

Revision of River & Lake Typology in Bulgaria within Ecoregion 12 (Pontic Province) and Ecoregion 7 (Eastern Balkans) According to the Water Framework Directive

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Abstract. A revision of river and lake typology in Bulgaria has been done within the Ecoregion No. 12 Pontic province and Ecoregion No. 7 Eastern Balkans according to the Water Framework Directive 2000/60/EC. Certain geographic changes between the Ecoregion No. 12 and Ecoregion No. 7 have been proposed based on existing biogeographic data, at the beginning. The whole part of the Danube and Black Sea River Basin district have been associated to the Pontic Province (ER No. 12) as well as the rest part of the Southern Bulgaria (Maritsa river basin, Mesta RB and Struma RB) has been allied to the Eastern Balkan (ER No. 7). A serious reduction of the total number of river types (from 33 to 16 types) was justified using clear hydromorphological and biological criteria, e.g. ecoregion, vertical factors (4 altitude zones, main substratum characteristics, slope, and other supplementary factors such as fish and vegetation zonation, climate maps) and horizontal factors (calcareous geology, salinity, size category). Similar reduction of the number of lake types (from 33 to 17 types) was proposed in parallel with a significant modification of the lake typology method. Lake typology in Bulgaria was based on the obligatory factors (4 altitude zones, size typology based on surface area, depth, salinity and geology) and optional factors (residence time, mixing characteristics, e.g. monomictic, dimictic and polymictic, presence of profundal zone, reference trophic status). Seven lake types were identified as "reservoir types", which were only presented by heavily modified and artificial water bodies without any possibility for natural lake equivalent within the country or region. Four coastal lake types with various salinity (from freshwater <0.5 ‰ to hypersaline >40‰) have been reviewed as belonging to the category "transitional waters".

Keywords: ecoregion, typology, rivers, lakes, Water Framework Directive, Bulgaria

Abbreviations:

BEQ – Biological Quality Element

CPOM – Coarse Particular Organic Matter

ER – Ecoregion

FPOM – Fine Particular Organic Matter

RB – River Basin

WB – Water Body

WFD – Water Framework Directive 2000/60/EC

Introduction

The territory of Bulgaria is divided into 4 river basin districts for water management, govern by 4 river basin directorates (competent water authorities) in frame of Ministry of Environment and Water: Danube river basin (covering about half of the Bulgarian territory), Black Sea river basin district (comprising small river basins of all direct tributaries of Black Sea), East Aegean Sea river basin (river basin of transboundary Maritsa / Merich / Evros River) and West Aegean Sea river basin district (transboundary river basins of Struma/Strymonas and Mesta/Nestos). The analysis of the existing information show considerable unconformities in the approach and number of types at four river basin districts in Bulgaria, although applied in principle common algorithm at the initial typologization according System B of the Water Framework Directive (WFD) 2000/60/EC (EUROPEAN COMMISSION, 2000). The different level of river types' validation is one of the problems. For example East Aegean Sea River Basin Directorate has been reduced the total river types number to 6, while the number of types varies between 12 and 14 at the other Directorates.

There is a variety of possibilities towards unifying of types and thus reduction of the total river types number from 33 to 16, based on hydromorphological system of ROSGEN & SILVEY (1996) and classical altitude hydrobiological zonation (trout, barbell-chub and carp zones) (River continuum concept and its derivatives).

Similar opportunity exists on reduction of lake types from 33 to 17. The lake typology according System B is slightly developed in comparison with river one due to insufficient biological data and heavily modified water bodies domination. Dams (heavily modified and artificial water bodies) represent more than 90% from total lake water bodies. Therefore determination of ecological potential of separate types artificial lakes is essential for Bulgaria, rather than determination of ecological status of small number natural lakes (high

mountain glacial lakes, a few landslide lakes and Black Sea and Danube riparian lakes and swamps, usually under strong anthropogenic influence).

There are 4 types coastal lakes in Bulgaria depend on the salinity degree (from freshwater to hypersaline). They have to be referred to the category «transitional waters». A set of specific phenomena is insufficiently studied: seasonal and annual salinity variations (so called mixohaline conditions), heterogenic character of salinity in the range of one lake (vertical – halocline, horizontal variability), as well as unstable salinity (so called poikilohaline water bodies). Various salinity degrees determine unique ecosystems which in many cases have no analogue among neither freshwater nor coastal waters.

The border between two ecoregions № 12 Pontic province and № 7 Eastern Balkans is represented in Appendix № XI, map A of WFD 2000/60/EC (EUROPEAN COMMISSION, 2000) close to the Black Sea and does not respond to Bulgarian biogeography and thus is the basis of serious problems in determining typology, reference conditions, water bodies (WB) boundaries and hence in the accomplishment of additional requirements of the WFD (monitoring programmes, measurement programmes, etc.).

The existing river separation in Black Sea river basin district into two ecoregions (№ 12 for northern and № 7 for southern rivers) is unjustified from biogeographic point of view and will embarrass and even prevent developing of classification systems for fish fauna due to merging of diverse fish species inhabiting Black Sea rivers and lacking in Aegean Sea region and vice versa. Similar perplexities will emerge with metrics for benthic macroinvertebrates (macro-zoobenthos).

Material and methods

Study on all surface freshwaters (rivers and lakes) on the Bulgarian territory, as well as identification of “transitional waters” category close to the Black Sea was accomplished. GIS layers were applied at the research, available at the government

authorities (Basin Directorates), as well as specialized biological and hydromorphological approaches and data.

The applied approach was based on the following main pillars:

(i) Critical analysis and alteration of borders of the two ecoregions in Bulgaria № 12 Pontic province and № 7 Eastern Balkans: Appendix № XI, map A of WFD 2000/60/EC (EUROPEAN COMMISSION, 2000);

(ii) Holistic concepts for river continuum;

(iii) Hydromorphological basis of river and lake types.

Holistic concepts

Type-specific approach was applied, covering 16 river types and 17 lake types, determined according hydromorphological and biological criteria (biogeographic data, altitude zonation, connected with "river continuum" theories, „interrupted river continuum“, etc.). The above approach gravitates around so called holistic concept (VANNOOTE *et al.*, 1980), which was extended by the following concepts:

(i) Interrupted river continuum, i.e. Serial Discontinuity Concept (STANFORD & WARD, 1983) – includes geomorphology and detailed hydromorphology, barriers, tributaries, accumulation → discharging;

(ii) Hyporheic Corridor Concept (STANFORD & WARD, 1993) – revealing connections between rivers and ground waters;

(iii) Flood Pulse Concept (TOCKNER *et al.*, 2000) – for lowland river types and link between nutrients, organic matter and seasonal periodical floods;

(iv) Integrated conceptual models for standing waters (lakes and dams) – lakes are examined as more than trophic status (classical concept of lake ecosystems).

In the above connection the existing typology of rivers and lakes in Bulgaria made by competent water authorities (River Basin Directorates) without any field validation (hydromorphology and biology) was reconsidered. Actualization of types was proposed, based on existing science

foundation, principles and concepts, as well as on the gained practical experience in Bulgaria and other countries.

“Top – down” approach was applied. The validation process of the types' boundaries, identification of potential subtypes or special cases, and detail additional validation (especially for lake types) should be started with the first River Basins Management Plans 2010 – 2015.

The holistic concept defined several basic zones along every river system, connected with particular type ecosystems:

- **High mountain zone** (crenon) with little organic matter (leaves and twigs), on which base to be developed more complex and rich ecosystems. Fish fauna is often lacking and the species composition and abundance of the rest Biological Quality Elements (BEQ) (benthic macroinvertebrates, macrophyte flora, phytobenthos) are poor and limited by the environmental conditions. Generally the basic primary producer is periphyton (phytobenthos) from microalgae (diatoms, cyanobacteria, green algae, etc.), lower fungi, etc. overgrowth on rocks,

- **Mountain zone of CPOM** forming (Coarse Particular Organic Matter) (epirhithron, metarhithron). There are created complex benthos ecosystems with main participation of shredders and collectors. Fundamental role have communities developing on the fallen leaves and twigs from coniferous and deciduous trees. Trout zone with low fish diversity (2-3 species). Some macrophytes with scarce abundance appeared. Periphyton still plays major role.

- **Semi - mountain zone** (hyporhithron). Transitional zone between mountain rivers and streams and lowland rivers with low flow velocity. The rivers could reach middle size. Complex benthic communities are formed. Species scraping substrate (grazers & scrapers) dominate. Filter feeders species has serious presence. Periphyton (phytobenthos) has important meaning for the ecosystem. Typical barbellchub zone in Bulgaria. More sizable macrophyte overgrowth is formed in

sections with slower velocity and adequate substrate.

- **Lowland zone** (potamon). The zone gains river mouth and is characterized by slow velocity. FPOM (Fine Particulate Organic Matter) is formed in the zone. The rivers could reach very large size with typical slow velocity and sections of accumulated organic sediments. Specific benthic communities are characteristic on the basis of collectors (especially so called detritus feeders (detritivores) and sediment feeders). Phytoplankton and zooplankton become of significance for the first time. Aquatic macrophytes are abundant and determinant as primary producers. Periphyton' (phytobenthos) role tends to diminish. Fish communities are extremely rich (over 15 species) and include economically important fish resources (large biomass). Typical carp zone in Bulgaria.

Reviewing rivers as hyporheic corridor - Hyporheic Corridor Concept (STANFORD & WARD, 1993) defines particular river sections (whole rivers in some cases), which are strongly influenced by groundwaters into both directions (discharging, infiltrating). Generally such rivers have high values of hardness (electrical conductivity) and specific hyporheic fauna. Typical illustration is Dobrudja's losing rivers.

The Flood Pulse Concept (TOCKNER *et al.*, 2000) defines some specific lowland river types as so called flood plain rivers. For example small and middle sized lowland rivers (marsh or sandy rivers) in Upper Thracian Valley and the lowland sections of large rivers Danube, Maritsa, Tundja, etc.

Integrated conceptual approaches for standing waters (lakes and dams) determine basic criteria of lake typology:

- ✓ Trophic level of the WB - classical conception defining main types according nutrient status and eutrophication degree:

- **Oligotrophic** „lakes“ (high mountain and mountain zone);

Current type lakes are naturally poor in nutrients (P, N) and lacking eutrophication (phytoplankton growth).

- **Mesotrophic** „lakes“ (semi mountain and part of the lowland zone);

„Lakes“ with average nutrient level and slight eutrophication as phytoplankton and macrophytes growth.

- **Eutrophic** „lakes“ (shallow lowland lakes)

Lakes significantly loaded with organic material and nutrients in lowland areas, usually shallow (mean depth <6 m). High levels of eutrophication are characteristic (phytoplankton blooms) and generally rapid macrophyte growth.

- ✓ Depth zonation and micticity - shallow zone is determined (littoral) and deep zone (profundal, >15 m depth), presence and absence of stratification, thermocline and different residence time (water exchange);

- **Shallow lake ecosystems** (mean depth <15 m)

Shallow lake ecosystem determined by permanent water circulation (polymictic), absence of summer or winter stratification and in general species richness (phytoplankton, zooplankton, benthic invertebrates, macrophytes and fish fauna). The conditions are proper especially for macrophytes which sometimes overgrowth large part of the lake area.

- **Deep lake ecosystems** (mean depth >15 m)

There is clear delimiting of shallow littoral zone (often similar characteristics with shallow lakes) and well differentiated deeper zone (profundal) with completely different characteristics. Profundal is defined as a WB, separated from littoral in the range of a single lake in some countries. Well expressed dimictic conditions (spring and autumn circulation), presence of stratification and thermocline (in summer). Both water layers above and under the thermocline usually have different physico-chemical and biological features. Phytoplankton is concentrated in the upper layer (pelagial, epipelagial), called also compensatory zone, concurrent with euphotic layer. Macrophytes are located at the littoral zone. Benthic macroinvertebrates communities are completely different in the littoral (insects' larvae, molluscs, etc. with high extent of diversity) and profundal

(almost 100% detritus feeders' species, representatives of Oligochaeta and Chironomidae, low biodiversity). Deeper water layer (called batipelagial) has also very low degree of diversity (mainly bacterial communities and some zooplankton species). Heavy quantities of organic sediments conglomerate frequently in profundal and lead to anaerobic bacterial decomposition (ammonification, sulphate reduction and methanogenesis) and hypoxia/anoxia at bottom layer. Fish fauna also is concentrated basically in littoral zone and epipelagial. Thus profundal is defined as a "biological desert" (poor in species composition and very low productivity) in comparison to littoral. Both zones are in active interaction during spring and autumn water circulations.

Similar to rivers, determination of "lakes" types depends also on connections with ground waters (infiltration or discharging of aquifers) and water level variance. Some Black Sea and riparian lakes and swamps are completely dependent on groundwater supplies (Shabla Lake, Durankulak Lake, Velyov Vir Lake, Alepu swamp, Arkutino, etc.). Water level fluctuations could influence very strongly on the lake ecosystem, destroying completely macrophytes and macroinvertebrates in eu littoral zone.

Hydromorphological basis of river typology

The following hierarchical scheme is proposed towards river typology in Bulgaria (Fig. 1):

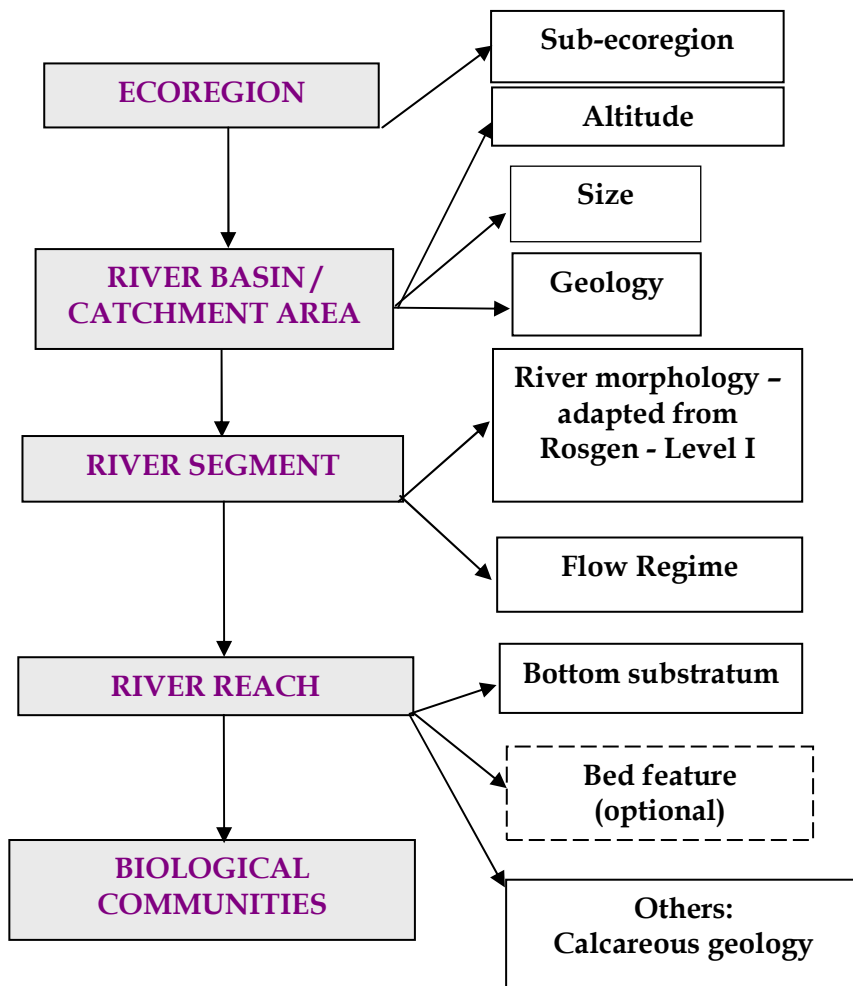


Fig. 1. Hydromorphological basis of river typology.

Altitude

The altitude defines 6 principal river types (Fig. 2 and 3) according classification system of ROSEN & SILVEY (1996).

Morphological characteristics - level 1

1. High mountain rivers with very steep slope - **type (Aa+), slope J >10%** and **type (A), slope J = 4 - 10%**;
2. Mountain rivers with moderate slope, low channel sinuosity- **type (B), slope J = 2 - 4%**;
3. Semi-mountain or lowland rivers with gentle slope, meandering - **type (C, E), slope J < 2%**;

4. Typical lowland rivers with braided channel or anastomosing (multiple channels) in depositional sections or at broad river valleys - **type (D), slope J < 4%** and **type (DA), slope J < 0.5%**;

5. Rivers with classic "entrench-ed, meandering" channels, gentle slope - **type (F), slope J <2%**;

6. "Gully" stream type is an entrenched, narrow, and deep, step/pool channel with a low to moderate sinuosity. - **type (G), slope J = 2 - 4%**.

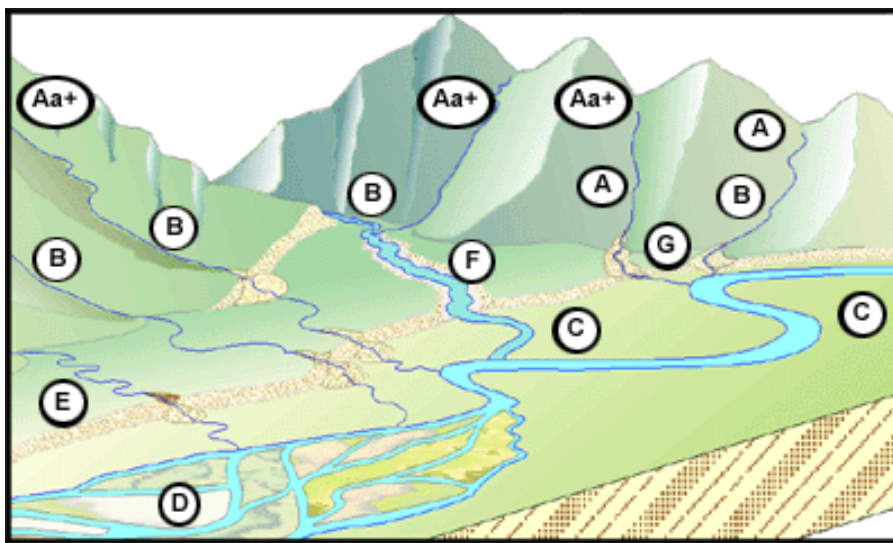


Fig. 2. Hydromorphological classification of rivers according altitude (after ROSEN & SILVEY, 1996).

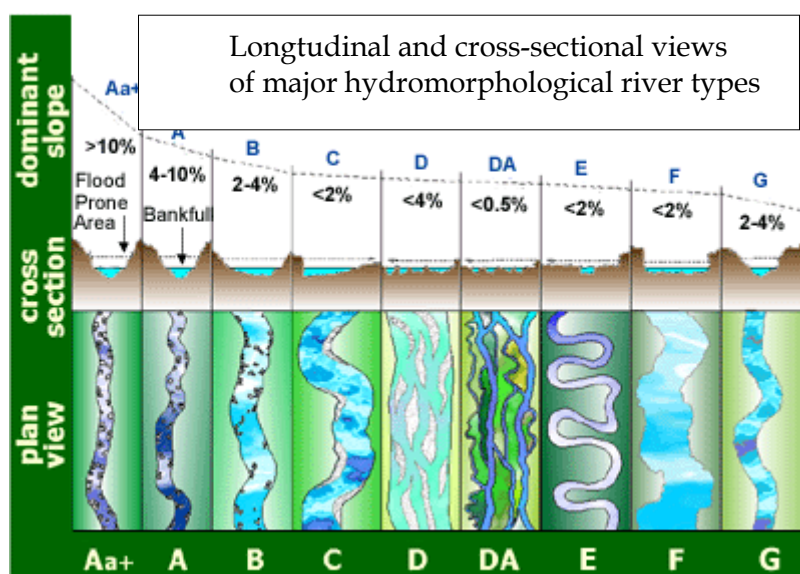


Fig. 3. Longitudinal and cross-sectional views of major hydromorphological river types (after ROSEN & SILVEY, 1996).

Size (catchment area and river size)

The catchment area is one of the most easily and reliably measurable parameters for river classification. According to the WFD 2000/60/EC (EUROPEAN COMMISSION, 2000) four dimension groups of catchment area are determined in applying System A towards river typologization: small size (<100 km²), medium (100 - 1000 km²), large (1000 - 10000 km²) and very large (10000 - 25000 km²).

After dimension classification following catchment area of WFD 2000/60/EC (EUROPEAN COMMISSION, 2000) there are 15 large rivers in Bulgaria (Danube Region - 6; Black Sea Region - 2; East Aegean Sea Region -

4; West Aegean Sea Region - 2). Special instance are Dobrudja's temporary rivers with large catchment areas (Suha, Tsaratsar, Kanagyol) which could not be adopted as large rivers due to their temporary character. There are many other tributaries of main rivers with catchment area >1000 km² (Sazliika, Vacha, etc.), which have also to be reviewed as large ones.

The following dimension criteria were defined in the current study in connection with the adopted approach for typologization after System B consistent with Bulgarian conditions (Table 1).

Table 1. Size criteria after System B consistent with Bulgarian conditions. * - Catchment areas between 2500 km² (Large Danube tributaries) and 1300 km² (Medium and small rivers) are not registered in Bulgarian part of Danube RB. ** - There are some exceptions, e.g. rivers Iskar, Struma, Mesta, etc.

River type according size	Catchment area	Examples
Very large rivers	> 800 000 km ²	only Danube River
Large Danube tributaries *	> 2 500 km ²	Ogosta, Iskar, Vit, Osam, Yantra, Rusenski Lom (6 rivers)
Large lowland rivers in Ecoregion 7	> 7 000 km ²	Maritsa, Tundja
Large Black Sea rivers	> 1 000 km ²	Kamchiya, Veleka, (Rezovska)
Medium and small rivers in Danube Region and Ecoregion 7 *	< 1 300 km ²	Archar, Lom, Tsibritsa, Gostilya, Pyasachnik, Mochuritsa
Medium and small Black Sea rivers	< 1 000 km ²	Ropotamo, Batova, Dyavolska
Semi mountain rivers (up to medium size) **	< 1 300 km ²	Semi mountain zone of all rivers in Bulgaria
Mountain rivers	< 500 km ²	Beli Iskar, Chepelarska, etc.
Small alpine rivers and springs	< 100 km ²	Malyovishka, Banderitsa, Damyanita, etc.

Geology

Current study adopted the approach assumed by RB Directorates separating rivers in Bulgaria into 2 major groups:

☑ Siliceous or mixed geology (silicate, calcareous);

☑ Strongly karst rivers (high values of hardness/electrical conductivity)

Third type defined in WFD - organic peat basis, is represented with insignificant cases (some small mountain peat marshes and lakes) and could be neglected in the view of general river typologization in Bulgaria.

River segment (morphological characteristics after ROSEN & SILVEY, 1996)

River segment is a part of river restricted for points of tributaries' inflows. It is a factor of continuity in attitude to river morphology.

River segment (flow regime)

Hydrological regime is suggested to be generally classified for the needs of river typology in the following manner:

1. Ephemeral stream - river streams, forming ephemeral flow under direct influence of local precipitations.

2. Intermittent stream - river streams, forming seasonal flow in different year periods - usually in the period of spring rainfall and thawing of snow, as well as separate WB in the period of dryness.

3. Perennial stream - permanent river streams, feeding in the dryness periods form groundwaters.

4. Headwater (river sections close to source) - could be perennial, intermittent or ephemeral.

5. Transitional river streams. River flows under influence of periodical inflows of sea water.

Rivers reach (substrate, river bed characteristic, slope)

„River reach” is a part form the river segment. It is also a factor of continuity, connected to a great extent with the river bed morphology (Fig. 4).

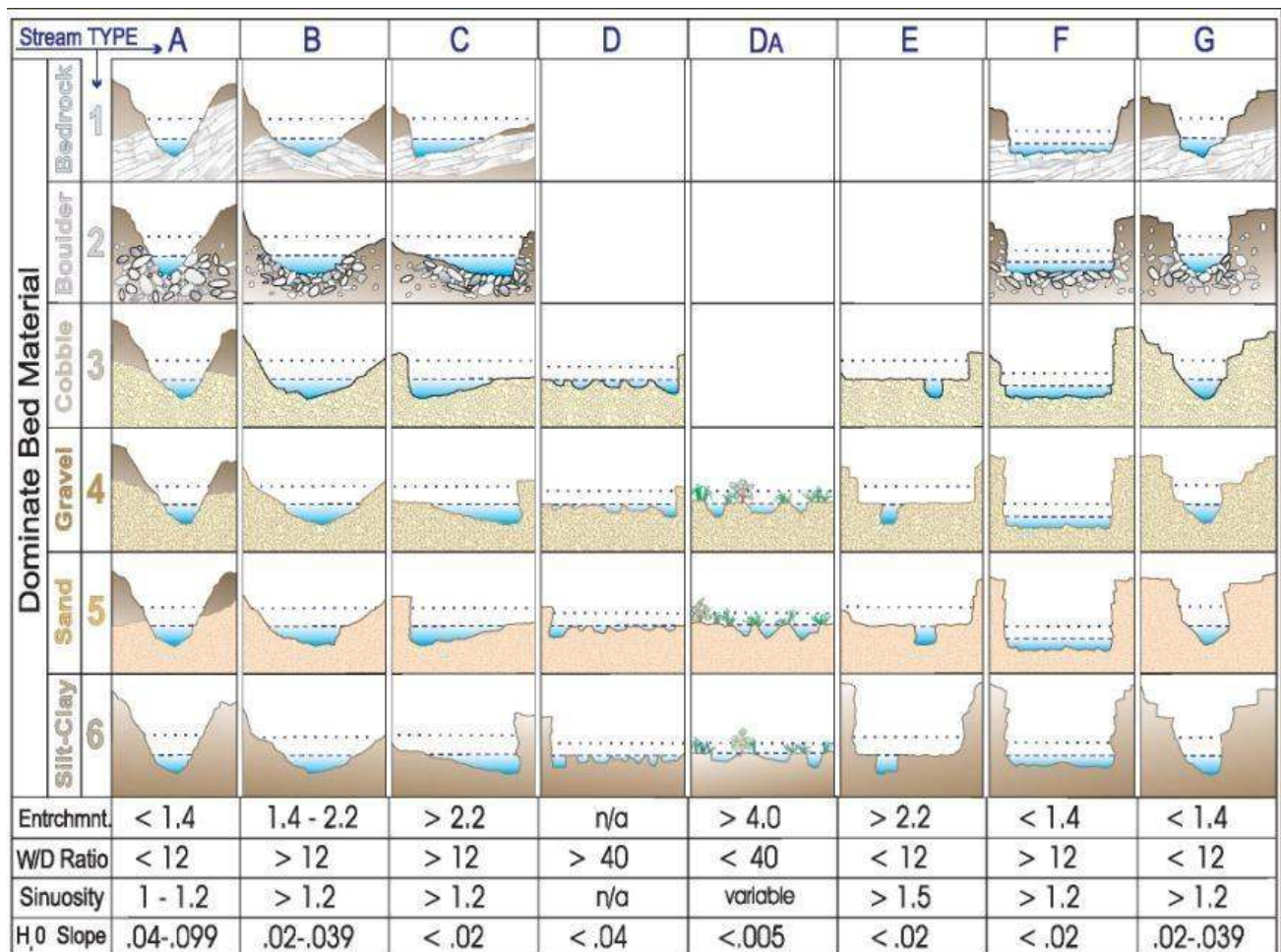


Fig. 4. Connection between hydromorphological river type, dominant substrate, river bed form, slope and other characteristics (after ROSEGEN & SILVEY, 1996).

The slope is important characteristic of different river types and has been classified as

follows: >10% (very steep), 4-10% (steep), 2-4% (moderate steep), <2% (slight sleep).

According to the river classification of ROSGEN & SILVEY (1996), 6 general river types are determined towards dominant bottom substrate (bedrock, boulders, cobble, gravel, sand and silt/clay) (Fig. 5).

Class-Naming Alphanumeric:	Channel Material	Particle size (in.)
1	BEDROCK	N/A
2	BOULDERS	> 10
3	COBBLE	2.5 to 10
4	GRAVEL	0.08 to 2.5
5	SAND	0.04 to 0.08
6	SILT / CLAY	< 0.04

Fig. 5. Classification according dominant substrate (after ROSGEN & SILVEY, 1996).
Substrate size is given in inches.

Ecological and hydromorphological basis of lake typology

The general criteria towards defining lake types after System B are as follows:

(i) "Lake" types which have natural equivalent; and "lake" types having no natural equivalent and represented only by heavily modified and artificial WBs;

(ii) Altitude differentiation of 3 basic trophic groups:

- High mountain and mountain types - correspond to ultra-oligotrophic and oligotrophic conditions (altitude parameters correspond to alpine and mountain river types);

- Semi mountain types - respond to mesotrophic conditions (altitude parameters correspond to semi mountain river types);

- Lowland types - mesotrophic to eutrophic (for shallow „lakes”) conditions;

(iii) Size characteristics;

- Large „lakes” > 10 km² surface area;

- Middle and small < 10 km² surface area;

(iv) Bathymetric characteristics:

- Deep „lakes” (Fig. 6). Availability of well developed and significant in size depth zone (profundal and bathyal (bathypelagic) zone), >15 m mean depth, which exists together with shallow littoral zone (<15 m) and epipelagial (euphotic zone);

- Shallow „lakes” (<15 m mean depth), lack of marked and large scale depth zone (profundal).

(v) Geology - absence of specific division of siliceous, calcareous and organic in Bulgaria. Common heterogeneous geology is in use at the moment.

(vi) Mixing characteristics

- Polymictic (generally shallow „lakes”) - lack of marked summer stratification and thermocline;

- Monomictic (one annual circulation) - rare type, probably only deep alpine glacial lakes;

- Dimictic (deep „lakes” with developed profundal) - spring and autumn circulation, typical stratification and thermocline;

(vii) Salinity - important characteristic only for transitional waters (Black Sea coastal lakes):

- Freshwater <0.5 ‰ salinity;

- Oligohaline (low salinity), 0.5 - 5 ‰ salinity;

- Meso- to polyhaline (medium to high salinity), 5 - 30 ‰ salinity;

- Hyperhaline (extreme salinity), >40 ‰ salinity.

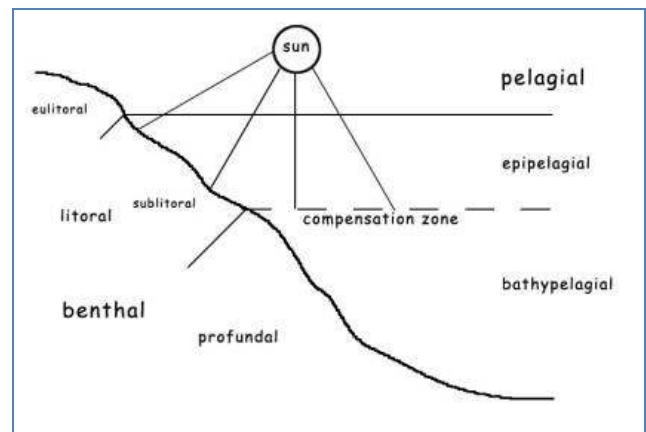


Fig. 6. Biological zonation of deep „lakes” (after <http://spoiwzp.sggw.pl/>).

Results and Discussion

Alteration of boundary between Ecoregion № 12 (Pontic Province) and Ecoregion № 7 (Eastern Balkans)

Suggested alterations

On the basis of the received results the

boundary between Ecoregion № 12 (Pontic Province) and Ecoregion № 7 (Eastern Balkans) to be specified and altered is suggested (Fig. 7) on the ground of the available biogeographic data (especially for fish and macroinvertebrate fauna) verified by the followed projects:

- “Assessment of reference conditions and maximum ecological potential of surface water types (rivers and lakes) on Bulgarian

territory” (Consortium for Biomonitoring, 2009-2010);

- “Developing classification system towards ecological status and potential assessment of the defined surface water types (rivers and lakes) on Bulgarian territory (in compliance with System B (Consortium for Biomonitoring, 2009-2011).

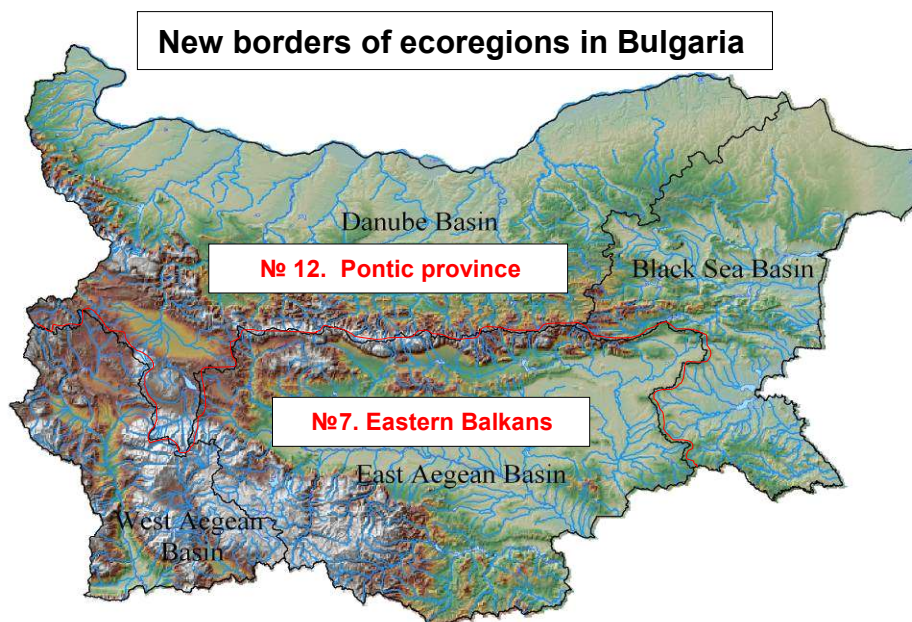


Fig. 7. Altered border between Ecoregion № 12 (Pontic Province) and Ecoregion № 7 (Eastern Balkans) in Bulgaria.

Thus both river basin districts (Danube and Black Sea) which naturally belong to the Black Sea catchment area are united (Ecoregion № 12 Pontic Province). In a similar manner both Mediterranean river basins (East Aegean and West Aegean) follow borders of the particular catchment areas, flowing towards Aegean Sea (Mediterranean Sea). Suggested new boundaries of Ecoregion 12 will cover the total area of Danube RB and respectively Black Sea RB district. Parts of Romania, Moldova, Ukraine and Belarus are included in the same Ecoregion. An intercalibration process has been launched including Bulgarian participation (Ministry of Environment and Water, Executive Environmental Agency, River Basin Directorates) in the frame of so called East

Europe Geographical Intercalibration Group (EE GIG).

The boundary between two ecoregions is presented at Appendix № XI, map A of WFD 2000/60/EC (EUROPEAN COMMISSION, 2000) sharing the Black Sea RB district and does not respond to the biogeographic data of the region as well as raises serious problems in defining typology, reference conditions, WBs' boundaries and thus the accomplishment of the additional requirements of WFD (monitoring programmes, programmes of measures, etc.).

The existed separation of the rivers from Black Sea RB district into two ecoregions (Pontic Province for northern and Eastern Balkans for southern rivers) is ungrounded by biogeographical point of view and will perplex

and even could prevented the development of multimetric fish index since unification of species common for Black Sea rivers and not typical for Aegean ones, and conversely.

Similar difficulties will be faced with metrics of benthic invertebrate fauna characterized by substantial biogeographic distinctions (Table 2).

Table 2. Typical species/taxa for Black Sea, East and West Aegean RB districts.

Black Sea Region	East Aegean Sea and West Aegean Sea Regions
Ecoregion № 12 Pontic Province	Ecoregion № 7 Eastern Balkans
Fish fauna	
<i>Chalcalburnus chalcoides</i> <i>Vimba vimba tenella</i> <i>Barbus bergi</i> <i>Rutilus frisii</i> <i>Leucaspius delineates</i> <i>Pungitius platygaster</i> <i>Clupeonella cultriventris</i> <i>Neogobius gymnotrachelus</i> <i>Mesogobius batrachocephalus</i> <i>Neogobius constructor</i> <i>Neogobius syrman</i> <i>Neogobius melanostomus</i> <i>Neogobius fluviatilis</i> <i>Salmo labrax</i> <i>Cobitis pontica</i> <i>Syngnathus abaster</i> Including recently registered species <i>Phoxinus stranjae</i> , <i>Gobio kowatchevi</i> (, <i>Alburnus mandrensis</i> , <i>Alburnus shishcovi</i> and salt-tolerant (eurohalinic) species entering from the sea.	<i>Vimba melanops</i> <i>Chondrostoma vardarensis</i> <i>Squalius orpheus</i> <i>Barbus cyclolepis</i> <i>Barbatula bureshi</i> , etc.
Benthic invertebrate fauna	
<i>Trichoptera</i> <i>Helicopsychidae</i> <i>Odonata</i> - some subspecies and species Ephemeroptera и Plecoptera - separate species Gastropoda Turbellaria/Tricladida Plus many other typical Pontic and Ponto-Euxinic species	<i>Odonata</i> - some subspecies and species Ephemeroptera и Plecoptera - separate species Gastropoda Turbellaria/Tricladida
Aquatic macrophytes	
The prevailing part of aquatic species is cosmopolitan and has no clear geographical specificity in the region. An exception are riparian species (helophytes) but they have minimal meaning.	
Phytobenthos (Diatoms)	
There are not enough data on biogeographical distribution of species, nevertheless geographical differences are expected.	

About 30% of the Black Sea rivers' fish species is not registered at the Aegean catchment area. At the same time none of the Aegean fish species is found at the prevailing part of small and middle Black Sea rivers. On the other hand all Bulgarian Black Sea tributaries show presence of Danube ichthyofauna with pontic taxa such as gobies (*Gobiidae*) – character for Ecoregion № 12 Pontic Province. It could be summarized that species form Pontic fauna and flora, biogeographically defining river basins characteristics are typical for the whole Black Sea region.

New concept towards river and lake types in Bulgaria

River and lake types in Bulgaria are substantially reduced from 33 to 16 river types, and from 33 to 17 lake types. Fundamental factors defining river and lake typology (in compliance with System B of WFD) (EUROPEAN COMMISSION, 2000) and a general view of new concept are presented at Tables 3 and 4.

Conclusions

Some of the major and significant conclusions after analysis of the results from the current study could be summarized as follows:

(i) Alteration of boundary between Ecoregion № 12 (Pontic Province) and Ecoregion № 7 (Eastern Balkans) was implemented and it would be a basis of concrete typologization at Black Sea Region for Basin Management in Bulgaria;

(ii) New concept was created for river and lake typology with the purpose of unifying the approach and existing types between separate basin regions;

(iii) Reduction of the number of river types in Bulgaria from 33 to 15 river types for freshwaters was accomplished;

(iv) Reduction of the number of lake types in Bulgaria from 33 to 13 lake freshwater types, among them 4 dam types (heavily modified and artificial water bodies) without natural equivalent in the region was established;

(v) For the first time in Bulgaria the category „transitional waters” was identified, represented by 1 river type and 4 lake types.

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Table 3. Ecological factors that determine the river typology in Bulgaria according to System B of the WFD 2000/60/EC.

Type code	River type	Obligatory factors					Optional factors					Comments
		Ecoregion / Sub-ER ¹	Altitude ²	Geology	Size	Distance from river source	Mean water slope/ Energy of flow	Valley shape	Mean substratum composition	Salinity ³		
R1	High mountain (Alpine) rivers	12-1; 7	> 1800 m vary to some extent	Mixed, siliceous, calcareous	<100 km ² , streams	<15 km	> 10%; Very steep; High E of flow	V, narrow w U	Bedrock, rocks, boulders	Fresh water; <0.5 ‰	High sediment supply systems, erode rivers	
R2	Mountainous rivers (Uplands)	12-1,2	Mountain zone - sometimes get down (validated)	Mixed, siliceous, calcareous	<100 km ² , streams (small rivers)	<40 km	4 - 10 % steep or 2-4% moderately steep; High E of flow	V, narrow w U	Boulders (>256 mm), cobbles (64 - 256 mm)	Fresh water; <0.5 ‰	Small riverbank terraces or non; sediment supply systems, erode rivers	
R3	Mountainous rivers (Uplands)	7	> (600) 800 m, vary to some extent (validated)	Mixed, siliceous, calcareous	<150 km ² , streams (rarely medium rivers <500 km ²)	<80 km	4 - 10 % steep or 2-4% moderately steep;	V, narrow w U	Boulders (>256 mm), cobbles (64 - 256 mm)	Fresh water; <0.5 ‰	Small riverbank terraces or non; sediment supply	

¹ Ecoregions (ER): 12 – Pontic province, 7-Eastern Balkans; Sub-ecoregions (sub-ER) only for ER Pontic province: 12-1 Danube sub-ER, 12-2 Black Sea sub-ER

² The altitude usually varies to great extent and it requires a validation during First River Basin Management Plan (RBMP) 2010-2015

³ Salinity is an obligatory factor for transitional waters represented by R16 Black Sea river firths

Type code	River type	Obligatory factors				Optional factors					Comments
		Ecoregion / Sub-ER ¹	Altitude ²	Geology	Size	Distance from river source	Mean water slope/ Energy of flow	Valley shape	Mean substratum composition	Salinity ³	
			(on)				High E of flow				systems, erode rivers
R4	Semi mountain rivers (gravel rivers)	12-1,2	Big variation, semi-mountain zone	Mixed, siliceous, calcareous	<1300 km ² , small and medium (rarely large)	Usually significant distance	<2% slight steep; Moderate E of flow	U with broader valley	Coarse gravels (16-64 mm), fine and medium gravels (2-16)	Fresh water; <0.5 ‰	Serious transport ability
R5	Semi mountain rivers (gravel rivers)	7	Big variation, semi-mountain zone	Mixed, siliceous, calcareous	<1300 km ² , small and medium (rarely large)	Usually significant distance	<2% slight steep; Moderate E of flow	U with broader valley	Coarse gravels (16-64 mm), fine and medium gravels (2-16)	Fresh water; <0.5 ‰	Serious transport ability
R6	Lower Danube	12-1	<30 m	Mixed	>800,000 km ² , very large	> 1500 km	<0.1% (practically lack of slope)	Broad river valley	Sand (0.064-2), silt (<0.064), clay, loess	Fresh water; <0.5 ‰	Sediment deposit area; Possible gravel supplements
R7	Large Danube	12-1	<80 m (certain)	Mixed	>2500 km ² , large	> 70 km	<0.5%; insignificant	Broad river	Sand (0.064-2), silt	Fresh	Sediment deposit

Type code	River type	Obligatory factors				Optional factors					Comments
		Ecoregion / Sub-ER ¹	Altitude ²	Geology	Size	Distance from river source	Mean water slope/ Energy of flow	Valley shape	Mean substratum composition	Salinity ³	
	tributaries		variation)				slope; Low E of flow	valley	(<0.064), clay, loess	water; <0.5 ‰	area; Possible gravel supplements
R8	Medium and small Danube rivers	12-1	<100 m (certain variation)	Calcareous, mixed, siliceous	<1300 km ² , medium and small (rarely large)	Variable significantly	<0.5% insignificant slope; Low E of flow	Broad river valley (often entrenched or deeply incised)	Sand (0.064 -2), silt (<0.064), clay, loess	Fresh water; <0.5 ‰	Sediment deposit area; Possible gravel supplements
R9	Losing karst rivers in Dobrudja area	12-1	<300 m	Calcareous	<4000 km ² , very small and temporary rivers (as Q)	Variable	Variable	Often entrenched or deeply incised	Variable	Fresh water; <0.5 ‰	Rapid seasonal variation of water level; Temporary rivers in many cases
R10	Large Black Sea rivers	12-2	<90 m (variable)	Mixed, siliceous	>1000 km ² , large	> 50 km	<0.5% insignificant	Broad river	Sand (0.064 -2), silt	Fresh	Sediment deposit

Type code	River type	Obligatory factors				Optional factors					Comments
		Ecoregion / Sub-ER ¹	Altitude ²	Geology	Size	Distance from river source	Mean water slope/ Energy of flow	Valley shape	Mean substratum composition	Salinity ³	
R11	Small and medium Black Sea rivers	12-2	<70 m (variable)	Mixed, siliceous	<900 km ² , small and medium	Variable	<0.5% insignificant slope; Low E of flow	Broad river valley (often incised)	Sand (0.064 -2), silt (<0.064), clay	Fresh water; <0.5 ‰	Sediment deposit area; Possible gravel supplements
R12	Large floodplain rivers	7	<150 (200) m variable	Mixed, siliceous	>7000 km ² , large and very large	> 60 km	<1% gentle slope;	Broad river valley	Sand (0.064 -2)	Fresh water; <0.5 ‰	Sediment deposit area; Often gravel supplements
R13	Small and medium floodplain rivers	7	<150 (350) m variable	Mixed, siliceous	<1300 km ² , Medium and small	Variable	<1% gentle slope;	Broad river valley	Sand (0.064 -2), silt (<0.064), gravel	Fresh water; <0.5 ‰	Sediment deposit area
R14	Sub-Mediterran	7	<500 (650) m	Mixed, siliceous,	<1100 km ² , Medium	Variable	Variable	Variable,	Variable	Fresh	Typical temporary

Type code	River type	Obligatory factors				Optional factors					Comments
		Ecoregion / Sub-ER ¹	Altitude ²	Geology	Size	Distance from river source	Mean water slope/ Energy of flow	Valley shape	Mean substratum composition	Salinity ³	
	lean rivers (temporary)		variable	calcareous	and small			all shapes		water; <0.5 ‰	rivers; Often torrential rivers with huge variation in water flow
R15	Karst springs	12, 7	Variable	Calcareous	<10 km ² , small streams near to the source	< 5 km	N.A.	N.A.	Variable	Fresh water; <0.5 ‰	Often high hardness (conductivity) and calcareous substratum
R16	Black Sea river firths	12-2	<5 (12) m	Mixed, siliceous	Variable	> 15 km	Non or very gentle slope	Broad river valley	Sands (0.064 - 2), silt (<0.064), clay	Mix oligohaline, often with seasonal salinity;	Sediment deposit area; Standing waters during low water level season

Table 4. Ecological factors that determine the lake typology in Bulgaria according to System B of the WFD 2000/60/EC.

Lake type code	Lake type	Obligatory factors					Optional factors				Comments
		ER/Sub-ER ⁴	Altitude ⁵	Mean ⁶ depth	Geology	Size/surface area	Depth (max.)	Residence time	Mixing characteristics	Salinity ⁷	
L1	High mountain glacial lakes	12-1; 7	> 2000 m	< 3 до 15 m (rarely >20 m)	siliceous, mixed	<0.15 km ² , very small	< 50 m	N.A.	monomictic	<0.5‰; fresh water	ultra-oligotrophic lakes
L2	Mountain lakes in ER 12	12-1,2	mountainous zone – getting down sometimes (validation)	Unstudied (<15 m or very shallow)	mixed, siliceous, calcareous	<0.1 km ² , very small	<15 m <80 m reservoirs	N.A.	polymictic	<0.5‰; fresh water	oligotrophic conditions
L3	Mountain lakes in ER 7	7	> (600) 800 m, variable (validation)	< 3 m (peaty lakes); <15 m (for reservoirs) - variable	organic (peat), mixed, siliceous, calcareous	<0.1 km ² , very small (natural lakes); < 5 km ² for HMWB	<6 m lakes <80 m reservoirs	N.A.	polymictic	<0.5‰; fresh water	natural dystrophic (peaty) lakes + mountain reservoirs (HMWB)
L4	Lowland or semi-mountain natural lakes & swamps in	12-1,2	variable, semi-mountain and lowland zones	< 3 m (rare more, small natural lakes and	mixed, siliceous, calcareous	<0.5 km ² dominated < 5 km ² (rarely, res.	<15 m	N.A.	polymictic	<0.5‰; fresh water	mesotrophic conditions

⁴ Ecoregions (ER): 12 – Pontic province, 7-Eastern Balkans; Sub-ecoregions (sub-ER) only for ER Pontic province: 12-1 Danube sub-ER, 12-2 Black Sea sub-ER

⁵ The altitude usually varies to great extent and it requires a validation during First River Basin Management Plan (RBMP) 2010-2015

⁶ There is lack of data for mean water depth of most of lakes and reservoirs in Bulgaria

⁷ Salinity is an obligatory factor for all transitional waters, e.g. for all Black Sea coastal lakes (types L7, L8, L9 и L10).

Lake type code	Lake type	Obligatory factors						Optional factors				Comments	
		ER/Sub-ER ⁴	Altitude ⁵	Mean ⁶ depth	Geology	Size/surface area	Depth (max.)	Residence time	Mixing characteristics	Salinity ⁷			
	ER 12		(validation)	swamps)		Rabisha)							
L5	Riverine marshes in ER 12	12-1,2	<80 m (variable)	< 3 m (rare more – for some excavation lakes)	mixed, siliceous	<5 km ² , very small to medium	<10 m deeper for artificial excavation lakes	N.A.	polymictic	<0.5‰;fresh water	mesotrophic to eutrophic conditions		
L6	Riverine wetlands in ER 7	7	<300 m (variable) (validation)	< 3 m (rare more – for same excavation lakes)	mixed, siliceous, calcareous	<0.5 km ² , very small	<6 m Deeper for artificial excavation lakes	N.A.	polymictic	<0.5‰;fresh water	mesotrophic to eutrophic conditions		
L7	Black Sea freshwater coastal lakes	12-2	<12 m	< 3 m (rare deeper)	mixed, siliceous, calcareous	<3.5 km ² , medium; >10 km ² for HMWB	<15 m Deeper for HMWB	N.A.	polymictic	<0.5‰;fresh water	mesotrophic to eutrophic conditions; Transitional waters		
L8	Black Sea oligohaline coastal lakes	12-2	<10 m	< 3 m	mixed, siliceous	Variable up to >10 km ² (Burgas Lake)	<10 m	N.A.	polymictic	0.5-5‰ oligohaline	mesotrophic to eutrophic conditions; Transitional waters		
L9	Black Sea	12-2	< 5 m	< 3 m	mixed,	Variable	<15 m	N.A.	polymictic	5-	salinity equal to		

Lake type code	Lake type	Obligatory factors						Optional factors				Comments
		ER/ Sub- ER ⁴	Altitude ⁵	Mean ⁶ depth	Geology	Size/ surface area	Depth (max.)	Residence time	Mixing characteristics	Salinity ⁷		
	mesohaline or polyhaline coastal lakes			(natural) < 15 m (HMWB)	siliceous, calcareous	up to >15 km ² (Varna Lake)		ctic	30% mesohaline & polyhaline	the Black Sea; Transitional waters		
L10	Black Sea euhaline & hyperhaline coastal lakes	12-2	< 5 m	< 1.5 m	mixed, siliceous	<20 km ² , large	<3 m	N.A.	>40% superhaline	eutrophic to polytrophic conditions; Transitional waters		
L11	Large deep reservoirs/ artificial lakes	12-1,2; 7	variable	>15 m	mixed, siliceous, calcareous	>10 km ² , large	<120 m profundal zone	multi-annual	<0.5‰; fresh water	Well-presented deep zone (profundal), with different ecological conditions than littoral zone; presence of thermocline in summer/ autumn		
L12	Small and medium-size semi-mountain reservoirs/ artificial lakes in ER	12	>150 (200) m (up to mountain zone) variable (validation)	variable	mixed, siliceous, calcareous	1-10 km ² , medium; or 0.5 – 1 km ² small	<80 m	annual, monthly or shorter period	<0.5‰; fresh water	Usually oligotrophic to mesotrophic conditions		

Lake type code	Lake type	Obligatory factors						Optional factors				Comments
		ER/Sub-ER ⁴	Altitude ⁵	Mean ⁶ depth	Geology	Size/surface area	Depth (max.)	Residence time	Mixing characteristics	Salinity ⁷		
L13	Small and medium-size semi-mountain reservoirs/artificial lakes in ER	7	150 (350) – 600 (800) m variable	variable	mixed, siliceous, calcareous	1-10 km ² , medium; or 0.5 – 1 km ² small	<80 m	annual, monthly or shorter period	dimictic; polymictic	<0.5‰; fresh water	usually oligotrophic to mesotrophic conditions	
L14	Large lowland reservoirs with medium depth in ER	12	usually <120 m variable	< 15 m	mixed, siliceous, calcareous	>10 km ² , large	<50 m profundal lacks or slightly developed	multi-annual; annual	polymictic	<0.5‰; fresh water	mesotrophic conditions; Lack of profundal zone and lack of summer stratification	
L15	Large lowland reservoir with medium depth in ER	7	usually <200 m variable	<15 m	mixed, siliceous, calcareous	>10 km ² , large	<50 m profundal lacks or slightly developed	multi-annual; annual	polymictic	<0.5‰; fresh water	mesotrophic conditions; Lack of profundal zone and lack of summer stratification	
L16	Small and medium-size lowland reservoirs/artificial lakes in ER	12-1,2	<120 m (validation)	<15 m (often <6m)	mixed, siliceous, calcareous	1-10 km ² , medium; or 0.5 – 1 km ² small	<50 m variable	annual, monthly or shorter period	polymictic	<0.5‰; fresh water	mesotrophic conditions	

Lake type code	Lake type	Obligatory factors						Optional factors				Comments
		ER/ Sub- ER ⁴	Altitude ⁵	Mean ⁶ depth	Geology	Size/ surface area	Depth (max.)	Residence time	Mixing characteristics	Salinity ⁷		
L17	Small and medium-size lowland reservoirs/ artificial lakes in ER	7	<200 m (validation)	<15 m (often <6m)	mixed, siliceous, calcareous	1-10 km ² , medium; or 0.5 – 1 km ² small	<50 m variable	annual, monthly or shorter period	polymictic	<0.5‰; fresh water	mesotrophic conditions	