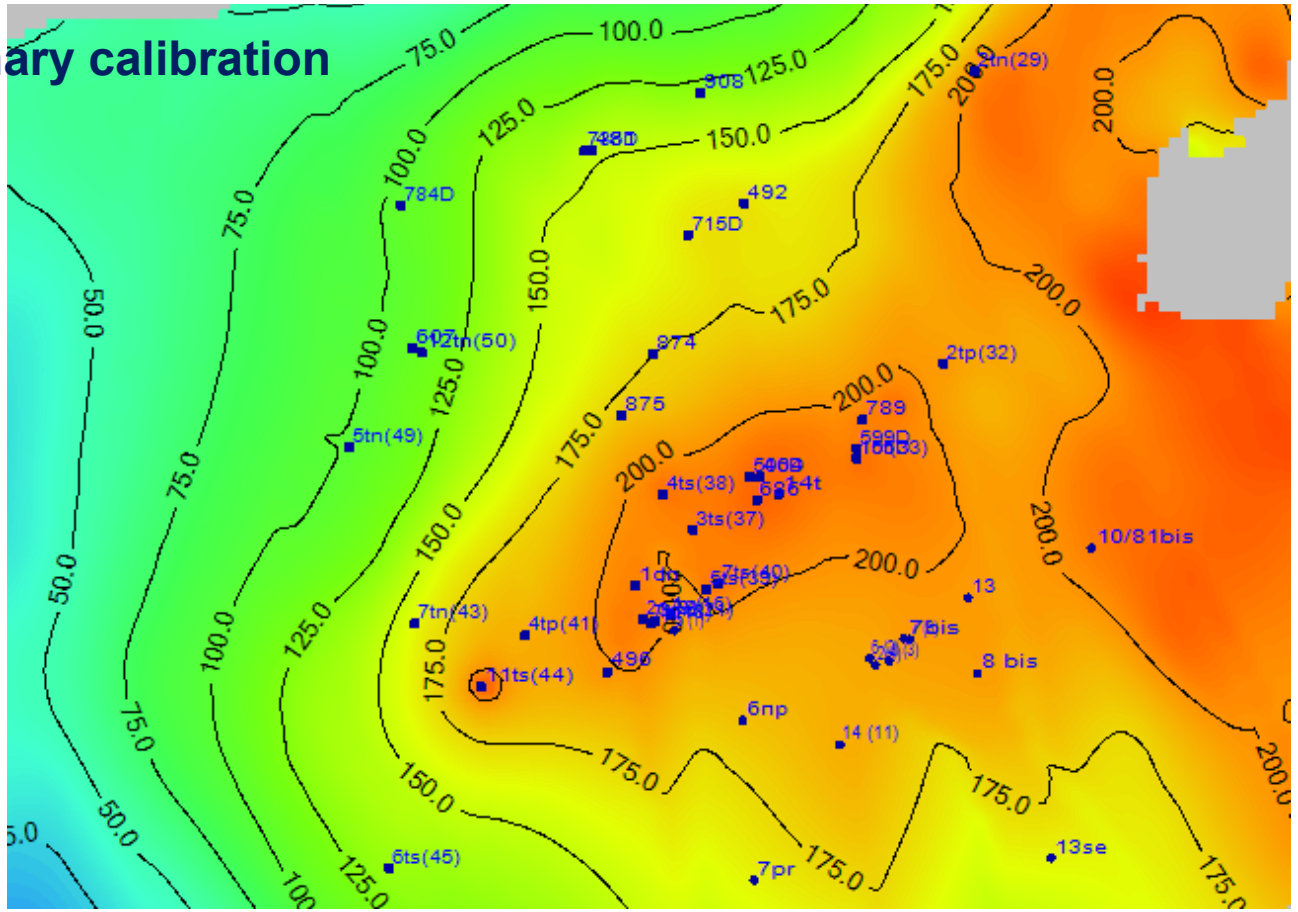
Non-stationary calibration

	1981		2020	
Recharge	m^3/day	l/s	m^3/day	l/s
Recharge at the boundary	7,197.7	83.3	7,197.7	83.3
Recharge at the split	756.9	8.8	756.9	8.8
Storage	9,489.6	109.8	3,937.6	45.6
Total	**17,444.2**	**201.9**	**11,892.2**	**137.6**
Discharge	m^3/day	l/s	m^3/day	l/s
Water abstraction from wells	9,953.3	115.2	7,331.1	84.9
Groundwater flow to an adjoining hydrogeological structure	6,345.1	73.4	4,597.7	53.2
Runoff of springs	1,237.5	14.3	159.1	1.8
Storage	57.6	0.7	607.6	7.0
Total	**17,593.5**	**203.6**	**12,695.5**	**146.9**
Imbalance	-149.3	-1.7	-803.3	-9.3

Groundwater balance of the Pretashkent TBA for 1981 and 2020 based on the results of non-stationary calibration



Map of the hydroisopiezes of the Pretashkent TBA based on the results of non-stationary calibration for 2020.

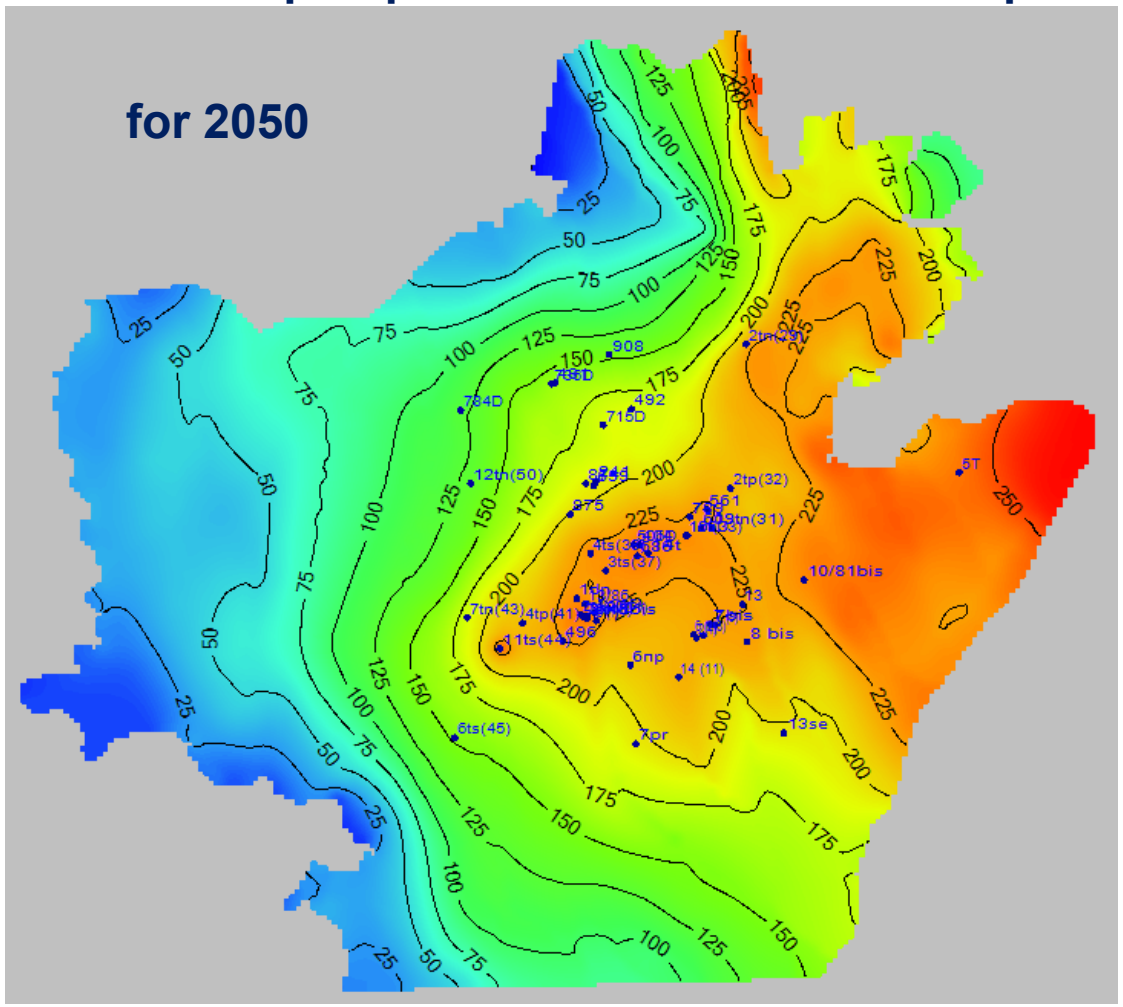


Map of isolines of depressions of the Pretashkent TBA based on the results of non-stationary calibration for 2020.

Forecast scenarios

Number of wells	Scenario 1 (well discharge rate in 2020)		Scenario 2 (maximum well discharge rate)		Scenario 3 (exploitable resources by wells)	
	l/s	m^3/day	l/s	m^3/day	l/s	m^3/day
Republic of Uzbekistan						
14	18.66	1,612.23	43.49	3,757.54	32.7	3,539.48
Republic of Kazakhstan						
36	84.58	7,307.76	316.74	27,366.34	98.7	8,527.6
Total for the aquifer	103.24	8,919.99	360.23	27,723.88	131.4	1,206.08

Map of predicted decreases in the piezometric surface of the Pretashkent TBA

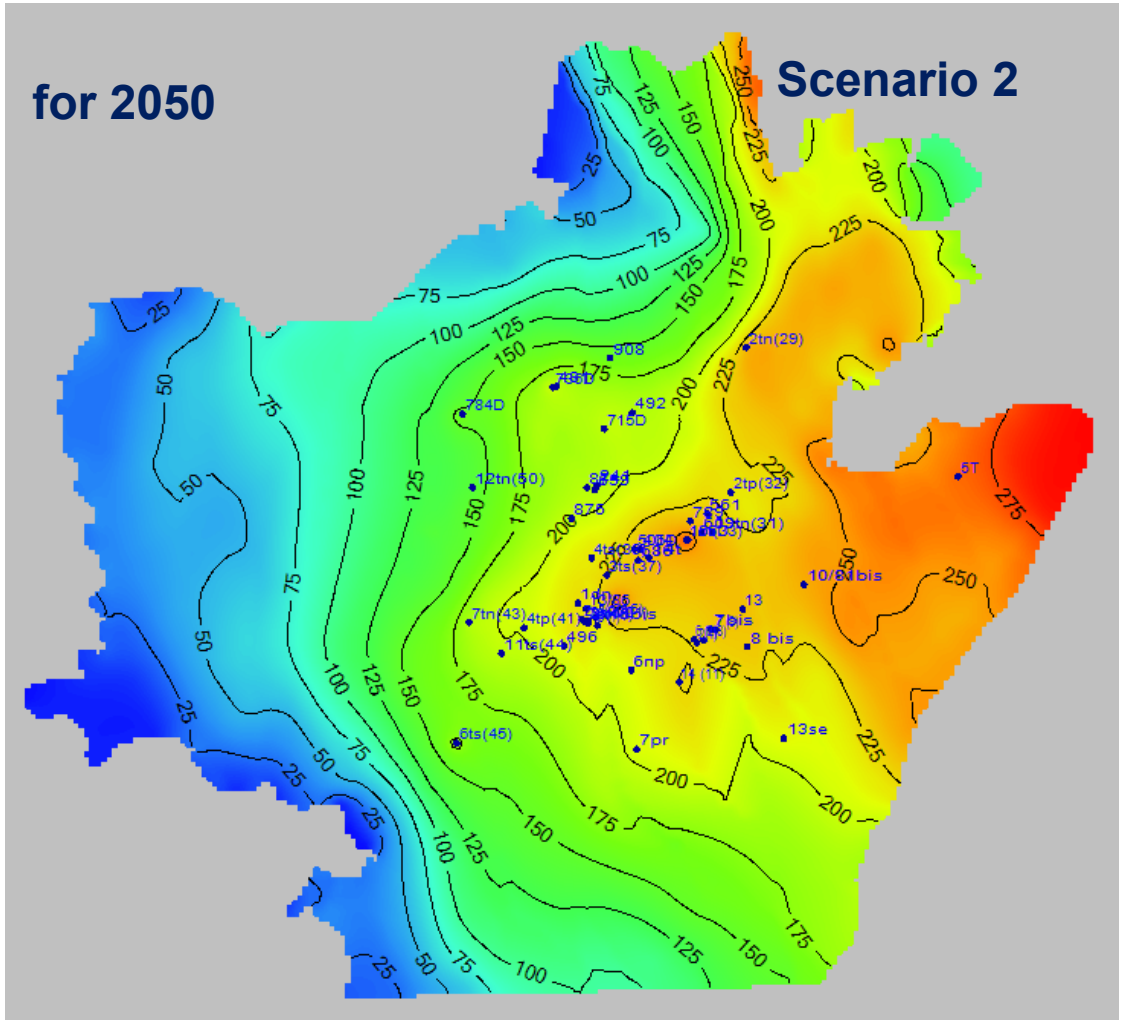


Scenario 1

Well number	Year of head decrease below the allowable level
Republic of Uzbekistan	

Republic of Kazakhstan	
3ts(37)	2049
4tp(41)	2038

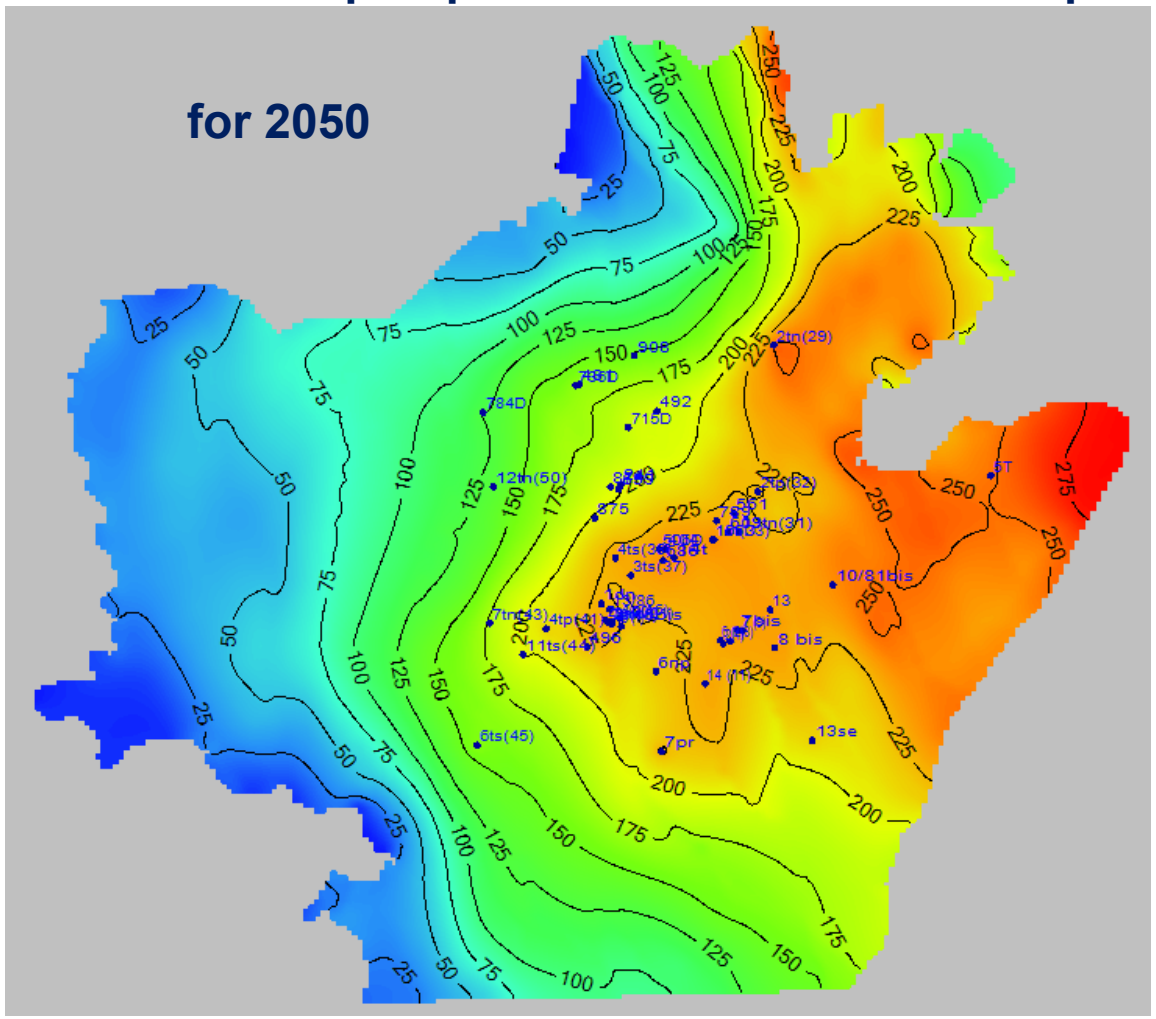
Map of predicted decreases in the piezometric surface of the Pretashkent TBA



Well number	Year of head decrease below the allowable level
Republic of Uzbekistan	
5(1)	2021
5t	2025
1(3)	2026
2(4)	2024
6(2)	2027
6pr	2028
7bis	2028
8bis	2028
10/81	2028
13	2026

Republic of Kazakhstan		***Republic of Kazakhstan***	
1dn	2021	14t	2021
3ts(37)	2021	105D	2021
4tp(41)	2021	241	2023
1r(16)	2022	404	2025
2tp(20)	2021	492	2026
2tp(32)	2026	496	2021
3md(21)	2021	506	2022
3md/bis	2021	0521	2023
4ts(38)	2021	0659	2023
7r(18)	2021	0686	2023
11ts(44)	2028	715D	2024
12tn(50)	2023	789	2024
13/86	2021	875	2023
13tn(31)	2023	908	2024

Map of predicted decreases in the piezometric surface of the Pretashkent TBA



Scenario 3

Well number	Year of head decrease below the allowable level
Republic of Uzbekistan	
5(1)	2021
5t	2028

Republic of Kazakhstan	
1dn	2021
3ts(37)	2028
4tp(41)	2029

The results of forecasting based on proposed forecast scenarios 1–3 will serve as a basis for the development of scenarios for Pretashkent TBA groundwater management – narratives describing what may happen in the future should a forecast scenario materialise.

When used further as a permanent operating one, the model should be adjusted in a coordinated way as new high-quality monitoring information arrives.

Non-stationary calibration of the model can be performed annually. The international experience of studying the operation of deep aquifers indicates that there is a possibility of changes (increases) of the elastic water yield due to the release of aquifer static pressure.

Variant tasks of level forecasting can be solved, for example, when wells are closed or liquidated, or their flow rate is regulated

CONCLUSIONS AND RECOMMENDATIONS

Joint (Kazakhstan – Uzbekistan) management of groundwater resources of the Pretashkent TBA should be based on the created mathematical simulation model.

For joint management of groundwater resources of the Pretashkent TBA based on the created mathematical simulation model, it is essential:

1. To make the created mathematical model of the Pretashkent TBA a permanent operating one in the two adjoining states: the Republics of Kazakhstan and the Republic of Uzbekistan

2. To build the capacity for international cooperation on optimal joint management of groundwater resources of the aquifer based on agreed scenarios and a permanent operating model and the exchange of Pretashkent TBA hydrogeological monitoring data.

3. To ensure on-going monitoring of the Pretashkent TBA groundwater (piezometric level, flow rate, groundwater quality) in all operating wells, regardless of their affiliation and purpose. To monitor the technical and environmental condition of water intake wells.

4. To improve the national legislation regarding mandatory groundwater monitoring in the Pretashkent TBA.

5. To limit the flow rate of wells in strict accordance with the values of exploitable resources agreed by the countries and approved for them.

6. To ensure the development of a system of accounting for the volume of aquifer groundwater abstraction and use at the national and interstate levels, and a regional water cadastre to register groundwater abstraction across the aquifer. The database of such accounting will be used as a main source of working material for the Pretashkent TBA water management model.

7. To upgrade the state groundwater monitoring system by installing modern equipment for recording the discharge rates and heads of wells. To implement data quality control measures in accordance with international standards. To develop groundwater quality monitoring programmes covering the entire aquifer.

8. To develop international cooperation between the adjoining states on Pretashkent TBA groundwater quality. To agree on water quality assessment standards and develop an arrangement for the exchange of these data between Kazakhstan and Uzbekistan.

Thank you for your attention!