Геолошки анали Балканскога полуострва Annales Géologiques de la Péninsule Balkanique	76	47–60	Београд, децембар 2015 Belgrade, December 2015

DOI: 10.2298/GABP1576047S

Conception to set up a new groundwater monitoring network in Serbia

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Abstract[2]. The Water Framework Directive of the European Union (WFD) adopted in year 2000. outlines number of water policy and management actions, where monitoring is of primary importance. Following WFD principles Serbia adopted new legislation in water sector aiming to conserve or achieve good ecological, chemical and quantitative status of water resources. Serbia, as most of the countries of former Yugoslavia mostly uses groundwater for drinking water supply (over 75%). However, the current situation in monitoring of groundwater quality and quantity is far from satisfactory. Several hundred piezometers for observation of groundwater level under auspices of the Hydrometeorological Service of Serbia are located mostly in alluviums of major rivers, while some 70 piezometers are used by the Serbian Environmental Protection Agency for controlling groundwater quality. Currently only 20% of delineated groundwater bodies are under observation. This paper evaluates current conditions and proposes to expand national monitoring network to cover most of groundwater bodies or their groups, to raise number of observation points to a density of ca. 1 object /200 km^2 and to include as much as possible actual waterworks in this network. Priority in selecting sites for new observation piezometers or springs has to be given to groundwater bodies under threats, either to their water reserves or their water chemical quality. For the former, an assessment of available renewable reserves versus exploitation capacity is needed, while to estimate pressures on water quality, the best way is to compare aquifers' vulnerability against anthropogenic (diffuse and punctual) hazards.

Key words: monitoring, groundwater, „good“ status, EU Water Framework Directive, Serbia.

Апстракт. Оквирна директива о водама Европске Уније (ОДВ) усвојена 2000. године, утврђује основне политике и управљања водним ресурсима, при чему је мониторинг вода од примарног значаја. Србија је усвојила основне принципе ОДВ кроз иновирани Закон о водама који промовише циљеве очувања или постизања доброг еколошког, хемијског и квантитативног статуса водних ресурса. Србија, као и већина земаља бивше Југославије, за пиће углавном користи подземне воде (око 75%). Међутим, тренутна ситуација у погледу мониторинга квалитета и квантитета подземних вода далеко је од задовољавајуће. Неколико стотина пијезометара за осматрање нивоа подземних вода под ингеренцијом Хидрометеоролошког завода Србије, налази се углавном у алувијонима већих река, док се око 70 пијезометара користи од стране Агенције за заштиту животне средине Републике Србије за узорковање и контролу квалитета подземних вода. Тренутно се само око 20% од укупног броја издвојених водних тела налази под мониторингом режима квалитета и квантитета подземне воде. Овај прилог даје преглед актуелног стања и садржи предлог проширења националне мреже мониторинга која мора да покрије издвојена тела подземних вода или њихов највећи део, како би се постигла пожељна густина од око 1 објекта на 200 km^2. При томе, у циљу рационализације трошкова, требало би у националну мрежу укључити што је могуће више јавних водовода и других корисника подземних вода. Приоритет у одабиру локације за нове осматрачке пијезометаре или изворе у карсту треба да имају водна тела под притиском на водне ресурсе (интензивна експлоатација), или на квалитет воде (регистрована загађивања или прекомерни садржај појединих компоненти хемијског састава). За оцену притиска на квантитет, потребна је реална процена расположивих обновљивих резерви вода у односу

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[2] The ideas and formulations of this paper are firstly presented at the XVI Serbian Geological Congress held in Donji Milanovac in May 2014. and were published in the form of an extended abstract in the Proceedings volume.

на актуелну експлоатацију, док је за процену притиска на квалитет воде најбољи начин да се упореди рањивост конкретних издани у односу на антропогену (дифузну и тачкасту) претњу загађивањем (оцена хазарда).

Кључне речи: мониторинг, подземне воде, „добар“ статус, Оквирна директива ЕУ о водама, Србија.

Introduction

The complex geology of Serbia and adjacent areas has produced hydrogeological heterogeneity and considerable variety in aquifer systems and groundwater distribution. The area is characterized by both, the presence of formations with small groundwater reserve (Paleozoic formations, magmatic and metamorphic rocks, Jurassic and Cretaceous flysch or deeper and thick sedimentary complexes), as well as Mesozoic carbonate rocks, and Tertiary or Quaternary alluvial and terrace deposits which can be very rich in groundwater. Serbia is therefore a relatively rich in groundwater reserves, deposited in different aquifer systems, but unequally distributed along the territory. The major groundwater reserves are accumulated in thick Quaternary and Neogene intergranular aquifers and in karstic aquifers which dominate in south-western and eastern regions of Serbia (STEVANOVIĆ 1995). Alluvial aquifers of large rivers (the Danube, Sava, Velika Morava and Drina) are particularly important and widely used for drinking water supply. Roughly 90% of the population has access to the public water supply, while some 75% of water for public water supply is abstracted from groundwater resources. In some areas, currently tapped resources are unable to quantitatively meet the population's water demand. However, there are other considerable groundwater resources especially in alluvium of large rivers or in karstic aquifers which are still underexploited. Artificial recharge is also not used to a large extent: Only around 1 m^3/s of water is delivered by such sources, which represents less than 5% of the estimated prospect (DIMKIĆ *et al*. 2011).

Most resources deliver a good natural groundwater quality. The main exception is the northern Serbian province of Vojvodina where thick Pleistocene and Neogene sediments of the Pannonian basin formed sub-artesian aquifers. The organic material has been deposited in the natural sediments, and groundwater is frequently loaded with organic substances and ammonia, occasionally, also arsenic or boron.

Although large groundwater consumer Serbia is not properly organizes monitoring of groundwater quality and quantity. Situation is not very different in other countries of former Yugoslavia with exception of those which already become EU members. The obligations of Serbia and steps to be taken to achieve EU standards in environmental sector and particularly requirements of Water Framework Directive (WFD, 60/2000) should definitely include reorganization of current Monitoring network and strengthening of technical capacity of responsible institutions.

History of the existing hydrological network and groundwater monitoring

Systematic groundwater monitoring in Serbia began immediately after World War II. Network of groundwater monitoring stations were set up in 1947. under a decision of the Federal Administration of the Hydrometeorological Service of the Federal People's Republic of Yugoslavia. In 1948, groundwater monitoring was initiated at 41 stations and as early as 1950. the number of stations grew to 233 and then in 1960. to 279. Unfortunately, some of the stations were shut down and abandoned from 1961. and 1990, such that in 1990. there were only 201 piezometers in place. However, after 1990, the Republic Hydrometeorological Service of Serbia (RHMS) placed increasing emphasis on groundwater monitoring. The number of restored and new piezometers grew and doubled by 2014. when the number of monitoring stations was 409 (Fig. 1). Groundwater levels and temperatures had been measured since the very beginning but groundwater sampling for analyses began in 1968. at 35 stations (piezometers). The number of stations has varied since 1969, from as low as 34 to a maximum of 84 (KOCIĆ 2004; NIKOLIĆ *et al*. 2012).

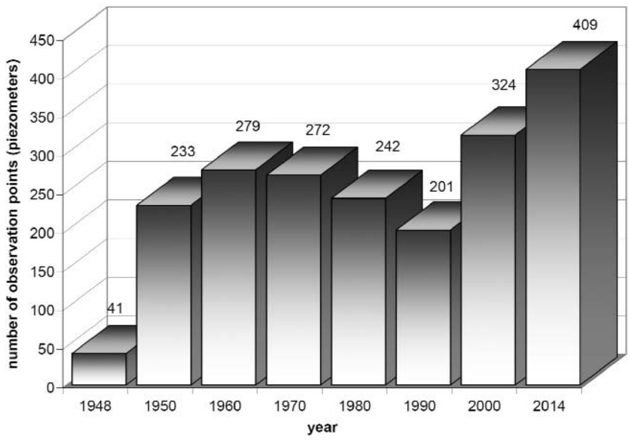

Fig. 1. Number of groundwater monitoring stations in Serbia after WW II.

In spatial terms, the stations have been set up solely in the alluviums of large rivers and at aquifers comprised of Quaternary (Pleistocene) sediments in the Province of Vojvodina. With regard to watersheds, the national network of stations covers the Velika Morava, Zapadna Morava, Južna Morava, Kolubara and Mlava rivers, the District of Mačva and the provinces

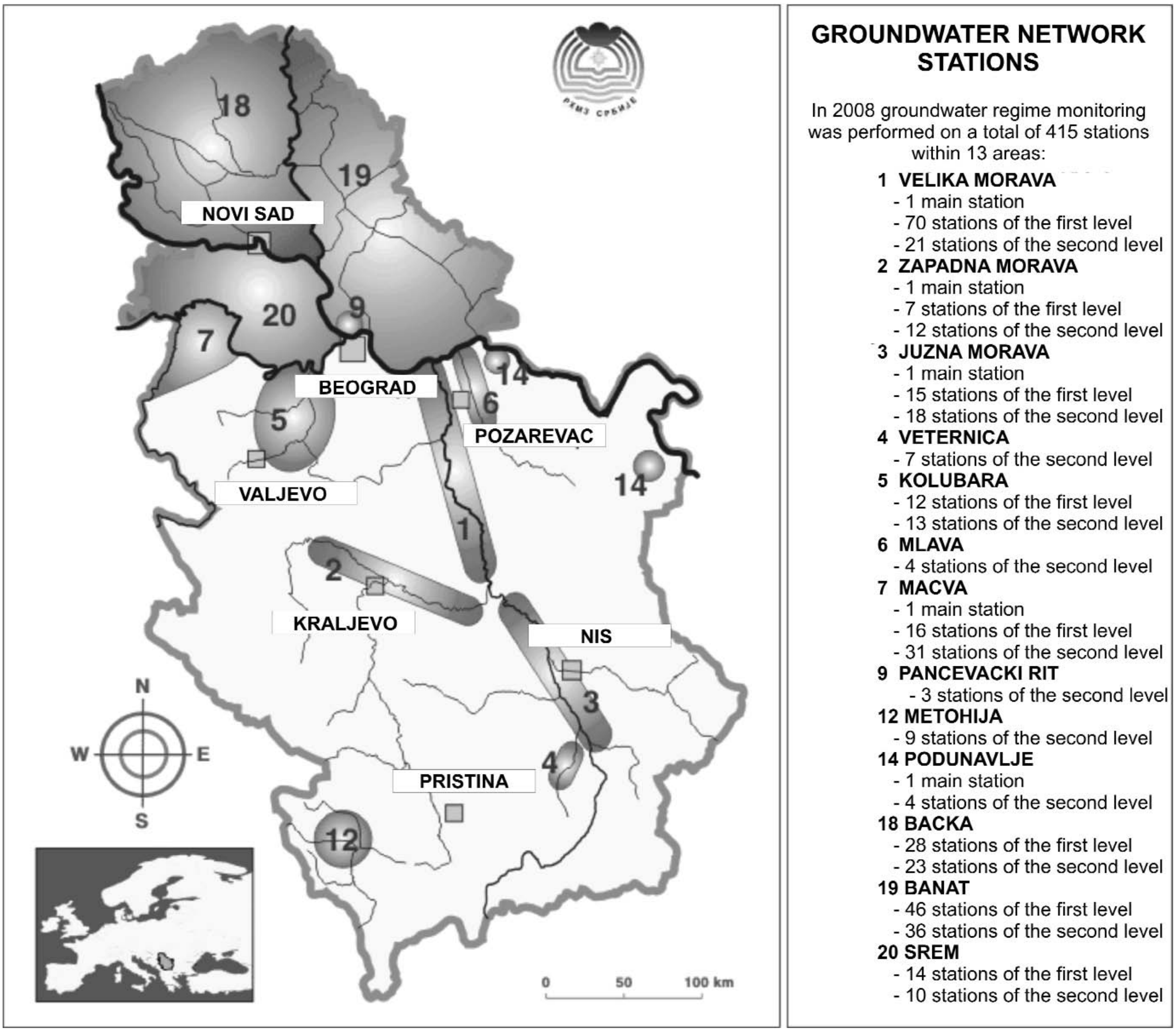

Fig. 2. Network of groundwater monitoring stations of Serbia.

of Kosovo & Metohija and Vojvodina. Figure 2 shows the distribution, along with the numbers and categories of stations.

Apart from monitoring groundwater that occurs in aquifers of the intergranular porosity type, regardless of the significance of the groundwater reserves, very little or no monitoring has been undertaken to date of the other types of aquifers (above all karstic aquifers). For instance, Vrelo Mlave (the source of the Mlava River) was the first karst spring where water level regime monitoring was started in 1949, at the Žagubica Station. Hydrometric surveys to determine the discharge rates of the spring began at that station in 1966, and monitoring and surveys of this spring have continued to the present.

In the mid-1990s, discharge measurements were made at 19 karst springs, but as part of only one or not more than two hydrometric survey campaigns. These springs included among others: Banja Spring (Rakova Bara), Krupaja Spring (Milanovac), Lešje Spring, Petnica Spring, Gradac Spring, Andrić Spring (Ravni), Tolišnica Spring, Gostilje Spring, Vapa Spring, Veliko vrelo (Strmosten) (STEVANOVIĆ *et al.* 2012b). Unfortunately, monitoring of these springs was mostly cancelled in period 2004–2006.

Out of RHMS programme, monitoring of groundwater is also undertaken at city level, and source level (waterworks), as well as in a portion of riparian lands of the Danube, Sava, and Tisa rivers which are within the backwater zone of the Djerdap dam (*Iron Gate Dam* constructed at Danube). The late Monitoring programme was put in place in 1977, to record the effects of the Danube's impoundment on the groundwater regime, to assess the effectiveness of drainage systems (new, reconstructed and non-reconstructed), to improve their operating modes, and to determine the need for and undertake timely interventions to protect the area. More than 700 piezometers were monitored during the past decades in order to define the groundwater regime and assess the Djerdap dam backwater impact on riparian lands (DIMKIĆ *et al*. 2011).

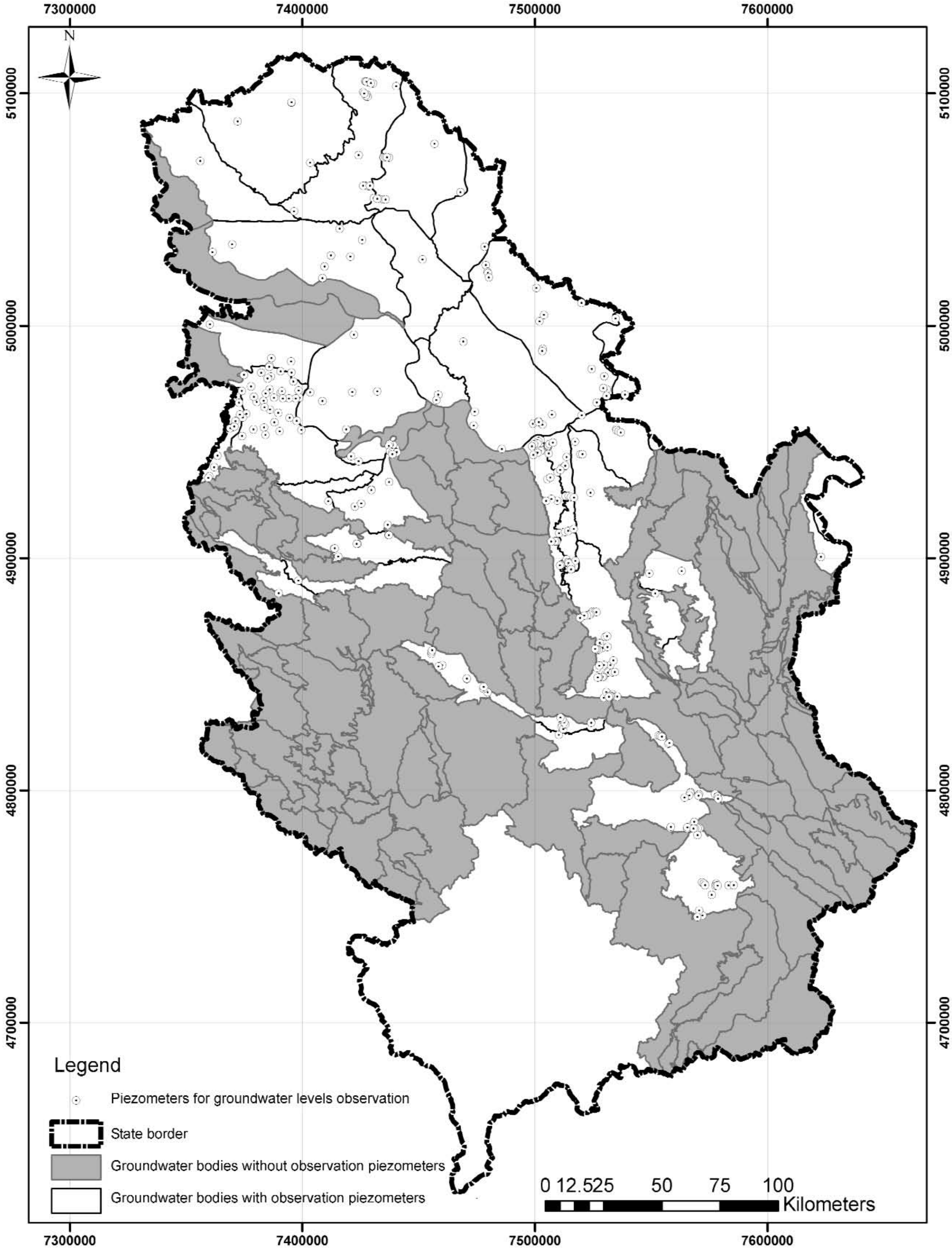

Fig. 3. Distribution of piezometers in groundwater bodies of Serbia.

EU Water Framework Directive and Serbia's implementation tasks

In October 2000, the European Parliament and the Council of the European Union adopted the Water Framework Directive (WFD, 2000/60/EC). In this directive, the European Union modified its previous approaches to recommend control of only heavy and specific pollutants such as nitrates, and established a new long-term strategy in the water sector. The WFD is founded upon the management of water resources at a river basin level. It identifies the conditions that are expected to ensure the implementation of sustainable water use and water protection, while its ultimate goal is to achieve "good status" of all natural water resources, or to ensure good chemical and ecological status of ground, and surface waters, respectively. The main EU objectives set forth in the WFD are:

- Comprehensive protection of all water resources;
- Good status of all water resources;
- Integrated river basin management;
- "Combined approach";
- Appropriate water pricing; and
- Public participation.

Serbia made its initial strides towards WFD implementation in 2003. within the scope of the International Commission for the Protection of the Danube River (ICPDR, 2009). Serbia took part in the preparation of the 2004 Roof Report for the Danube River Basin (DIMKIĆ *et al.* 2005). and generated a preliminary National Report at the beginning of 2005. Since then, in order to harmonize the country's water management policies with WFD requirements and objectives, Serbia enacted a series of laws and implementing legislation, including: *the Water Law* (Official Gazette of the Republic of Serbia 30/10), *the Law on Meteorological and Hydrological Activities* (OG 88/2010), *the Regulation on the Designation of Surface Water and Groundwater Bodies* (OG 96/2010) and *the Regulation on Ecological and Chemical Status Parameters of Surface Water Resources and Chemical and Quantitative Status Parameters of Groundwater Resources* (OG 74/10).

The WFD outlines the water strategy action that needs to be taken, where monitoring is of primary importance (STEVANOVIĆ & VUČETIĆ 2006, QUEVAUVILLER 2008). Serbia adopted *the Regulation on the Designation of Surface Water and Groundwater Bodies* in order to conserve or achieve good ecological, chemical and quantitative status of groundwater resources. A body of groundwater designated within a geological formation was taken as the basis for groundwater monitoring, or the smallest unit for monitoring network planning (UNITED KINGDOM TECHNICAL ADVISORY GROUP 2005a). All designated groundwater bodies (GWBs) have been classified as intergranular, karstic or fractured groundwater bodies. Following detailed analyses and several delineation stages, the initial number of GWBs of 208 (ĐURIĆ *et al.* 2004), was ultimately reduced to 153 (OG 96/2010). This was the first step towards WFD implementation concerning groundwater management.

Spatial distribution of monitoring objects – piezometers on delineated GWBs is shown on figure 3. The list of GWBs with established monitoring is presented in Table 1. It can be concluded that only 34 out of 153 or around 20% of all GWBs, have continual observation of groundwater table. The figures 4a and 4b present percentage of GWBs with number of observation points per 100 km^2. As an example 9% of GWBs has 5 or more observation points per 100 km^2. In contrast, 13 GWBs or 38% has between 0.5 to 0.177 piezometers per 100 km^2. This is equal to density of 1 object per 200 km^2 and 500 km^2, respectively (Fig. 5).

The figure 6 shows positions of the springs which were included in the observation by RHMS for certain period of time.

The next important step in implementation of WFD was GWB characterization, which allowed for the integration into groups of GWBs. The characterization included the determination/description and quantification of geological and hydrogeological conditions, particularly the geometry of the GWBs, the nature of the aquifer roof and floor, the rate of water exchange, and the dependence of terrestrial ecosystems on infiltrated or discharged groundwater (UNITED KINGDOM TECHNICAL ADVISORY GROUP 2005b). The focus was on chemical quality pressures–diffuse and point sources of pollution, as well as quantity pressures–abstraction rates and artificial recharge, if any (STEVANOVIĆ 2011). The WFD introduced *surveillance monitoring* and *operational monitoring*, depending on the nature of groundwater pressures. Operational monitoring requires a higher monitoring frequency and surveying of specific components, critical to water quality.

In the WFD, the groundwater level is the main parameter that defines the quantitative status. There is no exact limit, but it needs to ensure that long-term use will not threaten the available groundwater resource, that the environmental objectives of associated surface water bodies will be achieved and that there will be no threat to terrestrial ecosystems. Given that there was some doubt as to what over-exploitation means and when it occurs (CUSTODIO 1992; BURKE & MOENCH 2000), it was necessary to stay within relative categories. The problem with determining the chemical status is that maximum permissible concentrations have not been defined, except for a few parameters. To achieve objectives, if good status cannot be restored or attained, then the chemical status must be at least that which existed before applicable legislation was adopted, or before its implementation began.

RHMS has transferred its duties related to groundwater quality monitoring by means of piezometers to

Table 1. Groundwater bodies under systematic observation and actual number of piezometers.

No	Groundwater body - GWB	Area F (km²)	Number N*	Number N**	N*/ F	N**/ F
1	2	3	4	5	6	7
1	Severozapadna Bačka - top aquifer	1232.43	5	1	246	1232
2	Telečka - top aquifer	2643.55	11	3	240	881
3	Gornja Tisa - top aquifer	1772.02	30	4	59	443
4	Severni Banat - top aquifer	1545.78	19	3	81	515
5	Srednja Bačka - top aquifer	2068.06	16	3	129	689
6	Donja Tisa - top aquifer	1099.78	5	1	220	1100
7	Srednji Banat - top aquifer	1013.72	3	0	338	
8	Jugozapadni Banat - top aquifer	2228.19	16	2	139	1114
9	Vršačke planine	257.63	2	1	129	258
10	Jugoistočni Banat - top aquifer	2298.93	25	3	92	766
11	Beograd right bank of Sava	179.68	7	2	26	90
12	Pančevački rit	413.74	4	1	103	414
13	Negotin Kladovo - alluvium	462.86	4	1	116	463
14	Kličevac	604.28	4	1	151	604
15	Kostolac	1005.37	4		251	
16	Kučaj i Beljanica	726.52	2	2	363	363
17	Velika Morava alluvium left bank	468.26	27	3	17	156
18	Velika Morava alluvium right bank	429.31	28	3	15	143
19	Levač	718.98	2	1	359	719
20	Velika Morava Neogene - south	1321.17	38	3	35	440
21	Kučaj - west	288.06	1	1	288	288
22	Južna Morava Neogene - north	1153.38	21	3	55	384
23	Leskovac - Neogene	914.31	22	2	42	457
24	Rasina	497.41	1	1	497	497
25	Zapadna Morava - alluvium	588.04	21	3	28	196
26	Mačva Basic water bearing layer	763.41	40	3	19	254
27	Kolubara - Neogene	656.57	10	4	66	164
28	Valjevo	542.81	6	2	90	271
29	Lelić - karst	306.83	1	1	307	307
30	Ljig	565.82	1	1	566	566
31	Lozničko polje	243.88	11	2	22	122
32	Povlen	322.37	1	1	322	322
33	Zapadni Srem - Pliocene	1172.92	11	2	107	586
34	Istočni Srem - Pliocene	2248.99	10	1	225	2249
	Total	32755.06	409	34		

Note:
*- total number of piezometers for groundwater table observation
**- total number of piezometers for groundwater quality observation

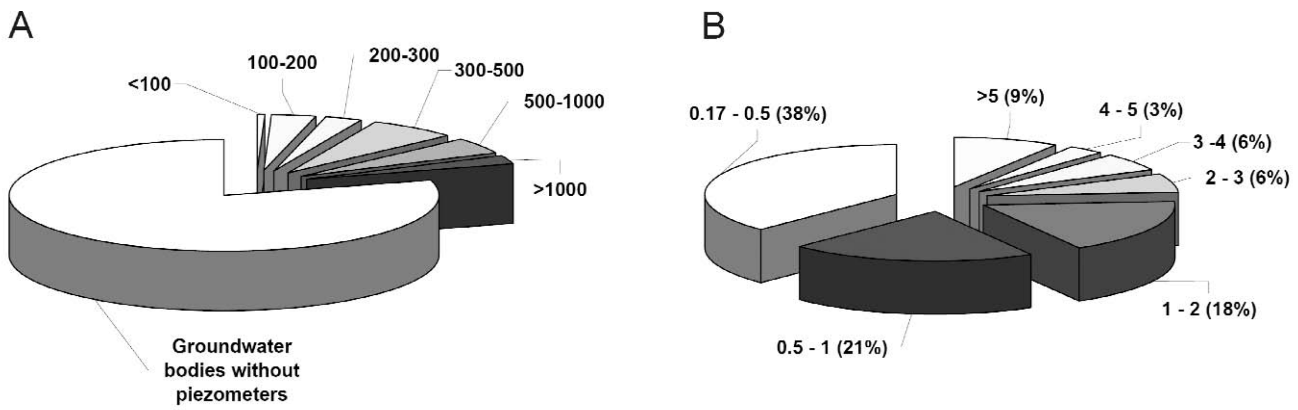

Fig. 4. **a,** Distribution of GWBs without or with piezometers and density (1 object per X km²); **b,** Percentage of GWBs with number of piezometers per 100 km².

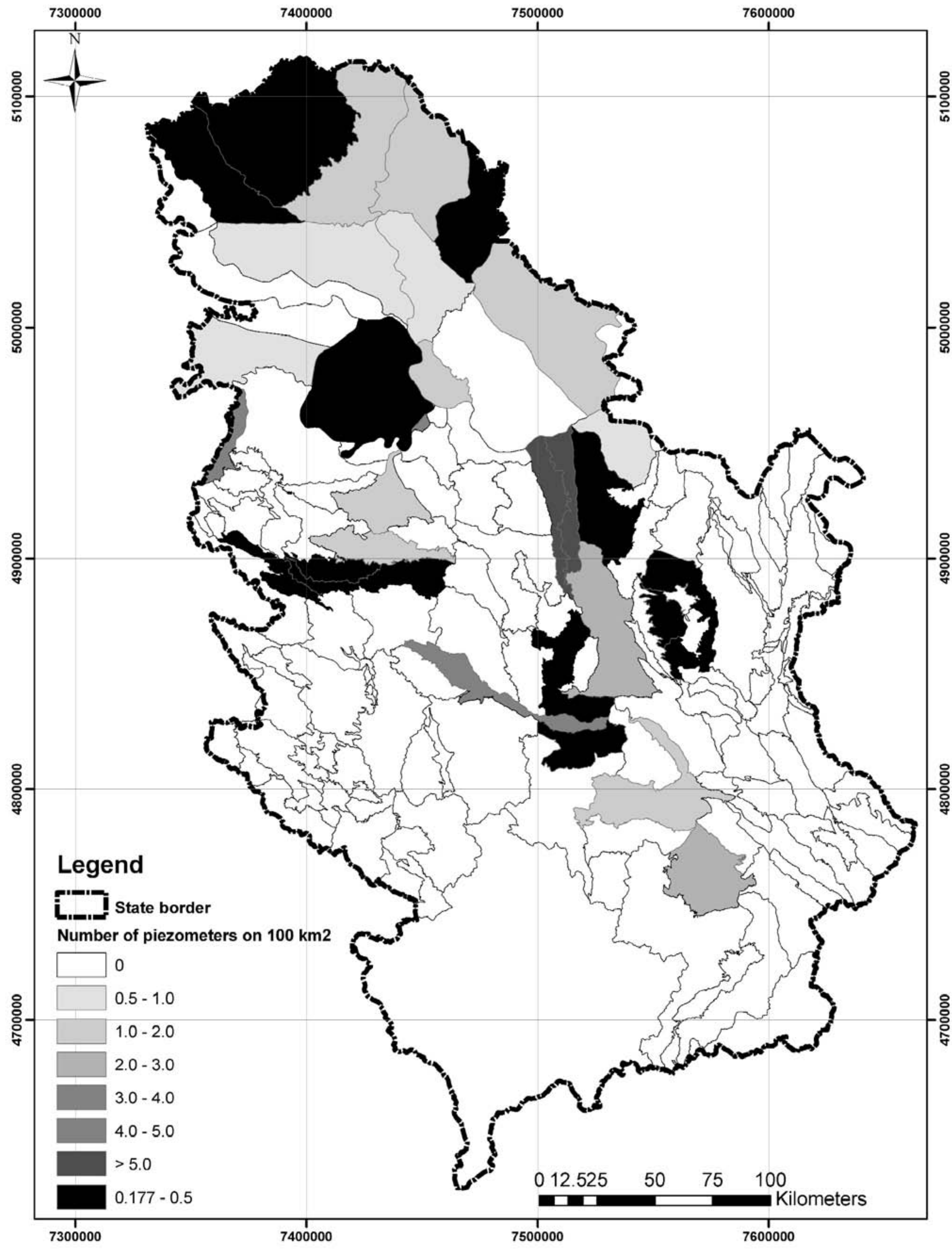

Fig. 5. Groundwater bodies which posses some monitoring boreholes (piezometers) and their density per 100 km^2.

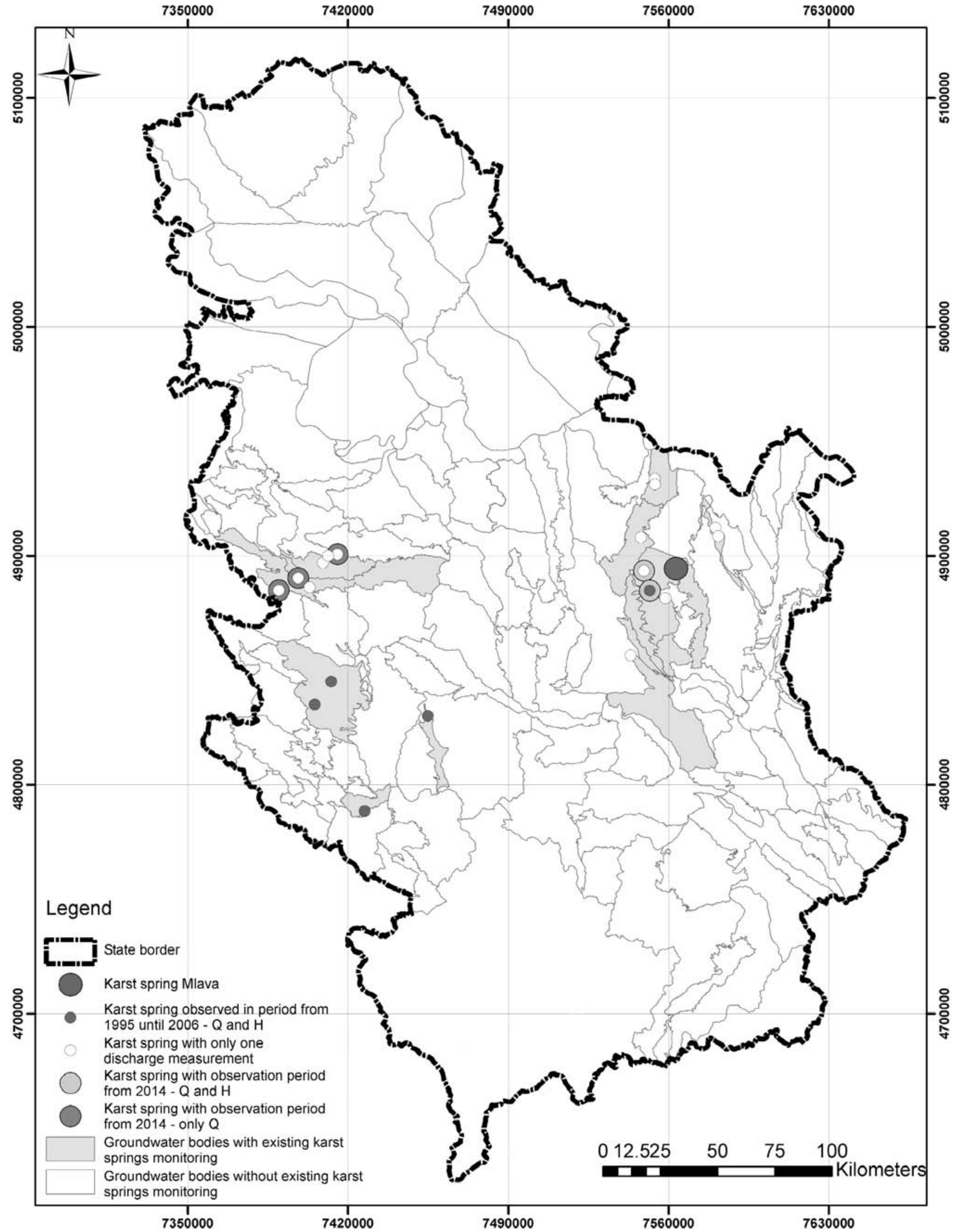

Fig. 6. Groundwater bodies in which some karstic springs were temporarily observed by RHMS.

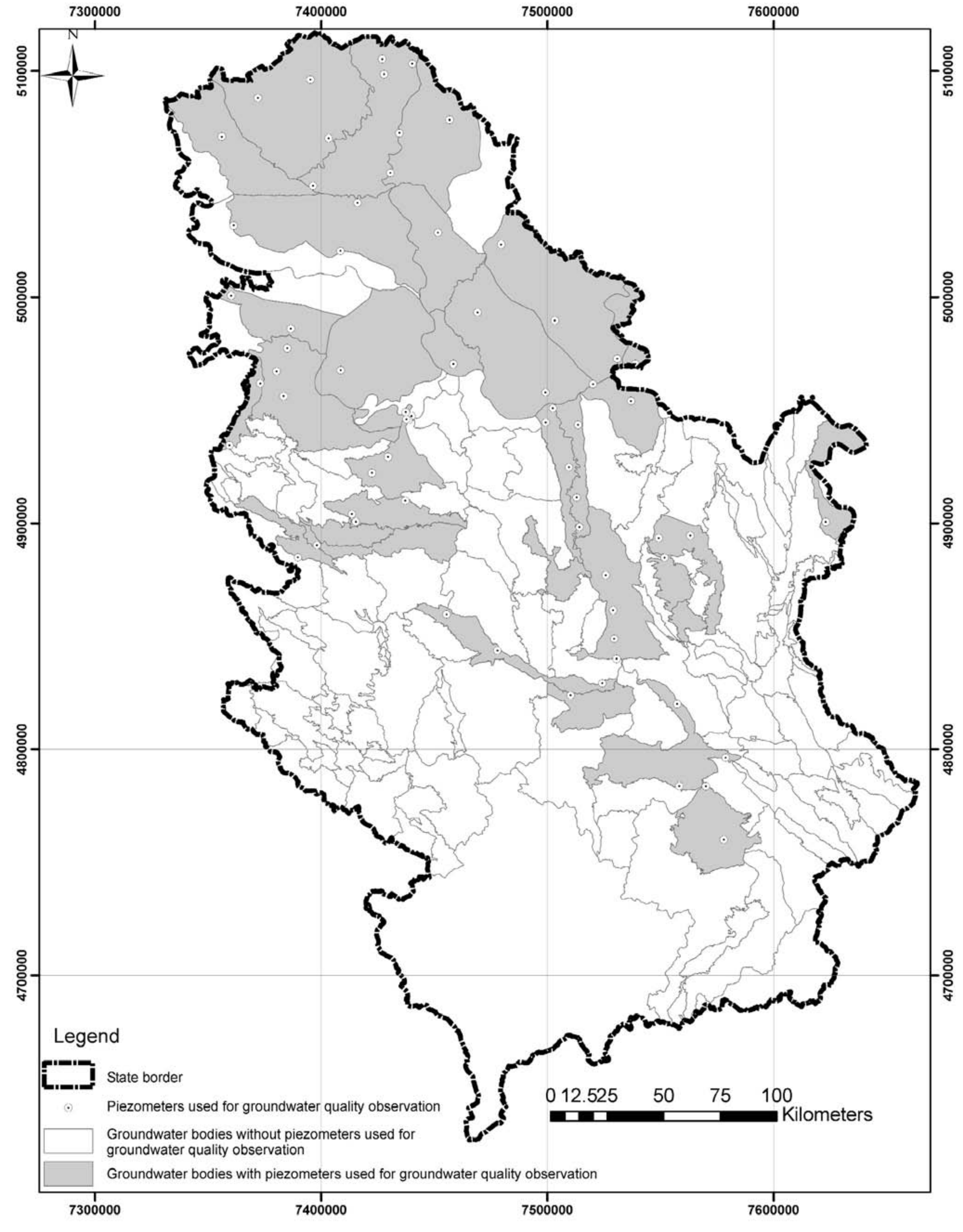

Fig. 7. Distribution of piezometers used for groundwater quality observation.

the Serbian Environmental Protection Agency (SEPA). In 2013. this network included 70 piezometers, while analyses comprise the determination of 66 physical, chemical and biological parameters. SEPA has been reporting to the public via its website and also to the European Environment Information and Observation Network (EIONET). Spatial distribution of piezometers which are used for groundwatwer quality observation, is shown on figure 7.

Criteria and conditions for Serbia's new groundwater monitoring network

In most of European countries, the density of water quality monitoring networks is lower than that of the networks that monitor groundwater level fluctuations. The main reasons lie in operating expenses (costly analyses) and the feasibility of collecting information from other entities (water users) in an organized manner. The network density is also a result of numerous other factors, such as the size of the country, assessed aquifer vulnerability to pollution, and population density. The effect of population density is, for example, apparent in Finland and the Netherlands. In sparsely populated Finland there are only 0.02 monitoring stations per 100km^2, while in the densely populated Netherlands, where groundwater is the main drinking water resource, there is one monitoring station on average per 10km^2 (STEVANOVIĆ 2011).

Monitoring of groundwater quality and quantity is a highly complex task and an obligation according to the WFD. However, considerable financial resources are needed to implement the WFD (FOSTER & MCDONALD 2014). For Example, Austria spends about 2 million € every year and Hungary as much as 4 million € solely on routine groundwater regime monitoring. Countries are also allowed to specify lower objectives for certain groundwater bodies, as needed, if the achievement of good status is not possible without major spending. Consequently, if an efficient approach is followed and if, for example, the obligations of water supply operators and other users are regulated, the water regime database can be substantially enlarged (STEVANOVIĆ 2011).

A number of strategic hydrogeological projects implemented from 2007 to 2001, including "*Groundwater Monitoring*" (GRUPA AUTORA 2010) have been major contributors to the improved knowledge of groundwater resources and the initial steps towards the establishment of a new monitoring network (STEVANOVIĆ *et al.* 2012a; MILANOVIĆ *et al.* 2014). One GWB has been selected per aquifer type and experts from the University of Belgrade-Faculty of Mining and Geology, the Jaroslav Černi Institute for the Development of Water Resources and the Serbian Geological Survey were commissioned to implement pilot monitoring projects following WFD principles. Unfortunately, funding ceased in the final stages of the projects, such that the proposal of a new monitoring network has been postponed.

Given Serbia's circumstances (size, complex geology, hydrogeological conditions), it is believed that at least one groundwater monitoring station per 200 km^2 is needed. This means a total of 400–500 objects in function. This number is close to the existing number of monitoring stations, at least with regard to groundwater quantity, but the way they are currently deployed is inadequate. Only the so-called "top aquifers" (i.e. alluviums of the largest rivers) are monitored. Systematic monitoring has to be the basis for proper GWB characterization and protection from potential polluters and accidental pollution.

Finally, a new monitoring network has to be gradually built. The target for its completion should be the year 2027. In order to get feasible and non-expensive network the existing waterworks and companies that got concessions for water extraction, must be obliged to fulfill their obligations to regularly observe discharges, water tables and chemistry of tapped springs and wells and to deliver this data to responsible authorities. As such, the number of regularly observed water points would increase along with network density. However, certain number of new boreholes would be required as many of GWBs do not have any intakes. In addition to, for objective assessment some piezometers have to be located outside radius of extraction wells used by waterworks.

As set up of monitoring network will rise in stages, prioritization in selection of monitoring sites should be given to GWBs under already recognized pressures. In term of pressure to groundwater quantity, an assessment of available renewable reserves versus exploitation capacity would be needed for each of GWB. When pressures to groundwater quality are considered, the best way for realistic assessment would be to compare aquifers' vulnerability against anthropogenic (diffuse and punctual) hazards. In Serbia, the aquifer vulnerability map in scale 1:500,000 has already been completed under above-mentioned project "*Groundwater Monitoring*" (Fig. 8).

For regional analysis of diffuse hazards the *Corine Land Cover Map* (EEA, 2006) can be very useful, while SEPA's data on pollutants and their distribution and loads can be used for an assessment of punctual (point) pressure.

Conclusion

Consistent WFD implementation and the setting up of a new groundwater monitoring network in Serbia are extremely important for improving knowledge about groundwater resources and their active protection. As an EU member-candidate, Serbia declared its commitment to the WFD back in 2003, but primarily a lack of funds and still unregulated water user obliga-

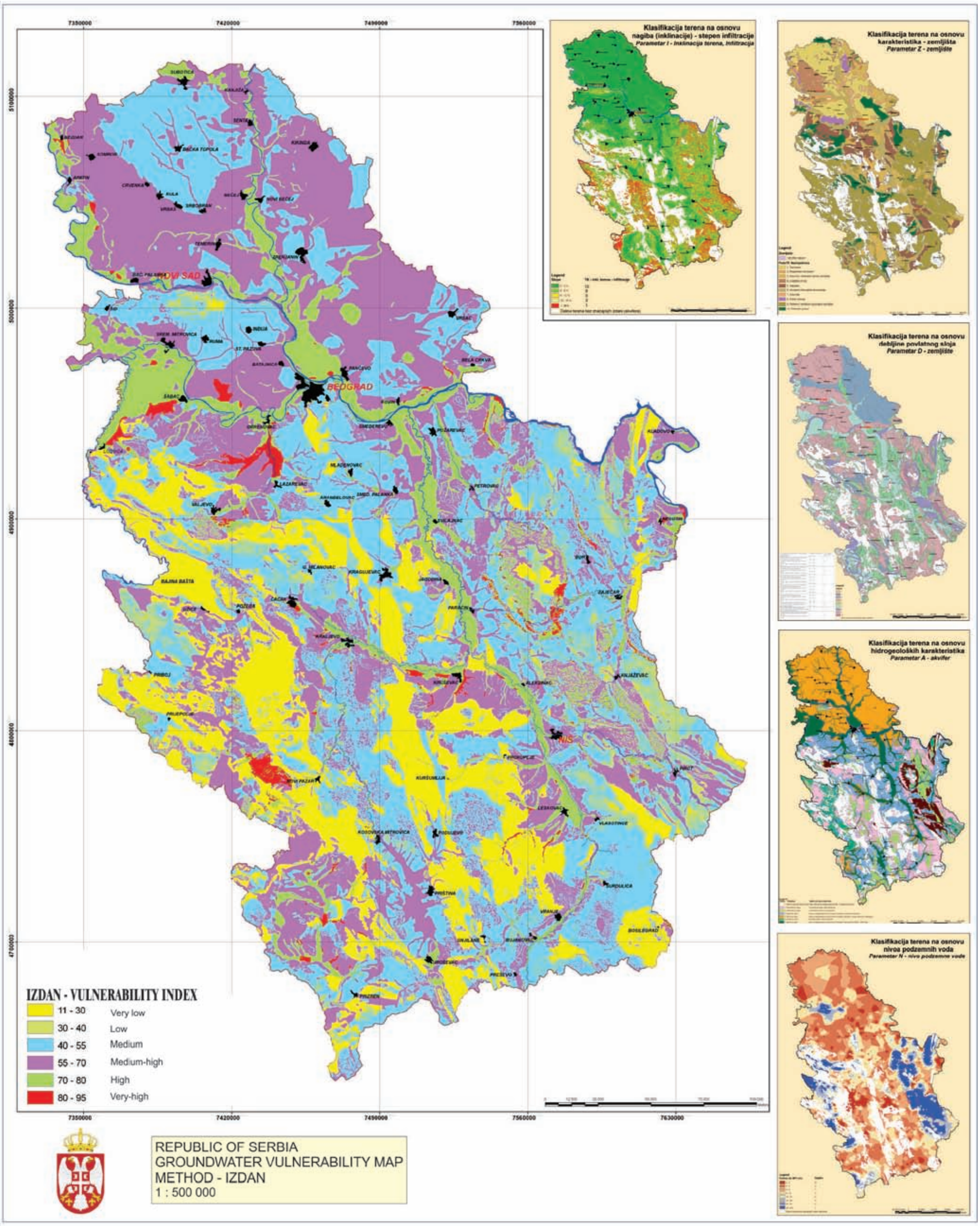

Fig. 8. Groundwater Vulnerability Map of Serbia (Milanović *et al*. 2010).

tions have lead to an unsatisfactory state of affairs in the monitoring of groundwater resources, which for the most part support drinking water supplies and are used by some 75% of Serbia's population.

Despite the fact that groundwater level regimes are monitored by more than 400 special-purpose piezometers in Serbia, nearly all of them have been deployed in the same type of alluvial aquifer, where groundwater levels are largely a reflection of river stages (which are also monitored). This is certainly a departure from hydrogeological "logic" and from the preferred approach to national groundwater monitoring, which needs to include all types of aquifers. As such, phreatic ("top") aquifers in Serbia's geological circumstances need to include aquifers in mountainous regions (e.g. karst aquifers are found in more than 30% of western and eastern Serbia), which have virtually not been monitored to date. Consequently, RHMS's concern for aquifers in the alluviums of large rivers, evident from the facts on the ground, needs to be (re)defined. The best solution would be to entrust the setting up of a monitoring service for other types of aquifers and the monitoring task itself to the Serbian Geological Survey. Strictly applied regulations to waterworks and concessionaires to measure and provide data on groundwater quantity and quality would relax needed investment in operation and maintenance of the new Monitoring network.

A new and efficient monitoring network, which covers all, or most of GWBs and all major tapped aquifers (not only alluvial, as at present), determined on the basis of hydrogeological exploration, and systematic groundwater quality and quantity data collection with active involvement of water users, are both national needs and obligations. Proposal is to reach density of 1 observation object / 200km^2 is also given. It took in consideration complex geology, hydrogeological settings, historical data, but also economic situation in the "transition" country. The scope and extent of monitoring, and the frequency of measurements and analyses, depend on the hydrogeological setting and the aquifer regime. In dynamic environments such as karst, monitoring will certainly be more frequent than, for instance, in the case of artesian aquifers in lowland river basins.

Acknowledgments

The study was supported by the Ministry of Education, Science and Technological Development of the Republic of Serbia, Project No. 176022. The authors also express their gratitude to Dr Aleksey Benderev (Sofia, Bulgaria) and an anonymous reviewer for their useful comments and suggestions.

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Резиме

Концепт формирања нове мреже за мониторинг подземних вода у Србији

Доношењем Оквирне директиву о водама 2000. године (ОДВ - *Water Framework Directive EU/WFD – 2000/60/EC*) Европска унија успоставила је нову и заједничку, дугорочну политику у домену вода. Основа Директиве је управљање водним ресурсима на нивоу речних сливова, а њом су дефинисани услови који треба да омогуће спровођење политике одрживог коришћења и заштите вода, док је основни циљ довођење свих природних вода у „добро стање", у погледу квантитета и квалитета. Следећи добру праксу чланица ЕУ, и већина земаља нечланица је у своје прописе о водама уградила концепт и решења ове Директиве које су усмерене на очување, заштиту и побољшање квалитета околине у смислу рационалне употребе вода и других природних ресурса. Концепт се базира на предострожности и превентивним акцијама, а које би обезбедиле "добар" статус вода до 2015, или најдаље до 2027. Оквирна директива прописује потребу израде Програма мера, као и Планова управљања речним сливовима. Посебна „Сестра Директива" ЕУ односи се на подземне воде и разматра и прописује услове за обезбеђивање смањења притиска на квантитет (акције за смањење прекомерне експлоатације) и квалитет подземних вода (очувати или успоставити добар хемијски статус).

У складу са захтевима ОДВ, државе су у обавези да формирају или прилагоде своје осматрачке мреже за подземне воде. Организација мониторинга подземних вода, праћење њиховог квалитета и квантитета, представља сложен задатак. ОДВ ЕУ уводи надзорни и оперативни мониторинг зависно од стања притиска на ове ресурсе: Оперативни се спроводи са гушћом фреквенцијом осматрања и праћењем специфичних компоненти, критичних за квалитет воде. Густина мреже је резултат бројних фактора, зависи од величине земље, оцењене угрожености издани од загађивања, интензитета експлоатације, уочених конфликата интереса у коришћењу ресурса, као и густине насељености. На пример, док је у ретко насељеној Финској свега 0.02 осматрачка објекта на 100 km^2, у густо насељеној Холандији где су подземне воде основни ресурс воде за пиће, просечно је на сваких 10 km^2 лоциран по један осматрачки пункт. За примену Директиве у пракси потребна су и значајна финансијска средства. На пр. Аустрија годишње инвестира око 2, а Мађарска чак 4 милиона еура, само за редовна осматрања режима. Државе могу да одреде и она подземна водна тела код којих је потребно поставити ниже циљеве јер је успостављање «доброг» статуса често немогуће без великих финансијских улагања.

У Србији стање у погледу мониторинга подземних вода није задовољавајуће. Иако се још 1947. године отпочело са праћењем режима подземних вода, а већ 1960. године било формирано чак 279 станица, у периоду од 1961. до данас, број осматрачких пијезометара је у константном опадању (сл. 1). Просторно посматрано станице су формиране искључиво у алувијонима већих река и изданима формираним у оквиру квартарних наслага у Војводини (сл. 2). На пијезометрима Основне мреже углавном се осматрају нивои подземних вода и температура вода, што је задатак Хидрометеоролошког завода Србије (РХМЗ), док се на око 70 пијезометра прати квалитет воде што је у обавези Агенције за животну средину (САЖС) која врши и извештавање према Европској агенцији за животну средину (EIONET). Иако је било више покушаја да се у националну мрежу укључе и јаки карстни извори, до данас се осматрања врше једино на Врелу Млаве у источној Србији.

Како би се стање у погледу мониторинга побољшало и вршило испуњавање обавеза према ОДВ у Србији је учињено неколико корака.

Измењени су законски прописи и донет нови Закон о водама (2010), извршене су делинеације и прелиминарне анализе водних тела подземних вода (ПВТ) као основних јединица за планирање осматрачке мреже, а у припреми су и планови управљања речним сливовима.

Након спроведених детаљних анализа као и више фаза рада на делинеацији, утврђен је број од 153 ПВТ у Србији (сл. 3). Други важан корак је тзв. карактеризација водних тела, која подразумева одређивање – опис и квантификацију геолошких, хидрогеолошких услова терена, посебно геометрије водног тела, карактера повлате и подине, брзине водозамене, зависности еко система на површини терена од инфилтрираних или истеклих подземних вода. Посебно се разматрају притисци на хемијски квалитет – дифузни и концентрисани извори загађивања, као и притисци на квантитет – обим експлоатације, и уколико постоји и вештачко прихрањивање.

Анализа указује да је у 2015. години само на нешто више од 20% ПВТ успостављена одговарајућа осматрачка мрежа. Тачније, само на 34 од укупно 153 издвојена водна тела постоје пијезометри за праћење нивоа подземних вода. Девет ПВТ има 5 или више осматрачких објеката на 100 km^2 (сл.4). Укупно 13 водних тела (или 38%) има 0.5 до 0.177 пијезометра на 100 km^2 што би дакле одговарало густини од једног објекта на 200 km^2, односно 500 km^2 површине територије (сл. 5,6).

Који су неопходни кораци за проширење мреже и како је погустити? Први услов за испуњавање ове обавезе у процесу даљег придруживања ЕУ (област *Животна средина*) је обезбеђивање средстава за рад РХМЗ и САЖС како би повећали број објеката (сл.7), спровели истраживачки мониторинг и успоставили потребну фреквенцију осматрања параметара квантитета и квалитета подземних вода. Такође, стриктним спровођењем већ прописаних обавеза постојећим водоводима или другим корисницима да врше осматрања и податке достављају недлежним службама, може се обезбедити значајан фонд допунских података о режиму вода.

У нашим условима (површина територије, комплексна геологија, хидрогеолошки услови) сматра се да би био потребан најмање један успостављени осматрачки пункт за праћење подземних вода на сваких 200 km^2. То би значило да је потребан број од око 400–500 пунктова осматрања. Број јесте приближан садашњем, бар када је у питању режим квантитета, али је концентрација објеката потпуно неадекватна и прате се само тзв. „прве издани“, заправо алувијони највећих речних токова. Континуирани мониторинг треба да буде основа да се свако ПВТ адекватно окарактерише и да се заштити од могућих потенцијалних и екцесних загађивача.

Нова мрежа се може и поступно развијати како би до 2027. године била приближно комплетирана. Приоритете за нове објекте би требало дефинисати на бази утврђених притисака који се могу оценити на следећи начин:

Притисци на квантитет. Најбољи начин за ову оцену је утврђивање односа експлоатисаних количина у односу на обновљиве (природно и вештачки) резерве подземних вода. Практични проблем може бити недостатак података о режиму издашности или осцилација нивоа, као и непоузданост података експлоатације. Билансне методе су најподесније за оцену величине обновљивих ресурса.

Притисци на квалитет. Треба да буду базирани на односу природне рањивости издани и ПВТ са једне стране, и с друге стране хазарду проистеклом из присуства дифузних и пунктуелних загађивача. Резултат треба да буде израда карата ризика (према дифузним и пунктуелним загађивачима) и она треба да садржи класификацију нивоа ризика (самим тим и притисака) услед антропогених активности. Регионалне карте рањивости издани су незаменљива подлога ових оцена (за територију Србије ову карту у размери 1:500,000 је израдила група аутора тзв. Стратешких пројеката реализованих у периоду 2007–2011, сл.8), док за карту дифузног хазарда корисно може послужити *Corine land cover map* израђена од стране Европске агенције за заштиту животне средине.

Подземне воде у Србији, као уосталом на целом простору бивше СФРЈ, су основни извор снабдевања пијаћом водом становништва (преко 75%). Стога постоје и посебне обавезе државе и њених институција, као и стручних и научних капацитета у погледу њихове превентивне и систематске заштите, обезбеђивања алтернативних изворишта и регулације постојећих у циљу повећања њиховог капацитета, а у условима све већих притисака изазваних антропогеним активностима и климатским променама. За испуњење ових циљева, први и основни услов је постојање података прикупљених ситематским мониторингом квантитета и квалитета подземних вода.