PECULIARITIES OF THE CHEMICAL COMPOSITION OF THE ORDOVICIAN AQUIFER AS A SOURCE FOR POTABLE WATER SUPPLY (St. Petersburg region)

Elena Kayukova

St. Petersburg State University, St.-Petersburg, RUSSIA

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Baltic Klint
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Koporye
Lopukhinka
Krasnoe Selo
Izhora plateau
Begunitsy
Gatchina
Korchany
Kikerino
Volosovo
0 5 10km


Республика Карелия
Финляндия
Ладожское озеро
БАЛТИЙСКОЕ МОРЕ
St. Petersburg
Эстония
Псковская область
St. Petersburg region

Geological map of pre-Quaternary rock of the Izhora Plateau

State geological map of the Russian Federation, scale 1: 1,000,000. Sheet O-36. St. Petersburg: VSEGEI Cartographic Factory, 2012.

Devonian Period

- D_2st - Starooskolsky horizon. Sands, sandstone
- D_2nr - Narovsky horizon. Clay

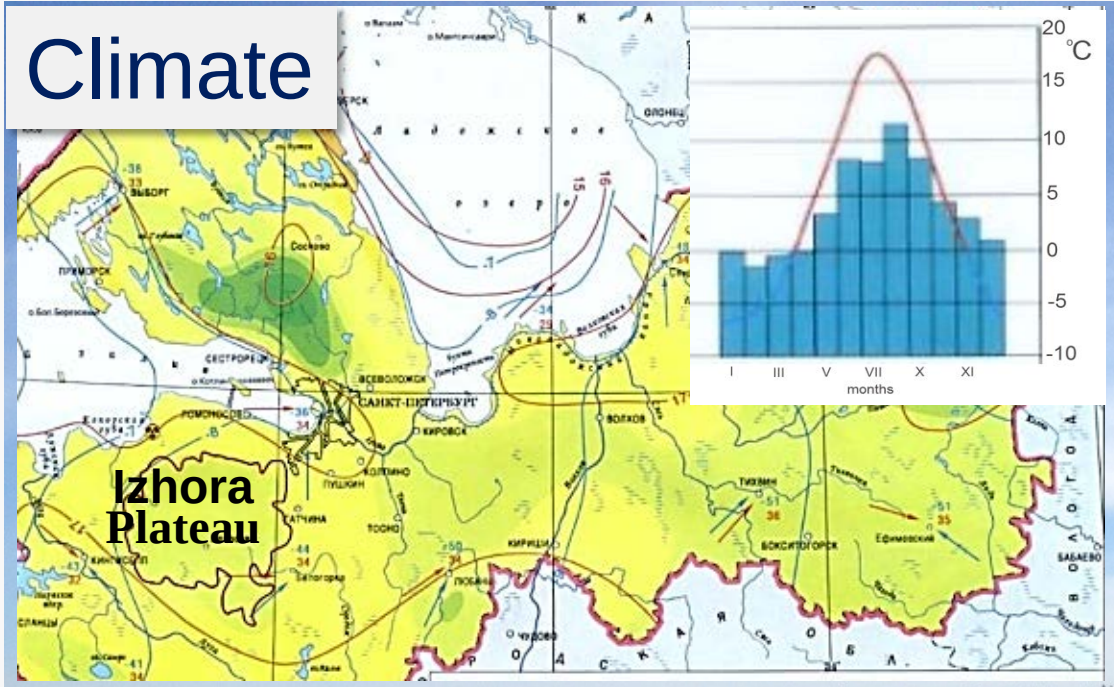
Ordovician Period

- O_3hr+kg - Yhvisky and kegelsky horizons. Limestone
- $O_3šn$, O_3it - Idaveresky horizon. limestone, clay interlayers and dolomites
- O_3kk - Kukruzesky horizon. limestone
- O_2tl - Azerisky and lasnamyazhsky horizons. Limestone and dolomite
- O_2kn - Kundsky horizon. Limestone and dolomite
- O_1-$_2vl$ - Volkhovsky horizon. Limestone and dolomite
- O_1pk+lt - Pakerortsky and leetsesky horizons. Obolovye sand, sandstone, Dictyonema shales

Cambrian Period

- $Є_2ts$ - Tiskresky horizon. Sands and sandstones
- $Є_1pr$ - Piritaskaya formation. Sandstones with interlayers clay
- $Є_1sv$ - Siverskaya formation. Clay with interlayers siltstone and sandstones
- $Є_1lm$ - Lomonosovskaya formation. Sandstones, siltstones and clays
- PR_3 - Upper Proterozoic rocks

Climate



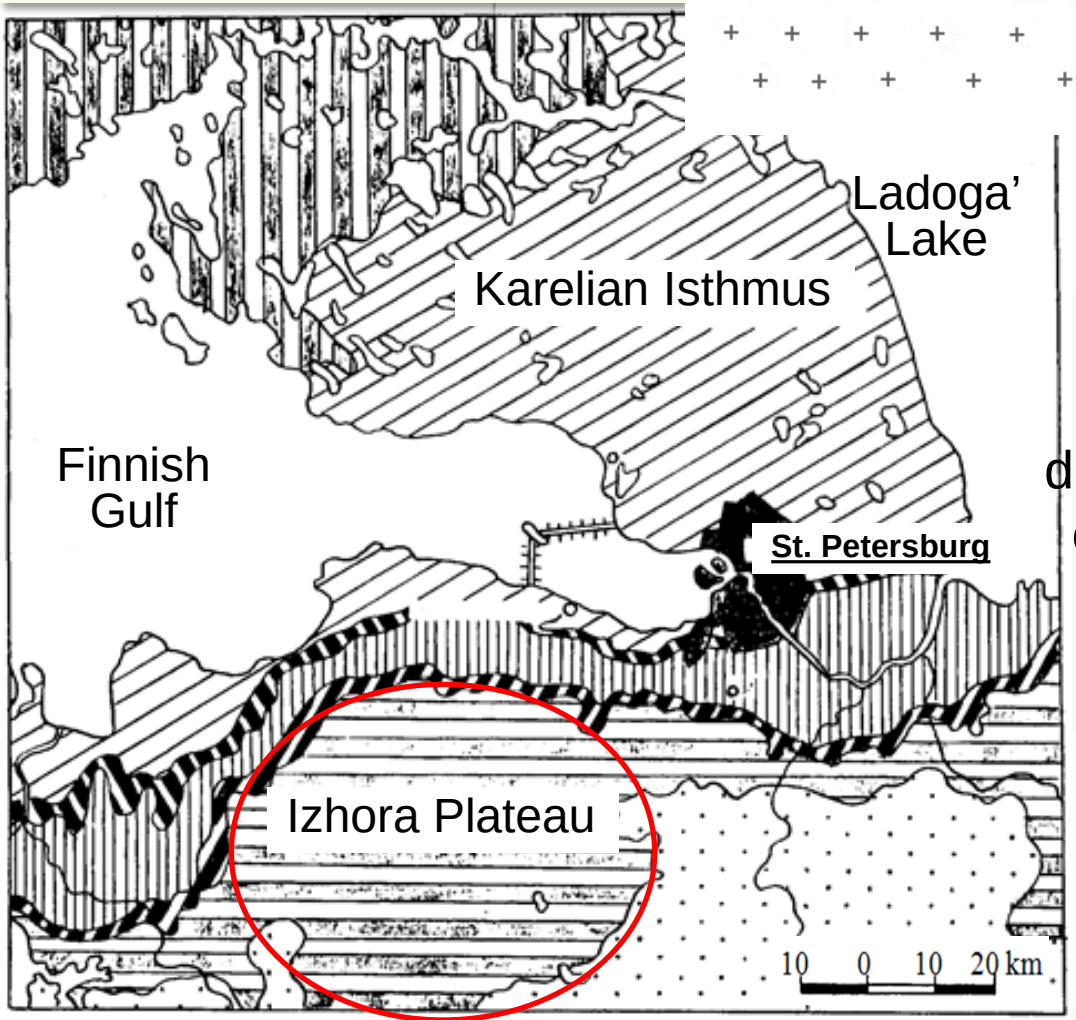
Rainfall, mm

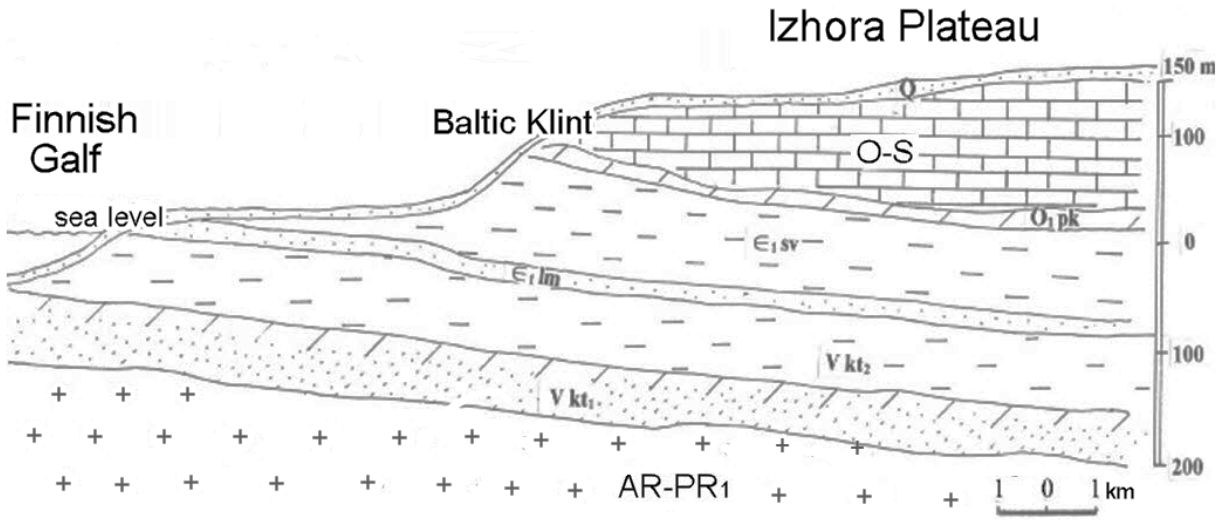
The main source of groundwater supply is precipitation and condensation.

Karst sinkholes emerge on the Izhora Plateau in quantities of 100–300 each year. Karst formations are often responsible for the decay of building foundations and road infrastructure.

period	average annual temperature, °C average (min-max)	average annual precipitation, mm/year average (min-max)
2021-2022	4,9 (1,2–6,7)	659 (189–887)
1973-2020	3,7 (-2,5–7,5)	нет данных

Hydrogeological scheme of St. Petersburg region





The recharge zone is the entire plane of the plateau, and the discharge zone is the southern edge of the plateau and the northern one (along the Baltic Klint).

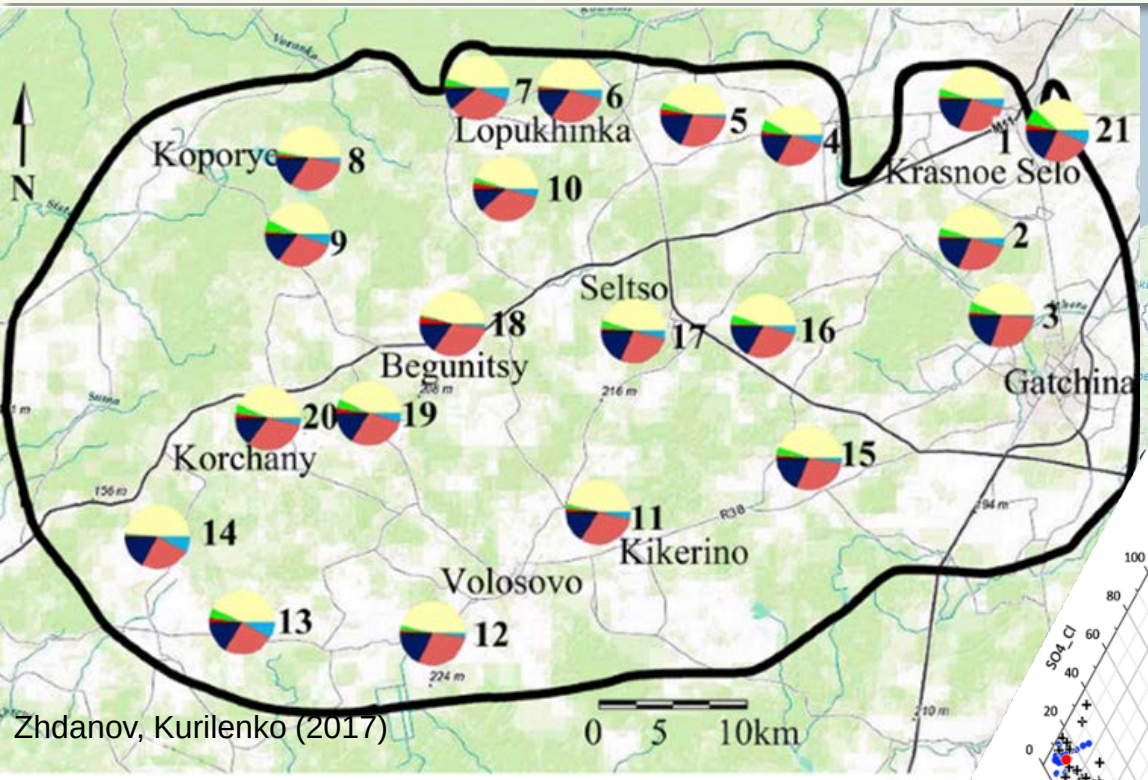
Main aquifer

AR-PR$_1$ | Cm$_1$ ln (aquiclude) | D$_2$

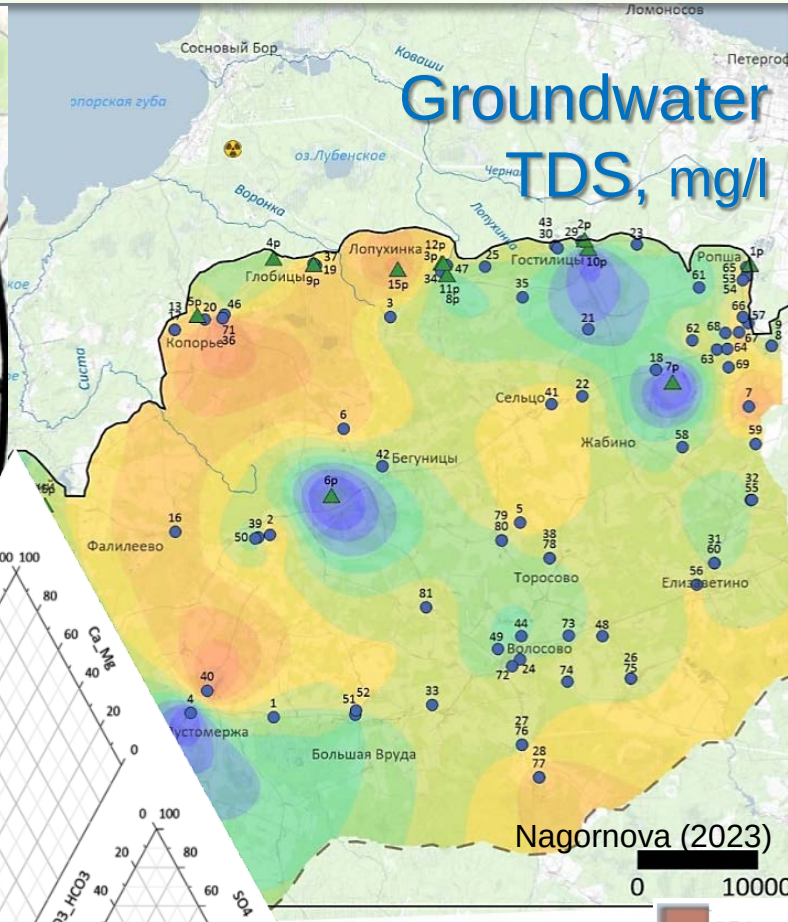
PR$_2$ gd | Cm - O | dam

Cm$_1$ lm | O$_2$

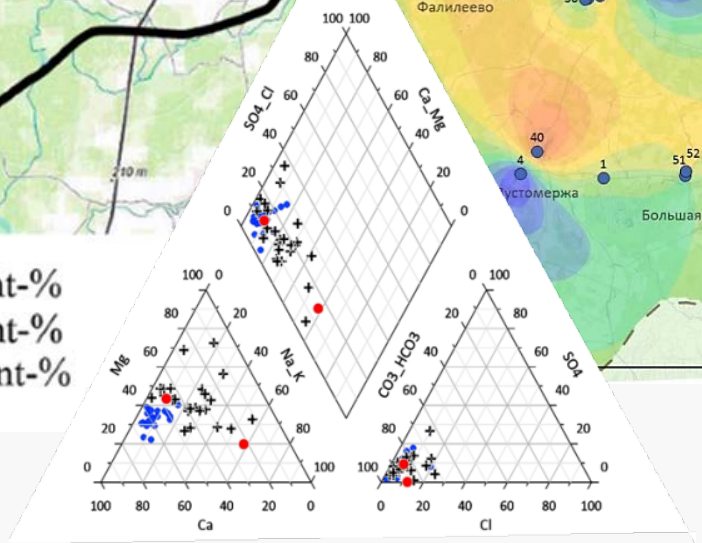
Groundwater chemical compositions in sampling sites



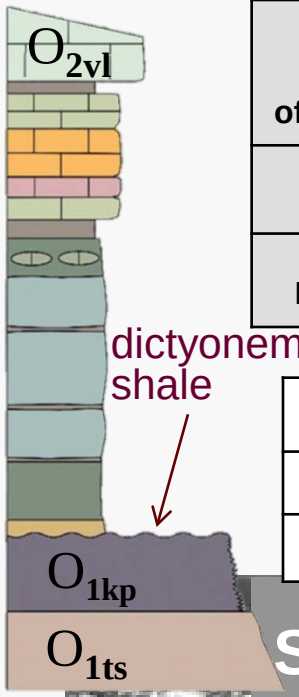
Zhdanov, Kurilenko (2017)



-Cl, equivalent-%
-SO_4,equivalent-%
- HCO_3,equivalent-%
-Na, equivalent-%
-Ca, equivalent-%
-Mg, equivalent-%



$$M\,(0{,}6-0{,}8)\,\frac{HCO_3(63-88)\,Cl(1-19)\,SO_4(1-11)}{Ca(40-74)\,Mg(24-45)\,Na(2-14)}\,pH(6{,}8-7{,}8)$$



Springs of St. Petersburg region	TDS		Ion concentration, *mg/l*								
	mg/l	pH	Ca	Mg	Na	K	HCO_3	SO_4	Cl	NO_3	Fe
Gdov aquifer, Carelian isthmus	1194	7.2	33	19	366	10	138	67	560	-	0.2
Ordovician aquifer, Izora Plateau, Ropsha	583	7,8	90	36	6	2	358	51	16	25	0.1

^{222}**Rn,** Bq/l			^{226}**Ra,** Bq/l
average	min	max	
120±15	103	130	1,7±0,4

The radioactive security of water
Gross α - 0.2 Bq/l
Gross β - 1.0 Bq/l
^{222}Rn - 60 Bq/l; ^{226}Ra, - 0.5 Bq/l

NRB 99/2009

Spring Klyuch, 19th century photo

$$M(0,6-0,8)\frac{HCO_3(63-70)\,Cl(16-19)}{Mg(44-45)\,Ca(40-41)\,Na(12-13)\,K3}\,pH(6,8-7,2)$$

Trace elements of groundwater

	average	median	max	n	
Al	0,0085	0,0056	0,0592	29	0,2
B	0,117	0,025	1,302	48	0,5
Ba	0,427	0,101	4,5	48	0,7
Cd	0,00009	<0,0001	0,00054	10	0,001
Cu	0,0022	0,0014	0,0162	28	1,0
Fe	0,296	0,027	2,9	39	0,3
Mn	0,016	0,0014	0,16	28	0,1
Mo	0,0008	<0,001	0,0083	4	0,07
Ni	0,0009	<0,001	0,004	13	0,02
Pb	0,0017	0,0017	0,0046	36	0,01
Sb	0,000008	<0,00001	0,000075		0,005
Sr	0,177	0,083	0,736	48	7,0
Zn	0,0079	0,004	0,086	45	5,0

Agricultural pollution

n		average	max	SanPiN 1.2.3685-21
58	NO_3	16,7	93	45 mg/l
39	NO_2	0,30	2,10	3 mg/l

Priority substances have been identified for assessing the quality of groundwater: total hardness, Fe, Mn, Ba, B.

When SI > 1, minerals tend to precipitate.
Saturation indices of the groundwater are supersaturated concerning Dolomite, Calcite, Aragonite

SI	wells	springs
	average (min-max)	average (min-max)
Dolomite	1,58 (0,97-2,03)	1,37(1,17-1,48)
Calcite	0,51 (0,17-0,68)	0,38 (0,29-0,56)
Aragonite	0,34 (0,0-0,52)	0,22 (0,12-0,39)

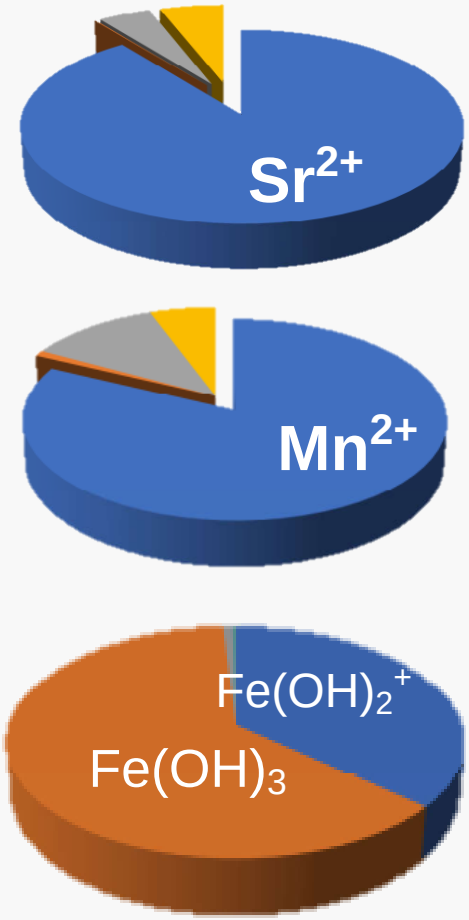
Correlation matrix analysis of groundwater

	TDS	Ca	Mg	Na	K	Cl	SO_4	HCO_3
TDS	1,0							
Ca	0,8	1,0						
Mg	0,7	0,4	1,0					
Na	0,4	-0,1	0,0	1,0				
K	0,4	0,3	0,2	0,1	1,0			
Cl	0,3	0,2	0,3	0,4	0,2	1,0		
SO_4	0,5	0,4	0,2	0,3	0,3	0,2	1,0	
HCO_3	0,9	0,7	0,7	0,2	0,3	0,0	0,2	1,0

Migration forms of basic ions in the groundwater of the Izhora Plateau. For calculation used program The Geochemist's Workbench

Na		K		Ca				Mg			
Na^+	$NaHCO_3$	K^+	KSO_4^-	Ca^{2+}	$CaCO_3$	$CaHCO_3^+$	$CaSO_4$	Mg^{2+}	$MgCO_3$	$MgHCO_3^+$	$MgSO_4$
96,5-96,9	2,8-3,1	99,6	0,4	79,9-82,0	1,3-1,7	10,9-12,8	5,5-5,6	80,4-82,3	0,8-1,1	9,9-11,8	6,7
96,1	3,2	99,3	0,7	78,5	0,2	11,3	9,1	78,3	0,2	10,3	10,9

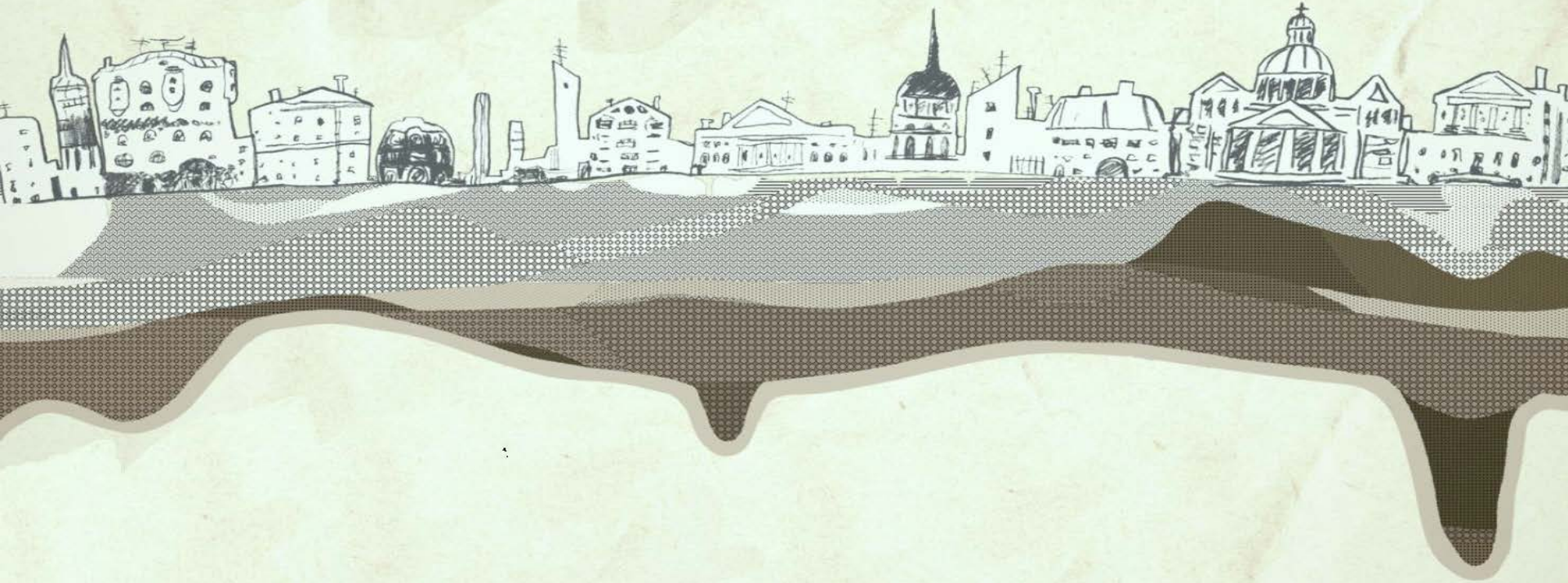
Ba	Ba^{2+}	92,7-92,8	88,5
	$BaSO_4$	7,2-7,3	11,4
Li	Li^+	98,7	97,6
	$LiSO_4^-$	1,3	2,4
Mn	Mn^{2+}	79,4-81,7	82,1
	MnCO3	4,0-4,7	0,9
	MnHCO3+	10,4-12,4	11,3
	MnSO4	3,4-3,5	5,6
Sr	Sr^{2+}	90,1-91,7	89,9
	SrCO3	0,3-0,4	0,1
	SrHCO3+	4,6-6,1	4,5
	SrSO4	3,4	5,5
Zn	Zn^{2+}	95,4-95,6	93,1
	ZnSO4	4,4	6,7
Ni	Ni^{2+}	96,2-96,3	94,3
	NiOH+	0,3-0,4	0
	NiSO4	3,4	5,7



Pb	$PbCO_3$	100	100
Al	$Al(OH)_2^+$	0,2-0,3	8,6
	$Al(OH)_3$	4,6-5,9	24,1
	$Al(OH)_4^-$	95,2-93,7	66,8
Cr	$Cr(OH)_2^+$	7,5-10,6	18,8
	$Cr(OH)_3$	87,1-90,5	54,5
	Cr^{3+}	1,8	0,1
	$CrOH^{2+}$	2,2-7,5	26,5
Fe	$Fe(OH)_2^+$	1,0-4,3	36,4
	$Fe(OH)_3$	9,9-50,2	62,5
	Fe^{2+}	31,2-62,6	0,7
	$FeCO_3$	4,6-8,8	0
	$FeHCO_3^+$	7,8-14.2	0,2
	$FeSO_4$	1,4-2,8	0,1

The potential yield of the aquifer is estimated of about 700 000 m^3 per year. However, these resources are not enough to supply water to St. Petersburg.

So, neither the quality, nor the quantity of groundwater within the immediate vicinity of St. Petersburg can provide the alternative water-supply for the city. The reasonable compromise is the combination of surface and underground water resources.



Thank you for your attention!