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EUWI+ EU WATER INITIATIVE FOR EASTERN PARTNERSHIP

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Delineation of groundwater bodies and design of a monitoring network in the Danube Prut and Black Sea River Basin District in Moldova under the European Union Water Initiative Plus

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Introduction

The "European Union Water Initiative Plus for Eastern Partnership (EaP) Countries (EUWI+)" involves six eastern neighbours of the EU: Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. The EUWI+ project addresses existing challenges in both development and implementation of efficient management of water resources. It specifically supports the EaP countries to move towards the approximation to EU acquits in the field of water management as identified by the EU Water Framework Directive (WFD).

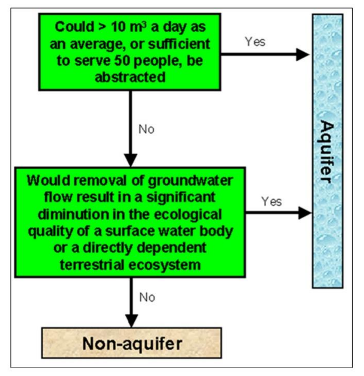
The Republic of Moldova has elaborated a "River Basin Management Plan for the Danube-Prut and Black Sea pilot river basin district in the limits of the Republic of Moldova" by the Institute of Ecology and Geography in accordance with the Directive 2000/60/EC from October, 23 2000 for the establishment of a framework of Community policy in the water sector and the Water Law of the Republic of Moldova no. 272 of 23.11.2011. This document needs an examination and update for the approval and implementation into practice.

The aim of this work is a review and update of the existing delineation and characterisation of groundwater bodies (GWB) in a way that enables an appropriate description of the quantitative and chemical status of these GWBs and the review of the groundwater monitoring network in the Danube-Prut and Black Sea River Basin of the Republic of Moldova.

The following tasks were performed:

- Review and update of the boundaries and the monitoring network of GWBs, production of datasets, GIS-shape file layers, accompanying metadata;
- Characterisation of each groundwater body both in text form and by completing templates.

Methodology



The following recommendations of the WFD have been considered when identifying GWBs in the Danube and Prut river basins:

- Different aquifer types (porous, fractured) have been distinguished from the hydrogeological map;
- Geological boundaries of the aquifers defined;
- Hydrodynamic differences of the aquifers analysed;
- Hydrochemical varieties of the aquifers evaluated;
- Groundwater abstraction (>10 m³/day) has been checked;
- Groundwater systems which consist of several layers of shallow aquifers with similar hydrodynamic and hydrochemical conditions have been considered;
- Artesian hydrogeological units with similar chemical and quantitative status have been assigned as GWBs;
- The lower boundary of the GWBs was determined by the depth from which it is not disproportionately expensive to pump water for different uses;
- Fragmentation of aquifers into unmanageable numbers of water bodies has been considered and small groundwater bodies with low practical use were grouped with main aquifers.

General characteristics

The general characteristic of delineated groundwater bodies (GWBs) for Danube – Prut – Black Sea basin

Nr.	GWB code	Index	Name of aquifer complex	Basin (sub basin) name	GWB surface, km²	Lithology	Thickness, m	Top layer depth, m	GW level, m	Charge of boreholes, l/sec	Filtration parameters: Kf, m/day, T, m²/day
1	**MDDBSGWQ120**	aA_3	Holocene alluvial-deluvial aquifer	Danube – Black Sea	**812,82**	Clay, loam, sandy loam, sand, gravel	0,5 - 20,0	0 - 10	0,5 - 9,0	0.7 - 0.8	Kf = 0,4 - 10,0 T = 0,2-200,0
2	**MDPRTGWQ130**	aA_3		Prut	**1412,73**						
3	**MDDBSGWQ220**	aA_{1+2} - aN_2^{2+3}	Pliocene-Pleistocene terraces aquifer complex	Danube – Black Sea	**1739,85**	Clay, loam, sandy loam, sand, gravel	0,5 - 15,0	0 - 10	0,0 - 20,0	0.005-0.22	Kf = 0.04 – 0,8 T = 0.02-12.0
4	**MDPRTGWQ230**	aA_{1+2} - aN_2^{2+3}		Prut	**1681,69**						
5	**MDDPBGWD310**	N_2p	Pontian aquifer	Danube, Prut, Black See	**3436,30**	Loam, clay with sand layers, sandy loam, sand	0,5 - 30,0	2,0 – 120,0	5 - 90,0	0.005-0.2	Kf = 2,0 – 5,0 T = 0.15 – 4,0
6	**MDDPBGWD420**	N_1s_3-m	Upper Sarmatian - Meotian aquifer	Danube, Prut, Black See	**8323,20**	Clay with sand layers, sand, conglomerate	0,5 - 20,0	1,0 - 20,0	0 - 40,0	0.001-0.7	Kf = 0,4 – 1,5 T = 0,2 – 27,0
7	**MDPRTGWQ510**	N_1kd_{1-2}	Middle Sarmatian, sandy clay formation	Prut	**5424,74**	Clay with sand layers, sand	1,0 - 20,0	0,5 - 15,0	0 - 25,0	0.01 - 0.23	kf = 0,08 - 1.40 T = 0.08 – 8,0
8	**MDDPBGWD620**	N1s2	Middle Sarmatian aquifer (congerian layers)	Danube, Prut, Black See	**6807,23**	Sand, clay with congerian layers	1,0 - 50,0	20,0 - 290,0	5 - 150,0	0.01-0.7	kf = 0,8 – 1,50 T = 10,0 – 50,0
9	**MDDPBGWD730**	N_1b-s_{1-2}	Badenian-Sarmatian aquifer complex	Danube, Prut, Black See	**8089,03**	Limestone, sandstone, clay with sand layers, sand, marl	10,0 - 150,0	50,0 - 180,0	25 - 170	0.009-2.5. up to 8.0	kf = 0,3 – 15,0 T = 3,0 - 200, (max 1000)
10	**MDPRTGWD740**	N_1b-s_1		Prut	**3991,36**						
11	**MDPRTGWD820**	K_2+S	Silurian – Cretaceous aquifer complex	Prut	**3992,22**	Limestone, sandstone, sand	1,0 - 30,0	7,0 - 215,0	1 - 200	0.1-3.9	kf = 0,3 – 12,0 T = 10 - 400

The general chemical composition of GWBs from DPBSB

GWB	Aquifer	pH	Mineralization, g/l	Hardness, German grade	Principal ions	Parameters exceeding MAL* (bold = anthropogenic)
MDDBSGWQ120	Holocene alluvial-deluvial aquifer	7,1 - 8,6	0,7 – 1,6	1,0 – 5,5	HCO_3-SO_4-Cl Na-Ca-Mg	Mineralization, NH_4, NO_3, NO_2, hardness, organic micropollutants
MDDBSGWQ130		7,1 - 8,6	0,7 – 1,6	1,0 – 5,5	HCO_3-SO_4-Cl Na-Ca-Mg	Mineralization, NH_4, NO_3, NO_2, hardness, organic micropollutants
MDDBSGWQ220	Pliocene-Pleistocene terraces aquifer complex	no monitoring data				
MDDBSGWQ230		no monitoring data				
MDDPBGWD310	Pontian aquifer	7,4 – 7,8	0,5 – 1,7	8 – 23,0	HCO_3-SO_4-Cl Ca-Na-Mg	SO_4 up to 450mg/l, NO_3, NO_2
MDDPBGWD420	Upper Sarmatian - Meotian aquifer	7,5 – 8,7	0,9 – 3,6	1,1 – 25,0	HCO_3 - Ca-Na SO_4-Cl -Na	Mineralization, SO_4, Cl, Fe, NH_4
MDPRTGWQ510	Middle Sarmatian, clay-sand formation	no monitoring data				
MDDPBGWD620	Middle Sarmatian aquifer (congerian layers)	7,8 – 8,0	0,6 – 2,5	0,8 – 5,6	HCO_3-SO_4,- HCO_3-Cl- Na;	Mineralization, Cl, NH_4, Fe, Mn, Sr, F
MDDPBGWD730	Badenian-Sarmatian aquifer complex	7,5 – 9,0	0,5 – 10,0	1,4 – 42,0	HCO_3-SO_4-Cl Na-Ca-Mg	Mineralization, Na, NH_4, NO_3, Fe, Mn, Sr, F, Se, Al
MDPRTGWD740		7,5 – 9,0	0,5 – 10,0	1,4 – 42,0	HCO_3-SO_4-Cl Na-Ca-Mg	Mineralization, Na, NH_4, NO_3, Fe, Mn, Sr, F, Se, Al
MDPRTGWD820	Silurian – Cretaceous aquifer complex	7,5 – 8,0	0,7 – 1,5	0,8 – 31,0	HCO_3-SO_4-Cl Na-Ca-Mg	Mineralization, Na (up to 600 mg/l), NH_4, NO_3, Al, Mn, Fe.

References

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2. Identification, Characterization and Delineation of Groundwater Bodies in Prut River Basin, Republic of Moldova. Hulla & Co. Human Dynamics KG , Report, 2013.
3. River Basin Management Plan for the Danube-Prut and Black Sea pilot river basin district in the limits of the Republic of Moldova Cycle I, 2017 – 2022. Report prepared by the Institute of Ecology and Geography of the Academy of Sciences of Moldova (ASM), 2016.
4. Water Law nr. 272 from 23.12.2011 Entry into force: 26 October 2013, Modification: LP 162 from, July 2014, LP 96 from 12 June 2014.
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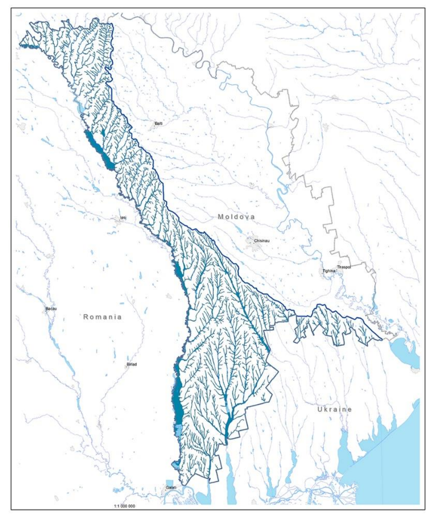
6. MONITORINGUL APELOR SUBTERANE ŞI CREAREA SISTEMULUI GEOINFORMAŢIONAL AL BAZINULUI ARTEZIAN AL REPUBLICII MOLDOVA", 2015, Regimul apelor subterane" pentru anii 2010-2014, Darea de Seamă, Agenţia Pentru Geologie şi Resurse Minerale, Întreprinderea de Stat „Expediţia Hidro-Geologică din Moldova 152 p. (Romanian).

Results and Conclusions



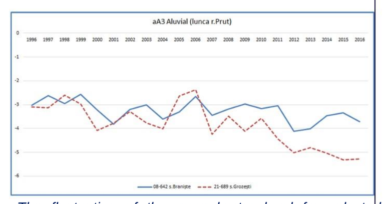
Holocene alluvial, deluvial aquifer – a,adA_3

Groundwater body MDDBSGWQ120

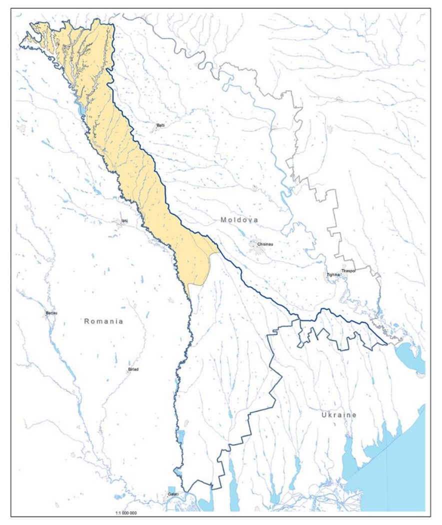
This GWB refers to the Holocene alluvial-deluvial aquifer of the Danube – Black Sea sub-basin. Quaternary water bearing sediments fully cover the surface of the basin but are mostly developed in the river valleys The alluvial aquifer is widely used for domestic water supply of individual consumers and separate settlements. This GWB is most vulnerable to anthropogenic impacts. The shortcomings of this GWB consist in poor water saturation of the aquifers and poor water quality. The main anthropogenic pressures are: agriculture activity, settlement impact (septic tanks) and intensive abstraction.

Groundwater body MDPRTGWQ130

This Holocene alluvial-deluvial aquifer is found along the Prut River valley and its tributaries. The recharge area corresponds to the spreading area. The GWB is recharged from precipitation, the interaction with surface waters (rivers) and linkage with deeper aquifers (Cretacic–Silurian, Baden-Sarmatian). Discharge takes place in lower aquifer horizons or drainage by rivers. The water regime of this GWB is close to the atmospheric conditions and has a good relation with surface waters. These GWB is most vulnerable to anthropogenic impacts.



The fluctuation of the groundwater level for selected monitoring wells



Lower Neocene Middle Sarmatian (sandy clay formation) aquifer N_1kd

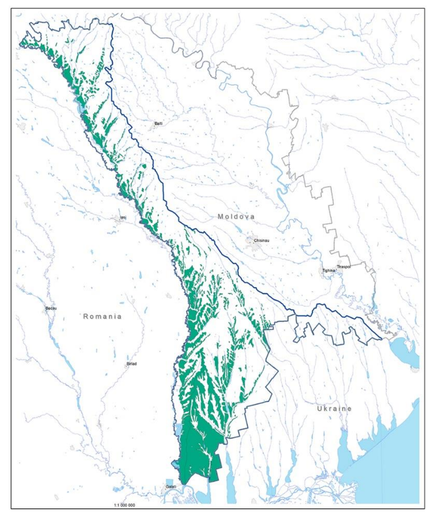
Groundwater body MDPRTGWQ510

This GWB is associated with the Middle Sarmatian clay-sand terrigenous formation (Codrii formation) of the central and north part of the studied basin. This formation is overlapped by deposits of Pliocene–Pleistocene terraces and alluvial-deluvial Holocene deposits.

Groundwater recharge coincides with the whole area of the GWB and is formed by precipitation and infiltration from upper aquifers. This GWB is drained by rivers, ravines and creeks. The principal discharge happens in the alluvial and alluvial-deluvial aquifers.

This GWB is linked to groundwater dependent ecosystems (wetland) through the groundwater discharge into river valleys and artificial lakes by springs or marshlands. The groundwater status is affected by several factors, mainly by land-use and climate change. They cause changes in groundwater recharge and flow dynamics, leaching of pollutants and deteriorate groundwater quality. Aquatic ecosystems associated with this GWB and their interaction are actually not studied.

Within the EUWI+ project new monitoring sites for the improvement of the groundwater monitoring network have been proposed.



Upper Neocene (Pliocene)–Quaternary (Pleistocene) aquifer N_2-A_{1-2}

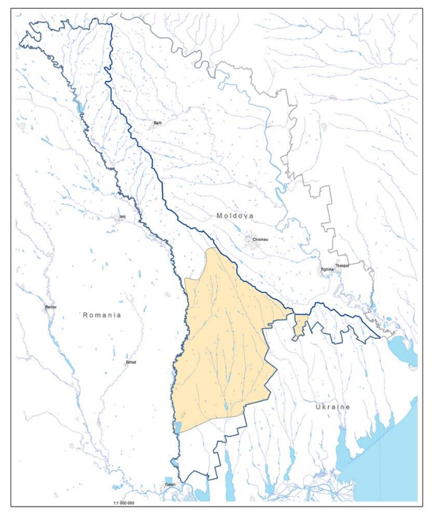
Groundwater body MDDBSGWQ220

This GWB refers to the Pliocene-Pleistocene terrace aquifer which is distributed on the terraces of rivers of Danube River–Black Sea basin. This GWB is widely used for local, rural water supply. The water of this aquifer complex is used by individual households, captured from springs, shallow wells, more rarely through deeper wells. The limiting factors of more intensive utilization of this GWB are the small water permeability of the terrace formation, the low aquifer capacity, the poor water quality (high mineralization, hardness, high content of nitrates, chlorides, sulfates). The main anthropogenic pressures are: agriculture activity, settlement impact.

Within the EUWI+ project new monitoring sites for the improvement of the groundwater monitoring network have been proposed.

Groundwater body MDPRTGWQ230

This GWB of the Pliocene-Pleistocene terrace aquifer is common in terrace deposits of the Prut river and its tributaries. This shallow aquifer is associated with wetland ecosystems related to the discharge of shallow groundwater by springs or marshlands. Springs discharge into lakes, situated at small rivers. The groundwater status is affected by several factors, mainly by land-use and climate change. These factors cause changes in groundwater recharge and flow dynamics, leaching of pollutants and groundwater quality. The interactions between groundwater bodies and associated aquatic ecosystems have actually not been studied. In the northern part of the territory terrace deposits are situated on Baden-Sarmatian or Cretaceous aquifers in river valleys and have a joint effect on the river ecosystem.



Lower Neocene Middle Sarmatian (Congeriev) aquifer N_1s_2

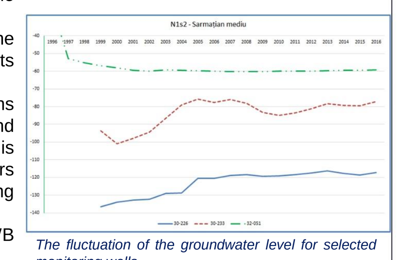
Groundwater body MDDPBGWD620

This GWB of the Middle Sarmatian Congerian aquifer is located in the central and south part of the studied area.

This GWB is used for centralized water supply in the southern part of the Republic. The groundwater is used for drinking water supply, although its chemical quality is not very favorable for consumption.

The recharge of this GWB takes place in the northern and central regions of the Republic of Moldova, where these sediments are close to the land surface and are linked with surface water and precipitation. Recharge is also taking place through infiltration of water from overlaying aquifers (alluvial, terraces deposits). Discharge takes place into the underlying Baden-Sarmatian aquifer.

There are no groundwater dependent ecosystems linked with this GWB due to its depth.



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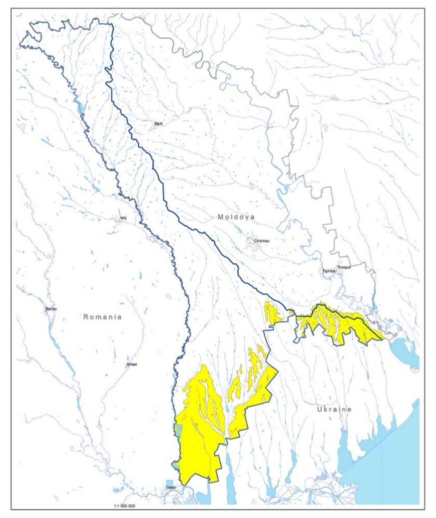


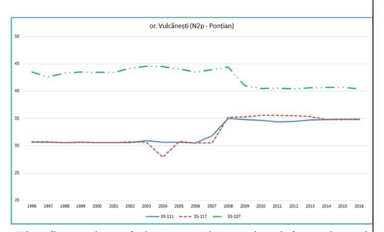
Upper Neocene Pontian aquifer N_2p

Groundwater body MDDPBGWD310

This GWB is associated with the Pontian aquifer which is located in the southern part of the Danube-Prut and Black Sea basin. The GWB is recharged from precipitation and inflow from aquifers situated above and below. Discharge occurs in river valleys and creeks or in lower aquifers. Groundwater flow is directed to the river valleys or along the base of ravines and creeks. The groundwater is used for drinking and agricultural water supply in the southern part of the basin and it is in most cases abstracted from springs and deep and shallow wells.

The main anthropogenic pressures are agriculture activity, settlement impacts (animal farms, septic tanks) and intensive abstraction. The negative factors of the increased use of this GWB are high mineralization, hardness and sulfate content as natural factors. The high nitrate content (up to 250 mg/l) in groundwater as result of the anthropogenic impact is found in the area where this GWB is shallow and unconfined.

This GWB is liked with wetland ecosystems dependent of the discharge of groundwater by springs or marshlands.



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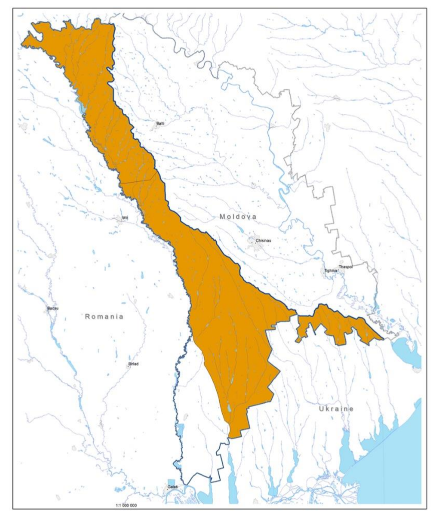


Lower Neocene Baden Sarmatian aquifer system N_1b-s

The Badenian-Sarmatian aquifer complex is widely spread in the studied region and it is most intensively used in the whole Republic of Moldova. The water reserves in the region allow for being used in centralized water supply networks. This aquifer is divided into two GWBs.

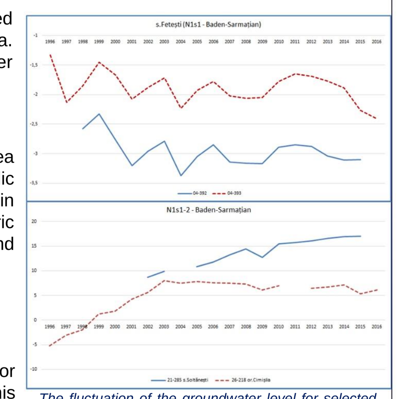
Groundwater body MDDPBGWD730

This GWB is situated in the south part of the Danube-Prut and Black Sea basin. Due to high groundwater abstraction and poor hydraulic characteristics an overall decline of the groundwater level is observed in the urbanised area of the basin. In some locations the piezometric groundwater level has dropped to about 100 m below surface and continues to fall.

Groundwater body MDPRTGWD740

This GWB is situated in the north part of Prut River basin.

Groundwater dependent ecosystems can be found at the Prut river or small river valleys in the north part of the basin in the area where this GWB is very shallow and close to land surface.



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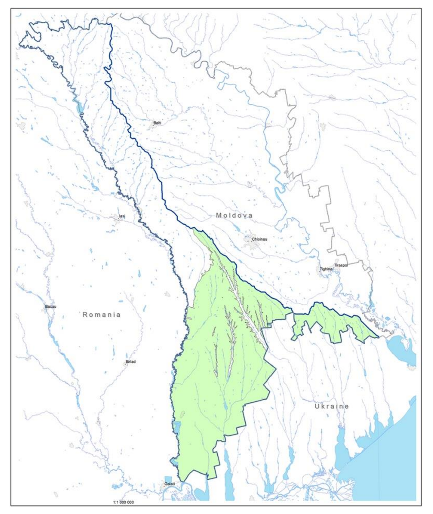


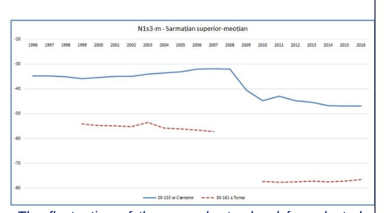
Lower Neocene Upper Sarmatian Meotic aquifer system N_1s_3-m

Groundwater body MDDPBGWD420

This GWB is associated with the Upper Sarmatian–Meotian aquifer which is situated in the southern part of the studied area.

The yields of exploitation wells vary between 0.05 and 7.0 l/sec. The groundwater system is used for potable and technical water supply.

This GWB is sensitive to pollution and anthropogenic impacts in the area where it reaches the land surface. In the south part of the territory this GWB is located at significant depths and it is overlain by impermeable layers (confined condition). The main anthropogenic pressures are agriculture activities, settlement impacts (animal farms, septic tanks) and intensive abstraction. Groundwater dependent ecosystems (wetlands) are situated in small river valleys. The GWB discharges to springs or marshlands; some springs are the heads of small rivers. The groundwater status is affected by several factors, mainly by land-use and the climate change.



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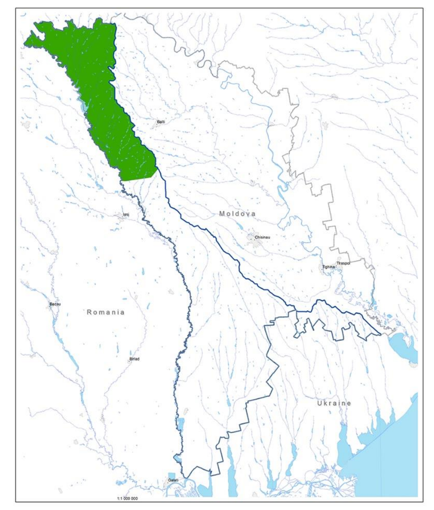
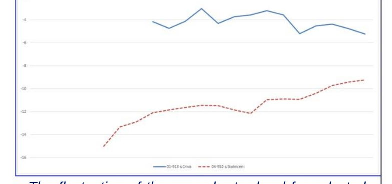


Cretaceous-Silurian aquifer system K-S

Groundwater body MDPRTGWD820

This GWB of the Silurian-Cretaceous aquifer system is widely used for local and centralized water supply (drinking water, technical production needs) in the northern part of the Danube-Prut River basin. In most cases the groundwater is simultaneously abstracted with the groundwater of GWB MDDPBGWD740 because it is hydraulically connected. The depth of the exploration wells ranges from 100 m in the North to 200-250 m in the Southern part of the studied area.

Groundwater dependent terrestrial ecosystems linked with this GWB are located at the Prut river or small river valleys on the Northern part of the basin in the area where this GWB is close to land surface.



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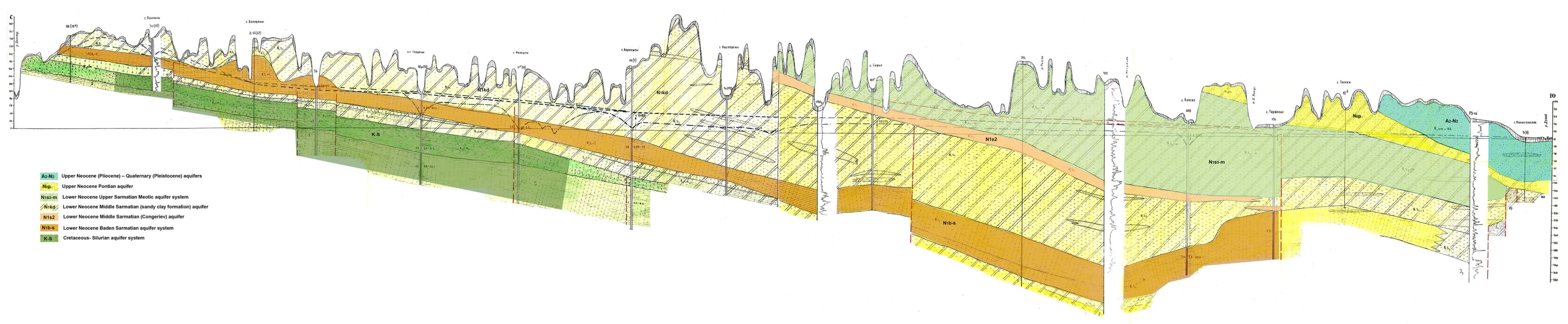

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