INTERNATIONAL SAVA RIVER BASIN COMMISSION

Sava River Basin Analysis Report

2009

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Prepared by

International Sava River Basin Commission (ISRBC) in cooperation with the Parties to the Framework Agreement on the Sava River Basin.

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FOREWORD

According to the Framework Agreement on the Sava River Basin (FASRB), the establishment of sustainable water management in the Sava River Basin is one of the principal objectives of the cooperation of the Parties to the Agreement. Development of the Sava River Basin Management Plan, in line with the EU Water Framework Directive (EU WFD) and under the coordinating role of the International Sava River Basin Commission (Sava Commission), certainly presents a key activity in this context.

As the first step toward the Sava River Basin Management Plan, substantial effort has been made during the past years in order to perform the Sava River Basin Analysis, as recognized at the 2nd Meeting of the Parties to the FASRB (Belgrade, June 1, 2009).

Sava River Basin Analysis provides the characterization and assessment of water resources in the Sava River Basin in accordance with Article 5 of the EU WFD, including an additional consideration of the important issues such as flood management and development of navigation in the basin. Accordingly, the Analysis has been accepted by the Sava Commission "as a good basis for further activities on development of the Sava River Basin Management Plan".

The commitment of the Parties to respect the EU WFD, although not all of them are legally bound to do so, as well as a good cooperation of the Parties in development of the Sava River Basin Analysis, have granted a positive perception of the European Commission, which finally resulted in a decision of the EC to provide support for remaining steps in development of the first Sava River Basin Management Plan, including filling-up the gaps identified in the Analysis.

The major part of the work on development of this Report has been done by the Sava Commission's Permanent Expert Group for River Basin Management, whose great effort is highly appreciated and acknowledged.

I would also like to express my gratitude to other expert groups and the Secretariat of the Sava Commission that significantly contributed to development of the Sava River Basin Analysis, as well as to preparation of the Report.

Additionally, I would like to thank to many experts from the Parties, from various fields of expertise, to external consultants and the International Commission for the Protection of the Danube River, for their contribution to the Analysis.

A fruitful joint work done so far, as well as the Analysis itself, I see as a promising sign for further efforts to be invested in development of the Sava River Basin Management Plan.

Dejan Komatina, Ph.D.
Secretary of the Sava Commission

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LIST OF ACRONYMS AND ABBREVIATIONS

Aarhus Convention	*Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters*
ADN	*European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways*
AGN	*European Agreement on Main Inland Waterways of International Importance*
Ad hoc HM EG	*Ad-hoc* Expert Group for Hydrological and Meteorological Issues
AIS	Aquatic Invasive Species
AIS Network	Automatic Identification System Network
AL	Republic of Albania
AOX	Absorbable Organically Bound Halogens
AQEM	The Development and Testing of an Integrated Assessment System for the Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates
ASPT	Average Score Per Taxon
AWB	Artificial Water Body
BA / B&H	Bosnia and Herzegovina
Belgrade Convention	*The Convention on the Danube Navigation Regime*
BMWP index	Biological Monitoring Working Party Index
BOD	Biochemical Oxygen Demand
BQE	Biological Quality Element
BQI	Biological Quality Index
CARDS	Community Assistance for Reconstruction, Development and Stabilization
CBA	Cost Benefit Analysis
CBS	Central Bureau of Statistics
CEE	Central and Eastern Europe
CEVNI	*European Code for Inland Navigation*
CIS Guidance	Common Implementation Strategy Guidance
CLC 2000	Corine Land Cover 2000
COD	Chemical Oxygen Demand
DPSIR	Driver-Pressure-State-Impact-Response
DRPC	*Danube River Protection Convention* (*Convention on Cooperation for the Protection and Sustainable Use of the Danube River*)
DTD	Danube-Tisza-Danube
DTM	Digital Terrain Model
EC	European Commission
ECDIS	Electronic Chart Display and Information System

EEA	European Environment Agency
EFAS	European Flood Alert System
EFD	European *Flood Directive*
EIA	Environmental Impact Assessment
ENC	Electronic Navigation Chart
EPER	European Pollution Emission Registry
EPT	Ephemeroptera, Plecoptera and Trichoptera
ER	Eco-Region
ERI	Electronic Ship Reporting
Espoo Convention	*Convention on Environmental Impact Assessment in a Transboundary Context*
EU	European Union
EU WFD	EU *Water Framework Directive*
FAO	Food and Agriculture Organization
FASRB	*Framework Agreement on the Sava River Basin*
FBA / FB&H	Federation of Bosnia and Herzegovina (BA)
FIP	Future Infrastructure Projects
FMAFWM	Federal Ministry of Agriculture, Forestry and Water Management (FB&H)
FRM	Flood Risk Management
FRMP	Flood Risk Management Plan
FMAWMF	Federal Ministry of Agriculture, Water Management and Forestry (FB&H)
GDP	Gross Domestic Product
GES	Good Ecological Status
GIG	Geographical Intercalibration Group
GIS	Geographic Information System
GTS	Global Telecommunications System
GVA	Gross Value Added
GW	Groundwater
GWBs	Groundwater Bodies
Helsinki Convention	*Convention on the Transboundary Effects of Industrial Accidents*
HMIFFWS	Hydro-Meteorological Information and Flood Forecasting / Warning System
HMS	Hydro-Meteorological Service
HMWB	Heavily Modified Water Bodies

HR	Republic of Croatia
HRK	Croatian Kuna
HPP	Hydro-Power Plant
HTV	Croatian Television
HWSD	Harmonized World Soil Database
HYCOS	Hydrological Cycle Observing System
HYMO	Hydromorphological
ICP	Integrated Cadastre of Polluters
ICPDR	International Commission for the Protection of the Danube River
IMPRESS CIS	Guidance Document No.3 Analysis of Pressures and Impacts *Impress*
IPPC	Integral Pollution Prevention and Control
ISRBC	International Sava River Basin Commission
IUCN	International Union for Conservation of Nature
IWT	Inland Waterway Transport
JDS	Joint Danube Survey
LPNP	Lonjsko Polje Nature Park
MANS	Nonlinear Model of River Flow
MAP D-Phase	Mesoscale Alpine Programme
ME	Republic of Montenegro
MKGP	Ministry of Agriculture, Forestry and Food (SI)
MoAFWM	Ministry of Agriculture, Forestry and Water Management (RS-B&H)
NAIADES	Navigation and Inland Waterway Action and Development in Europe
NGO	Non-Governmental Organization
NHMS	National Hydro-Meteorological Service
NN	Official Gazette
NtS	Notices to Skippers
ORUCZ	Regional Division for Civil Protection (BA)
OŠCZ	Municipal Headquaters for Civil Protection (BA)
PAH	Polycyclic Aromatic Hydrocarbons
PE	Population Equivalent
PEG FP	Permanent Expert Group for Flood Prevention
PEG NAV	Permanent Expert Group for Navigation
PRSP	Poverty Reduction Strategy Paper
PS	Pumping Station
PWMC	Public Water Management Company (RS)
Ramsar Convention	*The Convention on Wetlands of International Importance especially as Waterfowl Habitat*

RB	River Basin
RBA	River Basin Analysis
RBMP	River Basin Management Plan
RHMSS	Republic Hydrometeorological Service of Serbia
RIS	River Information Service
RS	Republic of Serbia
RS (BA) / RS-B&H	Republika Srpska (BA)
Sava Commission	International Sava River Basin Commission
Sava WMD	Water Management Department for the Sava River Basin District (BA)
SCC	Waterway Classification of the Sava Commission
SEA	Strategic Environmental Assessment
SEE	South East Europe
SEEDRMI	South East Europe Disaster Management Initiative
SEETO	South East Europe Transport Observatory
SFRY	Socialist Federal Republic of Yugoslavia
SI	Republic of Slovenia
SRWTS	Sava River Waterway Transport System
SS	Suspended Solids
SWB	Significant Water Body
TG	Task Group
TNMN	Transnational Monitoring Network
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
UNECE	United Nations Economic Commission for Europe
UNECE Water Convention	*Convention on the Protection and Use of Transboundary Watercourses*
UNESCO	United Nations Educational, Scientific and Cultural Organization
UWWT Directive	*Council Directive 91/271/EEC concerning Urban Waste-Water Treatment*
UXO	Unexploded Ordnance
VHF	Very High Frequency
WANDA	Waste Management for Inland Navigation on the Danube
WB	Water Body
WMBO	Water Management Branch Office
WMO	World Meteorological Organization
WWTP	Waste Water Treatment Plant

Part I: Sava River Basin overview and general characteristics

1. Introduction

1.1. Framework Agreement on the Sava River Basin (FASRB) in context of cooperation in river basin management

1.1.1. History of cooperation towards the FASRB

After dissolution of the Socialist Federal Republic of Yugoslavia in the early 1990-ies, the Sava River, which was the biggest national river, has become an international river of recognized importance. The arising need for cooperation in management of the shared waters of the Sava River Basin led to beginning of the process known as the Sava Initiative. It was formally initiated with the *Letter of Intent concerning the International Sava River Basin Commission Initiative*, signed in Sarajevo on November 29, 2001, by the Ministers of Foreign Affairs of the Republic of Croatia, the Republic of Slovenia, the Federal Republic of Yugoslavia, and the Minister for Civil Affairs and Communications of Bosnia and Herzegovina.

A successful process of negotiations run under the „umbrella" of the Stability Pact for South-Eastern Europe, the four riparian countries of the Sava River Basin - Bosnia and Herzegovina, Republic of Croatia, Federal Republic of Yugoslavia (later on Serbia and Montenegro, and then Republic of Serbia) and Republic of Slovenia, finally resulted in conclusion of the *Framework Agreement on the Sava River Basin* (FASRB). The FASRB was signed at Kranjska Gora (Slovenia), on December 3, 2002.

The FASRB entered into force on December 29, 2004, thirty days after the Depositary of the Agreement (Republic of Slovenia) notified the signatories on reception of the last instrument for the ratification procedure. The FASRB presents the first multilateral agreement in the region after the agreement on succession.

1.1.2. Goals of the FASRB

The FASRB emphasizes the importance of transboundary cooperation of governments, institutions and individuals for sustainable development of the Sava River Basin.

It defines three main goals of the process of cooperation:

- Establishment of an international regime of navigation on the Sava River and its navigable tributaries which included set-up of conditions for safe navigation on the River Sava and its tributaries;
- Establishment of sustainable water management which included cooperation on management of the Sava River Basin water resources in a sustainable way, including integrated management of surface and ground water resources, in a manner that would provide:
    - water in sufficient quantity and of appropriate quality for the preservation, protection and improvement of aquatic eco-systems (including flora and fauna and eco-systems of natural ponds and wetlands);
    - waters in sufficient quantity and of appropriate quality for all kinds of water utilization;
    - protection against detrimental effects of water (flooding, excessive groundwater, erosion and ice hazards);
    - resolution of conflicts of interest caused by different uses and utilizations; and
    - effective control of the water regime;
- Undertaking measures to prevent or limit hazards, and reduce and eliminate adverse consequences, including those from floods, ice hazards, droughts and incidents involving substances hazardous to water.

The cooperation in achieving the main goals of the FASRB is based on the following principles:

- Sovereign equality, territorial integrity, mutual benefit, and good faith;
- Mutual respect of national legislation, institutions and organizations;
- Cooperation in line with the EU *Water Framework Directive* and other related Community legislation;
- Regular exchange of information within the basin on: water regime, navigation regime, legislation, organizational structures, administrative and technical practices;
- Securing the integrity of the water regime in the basin,
- Reduction of transboundary impacts caused by economic and other activities.

1.1.3. International Sava River Basin Commission (Sava Commission)

The implementation of the FASRB is coordinated by the Sava Commission, which is the joint institution established as an international organization, and with the permanent Secretariat as its executive body.

The Sava Commission is consisted of two representatives of each Party, one member and one deputy member. It is mandated with a number of tasks and responsibilities specified in Annex I to the FASRB – *Statute of the Sava Commission*. The specific peculiarity of the Sava Commission within the family of European basin organizations, provided by the FASRB, is integration of navigation and environmental protection within one institution – providing the Sava Commission with the broadest scope of responsibilities among similar river bodies.

The Sava Commission is given the capacity for making decisions in the field of navigation and providing recommendations on all other issues.

Principal scheme of the functioning and decision making process of the Sava Commission can be seen in Figure I-1.

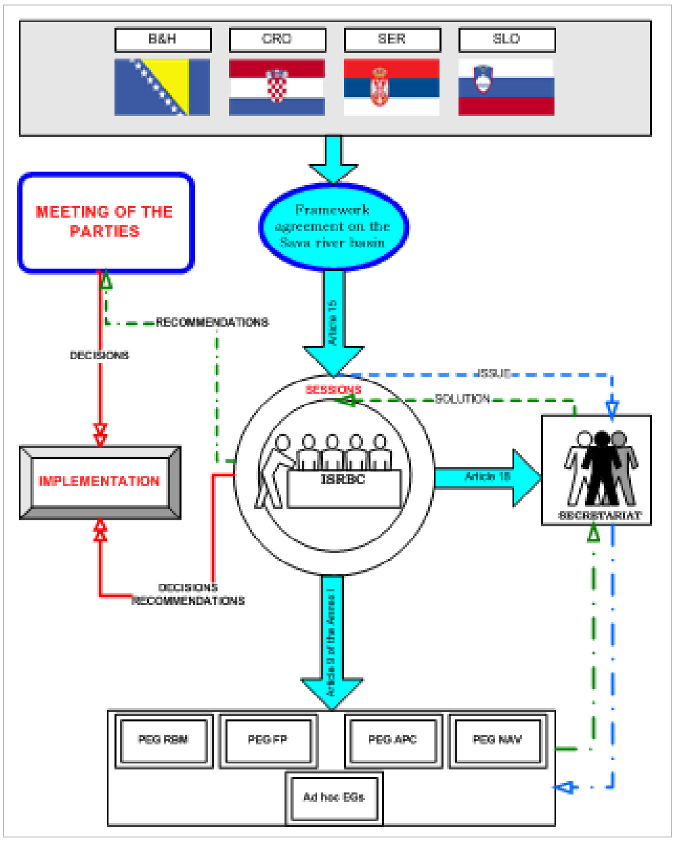


Figure I-1: Principal scheme of the Sava Commission functioning

2. General Characteristics of the Sava River Basin

2.1. Sava River Basin – basic facts

2.1.1. Location, area and countries sharing of the basin

The Sava River Basin is a major drainage basin of the South Eastern Europe covering the total area of approximately 97,713.20 km^2 (Figure I-2). Geographically, it spreads between 13.67 ºE and 20.58 ºE longitude and between 42.43 ºN and 46.52 ºN latitude, and represents one of the most significant sub-basins of the Danube River Basin, with the share of 12 %.

Figure I-2: Location of the Sava River Basin

The northern part of the catchment borders with the Drava River Basin, which is also a tributary of the Danube River. The watershed between the southern part of the Sava River Basin and the Adriatic Sea catchments goes over relatively high and rugged mountains.

The basin area is shared between five countries: Slovenia, Croatia, Bosnia and Herzegovina, Montenegro and Serbia, while a negligible part of the basin area also extends to Albania (Table I-1 and Figure I-3).

Table I-1: Countries in the Sava River Basin

State	Flag	ISO ALPHA-2 Code	ISO ALPHA-3 Code	FASRB status
Republic of Slovenia		SI	SVN	Party
Republic of Croatia		HR	HRV	Party
Bosnia and Herzegovina		BA	BIH	Party
Republic of Serbia		RS	SRB	Party
Republic of Montenegro		ME	MNE	
Republic of Albania		AL	ALB	

Except for Serbia and Albania, its watershed covers 45 % to 70 % of the surface area of the other four countries. Its water resources constitute nearly 80 % of the total freshwater resources in those four countries. Table I-2 presents some basic figures with regard to the countries' share of the Sava River Basin (Sava RB) area.

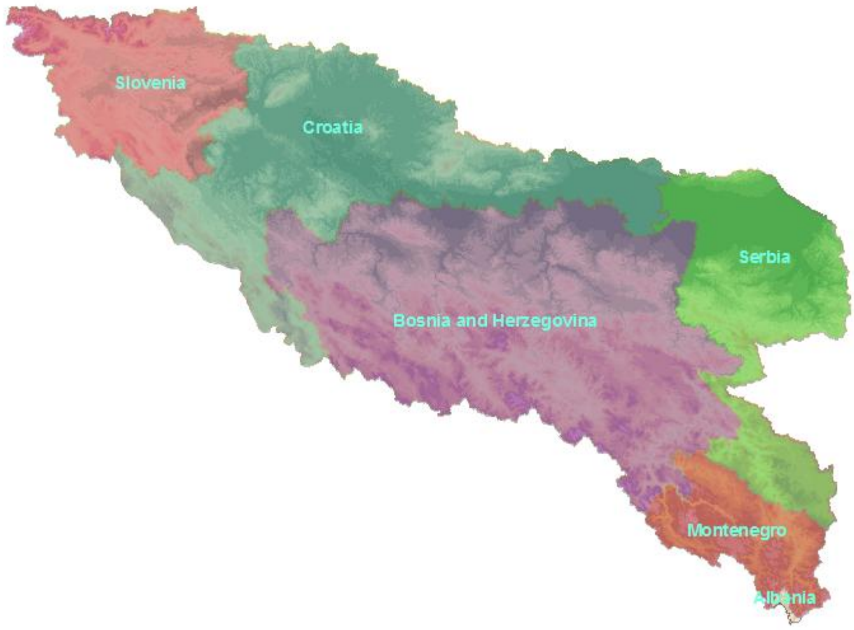


Figure I-3: Country share of the Sava River Basin

Table I-2: Share of the Sava countries territory belonging to the Sava River Basin

	SI	HR	BA	RS	ME	AL
Total country area [km^2]	20,273	56,542	51,129	88,361	13,812	27,398
Share of national territory in the Sava RB [%]	52.8	45.2	75.8	17.4	49.6	0.59
Area of the country in the Sava RB [km^2]	11,734.8	25,373.5	38,349.1	15,147.0	6,929.8	179.0
Share of Sava RB [%]	12.01	25.97	39.25	15.50	7.09	0.18

Population in the Sava River Basin is approximated to 8,176,000, which represents 46 % of the total population of all countries (excluding Albania and Montenegro). Particularly, the population of the Sava

River Basin in Bosnia and Herzegovina is 75 % of the total population, in Croatia 50 %, in Serbia 25 % and in Slovenia 61 %.

Economic activities developed in the Sava River Basin, generate more than 2,379,000 employed people. That is 29 % of all inhabitants in the Sava River Basin and 45 % of all employed people in all countries (excluding Albania and Montenegro). More on the socio-economic factors related to the Sava River Basin is provided in the Part III of this Report.

2.1.2. Relief and topography

Terrain in the Sava River Basin is very variable. It significantly changes from the source on the west to its confluence with the Danube River on the east (Figure I-4).

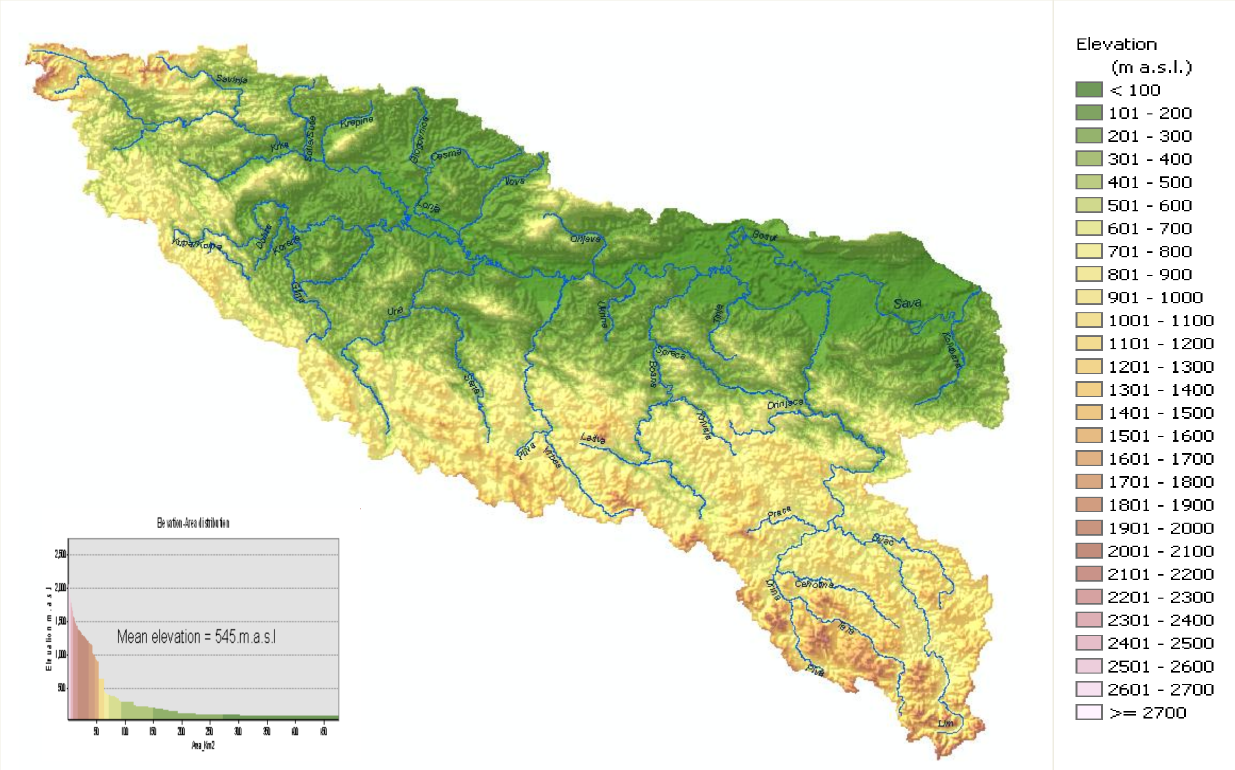


Figure I-4: Sava River Basin relief characteristics

Rugged mountains (the Alps and the Dinarides) dominate in the upper part of the basin which belongs to Slovenia, where the highest peak is Triglav (2,864 m a.s.l.[1]). Considerable part of this area is covered by forests.

Situation is somewhat different in the downstream parts of the basin. There is a remarkable distinction in landscape of the northern part (the left bank) and southern part of the basin (the right bank). The areas drained by right tributaries in the middle section of the Sava watercourse are also rugged. Numerous rivers run from the Dinaric Mountains in Croatia and Bosnia, having the general south-to-north direction. The mountains constituting these catchments range up to 2,500 m a.s.l. In spite of ruggedness, rocks and soils in central Bosnia are less vulnerable to erosion, and the terrain is characterized by green and often forested plateaus. In the north, lowland areas (of variable width) suitable for agricultural activities extend along the Sava River and lower parts of its tributaries.

Particularly rugged terrains appear in Montenegro and Northern Albania. The mountains of Montenegro include some of the roughest terrain in Europe. They average more than 2,000 meters in elevation and occasionally exceed a height of 2,500 meters (the peak of Bobotov Kuk in the Durmitor Mountains).

[1] a.s.l. = above sea level.

[2] Guidance Document No.2 *Identification of Water Bodies*, 2003.

The middle and lower part of the Sava River drainage area is characterized by flat plains and low mountains. This area is part of Pannonian Plain, a low-lying, fertile, agricultural region.

Generally, elevation of the Sava River Basin varies between approx. 71 m a.s.l. at the mouth of the Sava River in Belgrade (Serbia) and 2,864 m a.s.l. (Triglav, Slovenian Alps). Mean elevation of the basin is 545 m a.s.l.

Figure I-5 represents steepness of the terrain in the Sava River Basin (based on the calculation of the maximum rate of change from a cell to its neighbours), derived from the SRTM (Shuttle Radar Topography Mission) 90x90 m raster. According to FAO classification, the dominant slope in the basin is moderately steep. Mean value of slope in the Sava River Basin is 15.8 %.

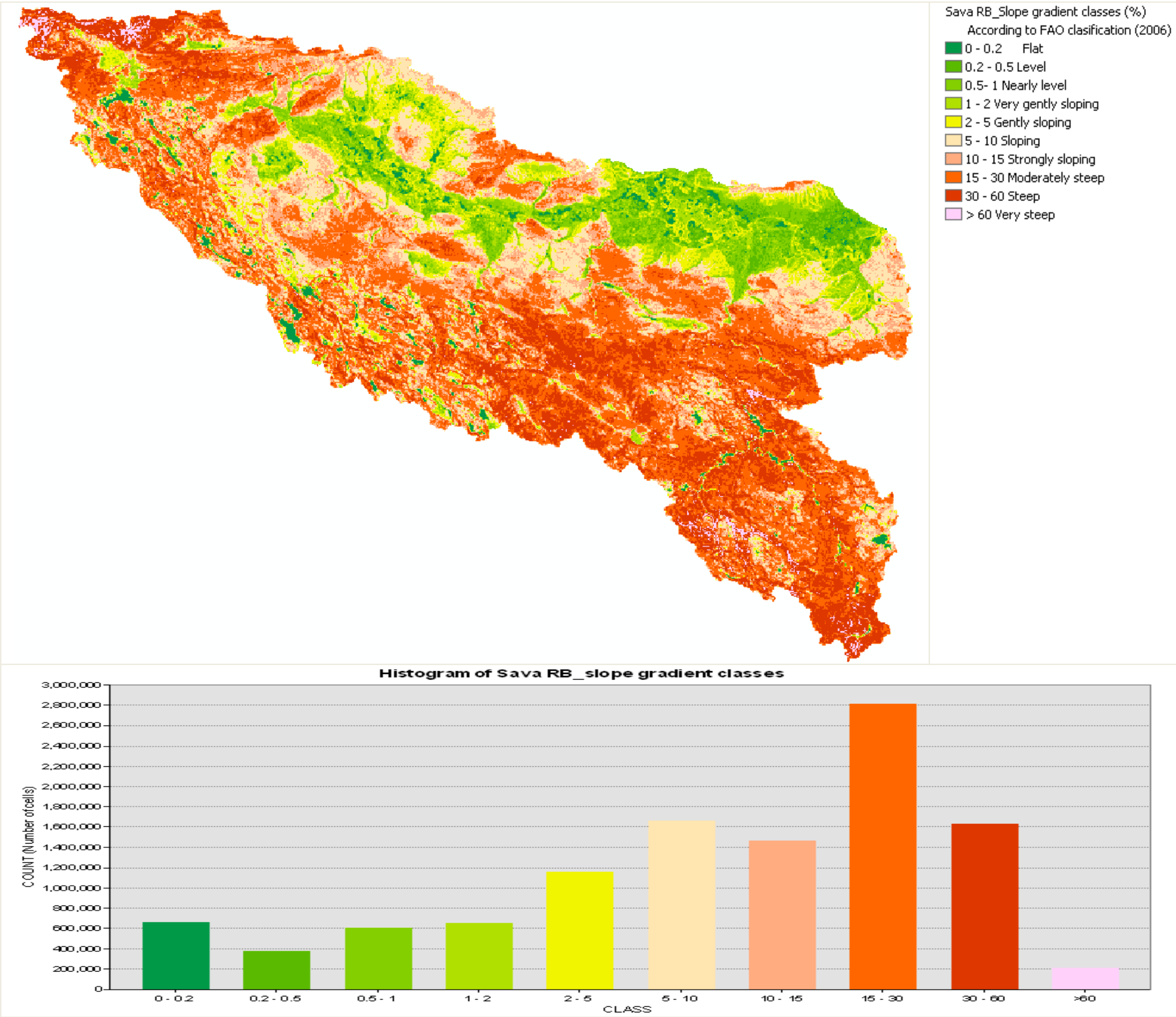
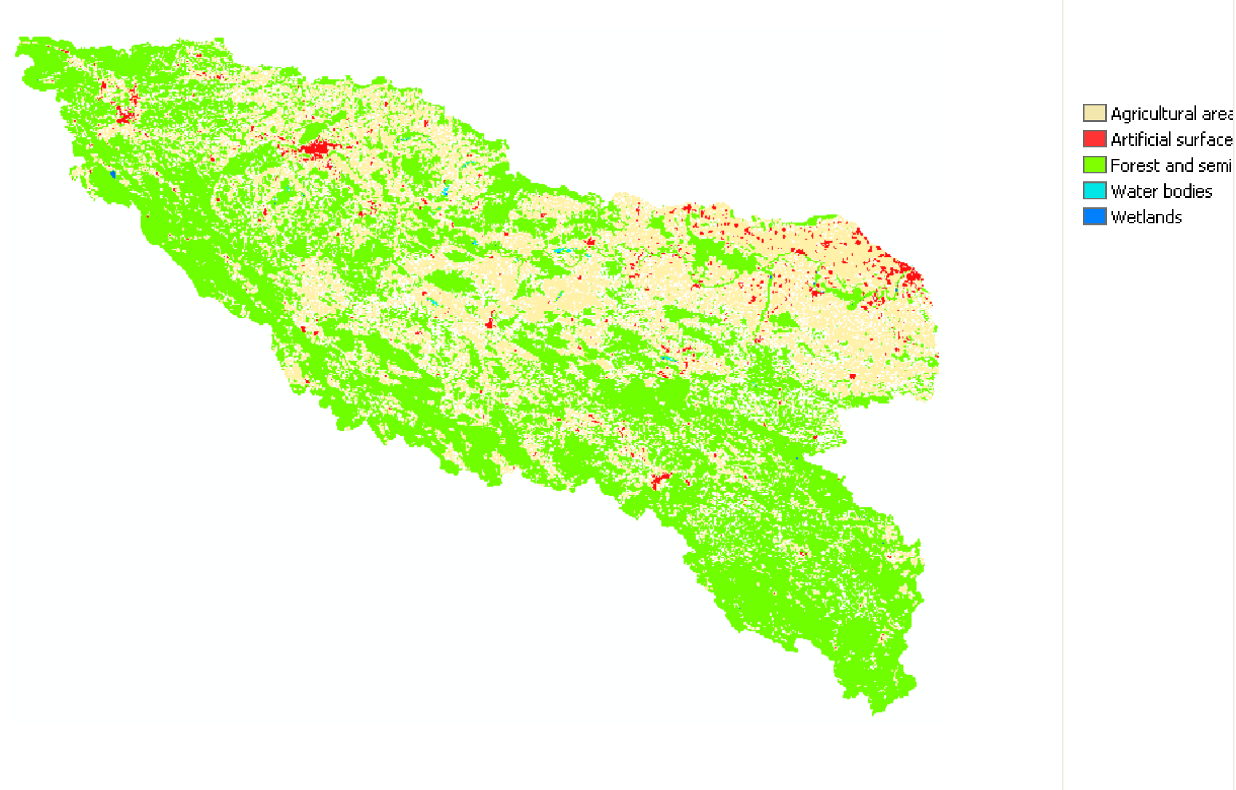


Figure I-5: Terrain slope (%) in the Sava River Basin

2.1.3. Land cover/land use in the basin

For an overview of the land cover/land use in the Sava River Basin, the EEA Corine database for Europe was used, and prepared for the entire area of the Sava RB, as shown in Figure I-6 and in Table I-3.



Land class	Share (%)
Artificial surfaces	2.23
Agricultural areas	42.36
Forests and semi natural areas	54.71
Wetland	0.08
Inland water	0.63

Figure I-6: Distribution of main land cover classes in the Sava River Basin (According to the CLC 2000)

Table I-3: Detailed Sava RB Corine land classes' data

Corine 2000 Land cover/use in the Sava RB	Area (km^2)	Share (%)
Continuous urban fabric	6.770	0.01
Discontinuous urban fabric	1,708.650	1.75
Industrial or commercial units	169.310	0.17
Road and rail networks and associated land	27.480	0.03
Airports	32.190	0.03
Mineral extraction sites	133.710	0.14
Dump sites	20.020	0.02

Corine 2000 Land cover/use in the Sava RB	Area (km^2)	Share (%)
Construction sites	8.160	0.01
Green urban areas	37.800	0.04
Sport and leisure facilities	24.680	0.03
Non-irrigated arable land	6,162.430	6.32
Permanently irrigated land	0.280	0.00
Vineyards	63.490	0.07
Fruit trees and berry plantations	123.900	0.13
Pastures	5,875.410	6.03
Complex cultivation patterns	16,990.640	17.43
Land principally occupied by agriculture, with significant areas of natural vegetation	12,068.440	12.38
Broad-leaved forest	29,596.930	30.37
Coniferous forest	5,384.240	5.42
Mixed forest	9,376.860	9.62
Natural grasslands	23,636.110	2.38
Moors and heathland	295.410	0.30
Sclerophyllous vegetation	0.400	0.00
Transitional woodland-shrub	5,874.040	5.92
Beaches, dunes, sands	25.570	0.03
Bare rocks	200.370	0.21
Sparsely vegetated areas	449.500	0.46
Burnt areas	2.360	0.00
Glaciers and perpetual snow	0.340	0.00
Inland marshes	81.260	0.08
Water courses	375.620	0.39
Water bodies	233.880	0.24
Total	97,713.200	100.00

2.1.4. Soils

According to Harmonized World Soil database (HWSD), the soils with the largest extent are the Cambisols (weakly to moderately developed soils) that cover 46.4 % of the basin (Figure I-7). Other important soil groups are the Luvisols (soils with subsurface accumulation of high activity clays and high base saturation), Leptosols (very shallow soils over hard rock or in unconsolidated very gravelly material), Podzoluvisols (leached soils) and Fluvisols (young soils in alluvial deposits).

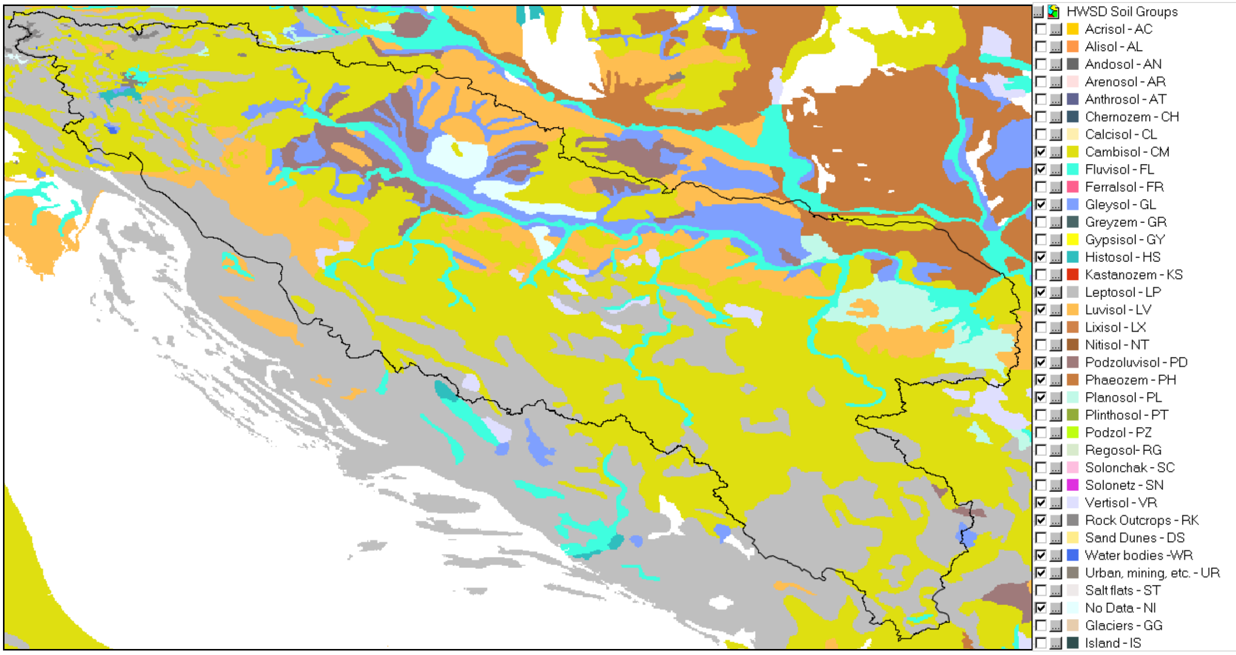


Figure I-7: Dominant soil groups in the Sava River Basin (HWSD)

2.2. Climate conditions

The Sava River catchment is situated within a wide region where the moderate climate of the northern hemisphere prevails. The cold and hot seasons are clearly distinctive. The winter can be severe with abundant snowfalls, while summer is hot and long.

Climate conditions within the basin can be classified into three general types:

- Alpine climate;
- Moderate continental climate;
- Moderate continental (mid-European) climate.

Alpine climate is prevailing in the upper Sava Basin within Slovenia, the moderate continental climate dominates in right tributaries' catchments within Croatia, Bosnia and Herzegovina and Montenegro, while the moderate continental (mid-European) climate primarily features in the left tributaries' catchments that belong to the Pannonian Basin.

Dividing lines between these three categories are not sharp, due to different degree of influence of various factors that determine the climate. Most significant factors that cause climatic modifications in the Sava catchment are orographic features that reflect upon most important climatic events: air temperature and precipitation and indirectly upon evapo-transpiration.

Average annual air temperature for the whole Sava Basin was estimated to about 9.5 $^\circ$C. Mean monthly temperature in January falls to about -1.5 $^\circ$C, whilst in July it can reach almost 20 $^\circ$C.

Precipitation amount and its annual distribution are very variable within the basin. Average annual rainfall over the Sava River Basin was estimated at about P = 1,100 mm.

The average evapo-transpiration for the whole catchment is about E = 530 mm/year.

More on the climate is given in the Part III of this Report.

2.3. Main hydrographic features in the Sava River Basin

2.3.1. Description of the Sava River and its main tributaries

The Sava River is formed by two mountainous streams: the Sava Dolinka (left) and Sava Bohinjka (right). From the confluence of these headwaters between the Slovenian towns of Lesce and Radovljica until it joins the Danube in Belgrade (Serbia), the Sava River is 945 km long. Together with its longer headwater, the Sava Dolinka River, in the north-west, it measures 990 km.

Its average discharge at the confluence (Belgrade, Serbia) is about 1,700 m^3/s which results in the long-term average unit-area-runoff for the complete catchment of about 18 $l/s/km^2$.

Hydrographic network in the basin is well developed. East of Ljubljana, the Sava flows through a 90 km long gorge and afterwards through the Karst Plain (Krško polje). Most important tributaries in the upper Sava River Basin are: Kokra, Kamniška Bistrica and Savinja (from the left side) and Sora, Ljubljanica and Krka (from the right). These rivers are characterized by a torrential nature (steep channel’s slope, high flow velocity and rapids).

As the geo-morphological processes caused the Pannonian Sea to recede, the Sava River grew longer, carving the Sava Trench (Savski rov) through which it flows to the east. The river runs through numerous towns that used to host considerable industrial capacities (Zagreb, Sisak, Slavonski/Bosanski Brod, Brčko, Sremska Mitrovica, Šabac, Obrenovac, Belgrade and others). Waste waters discharged from municipalities and industries along the Sava River as well as the tributaries were treated only at certain locations so the water quality used to be considerably endangered. Presently, situation is somewhat better as a result of decrease of industrial activities.

Together with the lower parts of the Bosnian watercourses, which are its tributaries, the Sava River created huge floodplains. At its middle and lower course, the Sava River begins to meander, subjective to gentle slopes of the Pannonian bed and by force of its many right tributaries. It changed its course many times through history. Old riverbeds turned into swamps and ponds known as „*mrtvaja*” and „*starača*”. The best known and largest pond is in Serbia which is also one of the biggest wild birds’ reservation areas in Europe - Obedska Bara.

Common feature of almost all right tributaries of the Sava River is their torrential behaviour, particularly in their upper sections. River channels are often deeply cut into the hard rocks, with very violent flow through gorges. These mountainous features are mostly pronounced in the Rivers Una and Drina.

Thanks to geological properties, the Una River is famous by several water falls appearing on its watercourse. As it approaches the confluence, the Una River becomes mild and slow moving. Further downstream the Sava River receives several right tributaries that drain central and northern part of Bosnia and Herzegovina. Most significant among them are Vrbas, Ukrina, Bosna, Brka and Tinja. Vrbas and Bosna are medium size rivers whose catchments are deeply penetrating into the central part of Bosnia and Herzegovina. They receive several mountainous tributaries each.

The other three above mentioned rivers (Ukrina, Brka and Tinja) drain rather smaller drainage areas of northern Bosnia (Tinja and Brka < 1,000 km^2).

Drina River is the largest and most important of all tributaries of the Sava River. Its drainage basin extends into four countries: Montenegro, Bosnia and Herzegovina, Serbia and a very small part extends to Albania. The river course is formed in Montenegro after merge of two mountainous streams (the Rivers Tara and Piva that drain very rugged mountains of northern part of Montenegro). In its further course it receives several tributaries: Sutjeska, Prača and Drinjača (from the left) and the Ćehotina, Lim, Rzav, Ljubovidja and Jadar (from the right). The Lim River is the most important tributary of the Drina River, whose catchment extends to Albania.

Going further downstream the Sava River near Belgrade receives two important tributaries from the right: Kolubara and Topčider River.

The left tributaries, except in the upper part of the catchment (in Slovenia) that was discussed above, drain mostly flat areas and low hills of Pannonian Basin. Consequently, the slopes and flow velocities are smaller and the streams are meandering. Most important rivers are Sutla/Sotla (SI and HR), Krapina, Lonja, Ilova and Orljava (HR), and Bosut (HR and RS). These rivers encompass much smaller part of the drainage than the right tributaries, thus making the Sava River catchment asymmetric.

2.3.2. Overview of the „Sava River Basin Analysis" rivers

For the purpose of this characterization report, as a common agreement of the Sava countries, the Sava River tributaries with catchment area above threshold value of 1,000 km^2 were taken as the limit for the scale of analysis for the Sava RB. Based on this arbitrary decision, the rivers listed in Table I-4 were analyzed during this exercise.

Table I-4: Agreed list of the Sava River Basin rivers for the purpose of the Sava RBA report

River	Con-fluence (l-left; r-right)	Trib. order	River basin size [km^2]	River length [km]	Countries sharing the (sub-)basins
Sava			**97,713.2**	**944.7**	**SI, HR, BA, RS, ME, AL**
Ljubljanica	r	1st	1,860.0	41.0	SI
Savinja	l	1st	1,849.0	93.9	SI
Krka	r	1st	2,247.0	94.6	SI
Sotla/Sutla	l	1st	584.3	88.6	SI, HR
Krapina	l	1st	1,237.0	66.9	HR
Kupa/Kolpa	r	1st	10,225.6	297.4	HR, SI, BA
Dobra	r	2nd	1,428.0	104.2	HR
Korana	r	2nd	2,301.5	138.6	HR, BA
Glina	r	2nd	1,427.1	112.2	HR, BA
Lonja	l	1st	4,259.0	49.1	HR
Česma	l	2nd	3,253.0	105.7	HR
Glogovnica	r	3rd	1,302.0	64.5	HR
Ilova (Trebež)	l	1st	1,796.0	104.6	HR
Una	r	1st	9,828.9	214.6	BA, HR
Sana	r	2nd	4,252.7	141.9	BA
Vrbas	r	1st	6,273.8	249.7	BA
Pliva	l	2nd	1,325.7	26.8	BA
Orljava	l	1st	1,618.0	87.6	HR
Ukrina	r	1st	1,504.0	80.7	BA
Bosna	r	1st	10,809.8	281.6	BA
Lašva	l	2nd	958.1	56.6	BA
Krivaja	r	2nd	1,494.5	73.5	BA
Spreča	r	2nd	1,948.0	138.8	BA

River	Con-fluence (l-left; r-right)	Trib. order	River basin size [km^2]	River length [km]	Countries sharing the (sub-)basins
Tinja	r	1st	904,0	99.4	BA
Drina	r	1st	20,319.9	346.0	ME, AL, BA, RS
Piva	l	2nd	1,784.0		ME
Tara	r	2nd	2,006.0		ME, BA
Ćehotina	r	2nd	1,237.0	125.0	ME, BA
Prača	l	2nd	1,018.5	55.0	BA
Lim	r	2nd	5,967.7	193.0	AL, ME, RS, BA
Uvac	r	3rd	1,596.3	114.5	RS, BA
Drinjača	l	1st	1,090.6	87.5	BA
Bosut	l	1st	2,943.1	186.0	HR, RS
Kolubara	r	1st	3,638.4	86.6	RS

Table I-4 represents the Sava River and its most important tributaries with catchment areas larger than 1,000 km^2 (with the exception of the Lašva River with drainage area of 958.1 km^2, Tinja River with drainage area of approx. 904 km^2 and the Sutla/Sotla River (584.3 km^2), selected as an important boundary river between Slovenia and Croatia.

These rivers are also presented on Figure I-8.

Figure I-8: The Sava River Basin hydrographic network – rivers included in the analysis

Location of the Sava River Basin rivers with their associated catchments can be seen in Figure I-9 and an overview of the distribution of catchment over territories of the Sava countries is given in Figure I-10.

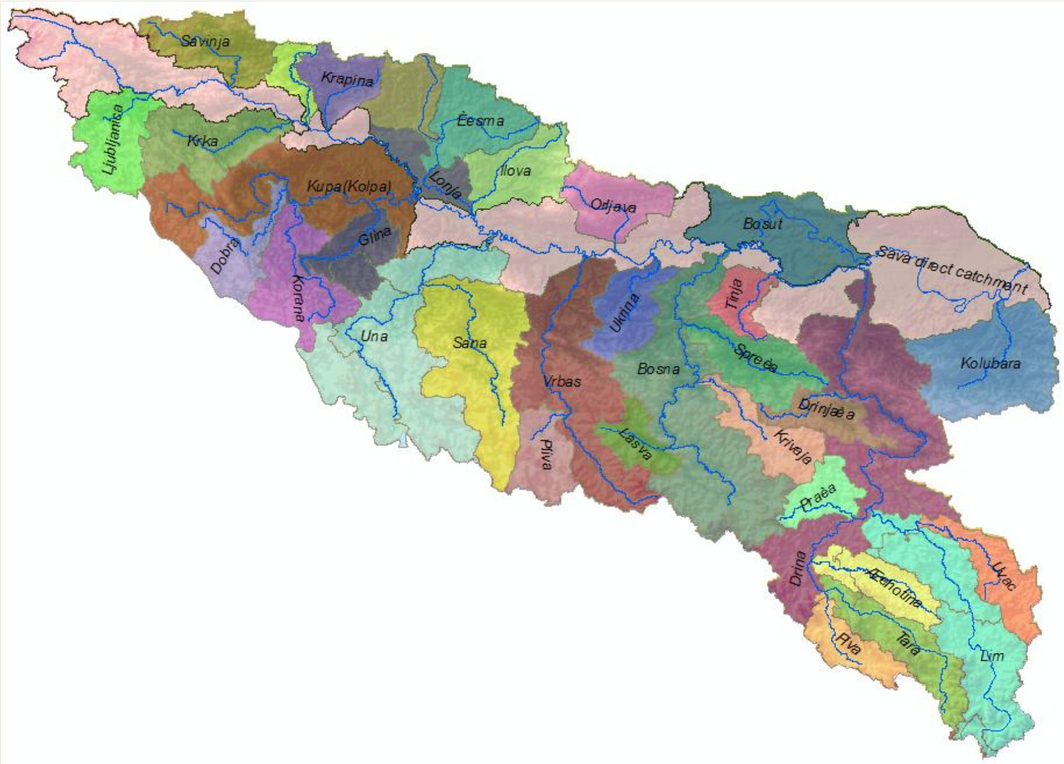


Figure I-9: Sava River sub-basins (with catchment areas larger than 1,000 km^2)

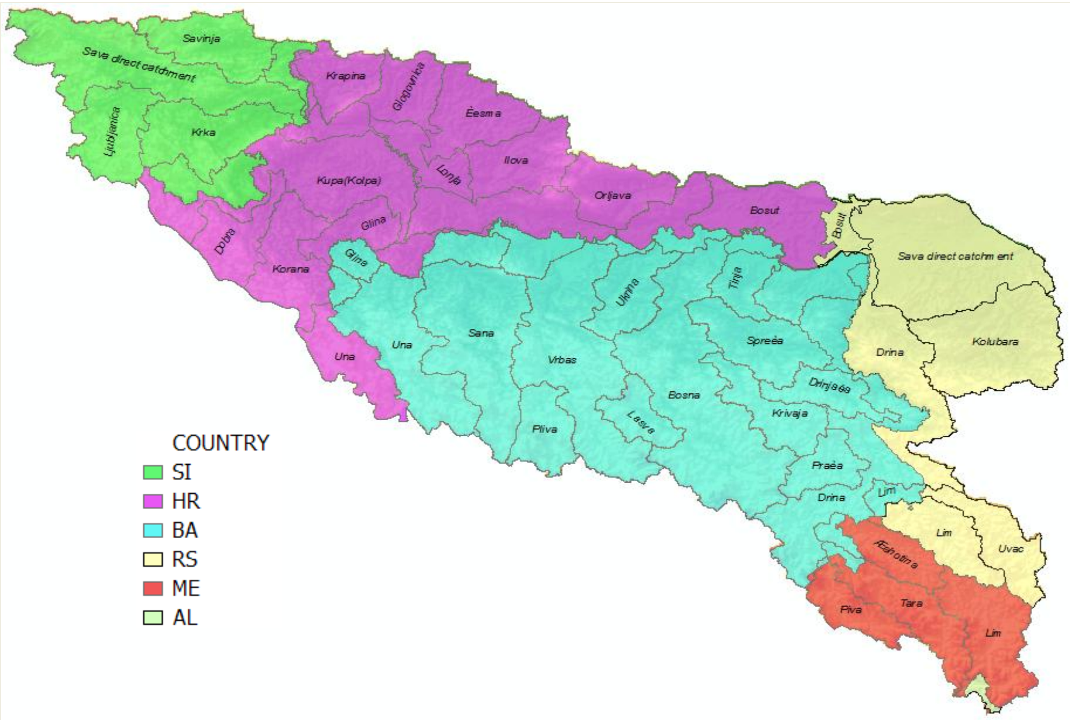


Figure I-10: Sava River sub-basins – overview by the Sava countries

Detailed characteristics of flow regime of the Sava River and its main tributaries are analyzed in the Part III of this Report.

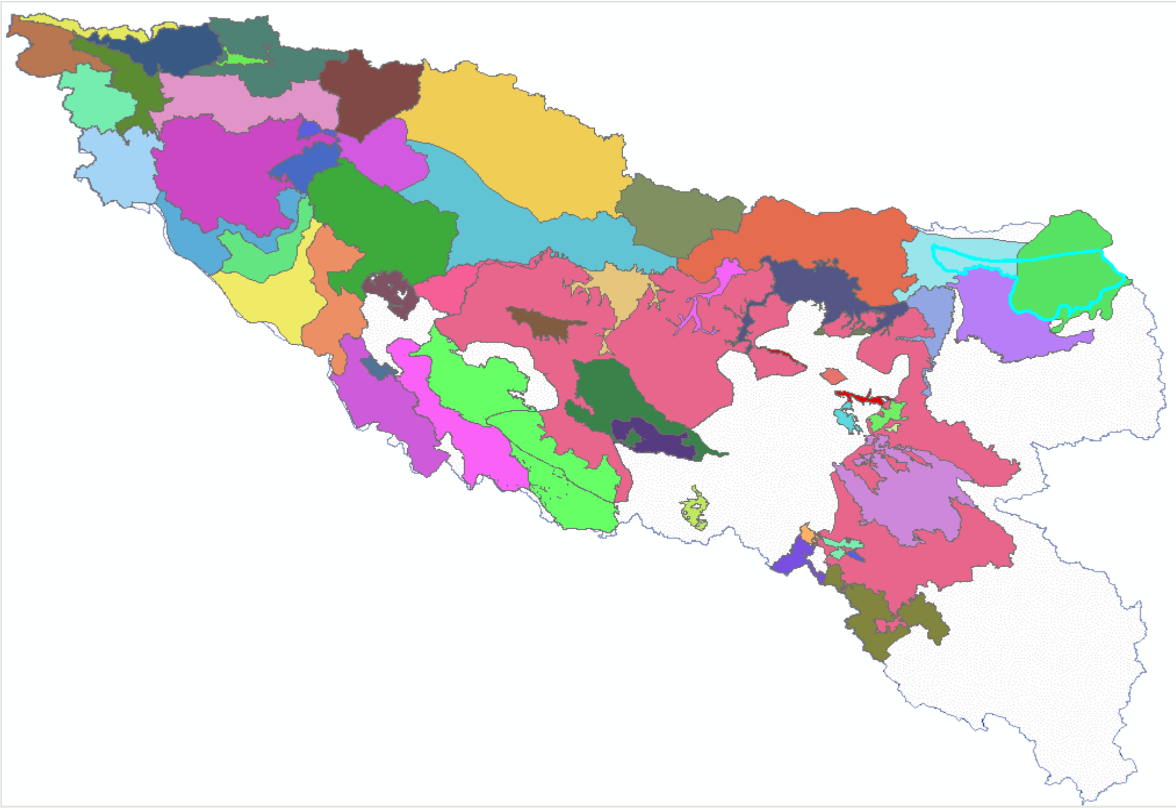
2.4. Groundwater

The territory of the Sava River Basin is distinguished by diverse geological structure and complex tectonic setting under which two main units determined by certain type of aquifers (water bodies) stand out. Those are Pannonian Basin with dominant inter-granular aquifers and Dinarides with limestone aquifers mostly. The border between the Pannonian Basin and Dinarides, approximately, extends along the route Celje-Zagreb-Karlovac-Prijedor-Stanari-Zvornik-Valjevo.

Pannonian Basin, in the northern part of the basin, forms a clearly defined spacious depression, complemented by new sediments of great thickness. It is characterized by two main types of aquifers: (1) block of deposits of Pliocene age, and (2) fluvial deposits of the Sava River and its tributaries. Water bodies of Pliocene complex, in principle, occupy large area, have artesian character and well munificence is relatively limited. They are important in a view of water supply due to their size and, practically, complete protection against pollution from surface terrain. Main aquifers present the fluvial deposits of the Sava River and downstream sections of its tributaries – Ljubljanica, Krka, Kupa, Una, Vrbas, Ukrina, Bosna and Drina, with well munificence more than 100 l/s. The water supply of all bigger settlements in alluvial plains and vicinity is based on these water bodies. Groundwater is directly hydraulically linked with the river courses and there is a possibility of pollution caused by river water as well as by surface terrain.

In Dinarides, area of Exterior Dinarides mainly belongs to the Adriatic Basin, while more spacious Interior Dinarides belong to the Sava River Basin. Interior Dinarides have more heterogeneous lithologic composition, but the limestone terrains prevail in this case as well. Therefore, leading aquifers of this region are the karstificated limestones of the mountain massifs and karst areas. Discharge of huge amounts of groundwater is done through forceful karst wellsprings on contacts with watertight stones. In Slovenia, major amount of groundwater is accumulated in limestone aquifers of Julian Alps, Savinja Alps and Karawanken chain; in Croatia – in Kapela massif, Kordun region, Zagorska and Zvečajska Mrežnica, Dobra River and especially in Kupa River Basin from the spring to Ozlje; in Bosnia and Herzegovina – in numerous limestone massifs occupying large space (such as massifs Igman – Bjelašnica, Treskavica, Jahorina and Romanija in eastern part, and massifs Vitoroga, Klekovače, Osječenice and Grmeča in north-western part); in Montenegro – karst of the northern part of the territory; in Serbia – in one part of the western Serbian karst. The extent of exploitation of this water potential of high quality is, so far, very low, although it provides the water supply for the majority of population and industry. Thanks to the inaccessibility of many karst terrains, the degree of pollution of the water bodies is small as well. However, possibility of pollution of groundwater accumulated in revealed aquifers from surface terrain is highly expressed, especially in regions of active abysses.

Reported groundwater bodies in the Sava River Basin (selected either using the threshold value of 1,000 km^2 or considered important) are shown in Figure I-11.



Legend

SI	HR	RS
Cerkljansko, Škofjeloško in Polhograjsko hribovje	Donji tok Kupe	OVK Istocni Srem
Dolenjski kras	Donji tok Une	PL Istocni Srem
Julijske Alpe v porečju Save	Istočna Slavonija - Sliv Save	PL Macva
Kamniško-Savinjske Alpe	Lekenik - Lužani	PL Zapadni Srem
Karavanke	Sliv Lonja - Ilova - Pakra	
Kraška Ljubljanica	Sliv Orljave	
Krška kotlina	Sliv Sutle i Krapine	
Posavsko hribovje do osrednje Sotle	Zagreb	
Savinjska kotlina	Žumberak - Samoborsko Gorje	
Savska kotlina in Ljubljansko Barje	Dobra	
Spodnji del Savinje do Sotle	Korana	
	Kupa	
	Mrežnica	
	Una	

BA	
FB&H	RS-B&H
Grmeč - Srnetica - Vitorog	Name not specified
Igman - Bjelasnica	Borogovo
Krekanski bazen	Grmeč-Srnetica-Vitorog-Lunjevača-Klekovača
Plješevica	Jahorina
Sarajevsko polje	Lijevce polje
Sjeverna Majevica	ManjačaČemernica
Sprečansko polje	Posavina I
Stupari	Posavina II
Unac	Prijedorsko polje
Velika Kladusa - Cazin	Ravna planina-Kasindo
Vlasšić - Čemernica	Romanija-Devetak-Sjemec
Vranica	Sarajevsko polje
	Semberija
	Sprečansko polje
	Treskavica-Zelengora-Lelija-Maglic
	Udrc

Figure I-11: Reported GW bodies in the Sava RB (threshold value 1,000 km^2 or important)

2.5. Ecological characterization

2.5.1. Wetlands

2.5.1.1. Ramsar sites

The Sava River Basin is of important significance due to its outstanding biological and landscape diversity. It hosts the largest complex of alluvial wetlands and large lowlands forest complexes. Some of these floodplains are still intact and support flood alleviation and biodiversity. Wetlands are cradles of biological diversity, providing the water and primary productivity upon which countless species of plants and animals depend on survival. They support high concentrations of birds, mammals, reptiles, amphibians, fish and invertebrate species. Wetlands are also important storehouses of plant genetic material.

These functions, values and attributes can only be maintained if the ecological processes of wetlands are allowed to continue functioning. Unfortunately, and in spite of important progress made in recent decades, wetlands continue to be among the most threatened ecosystems, owing mainly to ongoing drainage, conversion, pollution, and over-exploitation of their resources.

Because of the above mentioned ecological and cultural value of the wetlands, the Sava riparian countries have designated six sites in the Sava River Basin according to *The Convention on Wetlands of International Importance especially as Waterfowl Habitat* or so called *Ramsar Convention*. The locations and the main facts about the Ramsar sites are given in Figure I-12 and in Table I-5, respectively.

Figure I-12: Locations of the Ramsar sites in the Sava River Basin

Table I-5: Basic data about the Ramsar sites in the Sava River Basin

Country	Ramsar site	Designation date	Coordinates		Area (ha)	National status
			Lat.	Long.		
BA	Bardača Wetland (Bardača močvarni kompleks)	Feb. 2, 2007	45°06'N	17°27'E	3,500	Important Bird Area
HR	Lonjsko Polje and Mokro Polje	Feb. 3, 1993	45°21'N	16°21'E	50,560	Nature Park, Ornithological Reserve
	Crna Mlaka	Feb. 3, 1993	45°37'N	15°44'E	625	Ornithological Reserve
RS	Obedska Bara	Mar. 28, 1977	44°44'N	20°00'E	17,501	Nature Reserve
	Zasavica	Mar. 13, 2008	44°56'N	19°31'E	1,913	Important Bird Area, Special natu-re Reserve, partia-lly, Important Plant Area, partially
SI	Cerkniško jezero z okolico (Lake Cerknica and its environs)	Jan. 19, 2006	45°45'N	14°23'E	7,250	Natura 2000 site, Ecologically Important Area, Regional Park

2.5.1.2. Description of the Ramsar sites in the Sava River Basin

Bardača Wetland (Bardača močvarni kompleks) (BA)

Bardača wetland is situated in northern Bosnia and Herzegovina, between the Rivers Vrbas and Sava. About half of the Ramsar site comprises fishponds being constructed since the early 20th century and further enlarged in the 1960-ies for irrigation purposes. The ponds, floodplain forest, meadow and swamp areas support a range of endangered species and make an important nesting and stopover site for birds. There is a rich fish fauna (e.g., *Gymnocephalus schraetzer*, *Zingel streber*) and a range of amphibians such as *Salamandra salamandra*, *Rana dalmatina*, and the pond tortoise *Emys orbicularis*. The hydrological regime has been interrupted by the construction of channels, pump stations, and damming of nearby streams, but, in present, pressure comes from permanent, intensive agricultural practices such as intensive pasturing and unwise use of fertilizers and pesticides. Aquaculture and fish production remain a primary economic pursuit. With assistance from the Ramsar Small Grants Fund, a management plan is currently under development.

Lonjsko Polje and Mokro Polje (incl. Krapje Dol) (HR)

The Ramsar site and Important Bird Area Lonjsko Polje Nature Park (LPNP) represents mainly palustrine-riverine wetland located within the floodplains of the middle Sava River Basin (Central Posavina, HR). It is the largest maintained inundation area of the Danube River catchment and, at the same time, the key facility of the flood control system of the entire Sava River Basin (including Bosnia and Herzegovina and Serbia). Within the *Pan-European Biological and Landscape Diversity Strategy*, the World Conservation Union (IUCN) identified the site as a showcase of Best Practices of Conservation Planning in Rural Areas of CEE-countries. The Regional Tourism Master Plan recognized LPNP as the unit selling point for tourism development of continental Croatia. The high-ranked species and habitat diversity (approximately 7 habitats and 89 species mentioned in the EU *Habitats Directive*) is mainly caused by man-made landscape variety, traditional grazing activities with endangered autochthonous breeds and a natural micro-relief created by natural flood dynamics. Since the Sava River became international, effective flood control and conservation management demand an integrated approach. LPNP started to develop consultative processes and appropriate structures of involvement of stakeholders and local people both on a park scale and on a central basin scale.

Crna Mlaka (HR)

An area of fishponds surrounded by flooded oak woodland and meadows. The site is important for numerous species of breeding birds and as a staging area for such spring and autumn migrants such as the Great white egret, Osprey, and the Peregrine falcon. Human activities include commercial and recreational fishing and tourism.

Obedska Bara (RS)

Obedska Bara is a seasonally inundated area of the Sava River floodplain, with marshes, ponds, wet meadows, and an oxbow lake. Vegetation includes reedbeds and *Salix-Populus* and *Quercus* woodland. The area is important for various species of breeding waterbirds. River regulation has adversely affected fish stocks at the site. The lake is subject to rapid siltation and nutrient-enrich-ment, resulting in expansion of reedbeds and *Salix* scrub, to the exclusion of open water areas.

Zasavica (RS)

Zasavica is a seasonal/intermittent freshwater marsh on inorganic soil which includes sloughs, potholes, seasonally flooded meadows and sedge marshes. It is consisted of tree-dominated wetlands covered by freshwater swamp forest, seasonally flooded forest and shrubs swamps. Its large diversity of fauna represents its important biological values. In the area, the invertebrates, fishes, birds and mammals, among which some are the rare/endangered species, can be found. It is also a staging area for migratory waterbird species. There is an outstanding variety of flora species in Zasavica which is important for maintaining the geographic range of a plant species.

Cerkniško jezero z okolico (Lake Cerknica and its environs) (SI)

Cerknica Lake is the largest and most typical intermittent karst lake in its region. It is formed during rainy periods when the volume of water can no longer be drained through sinkholes, and the lake has no surface outflow, discharging exclusively underground. Numerous picturesque karst phenomena, such as karst sources, estavelles, ponors and ponor caves, abound, and the Križna cave is renowned for its underground lakes; the Rakov škocjan valley, formed by the collapse of ceilings of underground caves, and the Rak River are fed mainly by water from the lake. These special habitats support many rare and endemic species, such as cave beetle and cave salamander, and the lake is the only nesting site in Slovenia for the rednecked grebe, the redshank and the ferruginous duck as well as a breeding place for the corncrake. Remains of Palaeolithic, Mesolithic, and Iron Age settlements are found on Gorica Island in the middle of the lake, as well as prehistoric settlements from the 12^{th} to the 4^{th} centuries BC and a Roman necropolis nearby. Frequent, unpredictable flooding makes intensive agriculture impossible, but pasture and forest uses are widespread, besides some small recreation grounds; appropriate tourist facilities are needed to avoid adverse effects of unorganized tourism.

3. Water management in the Sava River Basin

3.1. Administrative framework

Bosnia and Herzegovina

In accordance with the *Dayton Peace Agreement*, Bosnia and Herzegovina is comprised of two entities: the Federation of Bosnia and Herzegovina (FBA) and the Republika Srpska, and Brčko District as a separate administrative unit as of March 8, 2000. The FBA consists of 10 cantons with total of 79 municipalities and the Republika Srpska of 62 municipalities (no canton level).

According to the *Constitution of Bosnia and Herzegovina*, water management is under competence of the entity ministries of agriculture, water management and forestry. In the FBA, the Sava River Watershed Agency in Sarajevo and Adriatic Sea Watershed Agency in Mostar are responsible for water management, while in the Republika Srpska this responsibility is given to the Water Agency for the Sava River District in Bijeljina and future water Agency for Trebišnjica River District in Trebinje. On state level, the Ministry of Foreign Trade and Economic Relations of BA is responsible for coordination of activities and harmonization of plans between the bodies of the entity governments, as well as for institutions on international level in the field of natural resources, environment protection, agriculture and energy. Ministry of Communications and Transport of BA, also on the state level, is in charge of navigation on rivers and sea (Figure I-13).

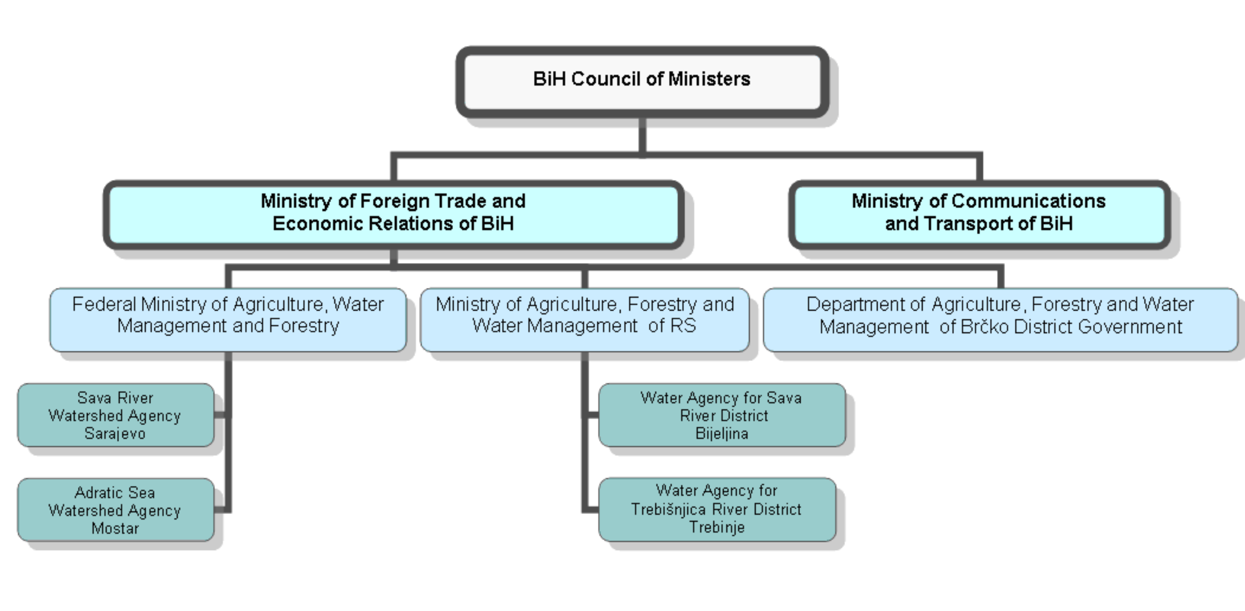


Figure I-13: Water Management in BA

Croatia

The bodies authorized and responsible for these activities are the Croatian Parliament, the National Water Council, the Government of the Republic of Croatia, the Ministry of Regional Development, Forestry and Water Management and other state administration bodies, local and regional self-government units, and Hrvatske vode as a national water management agency (Figure I-14).

The Ministry of Regional Development, Forestry and Water Management performs administrative and other expert tasks.

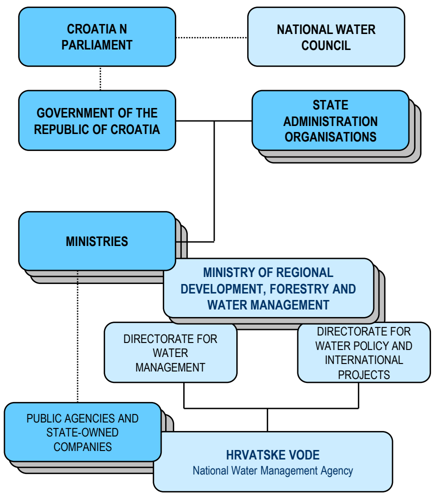


Figure I-14: Water Management within state administration

Serbia

Activities related to water management (control of water regime, water use, water pollution control, flood control, etc.) fall under jurisdiction of the Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Directorate for Water. In addition, the Ministry of Environmental Protection and Spatial Planning and some other ministries have certain roles in various aspects of water management.

JVP (Public Water Management Company) „Srbijavode" was established in 1996 to implement the water management activities. The structure was altered in 2003 by creation of the Provincial Secretariat of Agriculture, Water Management, and Forestry of the Vojvodina Province and the setting up of the new JVP „Vode Vojvodine" that covers water management responsibilities on territory of the Vojvodina Province. In 2008 new JVP „Beograd vode" was established for implementation of water management on the territory of the City of Belgrade.

Slovenia

The water management policy is defined in the *National Water Management Programme*, which strives to accomplish the following objectives:

- achieving the good water status,
- supplying the population with drinking water,
- ensuring the water protection in the designated protection areas,
- reaching the economic price of water, and
- minimizing the hazards.

3.2. Competent national authorities for WFD implementation

Bosnia and Herzegovina

Although Bosnia and Herzegovina is not a member of European Union, due to which is not obliged to implement the EU regulations, BA with its both entities has chosen to implement EU *Water Framework Directive* – 2000/60/EC (WFD). Such intention is expressed by transposition of the WFD basic principles and goals into the new water laws of the entities. The new water laws entered into force in May 2006 in Republika Srpska (*Official Gazette of Republika Srpska* No. 50/06) and in November 2006 in FBA (*Official Gazette of FBA* No.70/06).

Goals of the new water laws are the reduction of water pollution, achievement of good status and prevention of water degradation, achievement of sustainable use, ensuring of rightful access to water, stimulation of social and economic development, protection of ecosystem, reduction of risk from flooding and other harmful impacts of water, as well as the inclusion of public into decisions-making related to water.

In accordance with BA organization, the competent authorities for the WFD implementation are:

On state level:	Ministry of Foreign Trade and Economic Relations of BA;
On entity level:	Federal Ministry of Agriculture, Water Management and Forestry with Sava River Watershed Agency in Sarajevo and Adriatic Sea Watershed Agency in Mostar, Ministry of Agriculture, Forestry and Water Management of Republika Srpska with Water Agency for Sava River District in Bijeljina and future Water Agency for Trebišnjica River District in Trebinje;
On Brčko District level:	Department of Agriculture, Forestry and Water Management of the Brčko District Government.

Croatia

The competent authority for water management is the Ministry of Regional Development, Forestry and Water Management, which inter alia, consists of the Directorate for Water Management and the Directorate for Water Policy and International Projects.

Serbia

Water legislation in Serbia is not harmonized with the EU regulation yet. Therefore, activities in Serbia regarding the WFD implementation are carried out under the activities on implementation of the *Convention on Cooperation for the Protection and Sustainable Use of the Danube River*.

Based on the Conclusion of the Serbian Government, the Council of Ministers of Serbia and Montenegro, at its 37th session held on November 27, 2003 (Resolution 337-4/2003), designated the director of the Water Directorate of Serbia at the Ministry of Agriculture, Forestry and Water Management, as a head of the Serbia and Montenegro's delegation to the International Commission for the Protection of the Danube River (ICPDR).

Activities regarding the WFD implementation in Serbia are coordinated by the Ministry of Agriculture, Forestry and Water Management – Directorate for Water, with participation of Ministry of Environment and Spatial Planning.

Slovenia

In Slovenia, the effective water management is the responsibility of the Ministry of Environment and Spatial Planning. Tasks are delegated to departments within the Ministry, to the Environmental Agency of the Republic of Slovenia and the Inspectorate of the Republic of Slovenia for the Environment and Spatial Planning (Figure I-15).

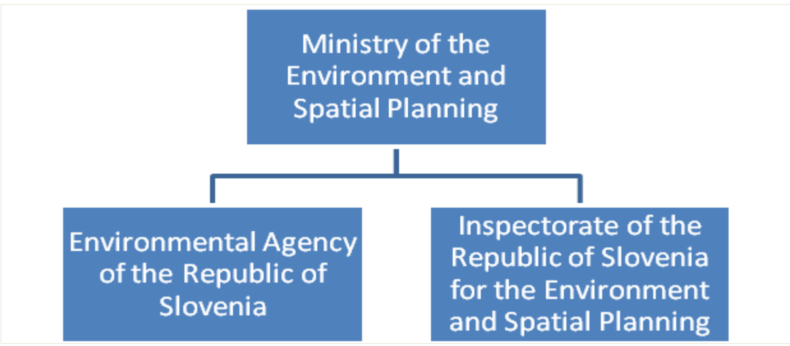


Figure I-15: Competent national authorities for WFD implementation in Slovenia

The expert assignments are carried out by the Institute for Water of the Republic of Slovenia and Geologic Survey of the Republic of Slovenia.

The Ministry of Environment and Spatial Planning is in charge of preparing of fundamental documentation relevant to implementation of the water management policy. It is competent to prepare regulations, governmental acts determining water use and water protection, water management acts as well to coordinate and harmonize policies and other water related issues at the level of EU.

Environmental Agency of the Republic of Slovenia operates in accordance with the territorial principles. It is responsible for database maintenance, monitoring of the status of water (quantity, quality and ecological status), preparation of administrative acts related to water protection, use of water resources, water management, public water management services and hydrologic forecast of natural disasters.

The Inspectorate of the Republic of Slovenia is responsible for controlling the implementation of the relevant legislation.

The Institute for Water of the Republic of Slovenia carries out the activities related to surface waters.

The Geologic Survey of the Republic of Slovenia carries out the activities related to groundwater.

3.3. Multilateral and bilateral arrangements

Besides the FASRB which is the umbrella for all activities related to cooperation in water management in the Sava RB, emphasized in the very beginning of this Report, the list of multilateral and bilateral agreements of the Sava countries is given in the following text.

3.3.1. Multilateral agreements

Review of Signatories and Parties of multilateral treaties and agreements relevant for the Sava River Basin is given in Table I-6.

Table I-6: Multilateral agreements relevant for the Sava River Basin

No	Treaty	In force	SI		HR		BA		RS	
			S	R	S	R	S	R	S	R
1	*UN Convention on the Law of non-Navigational Uses of International Watercourses* (*NY Convention*, 1997)	–								
2	*Convention on Wetlands of International Importance Especially as Waterflow Habitat* (*Ramsar Convention*, 1971)	•		•		•		•		•
3	*Convention on Environmental Impact Assessment in a Transboundary Context* (*Espoo Convention*, 1991)	•		•		•		•		•
4	*Protocol on Strategic Environmental Assessment* (SEA Protocol - Kiev, 2003 – *MoP Espoo Convention*)	–	•		•		•		•	
5	*Convention on the Protection and Use of Transboundary Watercourses* (*UN/ECE Water Convention* - Helsinki, 1992)	•		•		•				
6	*Protocol on Water and Health* (London, 1999 – in the framework of the *UN/ECE Water Convention*)	•	•			•				
7	*Convention on the Transboundary Effects of Industrial Accidents* (*Helsinki Convention*, 1992)	•		•		•				•
8	*Protocol on Civil Liability* (Kiev, 2003, in the framework of the *UN/ECE Water Convention* and *Helsinki Conv. – Ind. Acc.*)	–					•			

No	Treaty	In force	SI		HR		BA		RS	
			S	R	S	R	S	R	S	R
9	*Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters* (*Aarhus Convention*, 1998)	•		•		•				•
10	*Protocol on Pollutant Release and Transfer Register* (Kiev 2003 – MoP *Aarhus Conv.)*	–	•		•		•		•	
11	*Danube River Protection Convention* (Sofia, 1994)	•		•		•		•		•
12	*The Convention on the Danube Navigation Regime* (*Belgrade Convention* – 1948)	•				•				•
13	*Budapest Convention on the Contract for the Carriage of Goods by Inland Waterway* (*CMNI*, 2001)	•				•				
14	*European Agreement on Main Inland Waterways of International Importance* (*AGN*, 1996)	•				•		•		
15	*European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways* (*ADN*, 2000)	•				•				
16	*Framework Agreement on the Sava River Basin* (Kranjska Gora, 2002)	•		•		•		•		•
17	*Protocol on the navigation regime to the Framework Agreement on the Sava River Basin* (Kranjska Gora, 2002)	•		•		•		•		•

Notes: S – signed; R – ratified.

3.3.2. Bilateral agreements

Lists of bilateral agreements of importance for the Sava River Basin in light of Article 29 paragraph 3 of the FASRB are provided in the following tables.

Table I-7: Bilateral agreements between the Republic of Croatia and the Republic of Slovenia

Title	Signed	Entered into force
Agreement between the Government of the Republic of Croatia and the Republic of Slovenia on water management relations	Oct. 25, 1996	Mar. 19, 1998
Rulebook of the Permanent Croatian – Slovenian Commission for water management	Oct. 25, 1996	Mar. 19, 1998
Agreement between the Government of the Republic of Slovenia and the Government of the Republic of Croatia on cooperation on protection against natural and civic disasters	Sept. 22, 1997	Nov. 1, 1999

Table I-8: Bilateral agreements between Bosnia and Herzegovina and the Republic of Croatia

Title	Signed	Provisional enforcement	Entered into force
Agreement between the Council of Ministers of the Bosnia and Herzegovina and the Government of the Republic of Croatia on Water Management Relations	July 11, 1996		Jan. 31, 1997
Protocol on establishment of navigation on the Sava River waterway and its tributaries between Bosnia and Herzegovina and Republic of Croatia	Oct. 16, 1998		Nov. 15, 1998
Agreement between the Council of Ministers of the Bosnia and Herzegovina and the Government of the Republic of Croatia on cooperation on protection against natural and civic disasters	June 1, 2001	June 1, 2001	
Agreement between the Council of Ministers of the Bosnia and Herzegovina and the Government of the Republic of Croatia on navigation on the navigable waterways and its marking and maintenance	Feb. 20, 2004	Feb. 20, 2004	

Table I-9: Bilateral agreements between the Republic of Croatia and the Republic of Montenegro

Title	Signed	Entered into force
Agreement between the Government of the Republic of Croatia and the Government of Republic of Montenegro on water management relations	Sep. 4, 2007	Apr. 12, 2008

Part II: Water Quality

1. Characterization of surface waters (Art. 5 and Annex II of the WFD)

1.1. Identification of surface water categories

The EU *Water Framework Directive* differentiates the following water categories:

- Surface waters
  - Rivers
  - Lakes,
- Transitional waters,
- Coastal waters,
- Groundwater.

The Sava riparian countries agreed to analyze rivers with drainage area above 1,000 km^2, lakes with a surface area above 50 km^2 and reservoirs with a volume above 5 Mio m^3. This agreement had been reached mainly by „rule of thumb" taking into account that the scale of analysis for the Danube River Basin is 4,000 km^2.

The initial inventory activities revealed that only rivers, groundwater and reservoirs were of relevance at the basin-wide level. There are no lakes with the surface above the threshold value.

1.2. Typology

1.2.1. Surface water types and reference conditions

1.2.1.1. Eco-regions in the Sava River Basin

Annex XI of the EU WFD provides Map A in order to enable the development of a typology according to System A in Annex II1, paragraph 1.2. The Table II-1 presents eco-regions relevant for the Sava countries.

Table II-1: Eco-regions in the Sava RB

Eco-region	Countries with territories in the Sava RB
05 – Dinaric western Balkan	Slovenia, Croatia, Bosnia and Herzegovina, Serbia
04 – Alps	Slovenia
11 – Hungarian lowlands	Croatia, Serbia, Slovenia

In some cases the eco-regions provided by Annex XI Map A of the Directive might not be sufficient to develop a manageable typology. Croatia and Serbia have introduced sub-eco-regions to further differentiate the eco-regions given in the WFD, which are given in Table II-2.

Table II-2: Sub-eco-regions or bio-eco-regions in the Sava RB

Eco-region	Country	Sub-eco-regions or bio-eco-regions
04	Slovenia	No sub-eco-regions defined
		No sub-eco-regions defined
05	Bosnia and Herzegovina	No sub-eco-regions defined

Eco-region	Country	Sub-eco-regions or bio-eco-regions
	Croatia	Continental Dinaric sub eco-region
	Slovenia	No sub-eco-regions defined
		No sub-eco-regions defined
	Serbia	Upper Kolubara Hydro-faunistical complex
		Drina-Lim Hydro-faunistical complex
		Uvac Hydro-faunistical complex
11	Slovenia	No sub-eco-regions defined
		No sub-eco-regions defined
	Serbia	No sub-eco-regions defined, due to the uniform conditions.
	Croatia	No sub-eco-regions defined

Detailed description of eco-regions and sub-eco-regions has been provided by the countries as follows.

Bosnia and Herzegovina

Flora and fauna show different geographical distributions depending on natural characteristics of the environment. To account for these differences, the WFD requests that in defining of surface water types the development of ecological system of classification should be taken into account in order to assess the status of water body specific for each type more precisely. For this purpose, the eco-regions which actually present the regions of similar geographical distribution of plant and animal species, are used. They are therefore an important basis for definition of the bio-relevant surface water types.

Division of eco-regions did not consider the detailed delineation of boundaries of particular regions, since there were not enough precise data and the latter was not its goal. Simply by this division the intention was to create the basis for detailed delineation which would be conducted in continuity based on new researches and knowledge.

Need for such approach regarding the delineation of eco-region on the territory of Bosnia and Herzegovina, or in the area of sub-basins of tributaries of the Sava River in Bosnia and Herzegovina, arises from fact that the boundary of eco-region 11 and eco-region 5 is the Sava River.

Such division means, if looked at rigidly, that there is no migration of fauna from tributaries of the Sava River from its left (northern) side or even from the part of the Sava River, into its tributaries from the right (southern) side, even in zones of their mouth.

But obvious is the fact that similarity of geological, altitude, geo-morphological, climatic and other influence factors at the particular width of the zone of the left and right side of the Sava River, does not present an obstacle for such migration, which leads to the conclusion (expert assessment based on abiotic parameters) that this boundary has to be observed more flexible.

Such approach, from the same reasons, is implemented in neighbouring countries (Croatia on upstream and Serbia on downstream part of the Sava River). Their boundary points of eco-region 11, which goes down to the south over Sava River, and eco-region 5 which provided space for eco-region 11, served as starting point for defining of such boundary also in Bosnia and Herzegovina.

Generally, it follows the foothill of mountain massifs on the right (southern) side of the Sava River and it will, by later biological researches, be even more precisely defined. Other (southern) part of the Sava River Basin in Bosnia and Herzegovina belongs, therefore, to eco-region 5.

Eco-region 5: Lithological composition of the surface part is divided according to dominant participation of carbonate, silicate and siliceous formations with organic material. Carbonate sediments make the terrains of higher and high mountain massifs in the area of south, southwest and east part of BA, and smaller parts of the mountain massifs on the north of the country, as well. Carbonate type of rocks comprises all gray carbonate complexes and formations with dominant carbonate component - complexes of calcium carbonate, dolomite, limestone and dolomite with interbeds of cherk, tuffs, marlstone and shale; limestone formations with interbeds of sandstone; carbonate slates etc. Silicate and siliceous soil type is present in the largest part on north, while in middle area it mostly makes the underlaying stratum of mountain massifs, that is of river valleys and wide area of alluvial sediments. Inside this soil type, the siliceous-clastic formations of devon, carbon, upper permian, lower Triassic, cherk and limestone of Triassic-Jurassic, palaeogenic sandstones, neogene sandstones, clay sediments, etc., dominate. Beside the afore-mentioned, huge percentage have alkaline, ultra alkaline and acid metamorphic rocks. Organic soil type is conditionally separated on several isolated locations throughout BA. Those compositions are found on the inside siliceous - clastic and carbonate formations from chalk to quarterny. Presence of organic type is very small and comes to few percentages. This soil type covers various coal types: stone, umber, lignite and peat and half-bog and organogenic half-bog sediments with mudded residues. Concerning the altitude, area of Bosnia and Herzegovina is situated in between 90 m a.s.l. in the area of Posavina and Semberija and over 2,100 m a.s.l. on high mountains of the south-east and north-western part. Fertile plains are mostly situated in the valleys of Sava, Bosna, Drina, Vrbas and Una Rivers and the outstanding ones are Posavina, Semberija, Lijevče polje, etc. Unworked parts are mostly situated on higher altitudes, so dominant ones on those heights are bare mountain terrains and forest complexes. Beside those areas, parts of the middle and medium high mountains, with significant presence of pastures significant are also of importance.

Croatia

Eco-region 5 (continental Dinaric sub-eco-region karst) (Figure II-1): landscape with calcareous rock of mesosoic age, altitude 150-900 m a.s.l. Karst rivers are characterized by spectrum of karst phenomena like the calcite precipitation and creation of travertine barriers and underground sills. Solubility of calcareous substratum has led to creation of karst morphology, canyon valleys, karst sinkholes, karst fields and network of underground and/or periodical watercourses. Calcareous stream bed with dominant block cobble sediments and specific species of flora and fauna.

Eco-region 11 (Hungarian lowlands): typical lowland landscape with broad floodplains, altitude < 200 m a.s.l. and streams with meandering channel form, alluvial stream bed with dominant calcareous, siliceous, mixed or organic sediments (cobbles, gravel, sand), waters with diverse concentration of calcium carbonate are present.

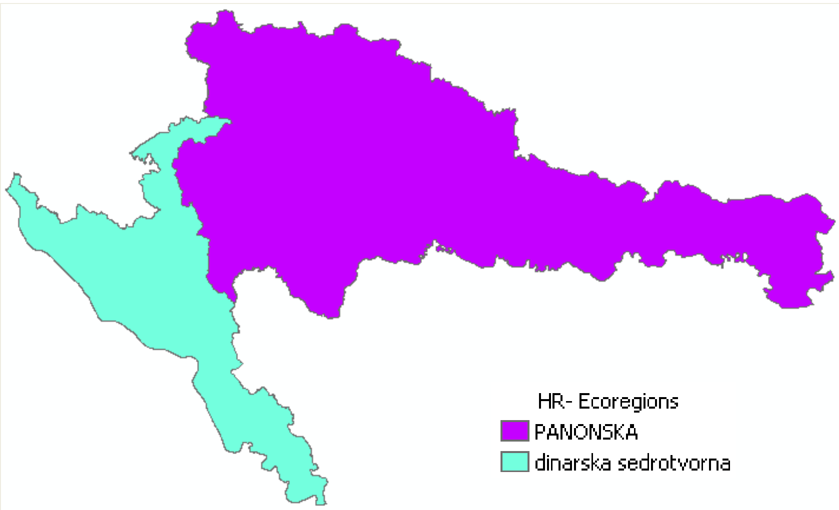


Figure II-1: Eco-regions in the Sava River Basin in Croatia

Serbia

Within the activities for WFD implementation in Serbia, the precise projection of borders of eco-regions, as well as designation of hydro-faunistical sub-regions was done.

Territory of Serbia comprises six eco-regions and the Sava River Basin is a part of the two of them (Figure II-2).

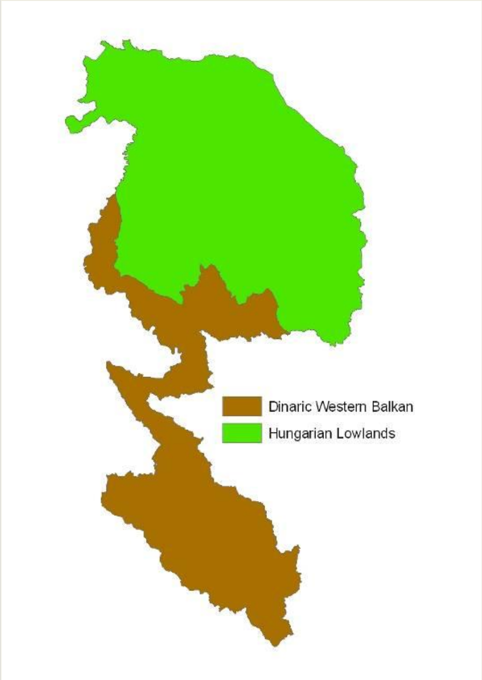


Figure II-2: Eco-regions in the Sava River Basin in Serbia

Eco-region 11 in the area of Serbia includes territory of about 29,185.7 km^2 and is located in northern lowland area of the country. This area is more homogenous regarding the general natural conditions than the hilly-mountainous area. Part of the Sava catchment belongs to eco-region 11 - part of the Kolubara Basin (lower Kolubara), as well as the main course of the Sava River and its tributaries.

According to our research, the region is characterized by fauna of water macro-invertebrates and fish characteristic for lowland areas of Europe.

Eco-region 5 in the area of Serbia includes the area of about 45,692.0 km^2. This region covers the part of the catchment of the Sava River - part of the Kolubara Basin (sub-catchments of the Rivers Gradac, Jablanica, Obnica, Ribnica incl. Lepenica), larger part of the Drina River Basin (except the most downstream part – see explanation bellow) and basin of the Lim and the Uvac Rivers.

The area is heterogeneous regarding the general natural conditions, but due to distribution of mountain massifs, as well as to historical factors, fauna of aquatic macro-invertebrates consisted mainly of the widely spread forms, but the taxonomy of narrow spreading, and forms of different level of endemic characteristics are also recorded. Heterogeneity caused certain differences in communities of water macro-invertebrates, and the area is divided into hydro-faunistical sub-regions.

Boundary between eco-regions 11 and 5

The boundary between the eco-regions 11 and 5, according to research results, is situated along the boundary of Kolubara Basin, but the areas of sub-catchments of the Rivers Gradac, Jablanica, Obnica, Ribnica and Lepenica belong to the eco-region 5. Those rivers are characterized by fauna of water macro-invertebrates, which is significantly differentiates from the one recorded in other tributaries of Kolubara and, according to the characteristics of the community, is more similar to rivers at the catchment of the Zapadna Morava and tributaries of the Drina, excluding the Rivers Jadar and Lešnica. Sector of the Drina, from mouth of the Lešnica, including catchments of the Rivers Jadar and Lešnica, belongs to eco-region 11. According to such designated boundary, eco-region 11 also includes the Sava River Basin. Although the so far done is not enough for the Sava tributaries, the basin of the tributaries, according to the general natural characteristics, belongs to the eco-region 11. In this area, there are no obstacles, which could stop the migration of fauna to north, and vice versa, and there are no conditions to form fauna which, could be significantly different from the one in northern areas. Upper part of the Tamnava River is, according to the recorded fauna, different from lower part of this river, as well as from the examined „lower" tributaries of the Kolubara River and it is not representative for this water body. Similar situation is expected in the area of upper part of the Ub River, and in rivers at the mountains Cer and Vlašić. This area makes a transitional area from the eco-region 11 to eco-region 5, and for this reason, it is separated as distinct hydro-faunistical sub-region.

Hydro-faunistical sub-regions within the Sava River Basin in RS

Hydro-faunistical sub-regions within the territory of Serbia are presented in Figure II-3.

In this phase, 13 sub-regions have been defined. Out of them, 4 are defined within the Sava Basin area, as follows:

- Area of eco-region 11, without the Nera River,
- Area of „Upper Kolubara",
- Sub-region Drina-Lim,
- Sub-region Uvac.

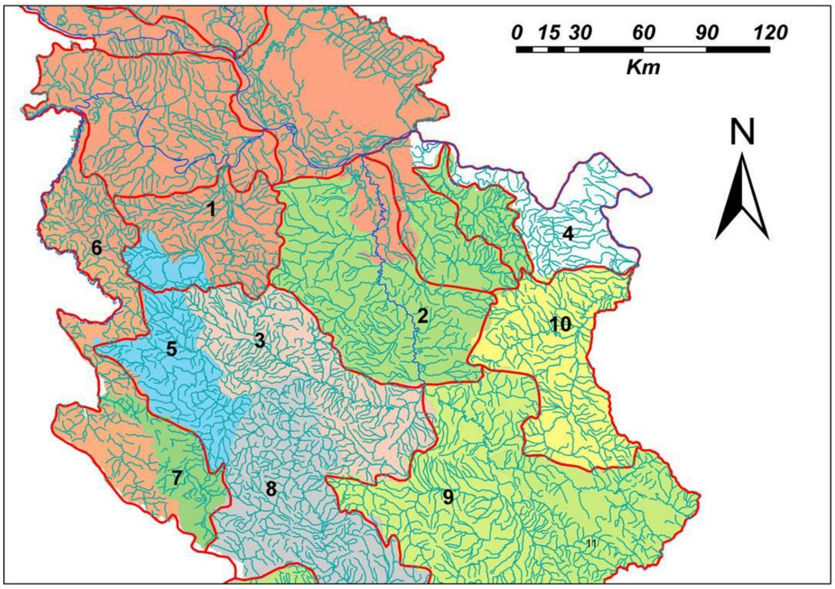


Figure II-3: Hydro-faunistical sub-regions in Serbia

Due to overall homogeneity of environmental factors, eco-region 11 in Serbia belongs to the same hydro-faunistical sub-region.

Slovenia

Eco-region 4 (Alps) represents the northern and north-western part of Slovenia (Figure II-4). However, most of the Sava plain in the central Slovenia belongs to **eco-region 5** (Dinaric western Balkan), but not most of the medium rivers with most of the catchment area in the Alps, i.e. Tržiška Bistrica, Kokra, Kamniška Bistrica and the Sava River to the confluence with Ljubljanica, which are part of the Eco-region 4. In the central Slovenia the border between eco-regions 4 and 5 is a natural border between mountains and the Sava plain but on the north-west not higher than to elevation of 400 m. On the south-west the eco-region 4 extends to the karst area without permanent surface rivers with catchment area > 10 km^2. However, the stream Hubelj to the confluence with Lokavšček also belongs to eco-region 4. On the east the eco-region Alps includes Pohorje and Kozjak and borders on the **eco-region 11** (Hungarian lowland - Pannonian lowland). The border is set at elevation of cca. 400 m. The whole hilly and plain north-eastern part of Slovenia and plains of Savinja River and Krško-Brežiška kotlina plain are part of the eco-region 11. In the Krško-Brežiška kotlina plain the border between eco-regions 5 and 11 is at elevation of 200 m, but all streams with karst spring belong to eco-region 5. Eco-region 11 also includes the Drava River, which in the upper part of Slovenia flows through the eco-region Alps, and the Sava River after the confluence with Savinja River. Section of the Sava River which flows through the Posavsko hribovje (eco-region 4) belongs to the eco-region 5. Southern Slovenia also belongs to eco-region 5, which is the largest eco-region in Slovenia and comprises more than 40 % of the Sava River Basin in Slovenia.

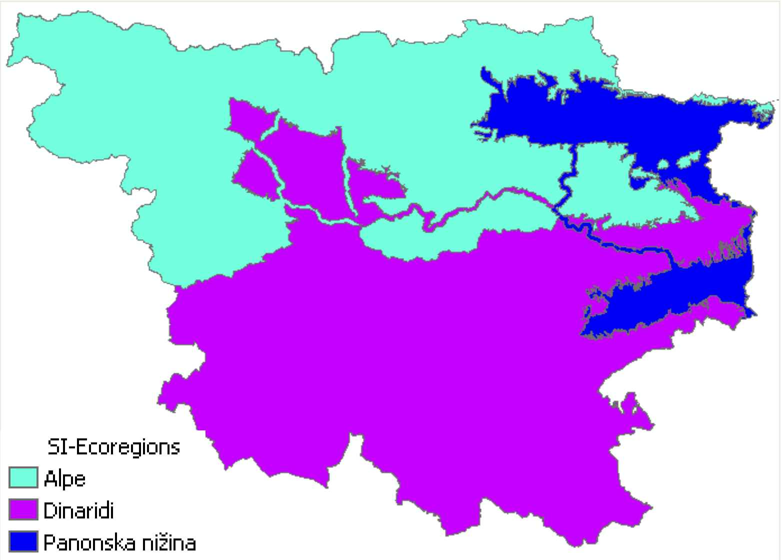


Figure II-4: Eco-regions in the Sava River Basin in Slovenia

1.2.1.2. Rivers

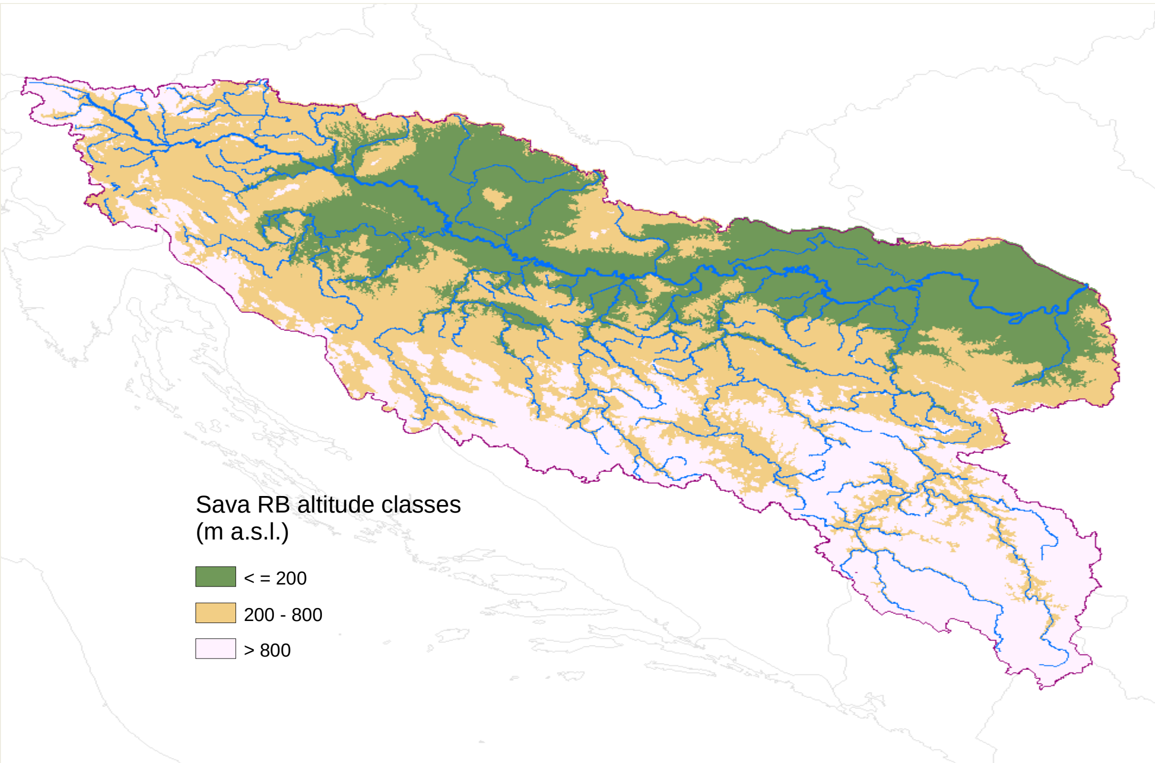


Figure II-5: WFD relevant altitude classes

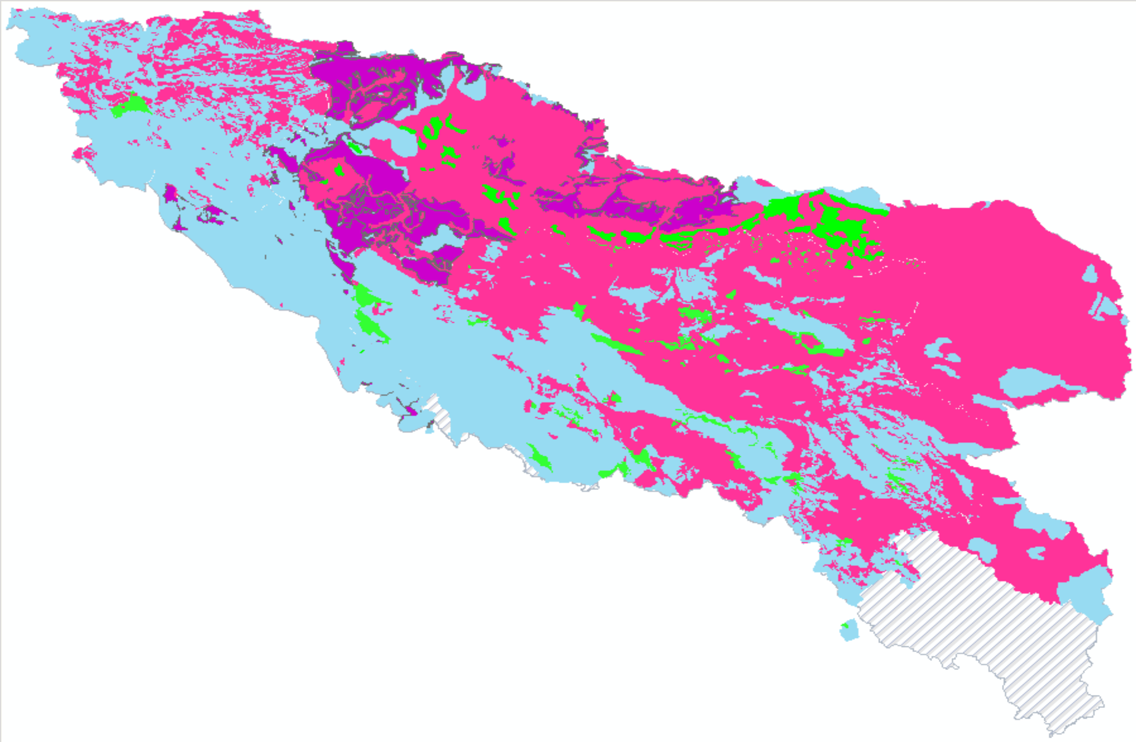


Figure II-6: Lithological map of the Sava River Basin

All countries in the Sava RB have decided to apply the System B according to Annex II, 1.2.1 of the WFD as more flexible, objective, credible and acceptable classification of the water body types.

Bosnia and Herzegovina

Development of typology of surface waters and defining of reference conditions in BA started with delay. The focus of attention is given to typology of surface waters. In 2006, a preliminary typology for rivers with basins > 4,000 km^2 was developed.

System B was used for preliminary river typology with the following obligatory abiotic parameters:

- altitude
- geological composition of catchment area
- size of catchment area, and
- size of dominant substrate of the bottom, as additional parameter.

The reason for selection of this additional parameter is the fact that BA is mainly of hilly-mountainous character, which as a consequence has relatively high lengthwise slopes of river beds with relatively large transport capacity of drawn sediment. Due to this fact, the structure of sediment is variable along watercourses and directly related to average lengthwise slope of the river bed.

Granulometric composition of the substrate of the bottom, created as the consequence of natural conditions of watercourse: lengthwise slope, water speed (flow) and chemical characteristics of the substrate of the bottom, have significant influence on spreading of particular aquatic communities and, therefore, also represent the important factor for preliminary typology. Substrate of the bottom is divided in 3 size categories: fine (clay, silt, sand, and gravel), medium (gravel and cobbles) and coarse (cobbles and boulders).

Classification of watercourses per altitude is very important obligatory parameter since it is, in the first place, directly related to water temperature and, in most cases, hydraulic conditions of the flow as well. According to the requirements of the WFD, the classification is obligatory for following altitude classes: to 200 m a.s.l., 200 – 800 m a.s.l. and over 800 m a.s.l. For the needs of classification in BA the additional class for altitude 200 – 500 m a.s.l. was introduced (Figure II-7) since all watercourses in BA with catchment size > 4,000 km^2 (except Vrbas) spring, or start, below 500 m a.s.l.

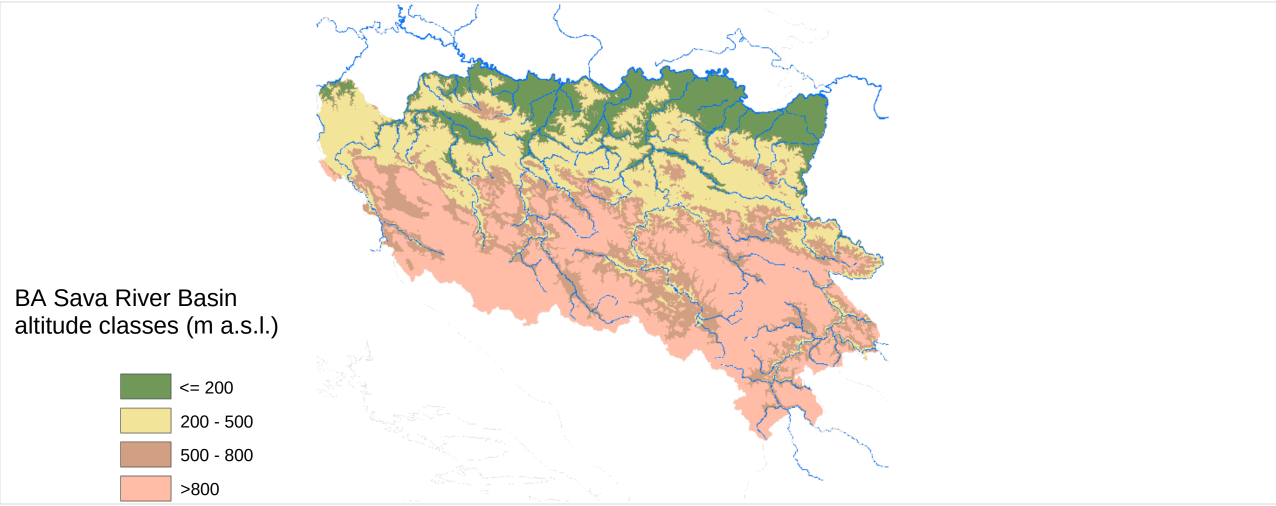


Figure II-7: WFD relevant altitude classes in BA

Basic requirement of the WFD is that geological conditions of the catchment area are represented through three obligatory soil types:

- dominant carbonate type, which significantly influence on water quality (e.g. hardness),
- dominant siliceous type, without significant influence on water quality, and
- dominant organic soil, with very large influence on water quality (organic materials).

Classification by the size of catchement area is the following:

- brooks – < 100 km^2,
- small rivers – 100 – 1,000 km^2,
- medium size rivers – 1,000 – 4,000 km^2,
- large rivers – 4,000 – 10,000 km^2,
- very large rivers – > 10,000 km^2.

The focus of attention to development of typology (due to the importance and defined criteria) is given to typology of surface waters. In this moment, therefore, the drafts of typology for watercourses, which will enable general insight into characterization of larger river basins, their current status and possible directions of development are given.

The final typology will be available after the definitive finalization of the Report for the part of river basin of Danube in BA.

Croatia

Watercourses types were characterized with GIS assistance. The current GIS layer of watercourses was supplemented with data on watercourse types according to System B.

A digital terrain model was used for the characterization of watercourse types according to the size of the catchment area and altitude (Figure II-8).

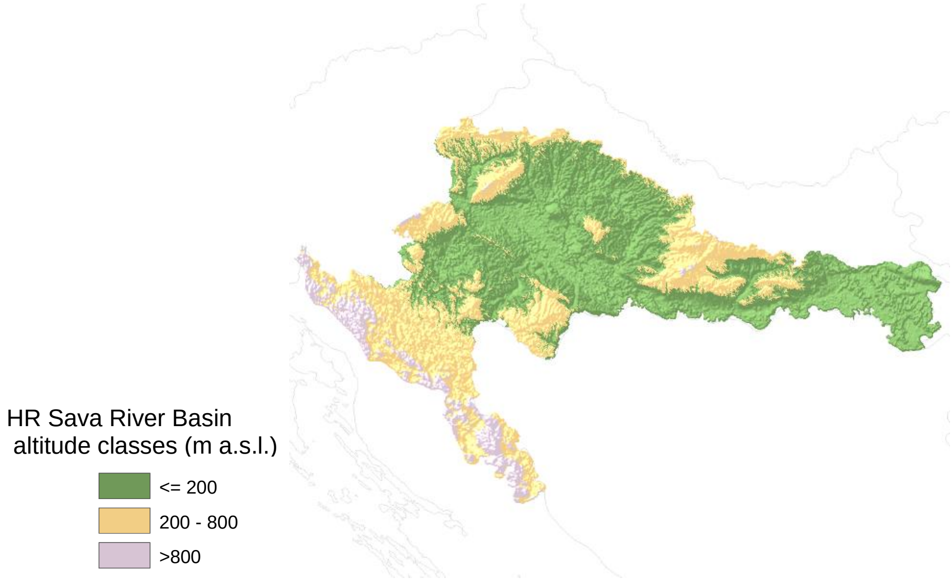


Figure II-8: WFD relevant altitude classes in HR

On basis of the characterized area of the accompanying catchment areas for all watercourse sections, it was possible to classify them as small, medium, large, and very large. Watercourses with catchment area less than 10 km^2 were not included in the typology, but classified into water bodies.

All watercourse sections were classified to the altitude classes in accordance with the characterized altitude of each watercourse section.

The mean annual flows at hydrological stations were adopted from studies or, where no measurement data were available, estimated on basis of data on catchment's areas and annual precipitation.

A **lithological** map of Croatia, prepared specifically for that purpose, was used for characterization of surface water body types according to geological characteristics. For each watercourse section, the surface representation of particular lithological classes on its catchment area was calculated, identifying as predominant the one with the greatest representation.

The watercourse sections for which a biological type was characterized on basis of expert judgment were assigned with that type. Other watercourses were assigned with type on the basis of abiothic parameters identified in above described manner. When it was not possible to classify a watercourse on basis of abiothic parameters, it has been classified as a special class, „untypified".

System B was chosen as a more flexible, objective, credible and acceptable classification of water body types, applying obligatory descriptors and optional descriptors, whose selection was based on the specific qualities of Croatia's environment and fauna.

Obligatory factors used: size of the catchment area, altitude and geology. In addition to those factors, the geographical position of eco-regions was determined based on the following principles: physiographic and geo-morphological characteristics, geological history and distribution of aquatic fauna, recent distribution of aquatic fauna, distribution of endemic species, and geological and lythological characteristics.

Among optional factors, some abiothic and biothic factors were used.

The following abiothic factors were used: physiographic factors (grain-size structure of the riverbed and the mean annual flow), hydrological regime (nival, pluvio-nival, or alluvio-nival regime), constancy of the flow (perennial or intermittent running water), and maximum water temperature.

The biological factors included in the typization of watercourses were the biocenotic structure of macrozoobenthos fauna and saprobiological characteristics of benthic communities determined by a PB saprobity index on the basis of the analysis of macroinvertebrate fauna. Water chemistry was included in the typization in terms of the concentration of dissolved oxygen and orthophosphates.

At border crossings and for shared river stretches, the above described typology was applied.

Further no specific inter-calibration types were designated.

There is no important difference between the typology of the Sava River and the tributaries.

Serbia

The Typology System for Running Waters of Serbia – Typology Based on Abiotic Parameters (Pre-Typology)

For proposal of typology in Serbia system B has been used, as more flexible approach, suitable for complex areas.

In April 2004, preliminary typology system scheme has been proposed with idea to present holistic typology that includes selected abiothic parameters, as well as biological criterions, as a starting point of effective, uncomplicated system for evaluation of ecological status/potential. The scheme was gradually applied, first on the rivers with basin size > 4,000 km^2 (2004, requested for ICPDR *Roof Report 2004*), via streams with basin area > 500 km^2 (2005), and finally on all rivers with basin size > 100 km^2 (2006). During 2007, proposed typology was evaluated by biological data. Aquatic macroinvertebrates, fish fauna, phytobenthos and phytoplankton were used for verification of the typology.

The following typological descriptors have been used:

- geology (obligatory parameter),
- altitude (obligatory parameter),
- catchments size (obligatory parameter), and
- substrate type (additional parameter).

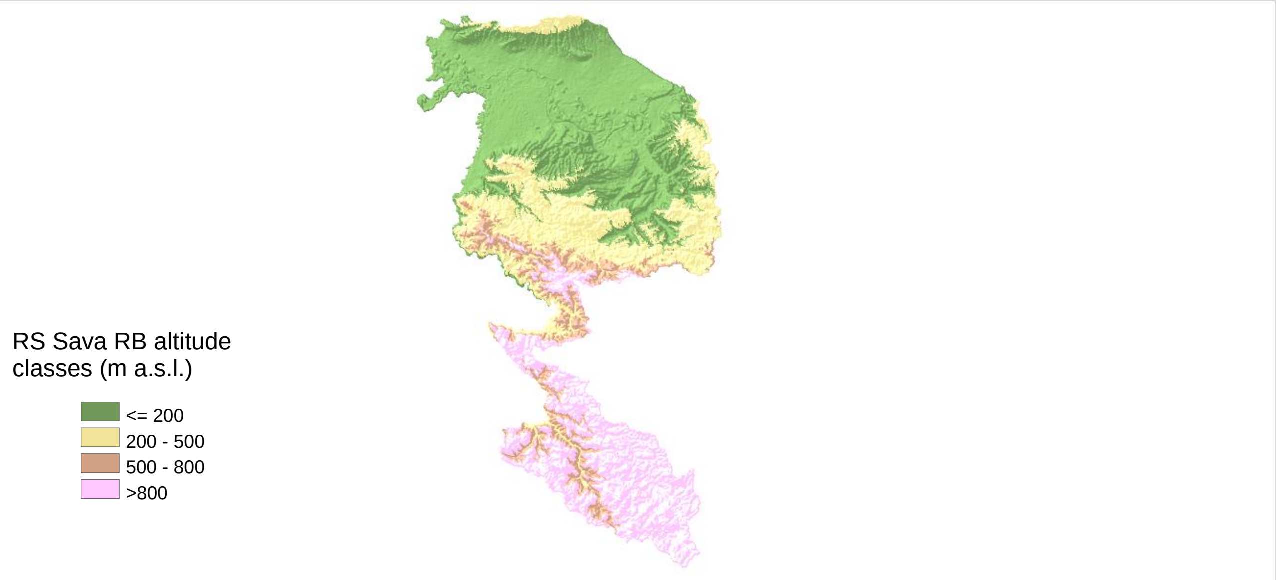


Figure II-9: WFD relevant altitude classes in RS

Substrate type was used as one of the most important factors which affect the distribution of aquatic biota.

The WFD delineates three main categories for geology: siliceous, calcareous and organic.

Mean substrate composition is used as the only optional factor within their System B typology.

Serbia differentiated the substrate size classes ‘fine’ (mixture of clay, silt, sand and gravel), ‘medium’ (mixture of sand, gravel and cobbles) and ‘coarse’ (mixture of gravel, cobbles and boulders).

Slovenia – no data submitted.

In total, this, so far resulted in 60 different river types in the Sava Basin (without Montenegro). All countries cover the obligatory factors (altitude, latitude, longitude, geology, size) given for System B in the WFD Annex II, 1.2.1. All countries have introduced mean substratum composition as an optional factor for river typology. Further Croatia and Slovenia have introduced additional optional factors (see Table II-3).

There are, however, differences with respect to class boundaries for the different descriptors Therefore, currently it is not possible to find out to what extent the typologies are comparable. It would be important to further investigate some options for harmonizing the selected typologies especially for rivers at border crossings and for stretches of rivers, which form the border between countries.

Table II-3: Factors applied in the typology of the Sava

Descriptor	Obligatory or optional System A or B	Country	Class boundaries				
Eco-region	A obligatory	WFD	05	04	11		
		SI	X	X	X		
		HR	X		X		
		BA	X				
		RS	X		X		
		ME	n.a.				
Altitude (h)		WFD	0-200 m	200-800 m	>800 m		
		SI	Not defined yet				
		HR	0-200	200-800	>800		
		BA	<200	200-500	500-800	>800	
		RS	<200	200-500	500-800	>800	
		ME	n.a.				
Catchment area [km^2]		WFD	<100	<1,000	<10,000	>10,000	
		SI	<10	10-100	100-1,000	1,000-10,000	>10,000
		HR	10-100	100-1,000	<10,000		
		RS	<100	100-1,000	1,000-4,000	4,000-10,000	>10,000
		BA	<100	100-1,000	1,000-4,000	4,000-10,000	>10,000
		ME	n.a.				
Geology		WFD	siliceous	calcareous	organic		
		SI	X	X			
		HR	X	X	X		
		BA	X	X	X		
		RS	X	X	X		
		ME	n.a.				
Mean substratum composition							
		HR	Bedrock, boulder, Boulder covered with travertine, Cobble, gravel, sand, silt, pebbles				

Descriptor	Obligatory or optional System A or B	Country	Class boundaries		
		BA	Fine substrates (clay, silt, very fine sand), gravel), medium (gravel, cobbles), coarse (cobbles, boulders)		
		RS	fine (clay, silt, sand, gravel), medium (sand, gravel, cobbles), coarse (gravel, cobbles, boulders)		
Other descriptors					
Discharge [m^3/s]		HR	<2	2-20	>20
specific		SI	Hydrology (permanent), karst spring influence, lake outflow influence, limnocrene spring influence		

Altitude: Only Croatia applied the size-classes according to the WFD.

Catchment areas: The countries have established different catchment areas than the ones suggested in WFD. Slovenia, Bosnia and Herzegovina and Serbia have established additional limits, but Croatia has set the maximum limit at 10,000 km^2.

Geology: All countries have delineated same categories of geology as suggested in the WFD (siliceous, calcareous and organic).

Optional factors: Bosnia and Herzegovina, Croatia and Serbia have defined additional refinements of mean substratum composition. Croatia and Slovenia have used other descriptors for definition of water types as discharge (HR) and specific descriptors (SI).

Table II-4: Number of river types in each country and eco-region

Eco-region →	4	5	11
BA		18	
HR		7	10
RS*		7	4
SI	8	6	7
ME	n.a.		
Total number	8	38	21

* RS: Only types for the Sava River and selected tributaries have been taken into account. For smaller rivers in the Sava RB in RS, another 13 types have been identified.

The Sava River has been divided in 11 different river types (Table II-5).

Table II-5: Stream types defined for Sava River

Country	River	Downstr. border	Upstr. border	Code	Type
RS	Sava	0	209	RS_Typ1.1	Very large rivers, lowland, silicious, fine sediments
BA	Sava	179	524	BA_Typ1.15	Very large rivers, lowland, siliceous, fine sediments
HR	Sava	213	375	HR_9b	Lowland very large rivers, siliceous, sand/gravel
HR	Sava	375	408	HR_8	Lowland very large rivers,siliceous, sand/gravel/pebbles
HR	Sava	408	521	HR_8	Lowland very large rivers,siliceous, sand/gravel/pebbles
HR	Sava	521	556	HR_8	Lowland very large rivers,siliceous,

Country	River	Downstr. border	Upstr. border	Code	Type
					sand/gravel/pebbles
HR	Sava	556	597	HR_8	Lowland very large rivers,siliceous, sand/gravel/pebbles
HR	Sava	597	662	HR_8	Lowland very large rivers,siliceous, sand/gravel/pebbles
HR	Sava	662	711	HR_7b	Lowland very large rivers,siliceous, gravel/pebbles
HR	Sava	711	725	HR_7b	Lowland very large rivers,siliceous, gravel/pebbles
SI	Sava	0	59.19	SI__VR6	Pannonian Sava, carbonate, large rivers
SI	Sava	59.19	116.23	SI__VR3	Dinaric Sava, carbonate,large rivers
SI	Sava	116.23	162.05	SI__VR1	Alpine Sava, carbonate,large rivers
SI	Sava	162.05	185.47	SI_4_PA-hrib-D_2	Medium-size rivers of Pre-alpine hills-Danube river basin, carbonate
SI	Sava (Dolinka)	185.47	211.93	SI_4_KB-AL-D_2_KI	Medium-size rivers of Carbonate Alps-Danube river basin with a karst spring influenc, carbonate
SI	Sava (Dolinka)	215.14	220.75	SI_4_KB-AL-D_1_LI	Small rivers of Carbonate Alps-Danube river basin with a limnocrene spring influence, carbonate

The types of the Sava River Basin tributaries are distributed mainly in eco-region 5 (Dinaric Western Balkans), only small number is distributed in eco-region 11 (Hungarian lowland) and eco-region 4 (Alps). The altitudes vary between 200-800 m a.s.l. Most of the tributaries are large rivers. Most of the main tributaries are siliceous and calcareous, and only a few are mixed and organic. The detailed data of the main tributaries types is available in Table II-6.

Table II-6: Number of stream types of relevant tributaries

Country	River	Number of tributaries stream type	Code/ abreviation	Name
BA	Drina	3	BA_Type 1.14	Very large lowland rivers, siliceous, medium sediments
			BA_Type 2.16	Large lowland-hilly rivers, siliceous, coarse sediments
			BA_Type 2.4	Large lowland-hilly rivers, calcareous, coarse sediments
	Lim	1	BA_Type 2.17	Large lowland-hilly rivers, siliceous, medium sediments
	Tinja	4	BA_Type 4.15	Small lowland rivers, siliceous, fine sediments
			BA_Type 4.14	Small lowland rivers, siliceous, medium sediments
			BA_Type 4.13	Small lowland rivers, siliceous, coarse sediments
			BA_Type 5.16	Lowland-hilly brooks, siliceous, coarse sediments
	Bosna	5	BA_Type 2.14	Large lowland rivers, siliceous, medium sediments
			BA_Type 2.16	Large lowland-hilly rivers, siliceous, coarse sediments
			BA_Type 2.4	Large lowland-hilly rivers, calcareous, coarse sediments
			BA_Type 3.4	Medium size lowland-hilly rivers, calcareous, coarse sediments
			BA_Type 4.4	Small lowland- hilly rivers, calcareous, coarse sediments
	Ukrina	2	BA_Type 4.14	Small lowland rivers, siliceous, medium sediments
			BA_type 4.17	Small lowland-hilly rivers, siliceous, medium sediments
	Vrbas	4	BA_ Type 2.14	Large lowland rivers, siliceous, medium sediments
			BA_ Type 3.4	Medium size lowland-hilly rivers, calcareous, coarse sediments
			BA_Type 4.7	Small hilly-mountanious rivers, calcareous, coarse sediments

Country	River	Number of tributaries stream type	Code/ abreviation	Name
			BA_Type 5.22	Mountainous brooks, siliceous, coarse sediments
	Sana	5	BA_Type 3.14	Medium size lowland rivers, siliceous, medium sediments
			BA_Type 3.2	Medium size lowland rivers, calcareous, coarse sediments
			BA_Type 3.1	Medium size lowland rivers, calcareous, coarse sediments
			BA_Type 3.4	Medium size lowland-hilly rivers, calcareous, coarse sediments
			BA_Type 4.4	Small lowland- hilly rivers, calcareous, coarse sediments
	Una	4	BA_ Type 2.14	Large lowland rivers, siliceous, medium sediments
			BA_Type 3.1	Medium size lowland rivers, calcareous, coarse sediments
			BA_Type 3.4	Medium size lowland-hilly rivers, calcareous, coarse sediments
			BA_Type 4.4	Small lowland- hilly rivers, calcareous, coarse sediments
HR	Sutla	3	HR_2a	Foothill small rivers, siliceous bed
			HR_4a	Foothill medium sized rivers, calcareous/siliceous
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
	Krapina	2	HR_3a	Lowland springbrooks, siliceous, sand, silt
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
	Kupa	5	HR_6	Lowland large rivers,lower flows,calcareous river basin, sliliceous, gravel, sand
			HR_13a	Foothill medium sized travertine rivers, calcareos, boulder covered with travertine
			HR_13b	Foothill medium sized nontravertine rivers, calareos, boulder, cobble
			HR_14a	Foothill large travertine rivers, calzareos, boulder covered with travertine
			HR_14b	Lowland large rivers, calareos, cobble, gravel
	Dobra	5	HR_11	Mountain springbrooks, calareos, bedrock, boulder
			HR_12b	Foothill nontravertine springbrooks, siliceous/calareos, boulder, cobble
			HR_13a	Foothill medium sized travertine rivers, calcareos, boulder covered with travertine
			HR_13b	Foothill medium sized nontravertine rivers, calareos, boulder, cobble
			HR_14b	Lowland large rivers, calareos, cobble, gravel
	Korana	4	HR_12a	Foothill travertine springbrooks, calcareos, boulder, gravel
			HR_13a	Foothill medium sized travertine rivers, calcareos, boulder covered with travertine
			HR_14a	Foothill large travertine rivers, calzareos, boulder covered with travertine
			HR_14b	Lowland large rivers, calareos, cobble, gravel
	Glina	4	HR_3c	Lowlands smaller rivers, siliceous, sand, silt
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
			HR_6	Lowland large rivers,lower flows,calcareous river basin, siliceous, gravel, sand
			HR_12b	Foothill nontravertine springbrooks, siliceous/calareos, boulder, cobble
	Lonja	1	HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder

Country	River	Number of tributaries stream type	Code/ abreviation	Name
	Česma	2	HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
			HR_13a	Foothill medium sized travertine rivers, calcareos, boulder covered with travertine
	Glogovica	2	HR_2a	Foothill springbrooks, siliceous, bedrock, boulder
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
	Ilova	2	HR_3a	Lowland springbrooks, siliceous, sand, silt
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
	Una	3	HR_6	Lowland large rivers,lower flows,calcareous river basin, sliliceous, gravel, sand
			HR_12a	Foothill travertine springbrooks, calcareos, boulder, gravel
			HR_13a	Foothill medium sized travertine rivers, calcareos, boulder covered with travertine
	Orljava	2	HR_2a	Foothill springbrooks, siliceous, bedrock, boulder
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
	Bosut	4	HR_3a	Lowland springbrooks, siliceous, sand, silt
			HR_3b	Lowland springbrooks, organic, silt
			HR_4b	Lowlands medium sized rivers, siliceous, cobble, boulder
			HR_5b	Lowland large rivers, siliceous/organic, silt
RS	Bosut	1	RS_P3_V1_SIL	Medium rivers, lowland, silicious
	Drina	1	RS_Typ1.2	Very large rivers, lowland, silicious, medium sediments
	Lim	2	RS_Typ1.6	Large, hilly, silicious, medium sediments
			RS_Typ1.7	
	Uvac	5	RS_P3_V2_SIL	Medium rivers, hilly, silicious
			RS_P3_V3_SIL	Medium rivers, mid-altitude, silicious
			RS_P3_V3_CAR	Medium rivers, mid-altitude, carbonates
			RS_P3_V4_CAR	Medium rivers, high-altitude, carbonates
			RS_P3_V4_SIL	Medium rivers, high-altitude, silicious
	Kolubara	2	RS_P3_V1_SIL	Medium rivers, lowland, silicious
			RS_P3_V1_CAR	Medium rivers, lowland, carbonates
SI	Kolpa/Kupa	2	5SA	Dinarids, medium catchment area, calcareous
			5SVA	Dinarids, large catchment area, calcareous
	Ljubljanica	1	5SVA	Dinarids, large catchment area, calcareous
	Savinja	2	4SS	Alps, medium catchment area, silicious
			11SVS	Pannonian lowlands, large catchment area, silicious
	Krka	1	5SVA	Dinarids, large catchment area, calcareous
	Sotla/Sutla	2	11SMS	Pannonian lowlands, small catchment area, silicious
			11SS	Pannonian lowlands, medium catchemnt area, silicious

Note: No data available for rivers Pliva, Lašva, Krivaja, Spreča, Piva, Tara, Ćehotina, Prača, Drinjača.

Table II-7: Number of types per eco-region, altitude, catchments size and geology class

	BA	HR	RS	SI	Total No
Ecoregions					
Ecoregion 4				8	8
Ecoregion 5	18	7	7	6	38
Ecoregion 11		11	4	7	22
Altitude					
<200	9	10	5	*	24
200-800	8	7	4	*	19
>800	1	1	2	*	4
Cathment area					
<1.000	8	11		13	32
1.000-10.000	8	7	8	7	30
>10.000	2		3	1	6
Geology					
siliceous	12	9	8	13	42
calcareous	6	6	3	8	23
organic		1			1
mixed		2			2

* Typology for number of types per altitude in SI has not been defined yet.

Reference Conditions

The EU WFD requires reference conditions to be delineated for near pristine conditions of each surface water type. The Directive addresses this issue in Annex II, 1.3. It prescribes that for each surface water type, type-specific hydromorphological and physico-chemical conditions shall be established representing the values of the hydromorphological and physico-chemical quality elements specified for the surface water type at high ecological status.

Approaches for delineation of reference conditions by countries

Bosnia and Herzegovina – FBA not defined yet, BA-RS no information submitted

Croatia

The characterization of surface water body types enables the establishment of type-specific reference conditions, which eventually represent the basis for identification of ecological status of water bodies.

Due to continuous national monitoring carried out within the water management sector (which will not significantly change according to the requirements of the WFD until investigative monitoring has not been carried out), as well as due to lack of other relevant data, the indicators and their values laid down by the *Regulation on Water Classification* (which identifies water classes I-V according to actual water quality in a given moment, as well as sets of indicators and limit values of indicators for a particular water class) were adopted as reference conditions, which are typically used for assessing the general ecological function of water.

Data from the national water quality monitoring at appropriate measuring stations, both recent and historical (when available), will be used for the establishment of reference conditions.

If needed, expert judgment will also be used for the establishment of reference conditions (particularly on the locations without monitoring stations within the national monitoring).

Individual types of watercourses will be classified into one of the above-mentioned water classes on the basis of the monitoring and analysis of data obtained from the national monitoring and on basis of the expert judgment.

Table II-8: Croatian criteria for selection of the potential specific reference conditions and reference sites

General conditions	Nearly natural status/very minor anthropogenic impact
Hydromorphological conditions	No alterations to type-specific annual flow characteristics No antropogenic disturbance of river continuity (only small-scale water structures can be taken into consideration)
Land use and aquatic habitats	Land use and aquatic habitats: little - only local impacts are required Type-specific alluvial plains with maintained lateral and vertical connectivity No alterations caused by anthropogenic use
Physico-chemical conditions	Nearly natural values (only those disturbances which do not disturb the consistency of the ecosystem are allowed)
Biological conditions	No major disturbance in the structure of aquatic community Presence of type-specific species Breeding of aquatic organisms ensured No fish farming, or at a minimum level
Exception criteria	Hydropower plants Anthropogenically induced disturbance of the continuum „Intensive" agriculture Excavation of bottom sediment Intensive fisheries Saprobiological water quality class (for the Dinaric and Pannonian eco-region > II-III) Chemical quality (exceeding the quality objective)

Table II-9: Croatian set of water quality criteria for the selection of the reference sites

Sets of indicators	Indicators
PHYSICO-CHEMICAL	pH
	Alkalinity (mg $CaCO_3$/l)
	Electric conductivity (µS/cm)
OXYGEN REGIME	Dissolved oxygen (mg O_2/l)
	Oxygen saturation, % Running water Stagnant water: - epilimnion - hypolimnion
	COD_{Mn} (mg O_2/l)
	BOD_5 (mg O_2/l)
NUTRIENTS	Ammonia (mg N/l)
	Nitrites (mg N/l)
	Nitrates (mg N/l)
	Total nitrogen (mg N/l)
	Total phosphorus (mg P/l) Runing water Stagnant water
MICROBIOLOGICAL	Coliform bacteria (total/l)
	Faecal coliforms (FC/l)
	Aerobic bacteria (BC/ml)
BIOLOGICAL	P-B saprobity index (S)
	Biotic index
	Level of trophy

Serbia

Within the process of the reference conditions definition, the following approaches have been used:

- Analyses of available recent data,
- Analyses of the historical data,
- Expert judgment.

It is expected that information on quality for majority of watercourse types that belong to the hilly and mountainous regions will be satisfactory from the „recent data-set" that enables definition of reference conditions, since there are still enough sites that could be characterized as natural and „near natural".

In case of lowland rivers, due to lack of the reference sites, the expert opinion and historical data must be combined with the data from recent investigations.

The framework of definition of the type-specific reference sites and reference conditions is done simultaneously with the work on typology of the aquatic ecosystems. The delineation of reference conditions corresponds to the suggestions that were presented within the WFD and subsequent projects, as for example, AQEM (*The Development and Testing of an Integrated Assessment System* for the *Ecological Quality of Streams and Rivers throughout Europe using Benthic Macroinvertebrates - Contract No. EVK1-CT-1999-00027*).

The same data-set that was used in development of typology and definition of type specific reference conditions. Our intention was to base our work on recent investigations as much as possible and to use expert judgment only in occasions where no satisfactory data is available – with the aim to minimize the influence of subjectivity.

In summary, this approach comprehended combination of the data from current investigations (2004-2007) and selected data from previous studies (1993-2003).

In regard to reference condition for BQI, reference values for selected community parameters for aquatic macro-invertebrates were identified and the reference fish community was defined for five fish types (groups of stream types).

For macro-invertebrate community, the reference values were analyzed for the following parameters: taxa richness (No. of taxa), taxa richness within selected faunistic/ecological groups, EPT index, No. of families, diversity indices, abundance, abundance of selected groups, the relation of functional feeding groups, BMWP index, ASPT score, Balkan Biotic Index, No. of sensitive taxa and Saprobic index.

In case of fish fauna, total number of taxa, the structure of the community, Margalef index, biomass and annual productivity were discussed.

Slovenia – no information submitted.

Reference conditions in the Sava River Basin

Reference conditions were so far defined for certain biological quality elements by Croatia, Serbia and Slovenia.

Reference conditions for rivers in the Federation of B&H are not defined yet. Tendering for defining the reference conditions is in progress. The project is expected to be finalized in February 2011. Only after reference conditions are in place, definition of ecological status in accordance with the WFD will be possible.

The countries used different methods for establishing the reference conditions. Spatially based data have been used in Serbia and Slovenia. Historical data have been used in Croatia, Slovenia and for fish fauna in Serbia. Expert data have been used in Croatia, Serbia and Slovenia.

The Table II-10 outlines the descriptors that have been applied in the Sava countries. The table cells in grey colour indicate which descriptors are considered to be obligatory for the WFD compliant assessment methods.

Table II-10: Descriptors applied for the definition of reference conditions for biological quality elements in rivers, fields in grey colour indicate obligatory descriptors for the WFD compliant assessment methods

Country	Finished by (month-year)	BQE	Taxonomic composition	Abundance	Diversity	Sensitive to insensitive taxa	Age structure	Biomass	Other
BA		Phytoplankton							
		Macrophytes and Phytobenthos							
		Benthic Invertebrates							
		Fish Fauna							
HR	12-2007	Phytoplankton							x
		Macrophytes and Phytobenthos							x
		Benthic Invertebrates							x
		Fish Fauna							x
RS	6-2008	Phytoplankton	x	x	x				
	12-2008	Macrophytes x and Phytobenthos (x)	x (x)	(x)	(x)				
	12-2006	Benthic Invertebrates	x	x	x	x			
	12-2006	Fish Fauna	x	x	x		x		
SI	-	Phytoplankton							
	12-2007	Macrophytes and Phytobenthos	x	x					
	12-2008	Benthic Invertebrates	x	x	x	x			
	12-2009	Fish Fauna	x				x	x	

1.2.2. Identification of Water Bodies

1.2.3. River Water Bodies

„Member States shall identify the location and boundaries of bodies of surface water …". „A body of surface water means a discrete and significant element of surface water such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal, a transitional water or a stretch of coastal water" (Annex II, 1.1 and Art. 2.10. of the WFD).

1.2.3.1. Methodology of delineation of water bodies in Sava River Basin countries

Bosnia and Herzegovina

The basis for designation of water bodies is significant change of the condition or the regime of surface watercourse within identified types of surface watercourses or planned activity in close or more distant future in order to reserve such reaches of watercourses (water bodies) for some specific purposes.

Basic criteria for defining of water bodies are:

- change of category of surface water,
- change of type,
- change of pressure
    - pollution
    - changes of hydrological regime
    - morphological changes,
- significant tributaries.

Based on these criteria, the boundaries of water bodies are delineated on: locations of border lines with other countries, locations of dams, locations of slowing down of reservoirs, boundaries of watercourse types, points of significant change of flow regime and discharge regime, change of type of dominant bottom sediment, locations of significant abstractions of water and on reaches of watercourses with significant hydromorphological changes (long dykes and embankments).

Croatia

The preliminary characterization of surface water bodies primarily takes into account „environmental" characteristics described through water classes, water types, physico-geographical characteristics of water and the basin. However, following the analyses required under the river basin management plan, individual surface water bodies are, if needed, identified more precisely taking into consideration „water management" characteristics (a risk of failing to achieve environmental objectives, the special status of the water body).

Since river basin management plans have not been completed, a preliminary assessment of surface water bodies has been carried out. In the process of their characterization, it was not possible to take into consideration the significance of particular water bodies for water management, particularly those below the limits to be characterized as separate water bodies.

Having in mind the scope of work and the form in which the results had to be presented, GIS has been used.

On basis of the performed analyses, it can be concluded that the applicability of the introduced concept of the water body, as the main element of water management, can be checked only after it has been coordinated with water management needs. The preliminarily identified water bodies will most likely have to be modified in the process. It can be expected that the preparation of each subsequent RBMP will include the reinterpretation of water bodies in order to, for a purpose of new division, enable clear identification of the status of water bodies and efficient monitoring of the effects of the newly-planned measures.

In the process of characterization of surface water bodies, the criterion of significant hydromorphological alterations (e.g. inflows of significant tributaries) has not been applied. Such criterion can, on the one hand, lead to an increased number of smaller surface water bodies. However, on the other hand, such newly-developed water bodies have more acceptable form in view of water management practice (they aim for watercourse sections, which are a traditional water management element). It would, therefore, be advisable to consider the impact of application of such criterion.

Even though the WFD refers to the protection of all water bodies, in practice, there is an aspiration to strictly define the criteria of minimally significant running water (minimum size of the catchment area) which a water body (WB) has to fulfill in order to be identified as a separate WB. The application of such approach was not justified particularly in the karst region due to the marked disproportion between water management significance, capacity (size) and availability of water resources. Other characteristics of the karst, first of all, the inreliability of the estimate of a catchment area, as well as of other water characteristics, also point to the conclusion that is not justifiable to use strictly predefined limits for the identification of water bodies. In order to designate the water bodies, the things to be taken into account are the size, significance for water management, and the need of protection.

Serbia

Delineation of the water bodies in Serbia was done in accordance with provisions of the related CIS Guidance[2]. Main criteria for delineation of water bodies were: change in surface water category, change of pressures (mostly hydromorphological changes) and the main tributaries' confluences (Table II-11).

Table II-11: Criteria for delineation of water bodies in Serbia

Criteria		RS
1	Change in surface water category	+
2	Change in type	+
3	Change in pressure	
	Pollution	+
	Alternation of hydrological regime	+
	Change in morphology	+
	Fisheries	–
	Dredging	+
4	Significant tributaries	+

Note: (+) means that status changes (presumed results of the Risk assessment) are not yet integrated into the water body delineation.

Slovenia

During period of 2004 – 2005, the following water bodies in Slovenia were delineated into SWBs (WB, AWB and HMWB candidates):

- rivers with catchment area of F > 100 km^2 and corresponding wetlands;
- natural lakes with surface area > 0.5 km^2;
- artificial channels > 3 km;
- water reservoirs on rivers and artificial lakes with a water surface area > 0.5 km^2;
- coastal waters;
- transitional waters.

The methodology of the delineation of surface water bodies is provided in the Guidelines (CIS 2003a), based on the WFD (The European Parliament and the Council 2000). The provisions of Article 4 („Delineation of surface water bodies and criteria used”) and 5 („Classification of water bodies”) were adopted as the methodological basis for the delineation of surface water bodies. A minimum length of a water body in Slovenia was established at 3 km.

Following criteria were applied to delineate water bodies in the Sava and in the tributaries:

Category of surface water
The surface water bodies were identified as falling within one of the following surface water categories, as set out in the WFD: rivers, lakes, transitional water and coastal waters.

Type of surface water
Based on the study of classification of surface waters in the period of 2004-2005 in the process of the first SWB delineation, the results of the study of ecological regionalization based on the hydro-eco-regions were used, upgraded with available data bases of abiotic factors, catchment area size and geology.

[2] Guidance Document No.2 *Identification of Water Bodies*, 2003.

Geographical and natural hydromorphological phenomena
In the SWB delineation, the geographical and natural hydromorphological phenomena, which have a significant impact on biological elements of the ecological status of surface waters and distinguish between parts of single types of surface waters were considered.

Anthropogenic physical changes of hydromorphological characteristics of surface waters
The designation of river reaches and lakes candidates for the HMWB status was carried out in a two-stage procedure, while acknowledging the rules and protocol of the HMWB candidate delineation.

Subdivision of surface water bodies
In the first delineation of SWB, among the delineation factors mentioned above, the assessment of the chemical water status was considered, provided by the Decree on the chemical status of surface waters for 2002. And furthermore, the data on water quality, existing monitoring network and results of the monitoring, as well as the best possible estimate according to the known or identified pressures.

System for delineating surface water bodies in Slovenia is good. It brings a lot of advantages and less disadvantages. One of disadvantages is that, in 2004, when delineation was carried out, typology of surface waters has not been applied. In 2004, the typology was not yet developed. So, in 2004 delineation was based on the results of the study of ecological regionalization.

Table II-12: The summary of criteria applied for the delineation of water bodies within the countries

Country	Change in surface water category	Change in type	Change in pressure/status	Significant physical features	Other
BA	x	x	x	x	Significant tributaries
HR	x	x	x	x	Karst phenomena
RS	x	x	(x)*	x	
SI	x	x	x	x	

* Only pollution.

1.2.3.2. River Water Bodies in the Sava River Basin

In total, the Sava countries have identified 26 water bodies for the Sava River (Table II-13) and 118 water bodies for the tributaries (data from BA are available for rivers with catchments larger than 4,000 km^2).

The Table II-14 and Figure II-10 summarize the results of the water body delineation in terms of numbers and length of water bodies in the Sava River.

Table II-13: Basic information about the water bodies in Sava River

Country	Number of WBs	Average length (km)	Min length (km)	Max length (km)
BA	3	115	90	141
HR	8	64	14	162
RS	3	70	32	102
SI	12	18	3.4	31.3
Total	**26**			

Table II-14: Number of water body delineation in terms of number and legth of water bodies in the Sava River per country

Country	<10 km	10-25 km	25-50 km	50-75 km	75-100 km	100-150 km	>150 km
	No	No	No	No	No	No	No
BA					1	2	
HR		1	4	1		1	1
RS			1	1		1	
SI	2	7	3				

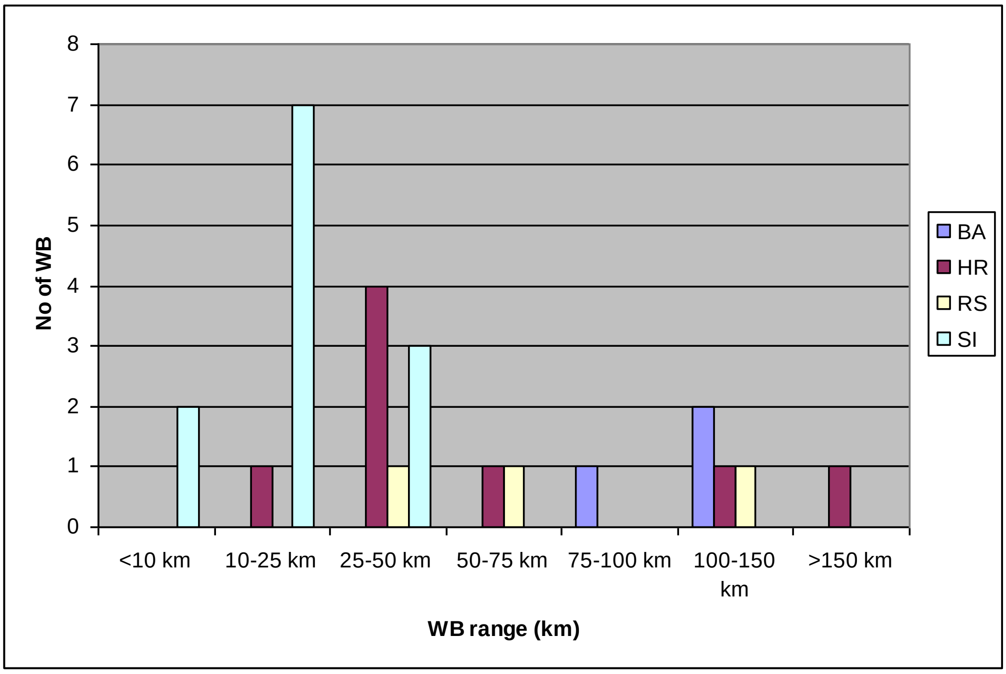


Figure II-10: Histogram of water body sizes for the Sava River

The description of the methodologies for the delineation of water bodies in the Sava River Basin shows that the criteria for the water body delineation are very similar for all riparian countries. Nevertheless, the Figure II-11 shows significantly different size-distributions of water bodies. On the one hand, this may occur due to differences in natural conditions, but, on the other hand, this may be the result of different „quantitative" definitions for the criteria. Even if the criteria for the delineation of water bodies are qualitatively the same in different countries, their quantitative interpretation may lead to a significantly different result. If, for instance, the criterion is „significant tributaries", it still remains to decide how the criteria „significant" will be quantitatively defined. Therefore, it is recommended to make the underlying criteria transparent.

The Tables II-14, II-15 and II-16 demonstrate that the results of the water body delineation are indeed significantly different for all Sava countries. Both, the average size, as well as the size distribution, are different. It remains to clarify, whether these differences stem from differences in natural conditions or they are a consequence of different methodological approaches.

Data for the Sava tributaries Lašva, Krivaja, Spreča, Piva, Tara, Ćehotina and Prača are missing.

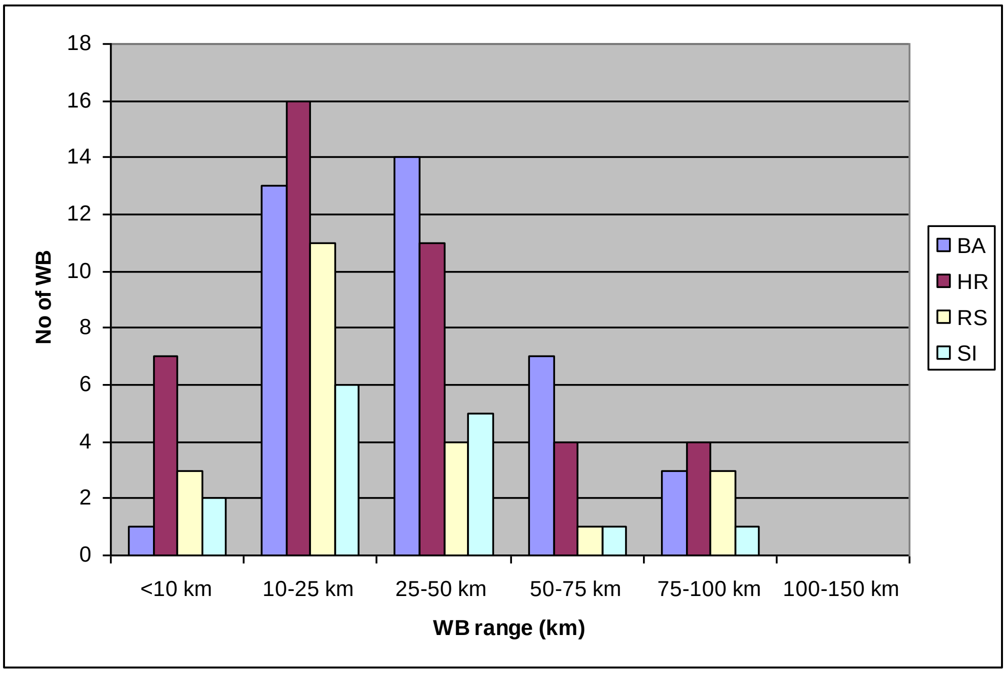


Figure II-11: Histogram of water body sizes for the Sava River tributaries

Table II-15: Basic information about the water bodies in the Sava tributaries

Country	Number of WBs	Average length (km)	Min. length (km)	Max. length (km)
BA	38	37	7	90
HR	43	33.9	0.1	166.2
RS	22	30	5	91
SI	15	29	3.2	85

Table II-16: Size distribution of water bodies in terms of number and length in the Sava River tributaries per country

Country	<10 km	10-25 km	25-50 km	50-75 km	75-100 km	100-150 km	>150 km
	No.	No.	No.	No.	No.	No.	No.
BA	1	13	14	7	3		
HR	7	16	11	4	4	0	1
RS	3	11	4	1	3		
SI	2	6	5	1	1		

1.2.4. Reservoirs in the Sava River Basin

The agreed threshold value for reservoirs relevant for this analysis is $5*10^6$ m^3. The basic data which are above the threshold value are shown in Table II-17.

Table II-17: Reservoirs in the Sava River Basin

Category (capacity range)	Country	Location		Reservoir			Dam height
		River Basin	River	Name	Volume	Purpose	
Mm^3					Mm^3		m
5-10	SI	Sava	Sava Dolinka	Moste	6.24	EP, FP	59.6
	RS	Kolubara	Velika Bukulja	Garaši	6.27	DW	35
	RS	Drina	Uvac	Radoinja	7	EP	42
	SI	Sava	Sava	Zbiljsko jezero	7	EP, FP	30
	SI	Sava	Sava	Vrhovo	8.65	EP, FP	24
10-50	SI	Sava	Sava	Trbojsko jezero	10.7	EP, FP	38
	SI,HR	Sotla/Sutla	Sutla	Vonarje (Sutlan-sko jezero)	12.4	DW, IW, FP, IR	19
	HR	Ilova	Pakra	Pakra	13.30	DW, IW, FP	5.0-8.4
	RS	Kolubara	Kladnica	Paljuvi Vis	14	IW	16
	RS	Drina	Lim	Potpec	44	EP	46
	BA	Sava	Rastosnica	Snjeznica	20.6	EP	
	ME	Drina	Ćehotina	Otilovići	17	IW, DW, FP	59
50-100	BA	Vrbas	Vrbas	Bočac	52.7	EP	52
	BA	Sava	Spreca	Modrac	88	IW, DW, FP, EP	28
	RS	Drina	Drina	Zvornik	89	EP	42
100-200	BA	Drina	Drina	Višegrad	161	EP	48.16
	RS	Drina	Beli Rzav	Lazici	170	EP	131
200-500	RS	Drina	Uvac	Uvac	213	EP	110
	RS	Kolubara	Jablanica	Rovni	270	DW,IR	12
	RS	Drina	Uvac	Kokin Brod	273	EP	82
	RS	Drina	Drina	Bajina Basta	340	EP	90
>500	ME	Drina	Piva	Mratinje	880	EP, FP	220

Legend on purpose: IR – irrigation; DR – drainage; DW - drinking water supply; IW – industrial water supply; R – recreation; EP – electricity production; FP – flood protection.

For the reservoirs above the threshold of 5 million m^3, the size distribution is given in Figure II-12.

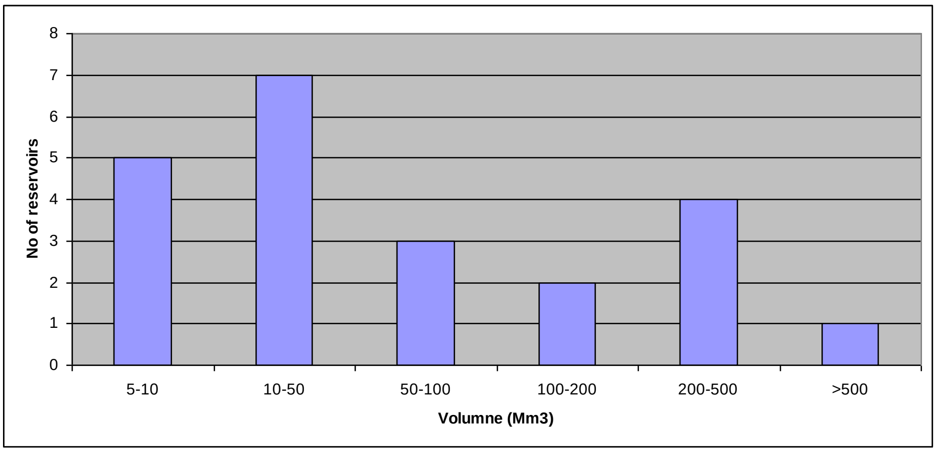


Figure II-12: Distribution of reservoir volumes in the Sava River Basin

Table II-18: Distribution of reservoirs per country

Country	5-10 Mm^3	10-50 Mm^3	50-100 Mm^3	100-200 Mm^3	200-500 Mm^3	>500 Mm^3
BA		1	2	1		
HR		2				
RS	2	2	1	1	4	
SI	3	1				
ME		1				1
Sum	5	7	3	2	3	1

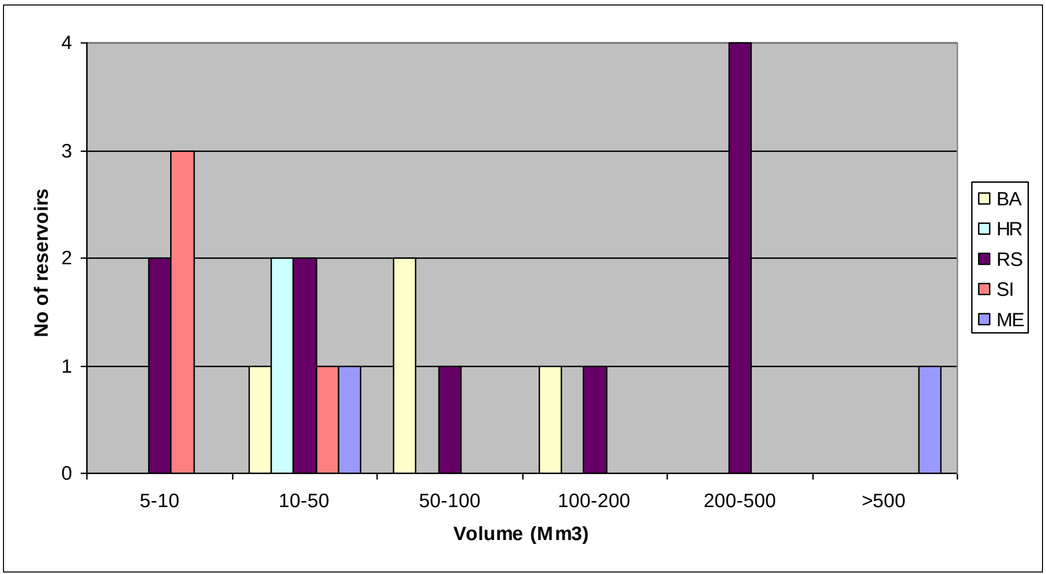


Figure II-13: Distribution of reservoir volumes in the Sava River Basin per country

1.3. Identification of significant pressures

The necessity to analyze pressures and impacts is stated in Article 5 of the WFD. The IMPRESS CIS Guidance document gives detailed explanations on understanding of the DPSIR approach and especially on specific definitions of (significant) pressures, impact and risk.

In this context, a pressure stands for any anthropogenic influence on natural conditions of a river, lake and groundwater, whereas a significant pressure means ‘having the potential to cause a more than marginal, at least locally (measurable) effect on a river, lake or groundwater body, irrespective of the detailed properties, size and typology of the respective water body’. As a subsequent step, an impact is the consequence of the combination of a significant pressure with a specific river (type), lake or groundwater. Predicting an impact means to include the specific properties of the respective river, lake, groundwater (size, type, sensitivity), etc. Thus, impact may be defined as a probability that a significant pressure causes a more than marginal, more than local alteration of the natural conditions in a specific river, lake or groundwater, though without considering the size of the water body. And finally, the risk of failure consequently includes the last two steps in the process and these are:

- Whether it is estimated that the impact will exceed a certain threshold, as expressed by the environmental objectives, which apply to the respective water body. In other words, this will be the risk to cause moderate or worse status.
- Whether the sum and combination of all pressures on the respective river, lake or groundwater are likely to cause a failure of the environmental objectives.

1.3.1. Driving forces

Driving forces related to settlements, industry, agriculture and waste management have been considered as key elements that exert or may exert significant pressure on surface water bodies (Table II-19).

Table II-19: Driving forces that have been considered for the analysis of pollution

		BA*	HR	RS	SI	ME
Settlements						
	>100,000	4	3	5**	1	
	10,000-100,000 PE	32	25	12	12	
	2,000-10,000 PE	95	78	19	56	
Industry			6	Not available	x	
Agriculture						
	Land use		x		x	
	Production figures		x		x	
	Other		x		Fertilizer consump-tion, livestock	
Aquaculture						
Forestry						
Impervious areas						
Mining						
Waste management			x			
	Active dumpsites				43	
	Past dumpsites					
Drainage						
Other			x			

* Number of agglomerations is taken from EU CARDS Water Quality Management Project – I Phase
** Inventory municipalities are part of the Belgrade region, discharge point is Danube
SI: x - represents the pressures that have been included in the analysis of the pollution

1.3.2. Significant pressures

1.3.2.1. Significant sources of organic pollution

Methodology per country

Bosnia and Herzegovina

Important step in water characterization is analysis of significant anthropogenous pressures and their impacts to water bodies. Through the analysis of the pressures it is important to focus on those pressures whose impact could be mitigated or eliminated through identification of appropriate measures, out of the broader spectrum of influential factors in the water body, in order to achieve appropriate status of the water body.

Status of the water bodies represents a sum effect of all pressures combined with all other characteristics of a specific water body.

Sum of effects of pressures is a result of simultaneous activity of different categories of pressures and intensities of their impact to changes in the water body, which are also dependent of dynamics in the water body. Having the latter in mind, the pressures, in general, can be divided in the following manner:

- Point pollution sources,
- Diffuse pollution sources,
- Changes of the water regime caused by changes of measures of water abstraction and regulation of the flow regime,
- Pressures caused by morphological changes, and
- Other categories of pressures.

Based on such division and quantification of influential parameters, undertaking an appropriate analysis process for each mentioned category in the area of the observed basin is needed, which would provide cause-and-effect connection between pressures and their impacts to water bodies.

This process should, in general, include four steps:

- Listing and location of individual causes (the driving forces) of pressures from the above mentioned categories of pressures, disregarding their current influence on water bodies,
- Identification (quantification) of the size (degree) of pressure according to impact parameters for each driving force from step (1) and setting apart those causes, which, due to their character and size of pressure, can have (individually or in group) significant negative consequences for water body,
- Assessment of the impact to water body (application of appropriate methods) based on results from step (2) and condition (quality, quantity and dynamics) of the observed and bordering water bodies, and
- Assessment of probability based on results from the first three steps and target status of the water body.

Unfortunately, due to lack of data it was impossible to perform detailed identification and quantification of mentioned influential parameters in this report, and, thus, also to perform all steps of the mentioned process. It has been planned to continue to work using the goal program formed based on the analysis of lacks seen during the work on this Report.

Croatia

The main point sources of pollution come from the population through municipal wastewater and from industrial activities. Point sources of pollution include pollution from public drainage systems, as well as all settlements that do not have wastewater drainage systems, and the settlements and industrial facilities that discharge their wastewater into drainage systems and natural recipients.

Waste disposal sites are one of the most significant uncontrolled sources of water pollution in Croatia.

The greatest pressure from diffuse points of pollution comes from agriculture (nutrients from fertilization and plant protection products). Diffuse pollution from agriculture has been estimated on the basis of land area, land use category, calculation of nutrients, and soil type assessment.

European experience shows that road traffic accounts for over 90 % of all pollutant emissions from traffic, while other types of traffic (rail, air, maritime, inland) account for around 10 % of emissions. The share of pollution load from traffic is small in comparison to other sources of pollution.

Pipelines have been identified as a potentially significant source of pollution.

Serbia

Significant point sources of pollution in Serbia are identified all settlements with constructed sewage system and emission load with more than 2,000 PE. If a facility for wastewater treatment is built, the basic parameters of water quality of treated water (BOD, COD, tot N and tot P), and the limits defined under the *Directive on municipal waste water purification* (UWWTD - 91/271/EEC) are used as the criteria.

Criteria for identification of significant pressures originating from the industry are belonging to certain industrial category and pollution load from direct discharges by following quality parameters: COD, nutrients, pesticides, heavy metals and organic micro pollutants. Limits are defined according to the *Directive on the integral pollution prevention and control* (IPPC) and to *European Pollution Emission Registry* (EPER).

Significant industrial categories are: food industry, chemical, leather industry, textile, pulp and paper industry, metal industry, metal surface treatment, thermal power plant, fertilizer industry, iron and steel industry and mining. In 2005, the Ministry of Environmental Protection created the preliminary survey of facilities, need to obtain an integrated permit. The 43 industrial facilities that are subject to reporting according to the *IPPC Directive* are identified in the Sava River Basin. Period of transition and change of the ownership of large industrial companies that marked the last decade of development, caused a revision of the preliminary list of pollutants and expectations are that a number of industry will be significantly lower.

Quantification of the load from settlements is done partly on the basis of available measured data and partly on the basis of expert judgment evaluated using the standard values. Adopted values are: BOD 0.060 kg/inh/day, 0.110 kg COD/inh/day, nitrogen 0.008 kg N/inh/day and phosphorus 0.0018 kg P/inh/day. Identified settlements with emission load over 100,000 PE are located on the territory of the city of Belgrade. These are the municipalities of Rakovica, Čukarica, Voždovac and parts of municipality of Novi Beograd and Zemun. Although territorially belong to the Sava River Basin, these municipalities have discharge point into the Danube River. Emissions of pollutants from other settlements is provided as a potential generated emission load and includes load from untreated wastewater from settlements (larger than 2,000 PE) with and without sewage system. On the territory of the Sava RB, three wastewater treatment plants are identified in Valjevo, Ruma and Irig of which only WWTP Valjevo works with satisfactory effects.

Slovenia

Slovenia's approach to define significant pressures of organic pollution is based on identification of agglomeration without waste water treatment and on emission monitoring data. The corresponding data were provided by the Environmental Agency of the Republic of Slovenia. In future the analysis will be upgraded by results of the immission monitoring data. In compliance with the urban waste water directive, Slovenia considered the following sources of organic pollution as significant pressures:

- Settlements larger than 2,000 PE without municipal waste water treatment plant,
- Discharges from food industry larger than 4,000 PE,
- Discharges from waste water treatment plants with capacity larger then 2,000 PE,
- Organic pollution from significant point sources.

Table II-20: Summary of the evaluation of the ICPDR emission inventory for municipal sources. Total wastewater load and percentage hereof that is discharged into the rivers.

Country	PE inventory	BOD	COD	N-tot	P-tot
		t/a	t/a	t/a	t/a
BA	1,302,600	27,906	57,662	4,893	932
HR	2,450,127	26,328	64,348	4,500	1,365
RS	562,760	13,847	25,622	2,089	427
SI	1,133,798	3,615	8,828	1,596	332
Total	5,449,285	71,696	156,459	13,078	3,056

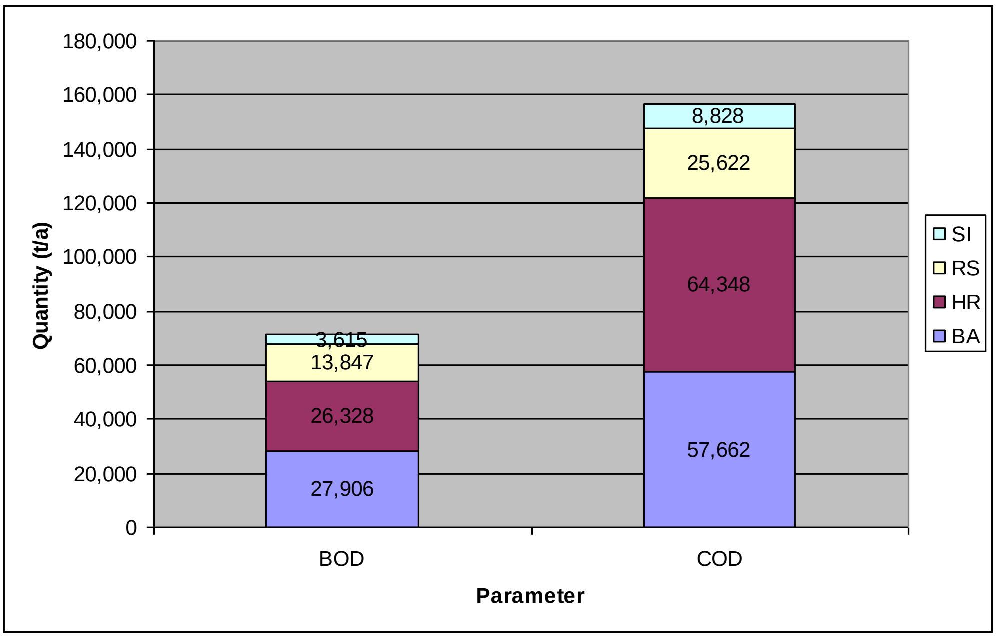


Figure II-14: Total wastewater load from agglomerations in the Sava River Basin from the respective country (BOD_5 and COD_5)

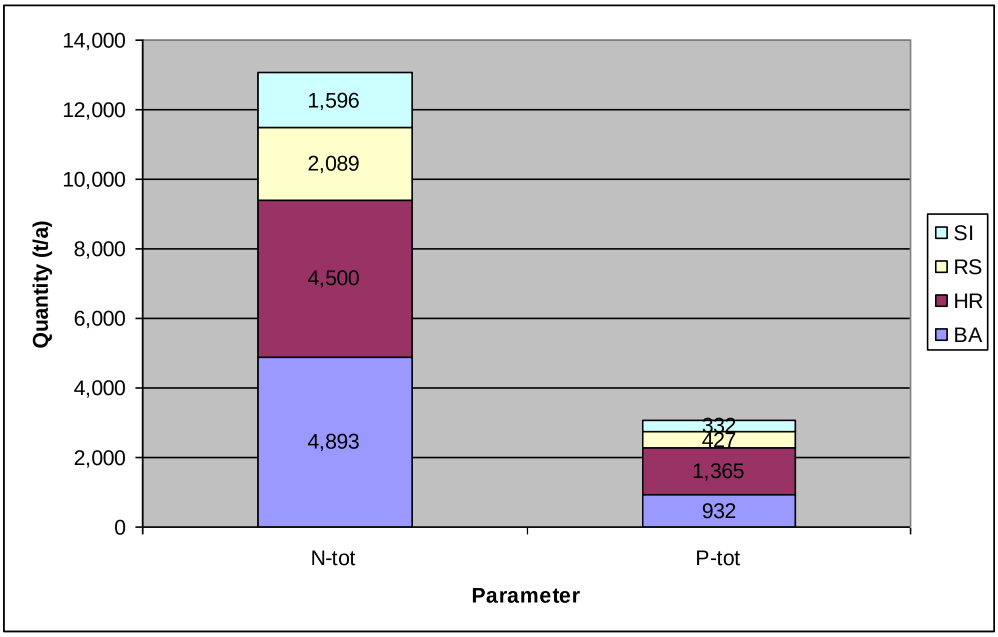


Figure II-15: Total wastewater load from agglomerations in the Sava River Basin from the respective country (N-tot and P-tot)

The countries have not submitted any data for industrial point sources in the Sava River Basin.

Table II-21: Number and type of significant point sources of organic pollution

Type of source	BA	HR	RS	SI
Untreated municipal effluent				
< 2,000 PE		n.a.	n.a	1614 (277,285 PE) [2]
2,000< >10,000		75	18 (95,253 PE) [1]	5 (12,280 PE) [6]
10,000< >100,000		15	10(241,734 PE) [1]	0[4]
>100,000		2		0[4]
Primary treatment				
< 2,000 PE		n.a		13 (9,675 PE)
2,000< >10,000		1		5 (14,400 PE)
10,000< >100,000		6		1 (50,000 PE)
>100,000				1 (360,000 PE)
Secondary treatment				
< 2,000 PE		n.a.		52 (35,815 PE) [5]
2,000< >10,000		2	1 (4,995 PE)	16 (100,600 PE)
10,000< >100,000	2	4	2 (72,452 PE)[1]	9 (323,750 PE)
>100,000		1		2 (300,000 PE) [5]
Industrial effluents				
< 2,000 PE			n.a.	n.a.
2,000< >10,000			n.a.	3
10,000< >100,000				
>100,000				

[1] Raw wastewater load
[2] Data for agglomerations between 50 and 2,000 PE (for 0 % of connection to sewage)
[3] Data for agglomerations between 2,000 and 10,000 PE (for 0 % of connection to sewage)
[4] For 0 % of connection to sewage
[5] For secondary and tertiary treatment
[6] Data for Slovenia for year 2004

Organic pollution from significant diffuse sources

There is no data submitted to cover the issue by any country.

1.3.2.2. Significant sources of hazardous substance pollution

Methodology per country

Bosnia and Herzegovina – See under paragraph 1.3.2.1.

Croatia

Water protection with respect to hazardous substances is carried out primarily by monitoring the application and movement of dangerous substances which enter water bodies by reducing and controlling point and diffuse sources of pollution and by implementing active measures within land use activities, including the activities implemented within environmental protection.

Pollution source management is carried out primarily on the basis of prioritized action: reduction and elimination of dangerous substances according to the criteria of toxicity, degradability and bioaccumulation; improvement of unfavorable water status; and fulfillment of international commitments. Data from the national water quality monitoring at appropriate measuring stations was analyzed. Expert judgment was used for the locations without measuring stations within the national monitoring program.

The problems arising during the process are the lack of results of existing monitoring for the new requirements set by the WFD. Furthermore, new regulations have been introduced, which made some aspects of water quality monitoring to change.

Regarding the steps for implementing the provisions of the *Dangerous Substances Directive*, a range of activities in different stages of realization is under way. River Basin Management Plans (RBMP), which will, *inter alia*, contain a programme of measures for the elimination of identified surface water pollution by List I substances, and a programme of measures for gradual reduction of surface water pollution by List II substances, have to be mentioned. Furthermore, the RBMPs will help redesign the current monitoring of surface water and groundwater and adapt it to the requirements of the WFD requirements, including the monitoring of potential presence of priority substances.

In the process of the RBMPs development, which is under way, the loads for the following dangerous substances in specific industries (large and small) have been calculated: Organochlorinated pesticides, Organophosphorus pesticides, Cr, Fe, Ni, Atrazine, Al, Cu, Pb, Cd, Cyanides, Barium, Tin, Silver, Phenols and Fluorides.

Significant loads are those appearing in watercourses (as evidenced through monitoring) in the quantity exceeding the limit values laid down by national legislation.

Serbia

One of the basic characteristics of future ICP (Integrated Cadastre of Polluters) is to present information on accurately defined hazardous and harmful substances. As previously noted, the information about the emission of dangerous and harmful substances from point sources will be available at the end of 2009.

Slovenia

In the pressure analyses of hazardous substance, the pollution relevant hazardous substances (Arsenic, Chromium, Copper, Zinc, hexachlorobenzene, hexachlorobutadiene, hexachlorociclo-hexane, COD, organic tin compounds, policiclic aromatic hydrocarbons (PAH), phenols, AOX, chlorides, cyanides, fluorides) and priority substances (cadmium, mercury, nickel, lead, dichloroethane, dichloromethane) were included.

For identification of significant sources of hazardous substances pollution, direct industrial discharges into water and ground were analysed. To define significant pressures, the criteria from the EPER register were applied. This approach is emission based and for now it does not consider protected areas, immission criteria or monitoring data.

Pollution from hazardous substance from point sources

Table II-22: Number and type of significant point sources of hazardous substance pollution

Type of point source		SI	HR	BA	RS	ME	Total
Settlements without wastewater treatment							
	Unit emissions	n.a.					
Industrial wastewaters							
	'relevant substances'	25 sources			No data		
	'priority substances'	9 sources			No data		

Pollution from hazardous substance from diffuse sources

Bosnia and Herzegovina, Croatia and Serbia – no data submitted.

Slovenia

Data source was sold amounts of plant protection products for Slovenia (kg) for a year 2004. The estimation of the amount which has been sold for catchments of surface water bodies in kg and kg per hectare has been made. Out of 154 plant protection products 26 have been chosen which were measured in national monitoring, those which are on priority list Annex X, those which are national relevant substances and those which were sold in amount over 50 tons in year 2004.

Significant pressures are on those catchments of surface water bodies where sold amounts of PPP are higher than median.

1.3.2.3. Significant sources of nutrients pollution

Methodology per country

Bosnia and Herzegovina – see under paragraph 1.3.2.1.

Croatia

The assessment of pollution loads from industry is based on the data on the annual quantities of discharged wastewater mean concentration values from the available wastewater analyses for the 2000-2005 period and maximum permissible concentrations of dangerous and other substances laid down by the water rights permits. The annual loads of COD-Cr, BOD_5, total nitrogen, total phosphorus, metals, phenols and pesticides have been calculated.

Municipal wastewater is mostly polluted with organic substances. The assessment of pollution load (t/year) from the population was carried out according to EU standards (60 g BOD_5 g/d/c, 135 COD-Cr g/d/c, 11 g N T/d/c, 2.5 g P T/d/c).

The greatest pressure from diffuse points of pollution comes from agriculture due to the input of nutrients present in fertilizers and plant protection products. Diffuse pollution from agriculture has been estimated on the basis of land area, land use category, calculation of nutrients, and soil type assessment.

The pressure was evaluated on basis of indicators related to regular agricultural activities; the assessment of pollution loads from agriculture thus includes the application of mineral fertilizers and the quantity of organic manure from animal farms. The real impact of the application of pesticides can be identified only by measurement, which is a costly process and carried out only in exceptional circumstances.

Serbia

The major nutrient inputs to a waterbody generally are wastewater discharges, land runoff, the atmosphere (precipitation) and groundwater (principaly nitrogen). The inputs from several of these sources, industrial, agroindustrial and especially the non-point sources were difficult to quantify reliably due to lack of data. In the case of individual sewerage systems and WWTP's evaluation for some settlements is based on measured data but for most of them loads are estimated useing specific factors presented in Chapter 1.3.2.1.

Slovenia

Estimation of total annual load (kg/year) of nitrogen and phosphorus to each surface water body was made from calculation of nitrogen and phosphorus balance on field, vineyard, grassland, orchard and other agricultural land from the Ministry of agriculture, forestry and food classification (MKGP) for hydro-geographical area II level. Calculated positive balance represented surplus of nutrient (kg/ha/a). Estimation of nutrient loss on nutrient surplus was taken from *Nutrient balance for Danube countries* (1997) and other projects. As for nitrogen, it was estimated that 20 % of surplus is lost (field, vineyard, orchard and other agricultural land from MKGP classification), 9 % of nitrogen surplus is lost on grassland. As for phosphorus, it was estimated that 1.5 % of surplus is lost on all agricultural land from MKGP classification. Finally, the calculation of total annual load (N, P) to each surface water body was done depending on contribution area composition (field, vineyard, grassland, orchard and other agricultural land from MKGP classification). The total annual load (N, P) was further statistically modeled with monitoring data for nitrate and phosphorus. Significant pressure for nitrogen was determined at concentration 4.6 mg/l NO_3. Significant pressure for phosphorus was determined at concentration 0.11 mg/l of total P. For natural lakes and artificial accumulations the total annual load was statistically modeled with monitoring data for lakes and artificial accumulations (only phosphorus). Significant pressure for phosphorus was determined at concentration 10 μg/l of total P.

Data retrieved from:

- Statistical Office of the Republic of Slovenia (fertilizers, livestock, crop production), 2000;
- Ministry of agriculture, forestry and food (land use), 2006;
- other national research projects.

Data gaps:

- consumption of mineral fertilizer on different land use was estimated from total annual sold amount;
- percentage of nutrient loss to environment was taken from national research projects.

Remark: there is no data available for assessment of pollution from nutrient substance from point and diffuse sources.

1.3.3. Identification of significant hydromorphological alterations

According to Annex II, 1.4 of the WFD, three categories of hydrological and morphological alterations should be considered:

- Estimation and identification of significant water abstraction for urban, industrial, agricultural and other uses, including seasonal variations and total annual demand, and of loss of water in distribution systems,
- Estimation and identification of the impact of significant water flow regulation, including water transfer and diversion, on overall flow characteristics and water balances,
- Identification of significant morphological alterations to water bodies.

Three HYMO pressure components have been identified in the Sava River Basin:

- Interruption of river and habitat continuity,
- Disconnection of adjacent wetland/floodplains,
- Hydrological alterations[3].

Further, potential pressures that may result from future infrastructure projects are being dealt with.

This chapter reflects findings on HYMO alterations and their significance from the ISRBC templates and DanubeGIS database (most recent national data).

Since national data have been provided in different scales or have not been provided at all, analyses below give general overview of the listed HYMO components and future infrastructure projects. Detailed analyses should be done in the next phase (e.g. the *Sava RB Management Plan*) when data from all countries are collected in the same scale.

Additionally, information on future infrastructure projects are also based on the related presentations delivered at the HYMO Workshop organized by the ISRBC (Zagreb, March 23, 2009).

1.3.3.1. Methodology per country

Bosnia and Herzegovina – see under paragraph 1.3.2.1.

[3] Hydrological alterations provoke changes in the quantity and conditions of flow.

Croatia

Assessment of risks that water bodies will not be able to achieve environmental objectives specified in the WFD due to anthropogenic alterations has an important role in the characterization of heavily modified surface water bodies.

The analysis of pressures and impacts has to be made:

- by indirect measuring of the impact on the sites where appropriate monitoring is provided, and
- by assessing the likely impacts of the known pressures.

At those sites at which the morphology of a water body is subject to several pressures, their joint impact shall be considered.

The WFD regards hydromorphological elements as support to biological elements. Essential hydromorphological elements are defined for rivers, lakes, transitional waters and coastal waters (Annex V of the WFD). For rivers, these are the quantity and dynamics of water flow, connection to groundwater bodies, river continuity, river depth and width variations, structure and substrate of the river bed, and structure of the riparian zone.

Human impact on freshwater ecosystems has been very marked in the last one hundred years or so. Its consequences are very often, not treated appropriately, or even underestimated. In Croatia, similar to European Union and the Danube countries, data on impacts of hydromorphological alterations, and for rare sections of rivers and lakes is very limited. Furthermore, the ways for describing and assessing the hydromorphological alterations have not been elaborated enough to fully meet the need of this analysis. Additionally, the interaction between individual morphological factors and ecosystems is often difficult to understand. There are, thus, some 350 criteria for the characterization and quantification of anthropogenic hydromorphological impacts on fish. It is for that reason that large part of the characterization of impacts of individual morphological pressures on ecosystems (biological elements) has to rely on expert judgment.

It cannot, therefore, be expected that the analysis of morphological pressures and impacts will be based on complex models which will fully describe the behaviour of ecosystems. Such approach may be justified in a small number of special cases if the analysis is supported by research results and observations. However, in most cases this analysis will be based on less demanding methods, which do not require large amounts of data and will be improved and upgraded as the knowledge on the behavior of the ecosystem broadens and the targeted collection of data on watercourse hydromorphology broadens.

The applied method has been adapted to the present status, which is most often characterized by insufficient knowledge of interrelation between individual morphological factors and ecosystems, and lack of precise data on morphological alterations. It is for that reason that the methodological framework has been structured in such a way to be comprehensive and adaptable, i.e. to enable simple inclusion of new knowledge of various complexity.

It would be advisable to initiate basic research which would improve the knowledge on the impact of hydromorphological alterations on ecosystems and reduce the share of currently prevailing expert judgment.

Serbia

Hydromorphological pressures and related risk analyses provided by Serbia were based on findings of the ICPDR HYMO Task Group.

The HYMO pressure/impact analysis focuses on three hydrological pressure types:

- Impoundment (alteration/reduction in flow velocity),
- Water abstraction (alteration in quantity of discharge/flow in the river),
- Hydropeaking (alteration of flow dynamics/discharge pattern in the river).

Criteria, as given by the HYMO TG, are as follows:

- impoundment length during low flow conditions is longer than 1 km;

- flow below dam is less than 50% of mean annual minimum flow of a specific time period (comparable with Q_{95});
- water level fluctuation is higher than 1 m /day.

Slovenia

Considering the hydromorphological elements defined in the EU *Water Framework Directive*, i.e. hydrological regime, river continuity and morphological conditions, different related pressures that are causing impacts on hydromorphological state were recognized in Slovenia. Analysis of hydromorphological pressures was treated separately for morphological and hydrological pressures. Since the impact of each hydromorphological pressure on biological elements and consequently ecological status is not yet defined, the criteria for significant pressures were prepared on the expert judgment. The magnitude of the negative impact of each pressure and combination of different pressures defines result of the hydromorphological risk assessment.

Pressures were collected from various databases (e.g. concessions and water rights for water use), expert evidences (e.g. list of large dams), researches (e.g. degree of modifications of river morphology) and expert knowledge based on field investigations.

1.3.3.2. Longitudinal continuity and habitat interruption

Criteria for longitudinal continuity and habitat interruptions (dams, weirs, ramps, sills, etc.) were defined at the ICPDR level. The same criteria were adopted for both Danube and sub-basin (Sava) level as listed below:

- for rithral rivers height > 0.7 m,
- for potamal rivers height > 0.3 m.

Sava riparian countries mostly provided data on large dams for the DanubeGIS. Data were reported in different scales, so that there are structures reported by Slovenia not only for the Sava RBA relevant rivers but also on other (minor) rivers. At the same time, Croatia and Bosnia and Herzegovina reported the data on structures built on rivers with catchment area larger than 4,000 km^2.

Based on the DanubeGIS data collection, Figure II-16 presents information on longitudinal continuity interruptions in the Sava River Basin.

The course of the Sava River is interrupted by 5 existing hydropower dams in Slovenia (Moste, Mavčiče, Medvode, Vrhovo, and Boštanj), also used for flood defense. These dams disrupt the longitudinal continuum of sediment transport, as well as migration of aquatic organisms (only the HPP Boštanj is equipped with fish migration aid). Downstream reaches of the Sava River are free-flowing.

Significant number of hydropower dams is also present in the Drina River sub-basin. Chain of dams on the Drina River consists of large dams Višegrad (BA), Bajina Bašta and Zvornik (RS). Zvornik dam is the only one equipped with fish migration aid, but its performance should be monitored. Hydropower dams are also built on the Lim and Uvac Rivers in RS, as well on the Piva River in Montenegro (Mratinje).

Slovenia reported 13 structures located on tributaries. Hydropower use is specified only for Zavrsnisko jezero, while the others have multipurpose use. Ten of those structures are equipped with functional fish migration aid.

Croatia reported one hydropower dam located on the Kupa River (HPP Ozalj).

Beside the Višegrad dam on the Drina River, **Bosnia and Herzegovina** delivered data on two dams on the Vrbas River. Both are aimed for hydropower production, while one is also used for flood protection and the other for urbanization.

Serbia reported not only dams, but also sills and weirs. Beside hydropower dams in the Drina River Basin, there is one sill on the Kolubara River used for water supply of the thermal power plant and a weir on the Bosut River. None of those structures is equipped with fish migration aids, but it is planned for the Kolubara sill.

Figure II-16: Overview of the longitudinal continuity interruptions in the Sava River Basin

Two significant structures located in Montenegro have been included in the Report (Mratinje and Otilovići dams).

1.3.3.3. Lateral connectivity interruption

Based on the ICPDR criteria, the lateral connectivity interruptions are presented by disconnected wetlands and former floodplains with potential for reconnection with area larger than 100 ha. Only Serbia uploaded data to the DanubeGIS (Obedska bara wetland). Other countries reported that they have no data relevant for these criteria or they did not deliver data on lateral continuity interruptions. Therefore, this dataset should be considered in the next phase of the Sava RB reporting (i.e. the *Sava RB Management Plan*) together with idea to change criteria for collection of this kind of data in order to match the Sava RB Analysis needs.

Considerations below give the general overview of the floodplains in the Sava RB.

Presently, the middle course of the Sava River, downstream of Zagreb, is characterized by a large-scale morphological floodplain. These include not only the Sava River, but also smaller waters flowing parallel to the Sava River. The large areas are used as polders and may be subject to controlled or natural flooding. Further, broad former floodplain areas may be found downstream, even though they are subject to a more or less intensive anthropogenic use. Other large-scale floodplains may be found in the Drina mouth area and along the RS section.

The main causes of reduction of wetland areas have been the expansion of agriculture uses and river engineering works mainly for flood control. In the large plains of the lower-middle and lower Sava an extensive flood protection systems and drainage networks were built up, and have caused a loss of wetlands.

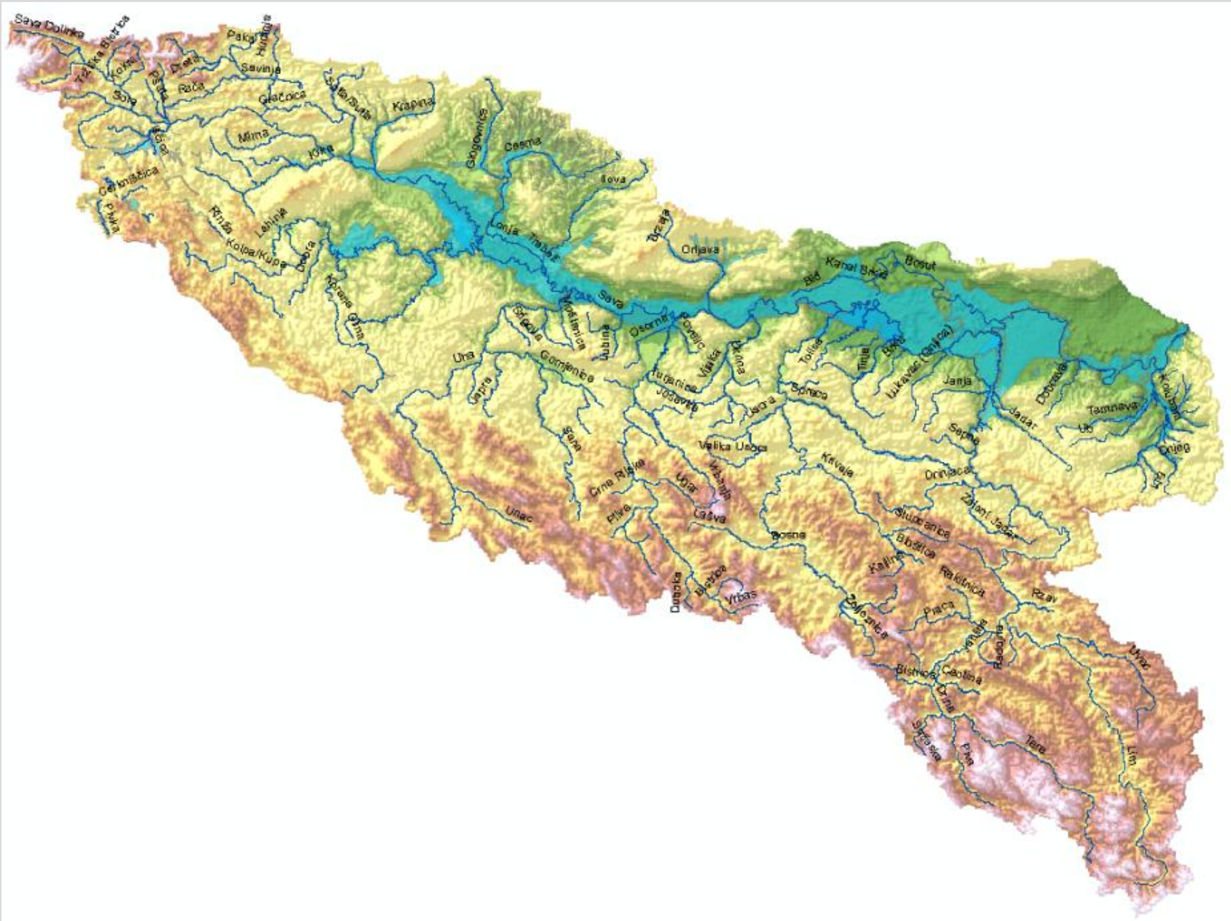


Figure II-17: Major floodplains in the Sava River Basin

Floodplains along main right tributaries of the Sava River are much smaller, due to specific topography. Left tributaries are flowing through lowlands.

1.3.3.4. Hydrological alterations

Hydropower generation, agriculture and industry can be identified as the main drivers causing hydrological alterations in the Sava River Basin. Water abstraction from rivers corresponds with many anthropogenic purposes and uses. For instance, water is being abstracted to supply drinking water, generate energy, to irrigate agricultural areas or to provide water for industrial processes.

The pressure/impact analysis focuses on three hydrological pressure types, which provoke specific hydrological alterations in rivers and that may impact the water status. In order to assess the significance of those pressures on water status, criteria have been established at the Danube level (also summarized in Table II-23).

Data on hydrological alterations were collected in HydroAlt template (DanubeGIS database). Data are available for SI and RS only, so the respective analyses are not possible at the Sava RB level.

Slovenia reported 18 hydrological alterations affecting 14 water bodies on the Sava River and tributaries. All reported hydro-alterations relate to all three pressures (impoundment, water abstraction and hydropeaking).

There are 8 hydrological alterations in Serbia - one on the Sava River (impoundment by the Iron Gate I reservoir) and others on tributaries.

Table II-23: Hydrological pressure types, provoked alterations and criteria for the pressure/impact assessment in the Sava RB

Hydrological pressure	Provoked alteration	Criteria for pressure assessment
Impoundment	Alteration/reduction in flow velocity of the river	Impoundment length during low flow conditions > 1 km
Water abstraction/ Residual water	Alteration in quantity of discharge/flow in the river	Flow below dam < 50% of mean annual minimum flow of a specific time period (comparable with Q_{95})
Hydropeaking	Alteration of flow dynamics/discharge pattern in the river	Water level fluctuation > 1m /day

1.3.3.5. Future infrastructure projects

In addition to the present degradation of the Sava River and its tributaries caused by existing hydromorphological alterations, a number of future infrastructure projects (FIP) are at different stages of planning and preparation. Those projects may provoke significant HYMO pressures on water status, as described above.

Based on the DanubeGIS data collection, information on future infrastructure projects is available only for Slovenia. That is most likely due to the fact that selection of the FIPs to be uploaded into the DanubeGIS should meet criteria as given below:

- Strategic Environmental Assessment (SEA) and/or Environmental Impact Assessments (EIA) are performed and
- transboundary effects are provoked.

Information on FIPs in each country was provided by representatives of different sectors on the HYMO Consultation Workshop (Zagreb, March 23, 2009). Mostly hydropower projects were considered by countries, while navigation issues were provided by the ISRBC representative.

Two dams with main purpose of hydropower production (Brežice and Mokrice) and also flood protection are planned in **Slovenia.** Both projects affect the Sava River. Strategic environmental assessment is already performed for both projects, while EIA is intended to be done. Both projects are under preparation and will probably have transboundary impact.

There are no official plans for FIP in **Croatia**. Although some studies on flood protection of the Sava River exist, their findings should not be taken as FIP at the moment.

Information for **Bosnia and Herzegovina** is available separately for countries' entities and those refer to the hydropower production projects only.

There is a decision on building of 4 HPPs on the Bosna, Drina, Unac and Vrbas Rivers in the **Federation of Bosnia and Herzegovina** in next 5 – 6 years. About 10 future HPPs are also under consideration as the „A" priority (Rivers Sana, Bosna, Vrbas, Drina, Una, Bioštica – Krivaja, Ugar). There are also 7 projects as the „B" priority but they can not be appointed as FIP in near future. Some transboundary projects with Serbia and Croatia are also considered but only as the initiative since bilateral agreements need to be made. At the same time, concession for 202 small hydropower plants is already issued in BA Federation.

Information on FIPs in the Republika Srpska is given by sub-catchments and river stretches. Designs for 3 HPPs planned on the upper flow of the Drina River and one on the Lim River are already prepared and included in spatial plans. Some HPPs on the middle and lower flow of the Drina River (common river section with Serbia) were also considered, but not in near future. Planning documents comprise two HPPs in the middle flow of the Vrbas River. Concessions are issued for 7 planned HPPs on the Bosna River. Some considerations related to HPP on the Una River were made in previous planning documents, but are not relevant any more.

Although there is none official information on FIPs in **Serbia**, remarkable but unexploited hydro-potential of the Drina River was appointed together with the fact that future development depends on harmonization of interests of different stakeholders.

Navigation issues comprise rehabilitation of the Sava River Waterway. This activity is recognized by the ISRBC as the priority and a feasibility study was performed in 2008. A multifunctional approach was used taking into account not only transport but also leisure, water management and environment. Basic documents (reviews) for EIA report were carried out, including proposal of environment protection measures, environmental monitoring program and evaluation of costs for environmental protection.

1.3.4. Other significant anthropogenic pressures

1.3.4.1. Accidental pollution

Croatia

In Croatia, some accidental pollution was caused by discharges from farming facilities and pre-treatment plants; by failures on drainage systems and treatment plants; traffic accidents with leakage of liquid fuel and other dangerous substances; damage to industrial facilities; irresponsible disposal of dangerous and harmful substances; bursting of supply lines; damage to storehouses (oil/oil derivatives leaking from fuel tanks, and other dangerous substances).

At times of low flows, the ecological function of water may be put at risk by larger polluters discharging wastewater into a watercourse. For such cases, measures of strengthened supervision at discharge points are provided and the discharge of technological wastewater is limited.

The problems arising in the process are the lack of data on current monitoring for all new requirements set by the WFD.

Slovenia

In Slovenia the evaluation of potential for accidental pollution of surface waters focussed on two major areas: traffic and point sources pollution. Traffic accidents represent the possibility of accidental pollution by leakage of dangerous substance. Because of that the proximity of roads and railway tracks were considered. The analysis showed that a possibility of accidental pollution from roads accidents is present on 85 % of surface waters and that 41 % of surface waters in the Sava River Basin is potentially at threat due to potential accidental pollution from railway accidents.

The accidental pollution can also originate from point sources because leakages from inappropriate disposal of different hazardous substances and from damaged industrial facilities and storehouses. Point sources, considered in the analysis, were evaluated as minor, major or other potential sources of accidental pollution on basis of the chemical properties and quantity of present hazardous material as well as the proximity to the specific water body. The analysis showed that possibility of major accidental pollution from point sources exists on 18 % of surface waters in the Sava River Basin.

BA and **RS** have not submitted any data.

1.3.4.2. Invasive species

Bosnia and Herzegovina

Monitoring of invasive species has not yet been provided systematically in Bosnia and Herzegovina. Damages caused by these species to autochtonous ichtio/fish-fauna of the country are difficult to be assessed in quantitative sense.

Ichtyologists are especially worried about the impact of invasive species in rivers of the Sava River Basin, where live numerous endemic fish species. Some species are introduced accidentally, and some were introduced for fish-stocking.

Table II-24: Alochtonic species of fish and their distribution in BA

River basin / Species	Vrbas River Basin	Bosna River Basin	Drina River Basin	Una and Sana River Basins	Ukrina River Basin	Sava River Basin	Tinja River Basin
Oncorhynchus mykiss	x	x	x	x			
Salvelinus fontinalis	x	x					
Salvelinus alpinus	x		x				
Carassius auratus gibelio						x	
Carassius auratus auratus						x	
Hypophthalmichthys molitrix	x						
Pseudorasbora parva					x		
Ctenopharyngodon idella	x	x	x	x	x	x	x
Ameiurus nebulosus	x	x	x	x	x	x	
Lepomis gibossus	x	x		x	x	x	
Total	7	5	4	4	4	5	1

Croatia

Some invasive alohton species which cause harm to land and water eco-systems by damaging biologic diversity, have been noticed in the Sava River Basin. Monitoring of invasive species has not yet been provided systematically.

Serbia

In Serbia the need for alien species monitoring and management has been underlined in the *National Water Quality Monitoring Strategy*. It stressed that the monitoring of Aquatic Invasive Species (AIS) has to be incorporated in routine monitoring scheme. In 2007, the *Action plan for control of introduction, monitoring and moderation of the influence of alien invasive species* has been proposed. The document is dealing, generaly, with alien invasive species, but significant part of the Action plan comprises the discussion on AIS. The preliminary list of AIS has beed presented, together with main vectors of introduction and proposal of further steps aiming to manage AIS.

The Sava River is under significant pressure of AIS in its lower part. Among other species, macroinvertebrates *Anodonta woodiana*, *Corbicula fluminea* (Mollusca: Bivalvia), *Orconectes limosus* (Crustacea: Decapoda) were underlined as the most prospectiveividers. Beside, *Branchyura sowerbyi* (Annelida: Oligochaeta), *Hypania invalida* (Annelida: Polychaeta), as well as several species of Amphipods were found with considerable population densities.

The investigated lower stretch of the Sava River (to rkm 206) could be characterised as the sector with high level of „biological contamination" (contamination with AIS), having the value 4 of the site-specific biocontamination index (maximal value, highest contamination).

According to the investigation performed within the national JDS 2 program (Joint Danube Survey 2 National Program, 2007, supported by Directorate for Waters, Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia), a bit better situation has been evaluated based on fish community, having the value 3 of the site-specific biocontamination index.

Slovenia

In Slovenia, an inventory of non native species in surface waters was build up, but no evaluation of the significance/importance of this kind of pressure to the rest of the ecosystem was performed.

1.4. Assessment of impacts in the Sava River Basin

1.4.1. Impacts on rivers

For the risk assessment status in the Sava River and its tributaries, following impacts have been considered:

- Impacts from organic pollution;
- Impacts from hazardous substances pollution;
- Impacts from nutrient loads;
- Impacts on rivers caused by hydromorphological alterations;
- Impacts from other pollution sources.

Bosnia and Herzegovina

Risk assessment in Federation of BA has not been performed yet. BA RS – no data submitted.

Croatia

Impact assessment, i.e. assessment of status in relation to pressures from water pollution was carried out for all segments of the watercourse and for all relevant chemical elements (BOD_5, COD-Mn, total N, total P). The calculation was made for mean load values and average flows.

The relevant values of chemical parameters were identified at monitoring stations on the basis of the measured data. The relevant values of the masses of individual chemical parameters were balanced on subwatersheds between the monitoring stations.

Based on hydromorphological quality elements and their description in the WFD, eight parameters were used for the characterisation of hydromorphological status.

The assessment was made for river segments with average length of 200 m.

For the assesment of impacts from organic pollution, the relevant values of chemical parameters were identified at monitoring stations on basis of the measured data. The relevant values of the masses of individual chemical parameters were balanced on subwatersheds between the monitoring stations. The difference between the sum of entries (inflow of masses from the upstream subwatersheds – monitoring stations at the upstream parts of the subwatershed) and inputs (identified pressures in the subwatersheds) and outputs (familiar relevant masses at monitoring station on the downstream part of the subwatershed) was balanced on entire subwatershed by a coefficient analogous to a continuous portion of decomposition of organic matter in the watercourse by means of simple exponential equation:

$$\frac{dL_t}{L_t} = -Kdt$$

where:

L_t – remnant of the undecomposed organic matter;

K – continuous portion of decomposition of organic matter in the watercourse.

The relevant spread of masses was calculated for each segment of the watercourse on the subwatershed on basis of the entries and inputs and the balancing coefficient. The relevant concentration was defined on the basis of the mean flow estimated for each segment of the watercourse.

To assess the impact of nutrient loads, the quantities of phosphorus used in Croatia for fertilization of agricultural land, and respectve chemical characteristics of soils should be considered. As a result, it can be concluded that the risk of harmful impact of phosphorus from the applied fertilizers in Croatia is very low. Certain problems may arise if a larger quantity of organic matter is discharged directly into the watercourses, but that is not a problem related to fertilization of agricultural land.

It is difficult to estimate the share of agriculture in the total phosphorus load to watercourses. According to the phosphorus balance for Croatia, it can be assumed that agriculture as a source of phosphorus pollution is a factor of secondary importance.

According to the study *Impact assessment of the spread of organic and mineral fertilizers on the pollution of surface water and groundwater in Croatia*, prepared by the Faculty of Agriculture of the University of Zagreb, the balance of nitrogen and phosphorous is expressed in tonnes per a unit of agricultural area for each county. Since agricultural areas include both, arable land and pastures, it was necessary to define the input of nutrients for each of the categories separately.

The results from the mentioned Study cannot be used for an exact and more detailed analysis of pressures from agriculture, since various categories of agricultural land are unevenly distributed, so the obtained results would not be realistic. That is why the methodology for calculating the pollution load from agricultural areas applied in the Iskar pilot project developed by the Bulgarian Ministry of Environment and Water was used.

Table II-25: Croatian unit emission values for nutrients and different land use types

Categories of agricultural areas	Total phosphorus (kg/ha/year)	Total nitrogen (kg/ha/year)
1 – Urban areas	1.0	6.6
2 – Crops	1.0	8.0
3 – Pastures	0.1	2.2
4 – Forests	0.06	1.1
5 – Other	0.0	0.0

Based on hydromorphological quality elements and their description in the WFD, eight parameters were used for the characterization of hydromorphological status.

The types of river sections were grouped into three categories based mostly on the types of the present fish species. Assessment was made for river sections of the average length of 200 m.

The mean weighting value was calculated for each hydromorphological parameter based on the pressure value for each river section. The mean weighting value was calculated on basis of length of the section under impact of a certain pressure.

This approach may be presented by following formula:

$$R_i = o_i \frac{\sum l_p u_p}{\sum l}$$

where:

R_i - risk for a river section, which cannot achieve good ecological status due to alterations of the hydromorphological parameter i,
o_i - ecosystem sensitivity due to changes of the hydromorphological parameter i,
u_p - impact of pressure p on the hydromorphological parameter i,
l_p - length of the section under impact of the specific pressure p,
l - total length of the river section.

The total risk of a river section, which cannot achieve good ecological status, equals to the maximum risk of eight hydromorphological parameters:

$$R = \max(R_i)$$

where:

R – total risk,
R_i – risk for the hydromorphological parameter i.

Serbia

Emission impact assessment analysis has been elaborated according to estimation of surface water quality status due to lack of measurement data. Water quality has been defined considering the RHMSS (Republic Hydrometeorological Service of Serbia) data for the reference monitoring stations for year 2004. Only for Kolubara Basin, the DPSIR methodology has been implemented according to the Sava CARDS project requirement.

Serbia has included 25 water bodies in the risk assessment analysis, 3 of them are in the Sava River and 22 in the Sava tributaries.

Slovenia

For the assessment of impact, the data on physico-chemical and biological status of the water bodies have been evaluated. Furthermore, the impact of hydromorphological alterations has also been assessed.

To evaluate impacts from organic pollution**,** the parameters BOD_5 and Saprobic index have been considered.

To evaluate impacts from hazardous substances**,** the pollution parameters measured in the national monitoring program have been considered. For these parameters, limit values for good / moderate status have been already established and validated in the intercalibration process, and used in the impact and risk assessment.

To evaluate impacts from nutrient loads, the parameters nitrate, nitrite, ammonium and total phosphorous have been considered. Limit values for these parameters have been decided on the expert judgment.

Impact of each significant pressure by hydromorphological alterations has been defined on the basis of the expert judgment. For final impact assessment, a number of significant pressures present on each water body and impact of interaction between different significant pressures have been considered.

In the analysis of impacts from other pollution sources, potential to accidental spills has been valuated. The results have been included in the refinement of the first risk assessment analysis.

Slovenia has included 27 water bodies in the risk assessment, 12 water bodies are on the Sava River out of which 7 water bodies are at risk not to achieve good ecological or chemical status. 15 water bodies are tributaries to the Sava River and 7 of these are evaluated at risk not to achieve good ecological or chemical status as defined by the WFD.

1.4.2. Impacts on lakes

Only Slovenia has provided some information on approach to impact assessment for lakes, though the lakes are below the threshold criterion of 50 km^2. However, for further refinement of this analysis the information was included in this report.

For methodological issues, the corresponding chapter Impacts on rivers could be referred.

Following hydromorphological elements have been included in the assessment: overgrowth of lake bed, structure of lake shore, riparian zone structure and land-use, adjacent land-use. The importance of each alteration was defined on basis of different weight. Modified weighted mean was calculated as final impact score.

1.5. Identification of AWBs and provisional identification of heavily modified water bodies

According to Article 2(8) of the EU WFD, „'Artificial water body' means a body of surface water created by human activity".

According to Article 2(9) of the EU WFD, „'Heavily modified water body' means a body of surface water which, as a result of physical alterations by human activity, is substantially changed in character, as designated by the Member State in accordance with the provisions of Annex II".

1.5.1. Methodology

Bosnia and Herzegovina

Methodology for preliminary designation of HMWB's is adjusted to regulations of the WFD (Annex II), which include the description of significant changes in hydromorphology (Annex II, 1.4) and the assessment whether these changes will have influence the achievement or non-achievement of good ecological status of the water body (Annex II, 1.5). In this context, the four basic criteria are used for provisional selection of the HMWB's (section) and those are:

- Minimum of 70 % of the section should show significant physical alterations and hydromorphological impacts, so that it can be regarded as heavily modified.
- One or more of the below listed water users whose manner of use is causing significant hydromorphological alterations should exist on the considered length of the section:
    - hydro-power,
    - navigation,
    - flood protection, and
    - urbanization.
- One or more of the following significant physical alterations (pressures) should be present:
    - dams/weirs,
    - channelling/straightening,
    - bank reinforcement/ fixation.
- These physical alterations are the consequence of the types of water use related to the use of above mentioned criteria.
- It should be concluded, based on the expert judgement, that the section, due to the mentioned hydro-morphological alterations, is at risk not to achieve the good ecological status. According to the WFD, this expert judgement should use an indirect criteria, based on physical parameters.

These criteria which, therefore, are taking into account the impacts of the main hydromorphological pressures in the river basin, are the following:

- non passable obstacles (weirs/dams) for migratory species,
- change of water category (e.g. change of river to dammed reservoir),
- impoundment with significant reduction of water flow,
- disruption of lateral connectivity, and
- other criteria, which need to be specified.

Croatia

In case of artificial (AWB) or heavily modified surface water bodies (HMWB), identification was made according to the characteristics of surface water categories which mostly correspond to the description of the said AWBs or HMWBs.

For each surface water body type, the type-specific hydromorphological and physico-chemical conditions, representing the values of the hydromorphological and physico-chemical quality elements specified for that surface water body type at high ecological status, shall be established. Type-specific biological reference conditions representing the values of the biological quality elements specified for that surface water body type at high ecological status shall be established as well. In applying these procedures to the HMWBs or AWBs references to high ecological status shall be construed as a references to maximum ecological potential. The values for maximum ecological potential for a water body shall be reviewed every six years.

A more detailed description of the principles behind the characterisation of the HMWBs is based on the CIS Guidance document No.4, *Identification and Designation of Heavily Modified and Artificial Water Bodies*.

To date, the common methodology for and criteria for designation of the heavily modified water bodies which could be directly applicable in practice has not beem defined on the EU level. In Croatia there is no official and precise methodology for designation of the heavily modified water bodies, which has disabled their designation in this moment due to incomplete data on morphological changes and their influence to environment.

Having that in mind, following two approaches will be used in identification of the heavily modified water bodies:

- For large structures, the individual analyses related to temporary identification of the heavily modified water bodies will be conducted.
- For smaller morphological changes, several criteria to enable pragmatic evaluation of their influence to achievement of good ecological status will be defined, paying attention to cummulative influence of several abstractions.

Problems in temporary identification of the heavily modified water bodies and especially in defining of the criteria are:

- lack of data on hydromorphological changes,
- lack of data on interaction between hydromorphology and ecosystem, or problems in quantification of influence of hydromorphological changes to ecosystems,
- insufficiency of the results of the existing biological monitoring for new requirements established by the WFD,
- consensus on biological criteria at EU level.

Serbia

Activities on the HMWB provisional identification in Serbia were primarily based on the relevant CIS Guidance Paper (CIS Guidance No.4, *Identification and Designation of Heavily Modified and Artificial Water Bodies*).

Specific criteria for the HMWBs identification at national level have not been defined so far. The HMWB identification process was mostly based on the expert judgment. It was considered that the following conditions should be simultaneously fulfilled:

- Certain use of water should be present: water supply, hydro-power production, flood protection, urbanization, dredging or exploitation of material from the river bottom, etc.
- As a result of the said uses, there are structures on the water body which cause significant physical changes (dams, dikes, embankments, etc.);

Mentioned criteria were also used as criteria for the WBs delineation on national level (e.g. reservoirs, long river stretches with both side dikes, etc.).

For purpose of the first draft of the *Danube RBMP*, as well as for the Sava RB Analysis, Serbia applied the criteria for the HMWB provisional identification set by the ICPDR HYMO Task group:

- water body is significantly physically altered (not only in hydrology, but also in morphology) – this has lead to change in character: the alteration is profound, widespread and permanent (according to the HMWB-guidance) and
- water body is failing the good ecological status – this has to be proven with high confidence (the biological monitoring result is based on the WFD compliant assessment method).

Slovenia

Criteria for selecting the artificial water bodies (AWBs):

- artificial water body means a body of surface water created by human activity,
- artificial channels longer than 3 km,

- artificial lakes and accumulations with surface area greater than 0.5 km^2.

Criteria for selecting a provisionally identified HMWB:

- water bodies with catchments area greater than 100 km^2,
- accumulations and artificial lakes on rivers with water surface area grater than 0.5 km^2,
- significant hydromorphological changes on surface waters or on part of surface waters,
- significant anthropogenic changes or hydromorphological elements of surface waters or part of surface waters.

The selection of a provisionally identified HWMB has been based on different specific uses that are causing significant hydromorphological changes. Such uses are:

- hydropower production,
- flood protection,
- navigation,
- urbanization,
- water supply,
- irrigation.

Significant physical alterations on the surface water bodies are weirs, dams, port facilities and canalisation that are causing disruption of river continuum, altered hydraulic, hydrological and morphological conditions.

In conclusion, these are affecting the biological quality elements, physicochemical quality elements and hydromorphological quality elements.

1.5.2. Identification of AWBs

Bosnia and Herzegovina

Identification of artificial water bodies is a part of characterization of the areas defined in Annex II of the WFD. There are no significant artificial water bodies in the Sava River Basin section in BA, and especially not those that could influence the regime of international waters.

Namely, most of the artificial water bodies are newly built canals in hydro-melioration cassettes in immediate Sava River Basin as well as some constructions that are used as intake facilities to bring water from the river into hydropower facility (River Vrbas – HPP Jajce II tunnel). These artificial water bodies will be subject to more detailed consideration in further phases of the project development.

Table II-26: AWBs in Bosnia and Herzegovina

Code of HMWB	Name	Length [km]	Main uses	Remarks
BA_A_DRI_1	Drina-Dasnica	32	Irrigation	
BA_A_VRB_1	Intake tunnel from reservoir to HE Jajce II	4	Hydropower	
BA_A_VRB_2	Channel system in downstream part of Vrbas		Flood protection	

Croatia – no AWBs

Serbia – no AWBs

Slovenia

Table II-27: AWBs in Slovenia

Code of AWB	Name	Length [km]	Main uses	Remarks
SI14912VT	Gruberjev prekop	3.23 km	Flood protection Urbanisation	
SI624VT	Velenjsko jezero	/	Mining	Secondary use is also tourism

Remark: Artificial water bodies Gruberjev prekop (Tributary: Ljubljanica River) and Velenjsko jezero (Tributary: Paka River) are located on the Sava River tributaries.

1.5.3. Identification of HMWBs on the Sava River

Bosnia and Herzegovina – Provisionally identified HMWBs

Table II-28: Description of the heavily modified water bodies for the Sava River in BA

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
BA_SA_1		Navigation Flood protection Urbanization	Bank reinforcement/ fixation	Gravel exploitation	
BA_SA_2		Navigation Flood protection Urbanization	Bank reinforcement/ fixation	Gravel exploitation	
BA_SA_3		Navigation Flood protection Urbanization	Bank reinforcement/ fixation	Gravel exploitation	

Croatia – Provisionally identified HMWBs

Table II-29: Description of the heavily modified water bodies for the Sava River in HR

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
KRA_T0001 Sava 001	Sava	flood protection urbanization	bank reinforcement / fixation dikes	flood protection urbanization	flood protection urbanization
KUP_T0001 Sava	Sava	flood protection urbanization navigation	bank reinforcement / fixation dikes	flood protection urbanization dredging	flood protection urbanization dredging

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
CES_T0001 Sava	Sava	flood protection navigation urbanization	bank reinforcement / fixation dikes	flood protection dredging urbanization	flood protection dredging urbanization
ILO_T0001 Sava	Sava	flood protection navigation urbanization	bank reinforcement / fixation dikes	flood protection dredging urbanization	flood protection dredging urbanization
STR_T0001 Sava	Sava	flood protection navigation urbanization	bank reinforcement / fixation dikes	flood protection dredging urbanization	flood protection dredging urbanization
BID_T0002 Sava 002	Sava	flood protection navigation urbanization	bank reinforcement / fixation dikes	flood protection dredging urbanization	flood protection dredging urbanization
BID_T0001 Sava 001	Sava	flood protection navigation urbanization	bank reinforcement / fixation dikes	flood protection dredging urbanization	flood protection dredging urbanization

Serbia – Provisionally identified HMWBs

Table II-30: Description of the heavily modified water bodies for the Sava River in RS

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgments used
RS_T_SA_1		Hydropower (impoundment by the Danube Iron Gate 1 reservoir, navigation, flood protection, urbanisation	Bank reinforcement/ fixation, both side levees	Change of water category (impoundment)	HPNS Iron Gate I reservoir; flood control dikes on both banks; and many reaches with bank reinforcement.

Slovenia

Table II-31: Description of the heavily modified water bodies for the Sava River in SI

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
SI111VT7	Retention basin HE Moste	Hydro-power Flood protection	Dams / weirs	Non-passable obstacles (weirs/dams) for migratory species Change of the water category (e.g. change of river to dammed reservoir) Sedimentation (silt and gravel)	Hydropower and flood protection as anthropogenic uses have impacts on migratory species. Another reason of failing to achieve the GES due to changes in hydromorphology is change of the water category.
SI1VT170	Sava Mavčiče - Medvode	Hydro-power Flood protection	Dams / weirs	Non-passable obstacles (weirs/dams) for migratory species Change of the water category (e.g. change of river to dammed reservoir) Sedimentation (silt and gravel)	Hydropower and flood protection as anthropogenic uses have impacts on migratory species. Another reason of failing to achieve the GES due to changes in hydromorphology is change of the water category
SI1VT713	Sava Vrhovo Boštanj	Hydro-power Flood protection	Dams / weirs	Non-passable obstacles (weirs/dams) for migratory species Change of the water category (e.g. change of river to dammed reservoir) Sedimentation (silt and gravel)	Hydropower and flood protection as anthropogenic uses have impacts on migratory species. Another reason of failing to achieve the GES due to changes in hydromorphology is change of the water category

1.5.4. Identification of HMWBs on the Sava tributaries

Bosnia and Herzegovina – provisionally identified HMWBs

Table II-32: Description of the heavily modified water bodies for the Sava tributaries in BA

Code of HMWB	River name	Geographical description	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)
BA_DR_1	Drina	Podrinje	Hydropower-planned Flood protection	Dams/weirs Bank rein-forcement	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_2	Drina	HPP Zvornik	Hydropower Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_3	Drina	HPP Tegare	Hydropower-planned Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_4	Drina	HPP B.Bašta	Hydropower Flood protection	Dams/weirs Bank rein-forcement	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_5	Drina	HPP Višegrad	Hydropower Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_6	Drina	HPP Goražde HPP Ustikol.	Hydropower-planned Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_DR_7	Drina	HPP Foča HPP B.Bijela	Hydropower-planned Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)

Code of HMWB	River name	Geographical description	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)
BA_LIM_1	Lim	HPP Mrsovo	Hydropower-planned Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_BOS_1	Bosna	Šamac-Doboj	Hydropower-planned Flood protection	Dams/weirs Bank rein-forcement	Impoundment with significant reduction of water flow
BA_VRB_1	Vrbas	Vrbas donji tok	Hydropower-planned Flood protection	Bank rein-forcement	
BA_VRB_2	Vrbas	B.Luka Novoselija	Hydropower-planned Urbanization	Dams/weirs Channelisa-tion Bank rein-forcement	Impoundment with significant reduction of water flow Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_VRB_3	Vrbas	HPP B Niska HPP Krupa	Hydropower-planned Flood protection	Dams/weirs	Change of the water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_VRB_4	Vrbas	HPP Bočac	Hydropower- Flood protection	Dams/weirs	Change of water category Changed discharge (effects caused by hydropeaking or residual water discharge)
BA_VRB_5	Vrbas		Hydropower Urbanization	Dams/weirs	
BA_TIN_1	Tinja		Flood protection Urbanization	Channelisa-tion/straigh-tening Bank rein-forcement	Disruption of lateral connectivity
BA_TIN_2	Tinja		Flood protection	Channelisa-tion/straigh-tening Bank rein-forcement	
BA_TIN_3	Tinja		Flood protection Urbanization	Channelisa-tion/straigh-tening Bank rein-forcement	Change of the water category

Code of HMWB	River name	Geographical description	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)
BA_UKR_1	Ukrina		Flood protection Urbanization	Channelisa-tion/straigh-tening	Change of the water category Impoundment with significant reduction of water flow
BA_UNA_1		Una lower section			
BA_SANA_3	Sana		Hydropower Urbanization	Dams/weirs	Non-passable obstacles (weirs/dams) for migratory species Impoundment with significant reduction of water flow

Croatia – provisionally identified the HMWBs for the Sava tributaries

Table II-33: Description of the heavily modified water bodies for the Sava tributaries in HR

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
KRA_S0001 Vonarije	Sutla	flood protection urbanization	dam	change of the water category urbanization	change of the water category urbanization
KRA_T0003 Krapina 001	Krapina	flood protection urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization
CES_T0010 Glogovnica 002	Glogovnica	flood protection urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization
CES_T0009 Glogovnica 001	Glogovnica	flood protection urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization
CES_T0007 Česma 001	Česma	flood protection urbanization	dikes bank reinforcement / fixation	dikes bank reinforcement / fixation	dikes bank reinforcement / fixation

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
CES_T0005 Prelošćica 001	Česma	flood protection urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization
CES_T0002	Lonja	flood protection urbanization	dikes bank reinforcement / fixation channelling/ straightening urbanization weirs	dikes bank reinforcement / fixation channelling/ straightening urbanization weirs	dikes bank reinforcement / fixation channelling/ straightening urbanization weirs
ILO_T0002	Ilova	flood protection urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization
ORA_T0002 Orljava 002	Orljava	flood protection urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization
ORA_T0001 Orljava 001	Orljava	flood protection urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization	dikes bank reinforcement / fixation urbanization

Serbia – Provisionally identified HMWBs

Table II-34: Description of the heavily modified water bodies for the Sava tributaries in RS

Code of HMWB	River name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
RS_DR_2	Drina	Hydropower	Dams	Impoundment by the large dam Change of the water category	HPP Zvornik Reservoir
RS_DR_4	Drina	Hydropower	Dams	Impoundment by the large dam Change of the water category	HPP Bajina Bašta Reservoir
RS_LIM_3	Lim	Hydropower	Dam	Impoundment by the large dam Change of the water category	HPP Potpec Reservoir

Code of HMWB	River name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)	Description for expert judgment used
RS_UV_4	Uvac	Hydropower	Dam	Impoundment by the large dam Change of the water category	HPP Radoinja Reservoir
RS_UV_5	Uvac	Hydropower	Dam	Impoundment by the large dam Change of the water category	HPP Kokin Brod Reservoir
RS_UV_6	Uvac	Hydropower	Dam	Impoundment by the large dam Change of the water category	HPP Uvac Reservoir
RS_BOS	Bosut	Agriculture	Weirs	Impoundment with significant reduction of water flow	Impound-ment

Slovenia

Table II-35: Description of the heavily modified water bodies for the Sava tributaries in SI

Code of HMWB	Name	Main uses	Significant physical alteration	Reasons for risk to reach GES (expert judgment)
SI14VT93	Mestna Ljubljanica	Flood protection Urbanization	Channelisation/straightening Bank reinforcement/fixation	Disruption of lateral connectivity

1.5.5. Length of HMWBs in the Sava River Basin

Table II-36: Length and number of the HMWBs on the Sava River

Country	total length	length of HMWBs	Perc. of total length	total No of WBs	No of HMWBs	Perc. of total WBs
	km	km	%			%
BA	338.8	338.8	100.00	3	3	100.00
HR	512	498	97.27	8	7	87.50
RS	210	104.4	49.71	3	1	33.33
SI	220.76	40.93	18.54	12	3	25.00

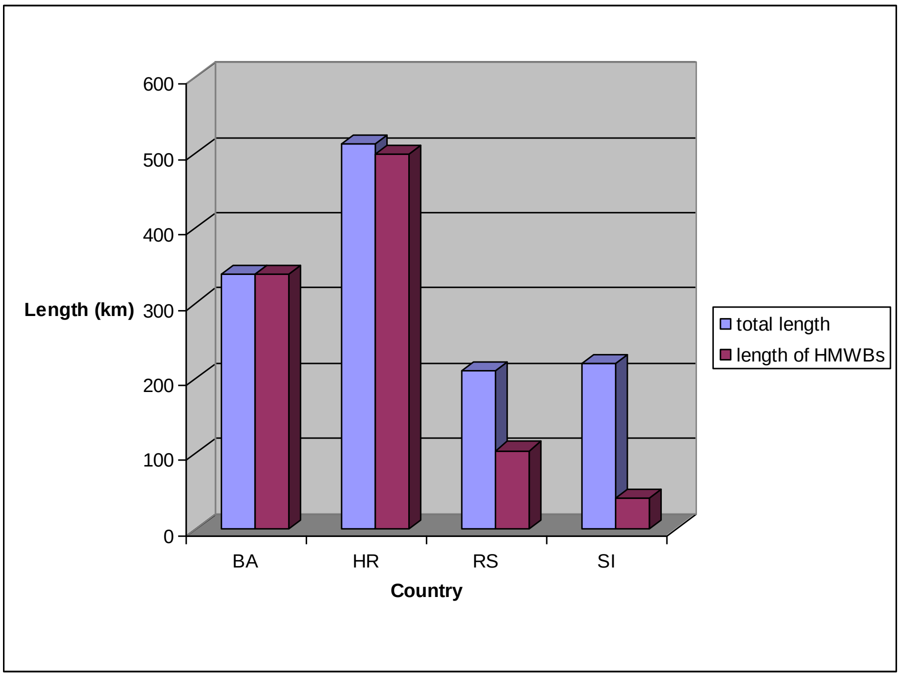


Figure II-18: Ratio between the total WBs length and the HMWBs length on the Sava River

Table II-37: Length and number of provisional HMWBs on the Sava tributaries

Country	total length	length of HMWBs	Perc. of total length	total No of WBs	No of HMWBs	Perc. of total WBs
	km	km	%			%
BA	1432	807	56.38	38	19	50.00
HR	1460	436.4	29.89	43	10	23.26
RS	570.8	146.3	25.63	22	7	31.82
SI	437.1	4.60	1.05	14	1	7.14

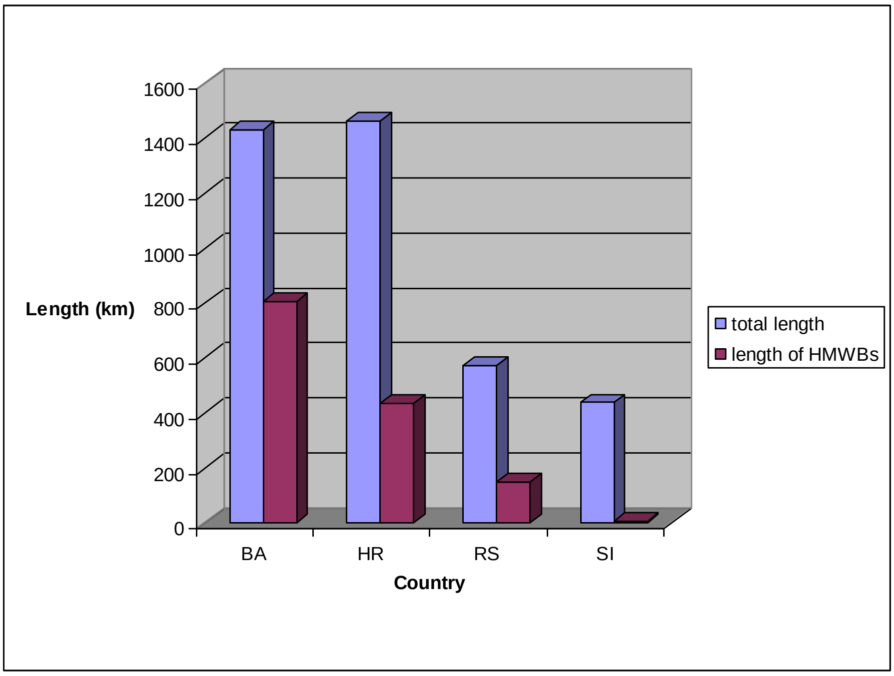


Figure II-19: Ratio between the total WBs length and the HMWBs length on the Sava tributaries

1.5.6. Uses affecting the provisional HMWBs in the Sava River Basin

Table II-38: Drivers for identification of provisional HMWBs on the Sava River

Country	total No WBs	Hydropower	Navigation	Flood Protection	Urbanization
BA	3	0	3	3	3
HR	8	0	6	7	7
RS	3	1	1	1	1
SI	12	3	0	3	0

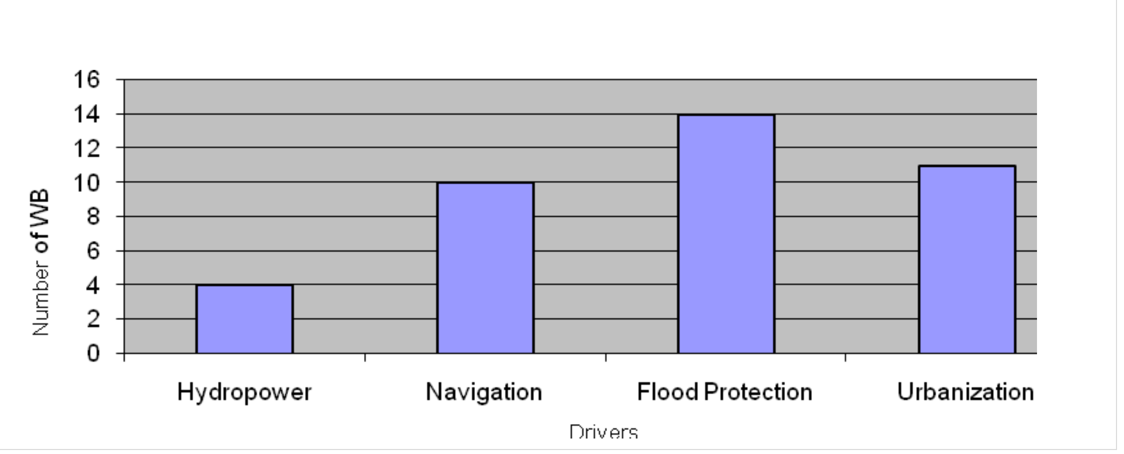


Figure II-20: Main users/drivers affecting the HMWBs on the Sava River

Table II-39: Drivers for identification of provisional HMWBs on the Sava tributaries

Country	total No WBs	Hydropower	Navigation	Flood Protection	Urbanization
BA	38	15	0	16	6
HR	43	0	0	10	10
RS	22	6	0	0	1
SI	14	0	0	1	1

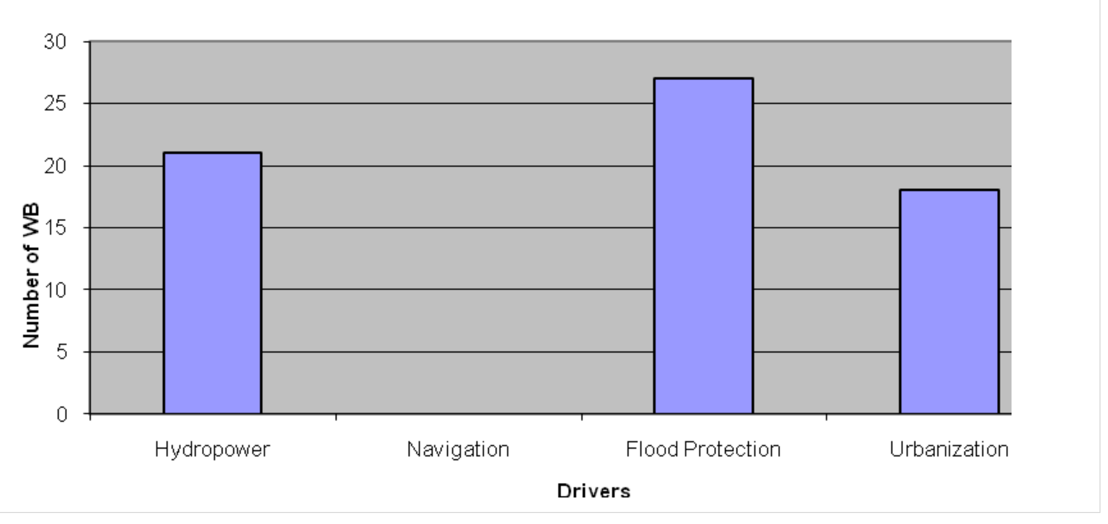


Figure II-21: Main users/drivers affecting the HMWBs on the Sava tributaries

1.5.7. Significant physical alterations affecting the HMWBs in the Sava River Basin

Table II-40: Physical alterations affecting the HMWBs on the Sava River

Country	total No WBs	Dams/weirs/ dikes	Channelisation/ straightening	Bank reinforcement
BA	3	0	0	3
HR	8	7	0	7
RS	3	0	1	1
SI	12	3	0	0

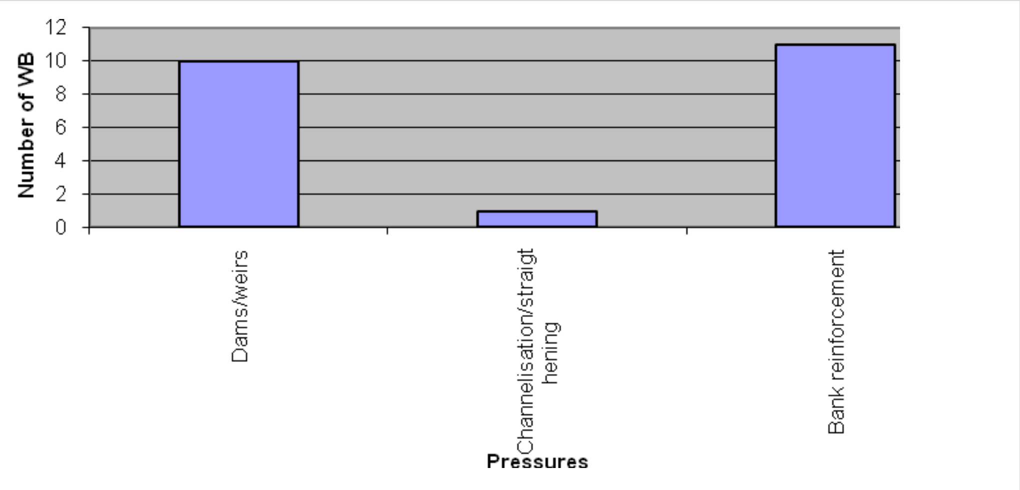


Figure II-22: Physical alterations affecting the HMWBs on the Sava River

Table II-41: Physical alterations affecting the HMWBs on the Sava tributaries

Country	total No WBs	Dams/weirs/ dikes	Channelisation/ straightening	Bank reinforcement
BA	38	14	5	7
HR	43	10	3	9
RS	22	7	0	0
SI	14	0	1	1

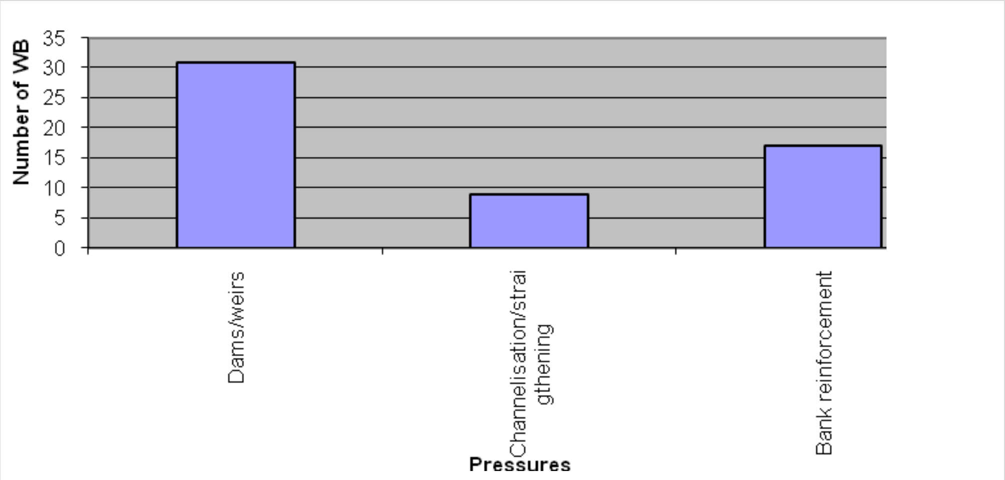


Figure II-23: Physical alterations affecting the HMWBs on the Sava tributaries

1.5.8. Expert judgment for assessing the risk on the HMWBs in the Sava River Basin

Table II-42: Reasons for assessing the risk on the HMWBs on the Sava River

Country	total No WBs	Not passable obstacles	Change of water category	Impoundment with significant reduction of water flow	Disruption of lateral connectivity	Other
BA	3	0	0	0	0	3
HR	8	0	0	0	0	7
RS	3	0	1	0	0	0
SI	12	3	3	0	0	3

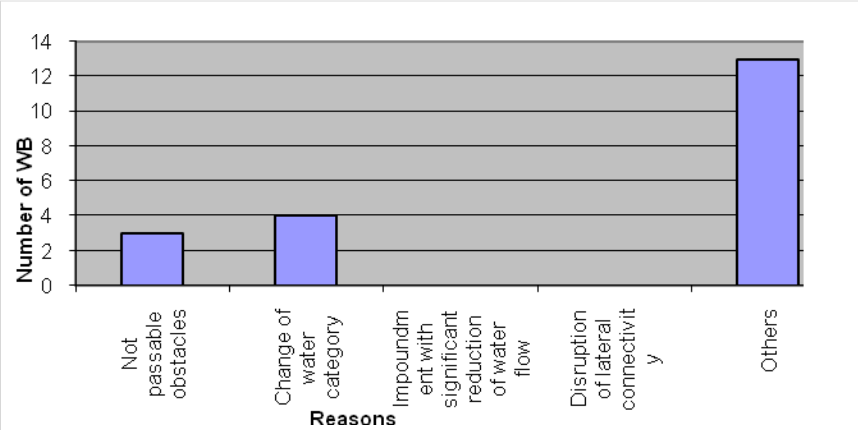


Figure II-24: Reasons for assessing the risk on the HMWBs on the Sava River

Table II-43: Reasons for assessing the risk on the HMWBs on the Sava tributaries

Country	total No WBs	Not passable obstacles	Change of water category	Impoundment with significant reduction of water flow	Disruption of lateral connectivity	Changed discharge *
BA	38	1	12	4	1	11
HR	43	9	1	0	9	0
RS	22	6	6	1	0	0
SI	14	0	0	0	1	0

*effects caused by hydropeaking or residual water discharge

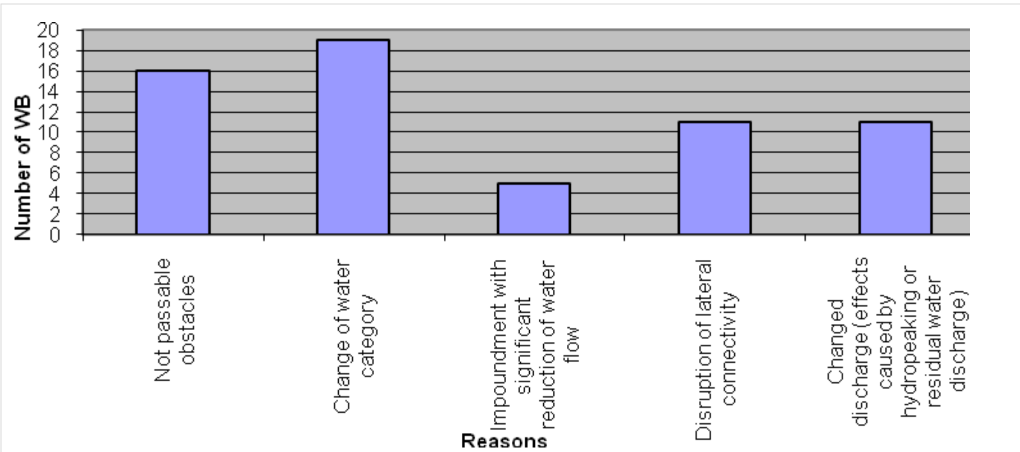


Figure II-25: Reasons for assessing the risk on the HMWBs on the Sava tributaries

1.6. Summary of the Risk Assessment

1.6.1. Risk Assessment of the Sava River

Bosnia and Herzegovina

Risk assessment for the water bodies in the FBA has been not performed yet. BA-RS – no information submitted.

Croatia

Table II-44: Summary of the information on the Sava water bodies in Croatia

Code/abbreviation with country code for water body	Information on risk: water body AT RISK	Information on risk: water body NOT AT RISK	Information on risk: water body POSSIBLY AT RISK	Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
KRA_T0001 Sava 001	x			48.63			hydromorphological alteration
KUP_T0001 Sava	x			65.29			hydromorphological alteration nutrient pollution
CES_T0001 Sava			x			40.88	hydromorphological alteration
ILO_T0001 Sava	x			35.71			hydromorphological alteration
STR_T0001 Sava	x			112.81			hydromorphological alteration
BID_T0002 Sava 002	x			32.54			hydromorphological alteration
BID_T0001 Sava 001	x			162.18			hydromorphological alteration
WBs not at risk					14		
Sava WBs in HR				**457.16**	**13.96**	**40.88**	

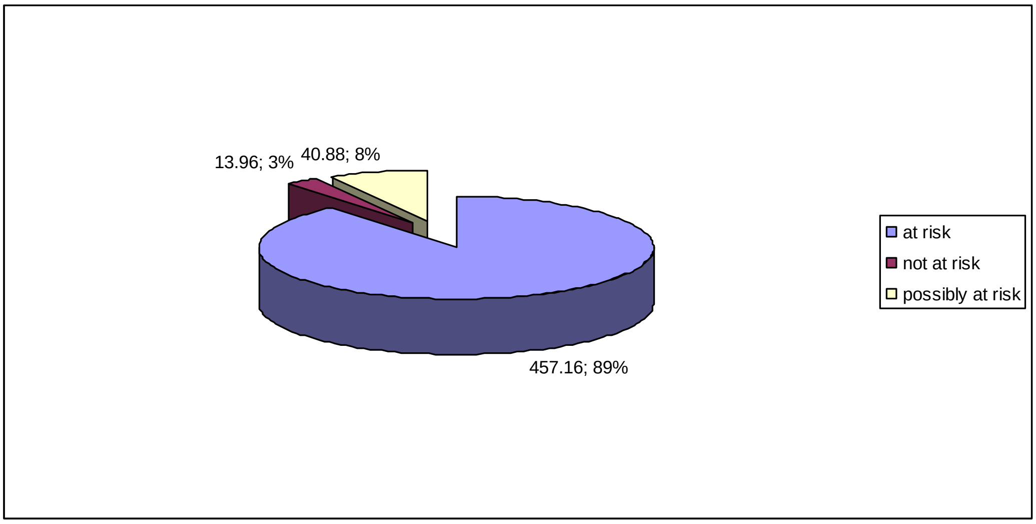


Figure II-26: Risk assessment status of the Sava WBs in Croatia

Serbia

Table II-45: Summary of the information on the Sava water bodies in Serbia

Code/abbreviation with country code for the water body	Information on risk			Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK				
RS_SA_1	x			102			hydromorphological alteration and possible hazardous substances pollution
RS_SA_2	x			75			possible hazardous substances pollution
RS_SA_3	x			32			possible hazardous substances pollution
Sava WBs in RS				**209**	**0**	**0**	

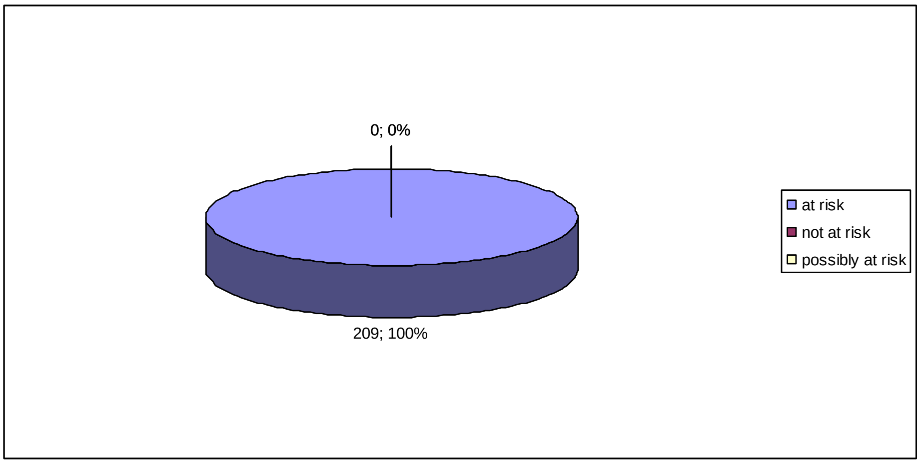


Figure II-27: Risk assessment status of the Sava WBs in Serbia

Slovenia

Table II-46: Summary of the information on the Sava water bodies in Slovenia

Code/abbreviation with country code for the water body	Information on risk			Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK				
SI111VT5		x			23.73		
SI111VT7	x			10.73			hydromorphological alteration and possible hazardous and organic pollution
SI1VT137			x			25.27	
SI1VT150			x			9.61	
SI1VT170	x			13.02			organic pollution and hydromorphological alterations

SI1VT310	x			22.17			hazardous substances pollution and possible hydromorphological alterations
SI1VT519		x			25.77		
SI1VT557	x			31.26			nutrient pollution
SI1VT713	x			17.18			hydromorphological alterations
SI1VT739			x			17.06	
SI1VT913	x			21.58			organic pollution, nutrient and hazardous substances pollution
SI1VT930	x			3.38			hazardous substances pollution
Sava WBs in SI				**119.32**	**49.5**	**51.94**	

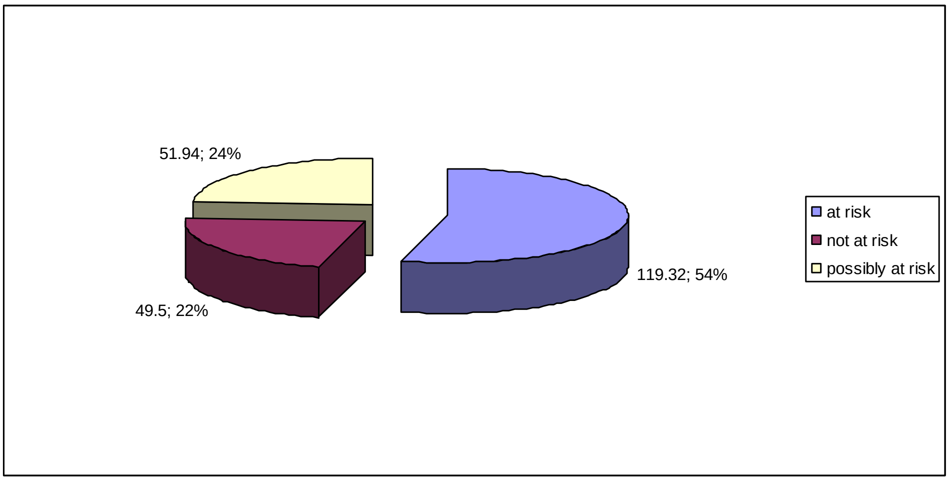


Figure II-28: Risk assessment status of the Sava WBs in Slovenia

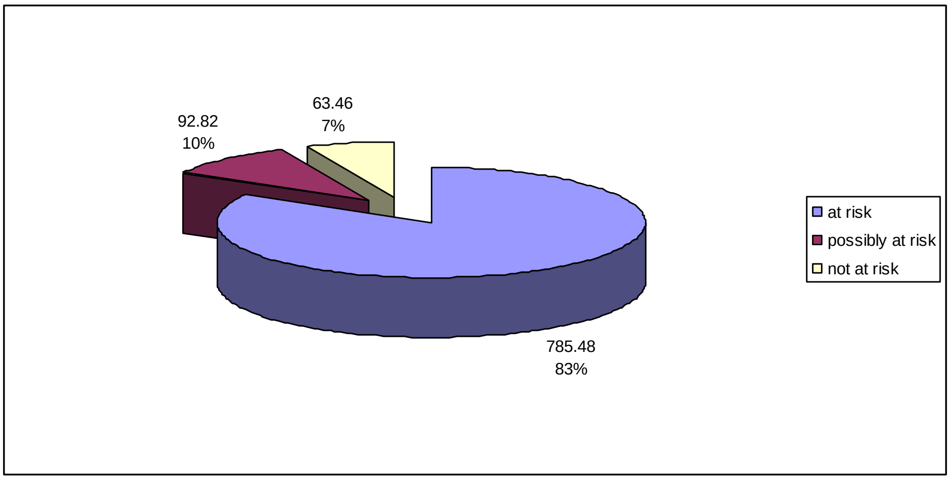


Figure II-29: Risk assessment status of the Sava WBs (data from HR, RS and SI available)

1.6.2. Risk Assessment of the Sava River tributaries

Table II-47: Summary of the information on the Sava tributaries in Croatia

Code/abbreviation with country code for the water body	Information on risk			Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK				
KRA_T0006 Sutla 002			x			24.5	nutrient pollution
KRA_S0001 Vonarije	x			6.68			hydromorphological alteration nutrient pollution
KRA_T0007 Sutla 003			x			20.86	nutrient pollution
KRA_T0003 Krapina 001			x			59.87	hydromorphological alteration nutrient pollution
CES_T0011 Glogovnica 003			x			9.73	nutrient pollution
CES_T0010 Glogovnica 002	x			40.4			hydromorphological alteration nutrient pollution
CES_T0009 Glogovnica 001	x			14.4			hydromorphological alteration nutrient pollution
CES_T0007 Česma 001			x			53.84	hydromorphological alteration nutrient pollution
CES_T0005 Prelošćica 001			x			28.35	hydromorphological alteration nutrient pollution
CES_T0002			x			47.95	hydromorphological alteration nutrient pollution
ILO_T0002	x			96.79			hydromorphological alteration nutrient pollution
ORA_T0002 Orljava 002			x			34.99	hydromorphological alteration
ORA_T0001 Orljava 001			x			53.06	hydromorphological alteration nutrient pollution
BID_T0003 Bosut	x			92.99			nutrient pollution
KUP_T0007 Kupa 006			x			5.11	nutrient pollution
KUP_T0023 Dobra 002			x			28.31	nutrient pollution
KUP_T0022 Dobra 001			x			20.41	nutrient pollution
KUP_T0012 Korana (Kupa) 005			x			18.61	nutrient pollution
KUP_T0011 Korana (Kupa) 004			x			23.25	nutrient pollution
KUP_T0010 Korana (Kupa) 003			x			26.73	nutrient pollution
KUP_T0017 Glina 005			x			16.77	nutrient pollution
WBs not at risk					696.4		
Sava WBs in HR				**251.26**	**696.4**	**472.34**	

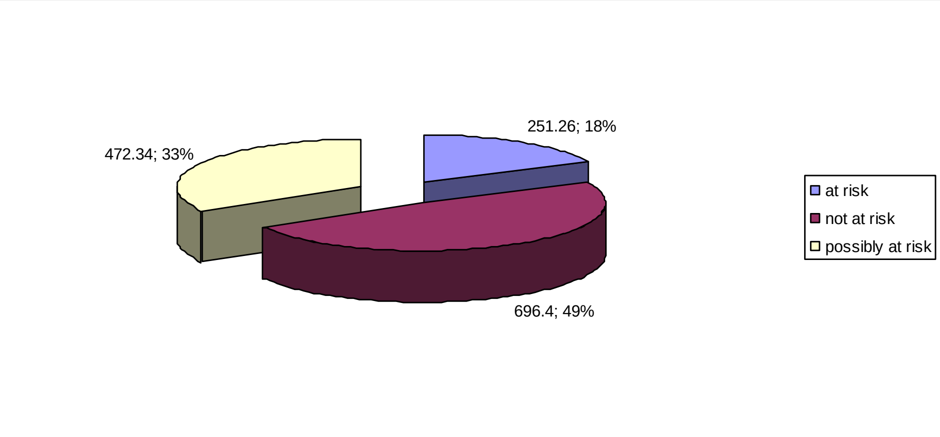


Figure II-30: Risk assessment status of the Sava tributaries WBs in Croatia

Table II-48: Summary of the information on the Sava tributaries in Serbia

Code/abbreviation with country code for the water body	Information on risk			river	Len-gth (km) at risk	Len-gth (km) not at risk	Len-gth (km) possibly at risk	Geographical location	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK						
RS_DR_1	x			Drina	91.0			downstream of HEPP Zvornik	possible hazardous substances
RS_DR_2	x			Drina	29.0			HEPP Zvornik Reservoir	hydromorphological and possible hazardous substances, nutrient and organic
RS_DR_3			x	Drina			79.5	HEPP Zvornik - HEPP Bajina Bašta	hazardous substances
RS_DR_4	x			Drina	56.8			HEPP Bajina Bašta Reservoir	hydromorphological and possible hazardous substances, nutrient and organic
RS_LIM_1			x	Lim			11.6	from RS border to HEPP Potpeć dam	hazardous sibstances
RS_LIM_2	x			Lim	17.4			HEPP Potpeć reservoir	hydromorphological and possible hazardous substances, nutrient and organic
RS_LIM_3			x	Lim			40.0	upstream of HEPP Potpeć to mouth of B. Bistrica	possible nutrient and hazardous substances

Code/abbreviation with country code for the water body	Information on risk			river	Len-gth (km) at risk	Len-gth (km) not at risk	Len-gth (km) possi bly at risk	Geographical location	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK						
RS_LIM_4 (Montenegro)				Lim				from mouth of B. bistrica to Plavsko lake	Remark: Risk assessment for WB RS Lim_4 has not been provided yet, because it is located in Montenegro
RS_UV_1			x	Uvac			15.0	from mouth of Lim to moouth of Bukova r.	possible hazardous substances
RS_UV_2		x		Uvac		20.5		from mouth of Bukova r. to moouth of Rasnička r.	
RS_UV_3			x	Uvac			8.3	from mouth of Rasničke r. to HEPP Radonja dam	hydromorpho-logical
RS_UV_4	x			Uvac	12.0			HEPP Radonja reservoir	hydromorpho-logical and possible hazardous substances, nutrient and organic
RS_UV_5	x			Uvac	18.1			HEPP Kokin Brod reservoir	hydromorpho-logical and possible hazardous substances, nutrient and organic
RS_UV_6	x			Uvac	22.0			HEPP Uvac reservoir	hydromorpho-logical and possible hazardous substances, nutrient and organic
RS_UV_7		x		Uvac		21.8		upstream of HEPP Uvac reservoir	
RS_BOS	x			Bosut	38.3			from mouth to HR-RS	hydromorpho-logical, nutrient, organic and possible hazardous substances
RS_KOL_1	x			Kolubara	13.0			from mouth of Sava to mouth of Tamnava	nutrient and possible organic and hazardous substances

Code/abbreviation with country code for the water body	Information on risk			river	Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Geographical location	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK						
RS_KOL_2		x		Kolubara		11.2		from mouth of Tamnava to mouth of Turija	
RS_KOL_3	x			Kolubara	25.6			from mouth of Turija to Pepeljevac	nutrient and possible organic and hazardous substances
RS_KOL_4	x			Kolubara	24.6			Pepeljevac - Popučke	nutrient and possible organic and hazardous substances
RS_KOL_5		x		Kolubara		7.1		Popučke - Valjevo	
RS_KOL_6	x			Kolubara	5.2			Valjevo -	
Sava tributaires WBs in RS					**353.0**	**60.6**	**154.4**		

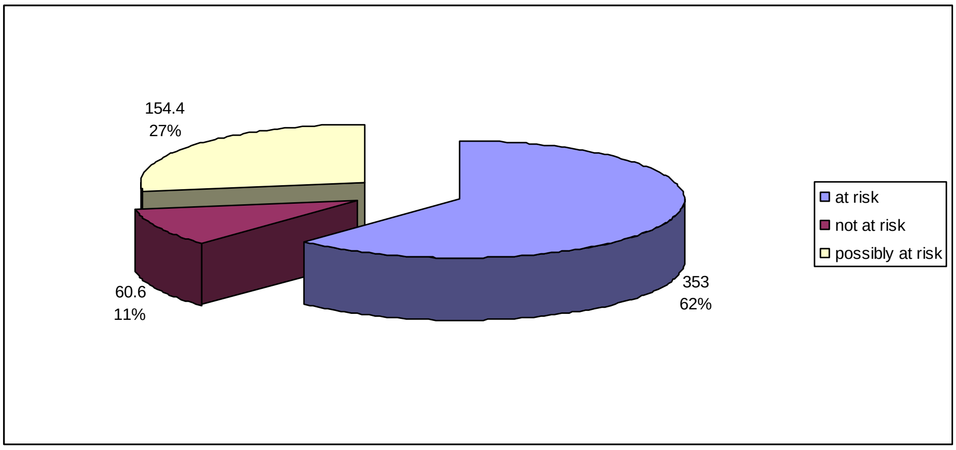


Figure II-31: Risk assessment status of the Sava tributaries WBs in Serbia

Table II-49: Summary of the information on the Sava tributaries in Slovenia

Code/abbreviation with country code for the water body	Information on risk			River	Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK					
SI14912VT		x		Gruberjev prekop		3.23		
SI14VT77		x		Ljubljanica		23.16		
SI14VT93	x			Ljubljanica	4.57			hydromorphological alterations and possbile nutrient

Code/abbreviation with country code for the water body	Information on risk			River	Length (km) at risk	Length (km) not at risk	Length (km) possibly at risk	Pressure
	water body AT RISK	water body NOT AT RISK	water body POSSIBLY AT RISK					
								pollution
SI14VT97	x			Ljubljanica	12.34			organic and nutrient pollution
SI16VT17	x			Savinja	44.99			nutrient pollution and possible hazardous substances pollution
SI16VT70	x			Savinja	24.54			nutrient pollution
SI16VT97	x			Savinja	24.52			organic pollution and possbile hazardous substances pollution
SI18VT31		x		Krka		29.38		
SI18VT77		x		Krka		26.12		
SI18VT97		x		Krka		39.32		
SI192VT1	x			Sotla	31.16			organic and hazardous substances pollution
SI192VT5	x			Sotla	58.66			organic and hazardous substances pollution
SI21VT13		x		Kolpa		21.3		
SI21VT50		x		Kolpa		85.04		
SI21VT70		x		Kolpa		12		
Sava tributaries WBs in SI					**200.78**	**239.55**	**0**	

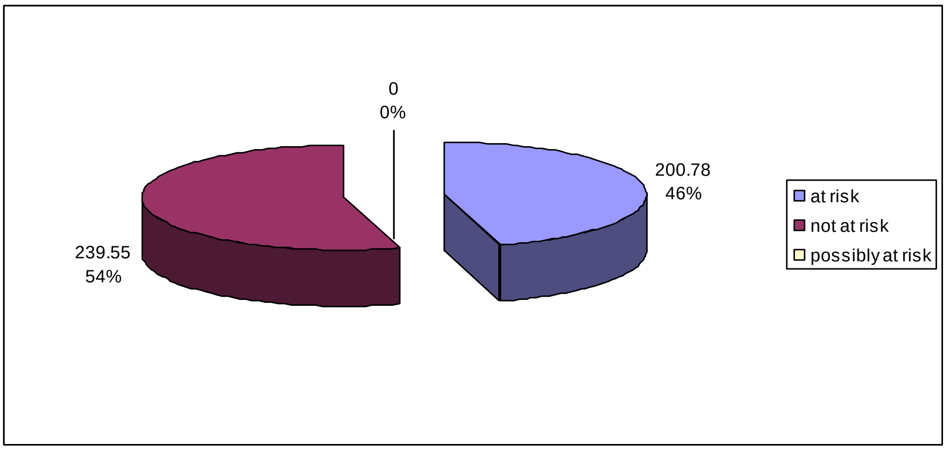


Figure II-32: Risk assessment status of the Sava tributaries WBs in Slovenia

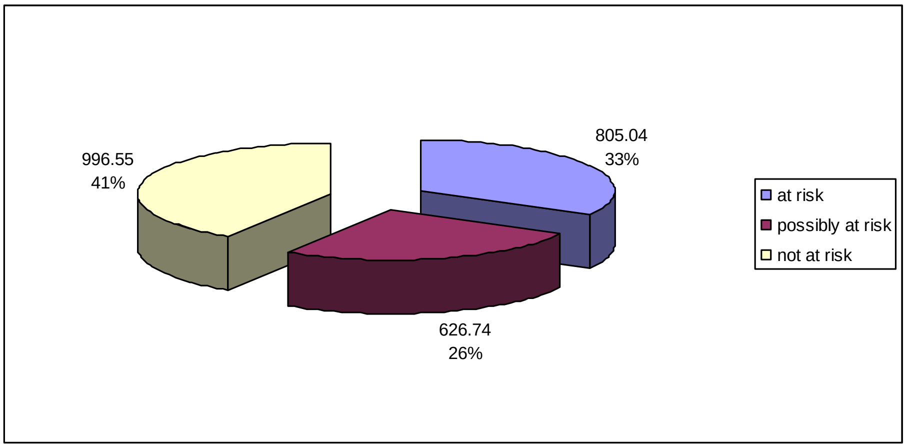


Figure II-33: Risk assessment status[4] of the Sava tributaries WBs

1.7. Water quality monitoring in surface waters

According to Article 8 of the EU *Water Framework Directive* (WFD), the Member States shall ensure the establishment of programmes for the monitoring of water status in order to establish a coherent and comprehensive overview of the water status within each river basin district. Such monitoring shall be in accordance with the requirements of Annex V of the WFD.

Article 8 of the Directive establishes the requirements for the monitoring of surface water status, groundwater status and protected areas.

For surface water bodies, the Directive requires that surface water bodies are sufficiently monitored in **surveillance programmes** to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. For surveillance monitoring, parameters indicative of all biological, hydromorphological and all general and specific physico-chemical quality elements are required to be monitored.

Operational monitoring is to establish the status of those water bodies identified as being at risk of failing to achieve their environmental objectives, and to assess any changes in their status resulting from specific measures. Operational monitoring programmes must use parameters indicative of the quality element or elements most sensitive to the pressure or pressures to which the body or group of bodies is subject. This means that fewer quality element values may be used in status classification.

1.7.1. National monitoring stations for water quality

Total number of quality monitoring stations in the Sava River Basin is 90. Some physical, organic, nutrients, heavy metallic and microbiologic parameters are measured at the quality monitoring stations. Physical parameters are measured at 90, organic at 68, nutrient at 68, heavy metals at 55 and microbiologic at 52 water quality monitoring stations. The distribution of water quality monitoring stations and water quality parameters is indicated in Figure II-34.

[4] Data from HR, RS and SI available.

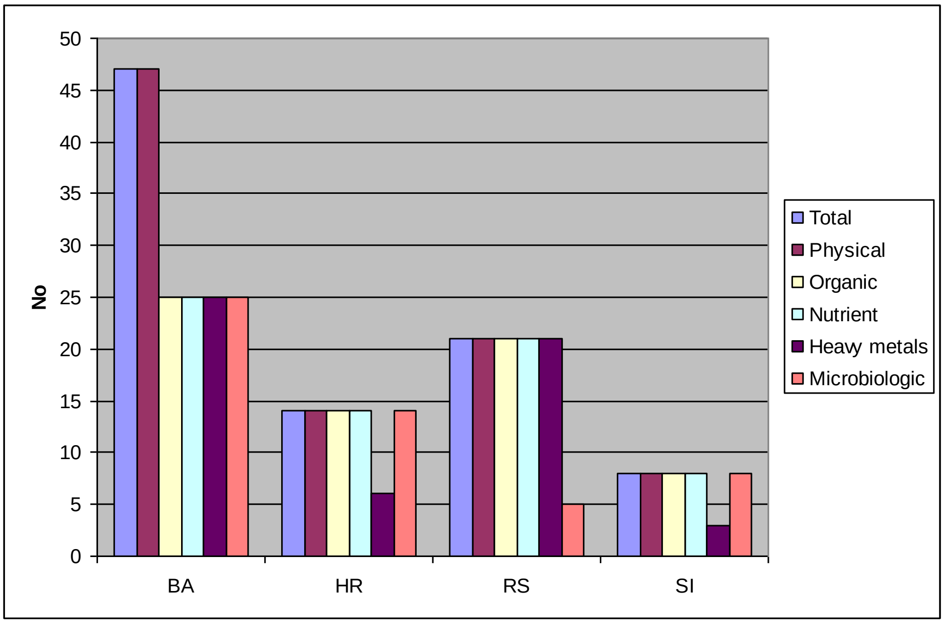


Figure II-34: Measured parameters at the water quality monitoring stations in the Sava River Basin

1.7.2. Transnational monitoring network (TNMN)

According to the *Convention on cooperation for the protection and sustainable use of the Danube River* (DRPC), the Parties to the FASRB cooperate in the field of monitoring and assessment. For this aim, they:

- harmonise or make comparable their monitoring and assessment methods, in particular in the field of river quality,
- develop concerted or joint monitoring systems applying stationary or mobile measurement devices, communication and data processing facilities,
- elaborate and implement joint programmes for monitoring the riverine conditions in the Danube catchment area concerning both, the water quantity and quality, sediments and riverine ecosystems, as a basis for the assessment of transboundary impacts.

The operation of the Trans-National Monitoring Network (TNMN), functioning since 1996, is aimed to contribute to implementation of the DRPC. Water quality data from the monitoring programme are regularly gathered by the Danube/Sava countries, merged at Central Point at Slovak Hydrometeorological Institute, processed by using the agreed procedures and provided to the ICPDR information system. The TNMN builds on the national surface water monitoring networks.

To select the monitoring locations for the purposes of international monitoring network in Danube/Sava River Basin, following selection criteria for the monitoring location have been set up:

- located just upstream/downstream of an international border,
- located upstream of confluences between the Danube and main tributaries or main tributaries and larger sub-tributaries (mass balances),
- located downstream of the biggest point sources,
- located according to control of water use for drinking water supply.

Twelve (12) TNMN stations are operating in the Sava River Basin, among them 9 stations on the Sava River (Jesenice-SI, Jesenice-HR, Jasenovac-HR, Jasenovac-BA, Županja-HR, Jamena-RS, Sremska Mitrovica-RS, Šabac-RS, Ostružnica-RS) and 3 stations on the main Sava tributaries (Modriča-BA-Bosna, Kozarska Dubica-BA-Una, Razboj-BA-Vrbas, Badovinci-RS-Drina).

Basic data on TNMN stations is given in Table II-50.

Table II-50: Basic data on the TNMN monitoring stations in the Sava River Basin

Country	River	Town /Location	Latitude (d m s)	Longitude (d m s)	Distance from the mouth (km)	Altitude (m)	Catchment (km²)	DEFF Code	Loc. profile	Remark
SI	Sava	Jesenice	45 51 41	15 41 47	729	135	10,878	L1330	R	
HR	Sava	Jesenice	45 51 40	15 41 48	729	135	10,834	L1220	R	
HR	Sava	Jesenice	45 51 40	15 41 48	729	131.63	10,834	L1220	L	
HR	Sava	Upstream Una Jasenovac	45 16 02	16 54 52	525	86.82	30,953	L1150	L	
BA	Sava	Jasenovac	45 16 00	16 54 36	500	87	38,953	L2280	M	
HR	Sava	Downstream Županja	45 02 17	18 42 29	254	85	62,890	L1060	M	
HR	Sava	Downstream Županja	45 02 17	18 42 29	254	85	62,890	L1060	R	
RS	Sava	Jamena	44 52 40	19 05 21	195	77.67	64,073	L2470	L	since 2001
	Sava	Sremska Mitrovica	44 58 01	19 36 26	136.4	75.24	87,996	L2480	L	since 2001
	Sava	Šabac	44 46 12	19 42 17	103.6	74.22	89,490	L2490	R	since 2001
	Sava	Ostružnica	44 43 17	20 18 51	17		37,320	L2500	R	since 2001
BA	Una	Kozarska Dubica	45 11 06	16 48 42	16	94	9,130	L2290	M	
	Vrbas	Razboj	45 03 36	17 27 30	12	100	6,023	L2300	M	
	Bosna	Modriča	44 58 17	18 17 40	24	99	10,308	L2310	M	
RS	Drina	Badovinci						L2520	L	since 2001

1.7.3. Water Quality Status Assessment and Water Quality Classification

For the water quality assessment, the following data for the Sava River were used:

- average measurements provided by the TNMN for the period 2000-2005 (where available),
- data provided by the TNMN for 2005.

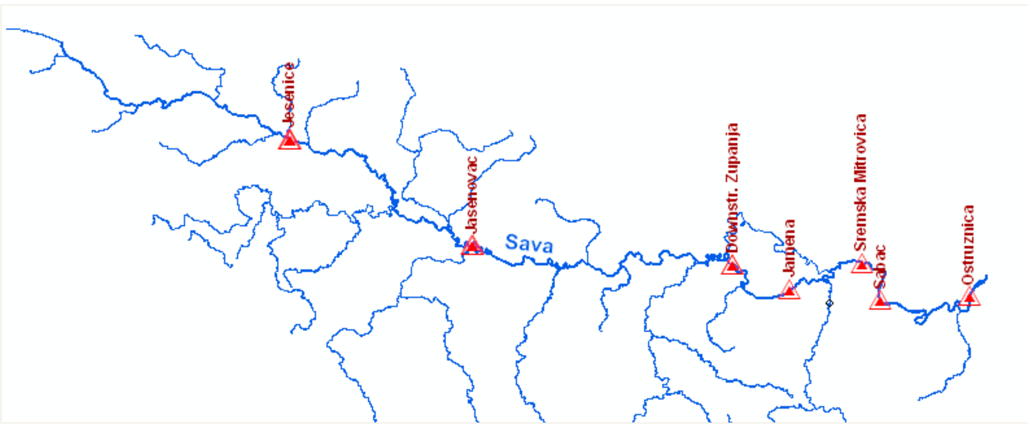


Figure II-35: Location of the TNMN monitoring stations providing data for the assessment

Water Quality Classification serves for international purposes for the presentation of current status and improvements of water quality and is not a tool for implementation of national water policy. Five classes are used for the assessment, with target value being the limit value of the class II. The class I should represent the reference conditions or background concentrations. The classes III – V are on the „non-complying" side of the classification scheme and their limit values are usually 2-5 times higher than the target values. They should indicate the seriousness of the excess of the target value and help to recognize the positive tendency in the water quality development.

For the characterization of the water status evaluation physical parameters (temperature, pH, suspended solids), organic substances (dissolved oxygen, BOD_5 and COD-Cr) and nutrients (NH_4, NO_2, NO_3, PO_4) have been taken into consideration.

The classification scheme for the selected parameters is presented in Table II-51.

Table II-51: Water Quality Classification used for the TNMN purposes

Determinant	Unit	Class				
		I	II TV	III	IV	V
		Class limit values				
Oxygen/Nutrient regime						
Dissolved oxygen *	mg/l	7	6	5	4	< 4
BOD_5	mg/l	3	5	10	25	> 25
COD-Cr	mg/l	10	25	50	125	> 125
pH	-		> 6.5* and < 8.5			
Ammonium-N	mg/l	0.2	0.3	0.6	1.5	> 1.5
Nitrite-N	mg/l	0.01	0.06	0.12	0.3	> 0.3
Nitrate-N	mg/l	1	3	6	15	> 15
Ortho-phosphate-P	mg/l	0.05	0.1	0.2	0.5	> 0.5

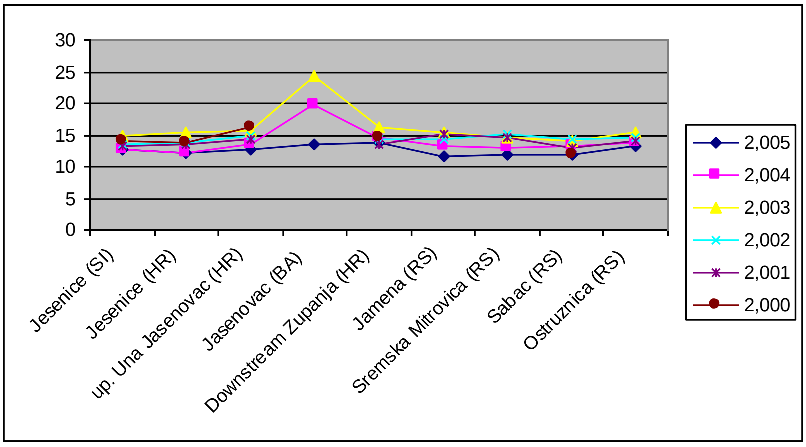
* values concern 10-percentile value
TV - target value

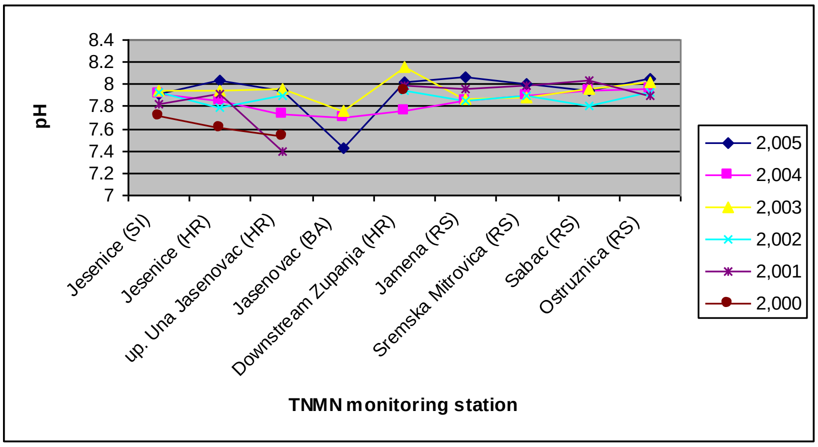
Physical parameters

The representative parameters of the water status characterisation for physical parameters are: temperature, pH and suspended solids (SS).

The results for the period of 2000 to 2005 (Figure II-36) demonstrate that:

- the average values of temperature are from 11.8 ºC (year 2000) to 24.25 ºC (year 2003);
- the average values of pH are from 7.389 (year 2001) to 8.16 (year 2003);
- the average values of SS are from 7.129 mg/l (year 2003) to 28.42 mg/l (year 2002).





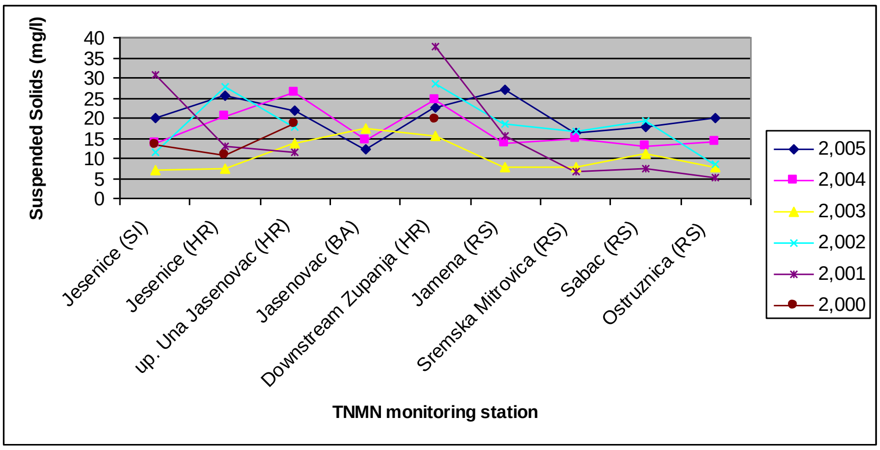


Figure II-36: The spatial-temporal evolution of physical parameters in the Sava River from 2000 to 2005

The results for year 2005 (Table II-52, II-53, II-54 and Figures II-37, II-38, II-39) demonstrate that:

- the values of the temperature are between 0.9 ºC (min) and 27 ºC (max);
- the values of pH between 6.9 (min) and 8.5 (max) have classified the Sava River in the II class for all monitoring sites;
- the values of SS are between 1.0 mg/l (min) and 276 mg/l (max).

In the respective tables and figures, C50 and C90* denote a percentile of a variable.

Table II-52: Values of temperature at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*
			°C	°C	°C	°C	°C
SI	SI02	Jesenice	2.9	12.7	26.1	12.4	20.3
HR	HR06	Jesenice	3.4	12.1	25.7	12.2	18.5
	HR07	us. Una Jasenovac	1.7	12.6	27.0	12.3	21.3
	HR08	ds. Županja	3.3	13.8	26.3	13.3	21.5
BA	BIH01	Jasenovac	5.6	13.5	22.7	13.3	
RS	SCG13	Jamena	0.9	11.7	22.2	11.7	19.9
	SCG14	Sremska Mitrovica	1.9	11.8	25.5	11.2	20.3
	SCG15	Šabac	2.1	12	25.8	11.6	20.1
	SCG16	Ostružnica	2.2	13.2	26.2	13.6	21.9

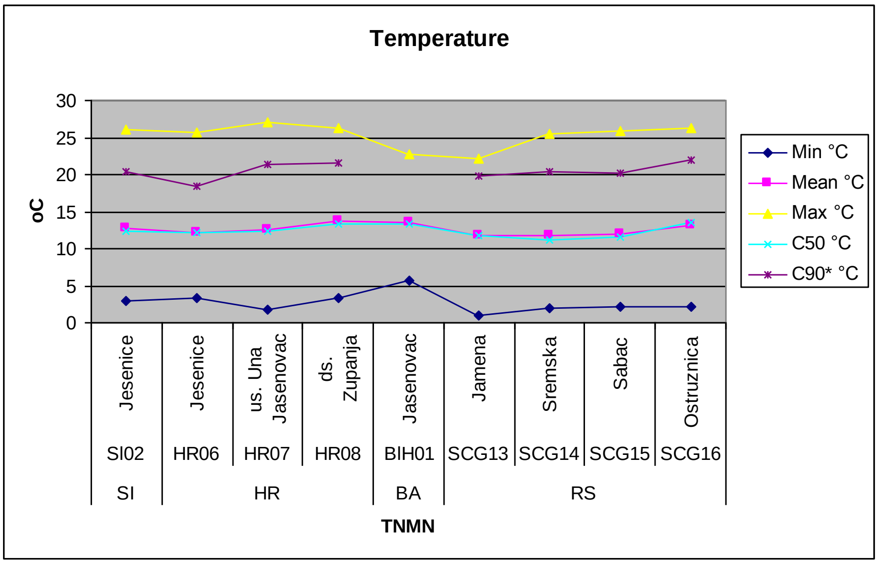


Figure II-37: Measured values of temperature at the TNMN stations in year 2005

Table II-53: Values of pH at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	SI02	Jesenice	7.6	7.9	8.2	7.9	8.1	II
HR	HR06	Jesenice	7.6	8	8.4	8.1	8.2	II
	HR07	us. Una Jasenovac	7.5	7.9	8.4	8	8.1	II
	HR08	ds. Županja	7.5	8	8.2	8.1	8.2	II
BA	BIH01	Jasenovac	6.9	7.4	8	7.4		II
RS	SCG13	Jamena	7.9	8.1	8.5	8.1	8.2	II
	SCG14	Sremska Mitrovica	7.8	8	8.4	8	8.1	II
	SCG15	Šabac	7.6	7.9	8.3	8.1	8.3	II
	SCG16	Ostružnica	7.8	8.1	8.5	8	8.3	II

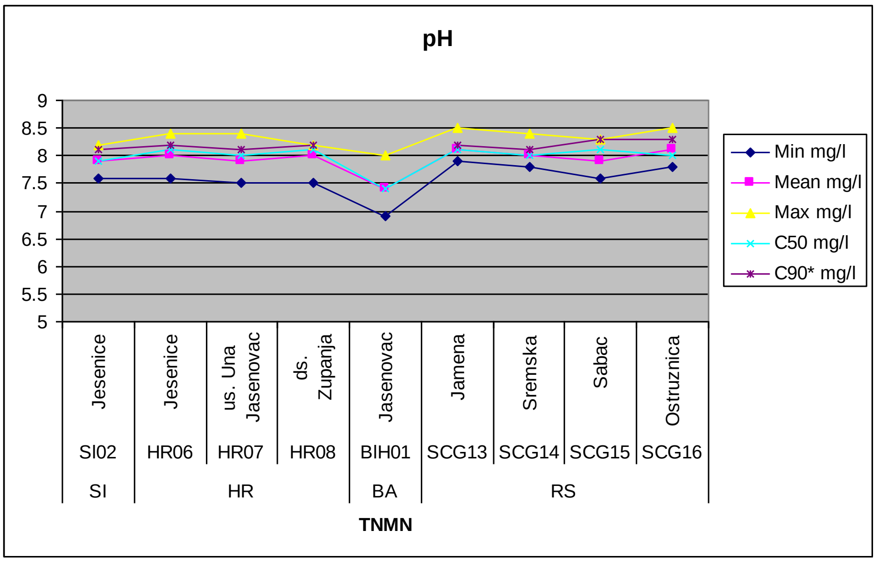


Figure II-38: Values of pH at the TNMN stations in year 2005

Table II-54: Values of suspended solids at the TNMN stations in year 2005

Country	Code	Location	Min mg/l	Mean mg/l	Max mg/l	C50 mg/l	C90* mg/l
SI	Sl02	Jesenice	1.9	18.4	161.8	4.4	32.5
HR	HR06	Jesenice	2	25.6	276	4.4	55.4
	HR07	us. Una Jasenovac	2.2	21.9	137	12.3	47.9
	HR08	ds. Županja	4.2	22.6	63.6	16.4	45.3
BA	BIH01	Jasenovac	1	12.2	55	4.9	
RS	SCG13	Jamena	2	27	108	19	53.2
	SCG14	Sremska Mitrovica	1	16.2	71	9	44
	SCG15	Šabac	1	17.9	121	11	30
	SCG16	Ostružnica	2	19.9	73	15	41

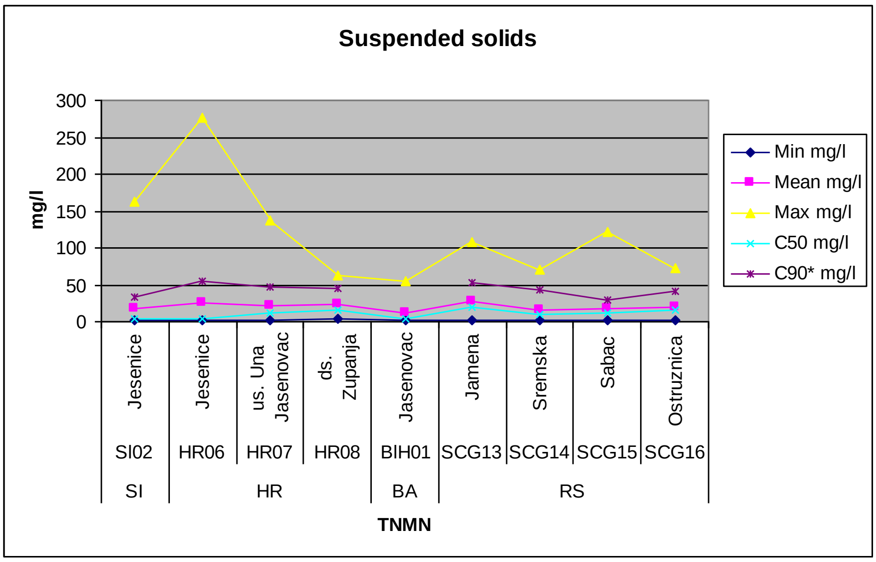


Figure II-39: Values of suspended solids at the TNMN stations in year 2005

Organic substances

The representative parameters of water status characterization for organic substance are: dissolved oxygen, BOD_5 and COD-Cr.

The results for the period of 2000 to 2005 (Figure II-40) demonstrate that:

- the average values of Dissolved Oxygen are between 7.765 mg/l (year 2002) and 15.78 mg/l (year 2001);
- the average values of BOD_5 are between 1.228 mg/l (year 2005) and 4.124 mg/l (year 2003);
- the average values of COD-Cr are between 6.031 mg/l (year 2001) and 18.11 mg/l (year 2003).

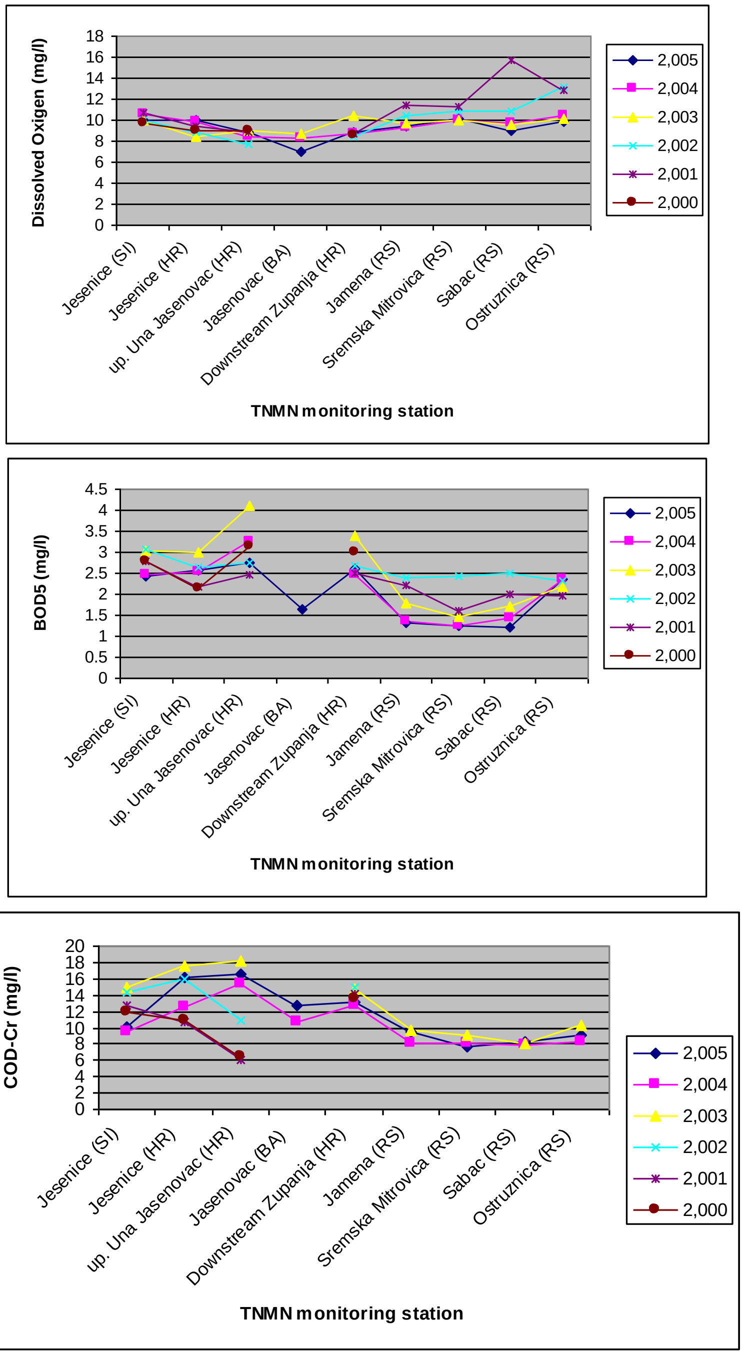


Figure II-40: The spatial-temporal evolution of organic substances in the Sava River from 2000 to 2005

The results for year 2005 (Tables II-55, II-56, II-57 and Figures II-41, II-42, II-43) demonstrate that:

- the average values of Dissolved Oxygen between 0.9 (min) and 27 (max) have classified the Sava River in the I class at Jesenice-SI, Jesenice-HR and Ostružnica-RS, in the II class at Jasenovac-HR, Županja-HR and Šabac-RS, and in the III class at Jasenovac-BA;
- the average values of BOD_5 between 0.2 (min) and 5.6 (max) have classified the Sava River in the I class at Jasenovac-BA, Jamena, Sremska Mitrovica-RS, Šabac-RS and in the II class at all other monitoring sites;
- the values of COD-CR between 1.0 (min) and 30.7 (max) have classified the Sava River in the I class at Sremska Mitrovica-RS, II class at Jesenice-SI, Jasenovac-BA, Županja-HR and in the III class at Jesenice-HR and Jasenovac-BA.

In the respective tables and figures, C50 and C90* denote a percentile of a variable.

Table II-55: Values of dissolved oxygen at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	SI02	Jesenice	8.3	10.6	14.7	10.3	9.3	I
HR	HR06	Jesenice	6.5	10	12.5	9.8	8.3	I
	HR07	us. Una Jasenovac	5.3	8.8	13.4	9.1	6.7	II
	HR08	ds. Županja	6.5	8.9	11.9	8.8	7	II
BA	BIH01	Jasenovac	5.2	7.1	8.6	7.2		III
RS	SCG13	Jamena	6.9	9.4	13.4	9.4	7.2	I
	SCG14	Sremska Mitr.	7.5	10.1	13.5	9.5	7.8	I
	SCG15	Šabac	5.4	9	12.4	8.7	6.6	II
	SCG16	Ostružnica	7	9.9	12	10.5	7.3	I

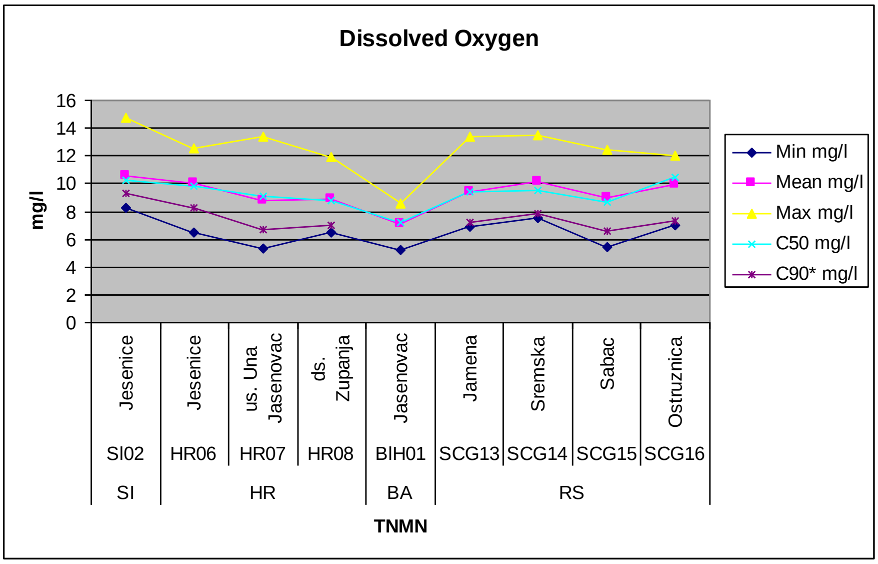


Figure II-41: Values of dissolved oxygen at the TNMN stations in year 2005

Table II-56: Values of BOD_5 at the TNMN stations in year 2005

Country	Code	Location	Min mg/l	Mean mg/l	Max mg/l	C50 mg/l	C90* mg/l	Class
SI	SI02	Jesenice	1	2.4	4.5	2.2	4	II
HR	HR06	Jesenice	1	2.6	5.6	2.3	3.8	II
	HR07	us. Una Jasenovac	1.4	2.8	4.4	2.7	3.8	II
	HR08	ds. Županja	1	2.6	5.1	2.5	3.9	II
BA	BIH01	Jasenovac	1.2	1.6	2.1	1.6		I
RS	SCG13	Jamena	0.5	1.3	3	1.2	2.3	I
	SCG14	Sremska Mitrovica	0.2	1.3	2.5	1.4	2.2	I
	SCG15	Šabac	0.5	1.2	3.3	1.1	1.7	I
	SCG16	Ostružnica	1	2.4	3.9	2.4	3.4	II

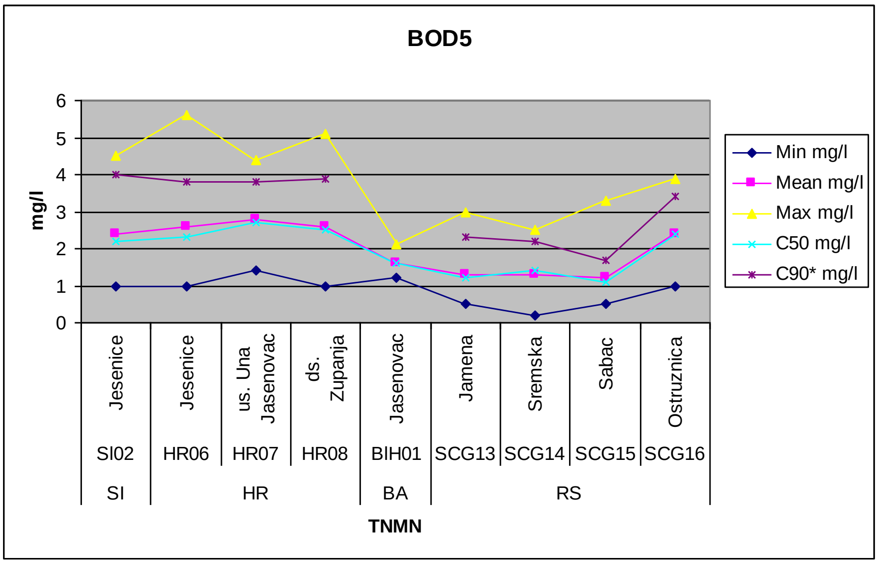


Figure II-42: Values of BOD_5 at the TNMN stations in year 2005

Table II-57: Values of COD-Cr at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	Sl02	Jesenice	6	10.2	21	9	14	II
HR	HR06	Jesenice	6.5	16.1	30.7	14.3	26.8	III
	HR07	us. Una Jasenovac	8	16.5	24.9	16.9	21.3	II
	HR08	ds. Županja	8.4	13.1	24.1	11.4	19.9	II
BA	BIH01	Jasenovac	1	11.8	30	10		III
RS	SCG13	Jamena	4.9	9.5	14.4	11.3	12.1	II
	SCG14	Sremska Mitrovica	5	7.6	10	7.4	9.5	I
	SCG15	Šabac	4.2	8.2	11.7	7.5	11.5	II
	SCG16	Ostružnica	5.5	9.2	16.8	8.7	11.1	II

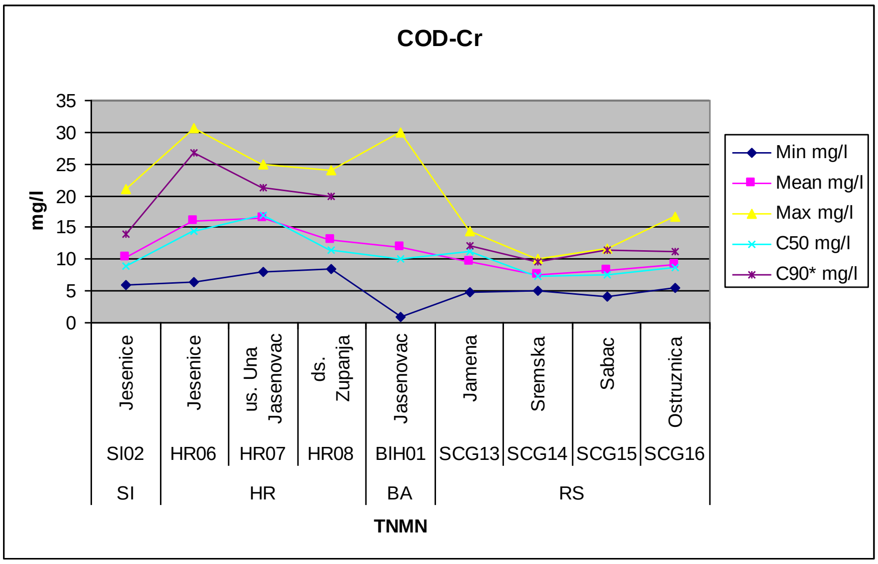


Figure II-43: Values of COD-Cr at the TNMN stations in year 2005

Nutrients

The representative parameters of water status characterization for nutrients are: NH_4, NO_2, NO_3 and PO_4. The results for the period of 2000 to 2005 (Figure II-44) demonstrate that:

- the average values of NH_4 are between 0.01 mg/l (year 2005) and 0.3 mg/l (year 2003);
- the average values of NO_2 are between 0.001 mg/l (year 2001) and 0.0525 mg/l (year 2003);
- the average values of NO_3 are between 0.64 mg/l (year 2003) and 2 mg/l (year 2002);
- the average values of PO_4 are between 0.0125 mg/l (year 2000) and 0.1724 mg/l (year 2003).

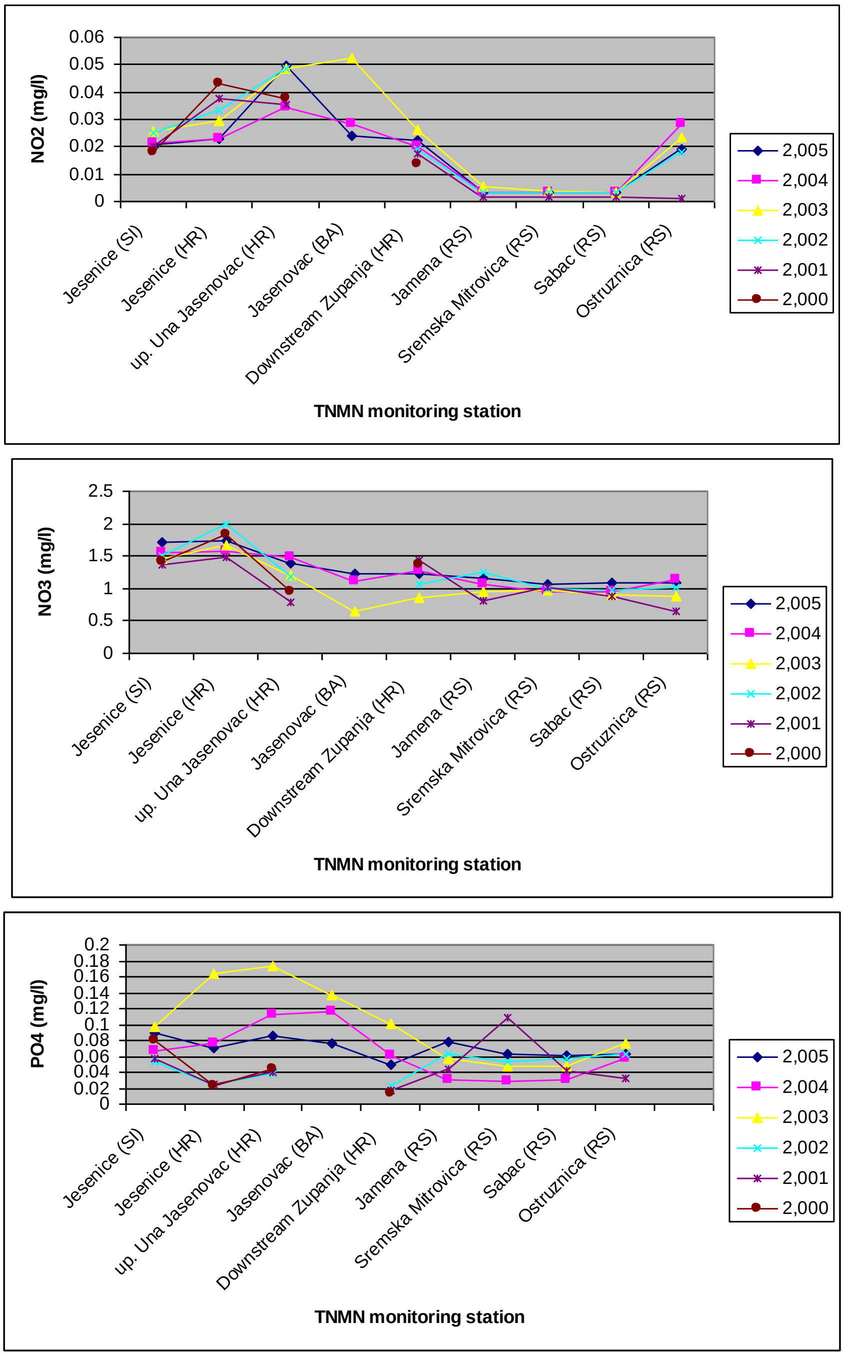


Figure II-44: The spatial-temporal evolution of nutrients in Sava River from 2000 to 2005

The results for year 2005 (Tables II-58, II-59, II-60, II-61 and Figures II-45, II-46, II-47, II-48) demonstrate that:

- the values of NH_4 between 0.004 (min) and 0.57 (max) have classified the Sava River in the I class at Jesenice-SI, Jesenice-HR, Županja-HR, Jamena-RS, Sremska Mitrovica-RS, Šabac-RS, II class at Jasenovac-BA, and Ostružnica-RS and in the III class at Jasenovac-HR;
- the values of NO_2 between 0.003 (min) and 0.568 (max) have classified the Sava River in the I class at Jamena-RS, Sremska Mitrovica-RS and Šabac-RS and in the II class at all other monitoring sites;
- the values of NO_3 between 0.096 (min) and 3.2 (max) have classified the Sava River in the II class at all monitoring stations;
- the values of PO_4 between 0.005 (min) and 0.431 (max) have classified the Sava River in the II class at Jesenice-HR, Županja-HR, Jamena-RS, Sremska Mitrovica-RS and in the III class at all other monitoring stations.

In the respective tables and figures, C50 and C90* denote a percentile of a variable.

Table II-58: Values of Ammonium (NH4-N) at the TNMN stations in year 2005

Country	Code	Location	Min mg/l	Mean mg/l	Max mg/l	C50 mg/l	C90* mg/l	Class
SI	SI02	Jesenice	0.004	0.035	0.143	0.016	0.096	I
HR	HR06	Jesenice	< 0.010	0.072	0.48	0.05	0.115	I
	HR07	us. Una Jasenovac	0.01	0.175	0.57	0.125	0.405	III
	HR08	ds. Županja	0.01	0.063	0.17	0.04	0.148	I
BA	BIH01	Jasenovac	0.01	0.134	0.26	0.125		II
RS	SCG13	Jamena	0.01	0.013	0.05	0.01	0.018	I
	SCG14	Sremska Mitrovica	0.01	0.013	0.06	0.01	0.01	I
	SCG15	Šabac	0.01	0.01	0.02	0.01	0.01	I
	SCG16	Ostružnica	0.01	0.066	0.42	0.01	0.242	II

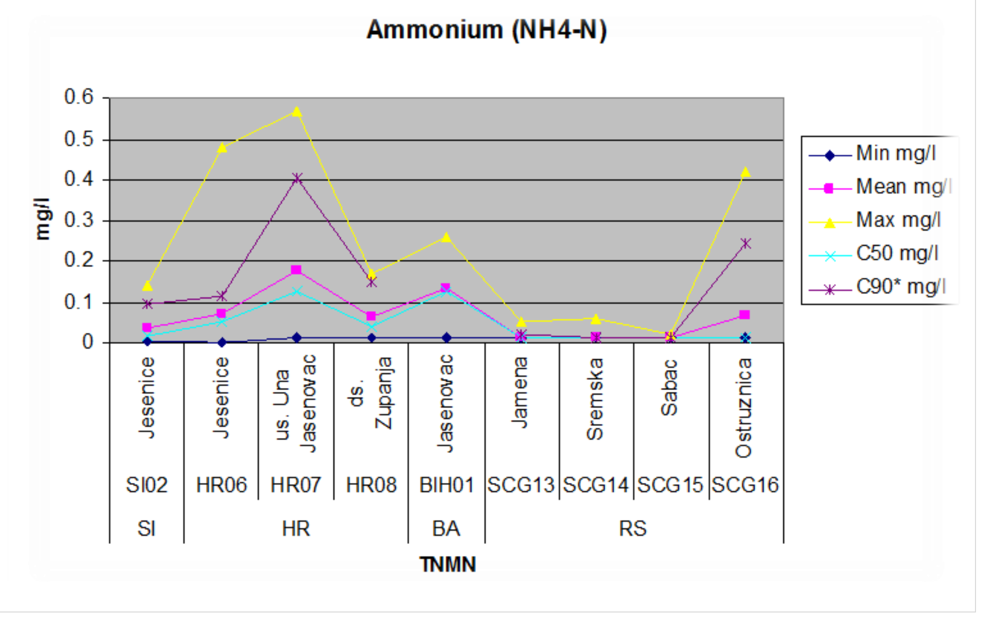


Figure II-45: Values of Ammonium (NH_4-N) at the TNMN stations in year 2005

Table II-59: Values of Ammonium (NO2-N) at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	SI02	Jesenice	0.004	0.02	0.053	0.019	0.033	II
HR	HR06	Jesenice	0.007	0.023	0.045	0.02	0.036	II
	HR07	us. Una Jasenovac	0.007	0.05	0.568	0.028	0.047	II
	HR08	ds. Županja	0.005	0.022	0.051	0.02	0.032	II
BA	BIH01	Jasenovac	0.011	0.024	0.048	0.19		II
RS	SCG13	Jamena	0.003	0.003	0.003	0.003	0.003	I
	SCG14	Sremska Mitrovica	0.003	0.003	0.003	0.003	0.003	I
	SCG15	Šabac	0.003	0.003	0.003	0.003	0.003	I
	SCG16	Ostružnica	0.003	0.019	0.068	0.017	0.045	II

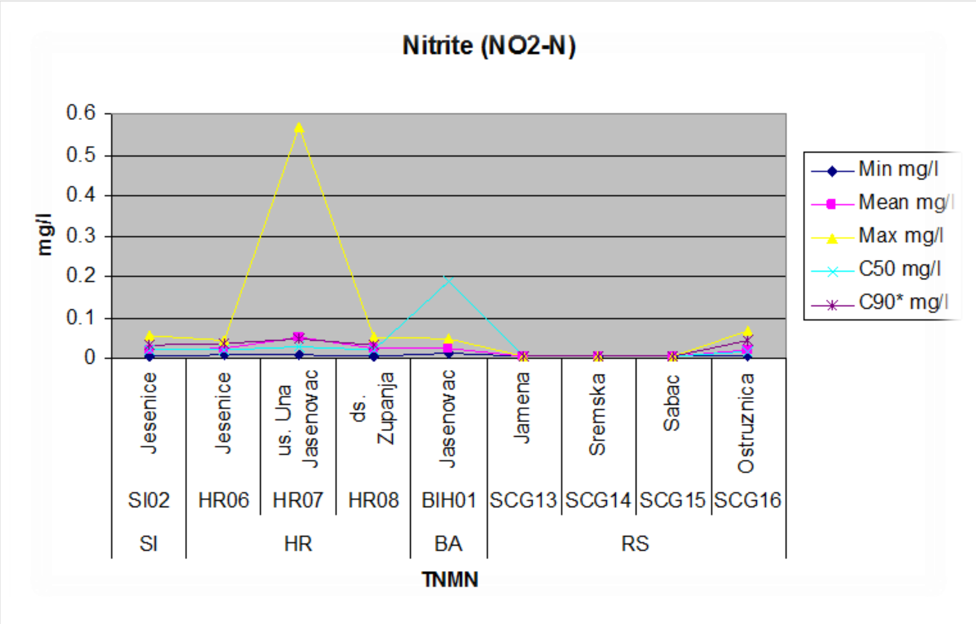


Figure II-46: Values of Ammonium (NO_2-N) at the TNMN stations in year 2005

Table II-60: Values of Ammonium (NO3-N) at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	SI02	Jesenice	1.346	1.705	2.084	1.652	1.989	II
HR	HR06	Jesenice	1.1	1.742	3.2	1.7	2.15	II
	HR07	us. Una Jasenovac	0.9	1.388	3	1.25	1.6	II
	HR08	ds. Županja	0.9	1.225	2.3	1.1	1.5	II
BA	BIH01	Jasenovac	0.77	1.229	1.575	1.32		II
RS	SCG13	Jamena	0.096	1.166	1.59	1.24	1.482	II
	SCG14	Sremska Mitrovica	0.79	1.067	1.44	1.1	1.25	II
	SCG15	Šabac	0.76	1.099	1.41	1.1	1.33	II
	SCG16	Ostružnica	0.2	1.091	2.55	1.08	1.508	II

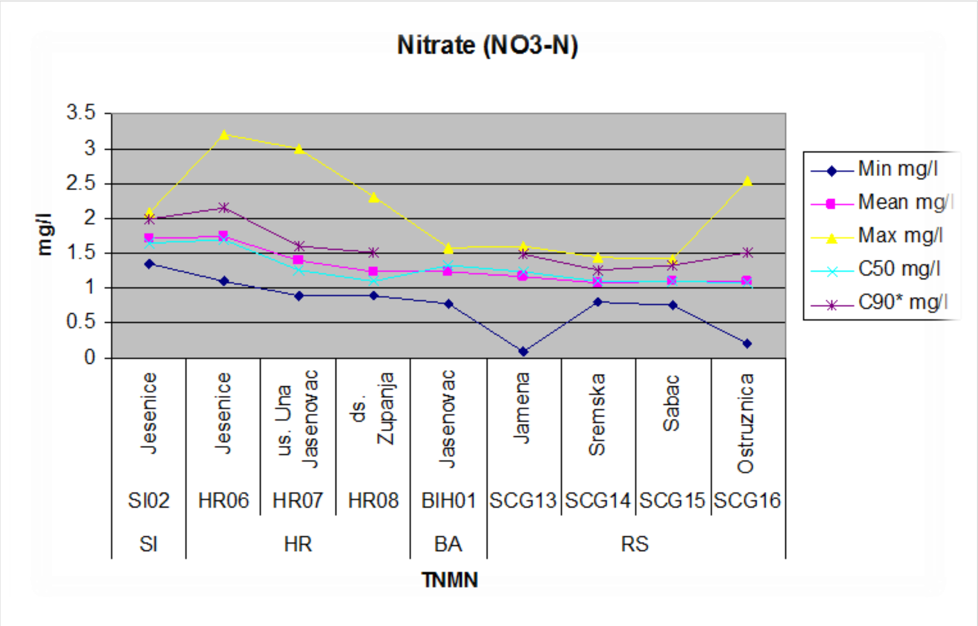


Figure II-47: Values of Ammonium (NO_3-N) at the TNMN stations in year 2005

Table II-61: Values of Orthophosphate (PO4-P) at the TNMN stations in year 2005

Country	Code	Location	Min	Mean	Max	C50	C90*	Class
			mg/l	mg/l	mg/l	mg/l	mg/l	
SI	SI02	Jesenice	0.029	0.09	0.365	0.065	0.191	III
HR	HR06	Jesenice	0.01	0.071	0.31	0.06	0.1	II
	HR07	us. Una Jasenovac	0.03	0.086	0.2	0.08	0.16	III
	HR08	ds. Županja	0.02	0.049	0.1	0.04	0.077	II
BA	BIH01	Jasenovac	0.037	0.077	0.12	0.085		III
RS	SCG13	Jamena	0.028	0.078	0.431	0.052	0.076	II
	SCG14	Sremska Mitrov.	0.009	0.062	0.426	0.04	0.07	II
	SCG15	Šabac	0.006	0.062	0.25	0.039	0.123	III
	SCG16	Ostružnica	0.005	0.063	0.154	0.059	0.115	III

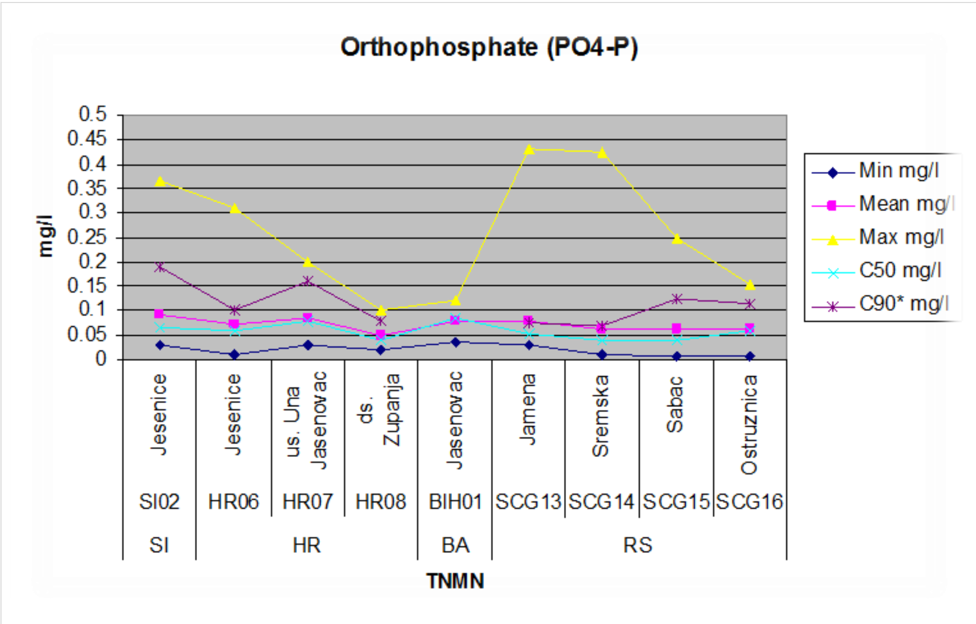


Figure II-48: Values of Orthophosphate (PO_4-P) at the TNMN stations in year 2005

1.8. Data gaps and uncertainties

1.8.1. General information on data gaps and uncertainties

Table II-62: Summary table of data gaps and uncertainties

Gap	BA	HR	RS	SI	Remarks
Lack of water quality monitoring data	x	x	x	x	
Lack of biological monitoring data	x	x	x	x	
Lack of data on hydromorphology and hydromorphology changes	x	x			
Lack of data on interaction between hydromorphology and eco-system	x	x			
Not identified WBs delineation		x			For example: Karst areas - underground runoff not defined
No harmonization on typology and WBs delineation	x	x	x	x	For example: BA-HR: Sava River BA-RS: Drina River RS-HR: Bosut River
Late start of typology process and defining reference conditions	x				
Lack of data for assessment of impacts	x			x	It is based on current evaluation of the chemical water status and biota which is not harmonized with WFD. It is result of current knowledge and available data
Synergistic effects of different pressures not evaluated yet				x	

Croatia

In this moment it is possible to give the review of the availability of data and its range, while the assessment of the quality – reliability and representativeness of the collected data will be possible only after completion of the pressure and impact analyses:

Although the chronological presentation of the work of hydrological stations is showing that the significant reduction of hydrological monitoring happened during period from 1990 – 1999, at the same time, it is necessary to emphasize that the State hydro-meteorological institute in cooperation with Croatian Waters is preparing the revision of hydrological network, by all means, should be taken into account.

Since this is the catchment area of the watercourse which is flowing mainly through the karst, the water bodies were identified not only based on the surface, but the underground runoff as well. Since only incomplete data, mainly collected from the reports that were - in its larger part - reported about 40 years ago, when the detection of the tracer was done using the quartz-lamp and each interpretation had a large dose of subjectivity, were available for the underground runoff, it is necessary to have the targeted researches – tracing by which it would be possible to identify the catchment wholes and their characteristics more reliably.

Problems in temporary identification of the heavily modified water bodies, and especially in defining the criteria, are:

- lack of data on hydromorphological changes,

- lack of data on interaction between hydromorphology and ecosystem, or problems in quantification of influence of hydromorphological changes to ecosystems,
- insufficiency of the results of existing biological monitoring for new requirements established by the WFD,
- consensus on biological criteria at EU level.

In regard to a need for developing the River Basin Management Plans, especially in the part that will refer to quantification of morphological changes of riverbed, the lack of monitoring and analysis of sediment transport and relatively small number of records of transversal profiles on unregulated parts of riverbed, especially of smaller watercourses, is emphasized.

In Republic of Croatia, in 2000, new regulations, which influenced the changes of some aspects of water quality monitoring, were passed. In such way the discontinuity in collection or interpretation of data was created. Due to that, all analyses related to water quality were conducted using samples from the period 2000 – 2004, while the data from pervious period can, at the same time, be used as the additional control.

During the analysis of spatial plans of the counties – which were used or should be used as the source of data on use of land/space, analysis of development component of economy as a whole, and similar – it was identified that this level of development (contents - thematically, methodologically and graphically) is not sufficient for conclusions and interpretations necessary for development of River Basin Management Plans. It has been proposed to conduct additional, short-term and targeted researches which will provide the minimum of necessary data.

Since the Republic of Croatia decided to use the biotic typology, which, due to lack of data, was made based on the expert assessments, in *Annual Water Management Plans for 2006 and 2007*, the financing of the comprehensive biological researches, which will serve for more precise identification of the boundaries of type, reference conditions and reference sites, was planned.

1.8.2. Gaps in the development of the typology and reference conditions

The typology has been developed individually by each country and adjustment or harmonization has not been completed yet. The adjustment of river type is needed between Serbia and Bosnia and Herzegovina and Croatia and Bosnia and Herzegovina. It should be discussed whether or not the reference conditions are needed for all obligatory descriptors of the WFD compliant assessment methods.

Bosnia and Herzegovina

Development of the typology for surface waters and definition of reference conditions in BA started with delay (for *ICPDR Roof Report 2004* – only for rivers with basin area > 4,000 km^2). Activities on preparation of typology and defining of reference conditions will be realized in two phases:

- 1st phase – to prepare preliminary typology, based on abiotic parameters (currently under preparation); Preliminary surface water typology based on classification according to the system B, based on abiotic parameters. Proposed typology system is a draft material for defining the classes of the surface water types for the Danube River Basin on Bosnia and Herzegovina territory. Preliminary typology covers following surface waters: the Sava River, as the main collector of surface waters that flows into the Black Sea, and its tributaries: the Drina, Lim, Bosna, Vrbas and Una Rivers. Proposed typology is the basis for international agreement on issues relating to transboundary waters for harmonization with the proposed typologies of the neighbouring countries. Based on the proposed Preliminary typology, there were, altogether, 11 types of surface waters, whose total surface is bigger then 4,000 km^2. According to this typology, water types are divided into 4 basic types with appropriate number of sub-types.
- 2nd phase – incorporation of additional abiotic parameters, as well as biological elements (currently under preparation); Second phase of the activities comprehends:
    - development and implementation of the typology system;
    - definition of the reference sites, communities and conditions.

Croatia

The typology was successfully implemented in the Sava River Basin. Approximately 10 % of the watercourses remained un-typified, i.e. on basis of their abiotic characteristics it was not possible to ascribe the appropriate type to them. Further research, which will include a biotic system of classification as one of the parameters, will have to identify to which ecological type (defined through biological classification), or to which of the new ecological types of running water, these un-typified water bodies belong. The use of GIS has proven to be essential for efficient characterization of the types. Such concept enables simple corrections, once the more accurate and precise data is collected. The main problem in applying the described methodology was input data – it took more than 90 % of the total time to correct the GIS layer of the watercourses, while certain irregularities related to other input data (DTM) were not a huge problem. Since the project does not encompass stagnant water, it would be advisable to finalize the activities related to definition of the national typology for that water category as soon as possible. Once the preliminary differentiation of watercourses by types is completed (on basis of the expert judgment), further activities related to the implementation of the WFD should be initiated, such as the identification of reference sites and reference conditions for each type, and the definition of the type-specific system for assessing the ecological status. More precise and reliable characterization of types (from areas to reference conditions) will be possible once the biological monitoring has been established and in function for several years. More precise identification of these indicators will enable better selection of the activities that would maintain and/or achieve good ecological status of water, on the one hand, and more objective monitoring of the effects of the implemented measures, on the other hand.

Serbia

Until now, formal activities on harmonization of the typology with neighbouring countries have not been undertaken within the Sava Basin.

Although Serbia was invited to participate on several meetings related to intercalibration exercises within the Eastern Continental GIG, and asked to nominate the intercalibration sites (based on request from Hungary), so far the intercalibration exercises have not been followed by the Serbia representatives. Three sites were nominated, one of them on the Sava River, downstream of the border with HR-BA.

Same approach was used for the typology of the tributaries.

As it was identified, the spatial typology could not be applied on all rivers without any compromise. This is, in particular, the case with large lowland rivers. Taking into consideration the level of simplification of relations in the nature implied by typological scheme, as well as the self-contained development of large rivers along the longitudinal gradient, different watercourses (with different overall characteristics) could be ranked in the same type. That was the case here. To surpass the problem without changing the approach, the subtypes were proposed.

For rivers at border crossings or shared river stretches:

BA-RS: The Drina River is a transboundary river between RS and BA, which flows along the state border between the mouth of Brusnički potok and the mouth to the Sava River. According to the typology used in Serbia the Drina River belongs to one type (RS Type 1.2 - very large river, lowland, siliceous, medium sediments). Delineation of water bodies has been implemented according to the modified category of surface water, morphological characteristics and changes of hydrological regime. Harmonization of the typology and water bodies on the Drina River between Serbia and Bosnia and Herzegovina.

The Bosut River is a transboundary river between Serbia and Croatia, which is cut by the state border. According to the typology accepted, the whole sector of the Bosut River on Serbian territory belongs to the type CS_P3_V1_SIL (medium river, lowland, siliceous bed). According to the criteria of division of river into water bodies, the whole Bosut River on Serbian territory presents one water body from the Sava River mouth up to the state border between Serbia and Croatia. The typology should be harmonized with Croatia.

Currently, there is less information about the methodology for selection of the reference sites. Therefore, it cannot be judged whether or not the reference sites and their deviation from a natural state or near pristine conditions are comparable across the country borders. Reference conditions for hydromorphological and physico-chemical quality elements are not covered by any of the countries at all.

Further activities comprise:

- Further development of the system for assessment of ecological status,
- Development of the system for evaluation of the HYMO status.

The evaluation of chemical status will be primarily based on the Directive amending the WFD (Directive 2008/105/EC).

Slovenia

The adjustment of river km is needed in Slovenia.

1.8.3. Data gaps and uncertainties for the identification of significant pressures relevant on the Sava River Basin scale

Croatia

Data on anthropogenically induced alterations to watercourses, primarily hydraulic structures, was in majority of cases vectorised from the existing „hardcopy" maps and other available documents, creating a first-hand GIS database, which will possibly be used for other purposes as well. After necessary revisions, the said database will be incorporated into the Water Information System – Inventory of Water and Water Structures. During this initial data collection campaign, only the minimally required number of attribute data was entered because, on the one hand, in majority of cases a detailed description of particular structures was not available, and, on the other hand, there is no reliable knowledge that could quantify the impact on ecosystems more adequately on basis of such attributes

Serbia

Primarily, the lack of the data on physical and chemical parameters on water bodies within hilly-mountainous area.

Further, the routine monitoring in Republic of Serbia provides the data on phytoplankton and phytobenthos. The data on aquatic invertebrates are scarce, but the data on aquatic macrophyte and fish, missing from routine monitoring.

Slovenia

The identification of significant pressures is not supplemented and validated by the monitoring data. Regarding the diffuse sources of pollution from agriculture, consumption of mineral fertilizer on different land use was estimated from total annual sold amount. Percentage of nutrient loss to environment was taken from the national research projects. Percentage of plant protection products used remained the same in 2003 and 2004. Land use is not dramatically changed in 2003 and 2004. Stores sell same plant protection products until they run out of stocks. Farmers buy what they are used to buy. In integrated production plant protection products which are allowed to be used, are prescribed. Calculations are done on sold quantities which can also mean that all sold amounts are not used in one year or are used geographically on other area.

1.8.4. Data gaps and uncertainties within the assessment of impacts on the Sava River Basin scale

Slovenia

Assessment of impact from different sources of pollution is still mainly based on status of chemical parameters in WB and on biota, or metrics required by the WFD.

Assessment of impact was based on the current evaluation of chemical status of water, which was not harmonized with the requirements of the WFD. Not all priority substances and chemical parameters relevant on national level were assessed due to lack of data.

Synergistic effects of different pressures were not evaluated yet.

1.8.5. Data gaps and uncertainties within the risk of failure analysis

Croatia

Analysis of risks in the Sava River Basin is under preparation. In the course of preparation of the Characterisation Report for the Kupa River Basin, which consists of various types of river sections with insufficient number of measuring stations, the identification of risks to achieve a good ecological status was a very unreliable process. The risk of failing to achieve good ecological status was analyzed in relation to the current status of water, pollution load, and hydromorphological alterations.

Slovenia

All uncertainties referred to assessment of pressures and impacts.

Reported risk assessment is the result of current knowledge and available data. This assessment is current cross-section in risk assessment development.

2. Characterization of groundwater (Article 5 and Annex II of the WFD)

According to Article 2 of the WFD (2000/60/EC), 'groundwater' means all water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil. An 'aquifer' means a subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or abstraction of significant quantities of groundwater. Finally, a 'body of groundwater' means a distinct volume of groundwater within an aquifer or aquifers. Groundwater bodies are subject to analyses and reviews as required under Article 5 and Annex II of the WFD. According to Annex II:

„*Member States shall carry out an initial characterisation of all groundwater bodies to assess their uses and the degree to which they are at risk of failing to meet the objectives for each groundwater body under Article 4. Member States may group groundwater bodies together for the purposes of this initial characterisation. This analysis may employ existing hydrological, geological, pedological, land use, discharge, abstraction and other data but shall identify:*

- *location and boundaries of the groundwater body or bodies,*
- *pressures to which the groundwater body or bodies are liable to be subject (...),*
- *general character of the overlying strata in the catchment area from which the groundwater body receives its recharge,*
- *those groundwater bodies for which there are directly dependent surface water ecosystems or terrestrial ecosystems.*"

According to paragraph 2.3 under Annex II, for those bodies of groundwater which cross the boundary between two or more Member States, further information on the impact of human activity on groundwaters shall be collected and maintained, where relevant.

This chapter provides an overview characterisation of the important transboundary groundwater bodies (GWBs) in the Sava River Basin. A size threshold of more than 1,000 km² was defined to select important transboundary GWBs to be included in this Sava River Basin Analysis.

2.1. Locations, boundaries and characterization of the GWBs

2.1.1. Methodology of the GWB delination

Bosnia and Herzegovina

The principle for designation of the water bodies of groundwaters is, in general, taken over from the document *Identification of Water Bodies* (CIS Guidance). The problem is that this document does not observe the groundwater bodies in karst, which are very dispersed in BA, and the importance of which, due to recharging of strong spring zones with good-quality water, which is necessary to be protected, and also due to utility value of these waters, deserves a especially sensitive analysis.

Therefore, this report may be regarded as a first step in a set of steps that will follow, with a goal to define the groundwater bodies very precisely, their importance for total development and risk for failure in achieving the good status.

Karstic zones

Basic criteria for designation of the groundwater bodies is the reliable defining of hydro-geological functions and characteristics of rock mass in the hinterland of stronger spring zones with ballanced discharge.

Second criteria is designation of hydro-geological boundary of the basin and its influence to increase of orographic surface of the basin, or extension of the influence zone to change of pressures on springs being influenced by that zone. Therein, all available data are used, especially those regarding the colouring (identification of the underground connections).

One of the important criteria is defining of the size (volume) and spatial range of groundwater body using, in the first pace, the monitoring data (hydrographs) of the emptying of underground (spring) zones.

Non-karstic zones

Methodology for defining the non-karstic zones and the size and dynamic characteristics of the water body is defined by implementation of standard methods of hydraulics based on the defining of granulometric composition, depth, water-permeability, abundance of the well identified by tests exercises, observation of the level of underground abstractions/pumping, analysis of data I on the quantities of pumping, etc.

Preliminary designation of the GWB's for different aquifers was conducted based on:

- geological boundaries of the water bodies
- hydrological (hydraulic) boundaries of the water bodies
- entering (in case of water going underground) and exiting points (springs) that control the recharge zone.

The method of delineation of the boundaries was adjusted to the porosity type of the aquifer and for intergranular porosity, mainly the hydro-dynamic models and expert judgements were used based on data on individual abstractions and granulometric composition of the aquifer, while, for aquifers of karstic-fissure porosity the hydro-geological and geological maps and data on identification of underground connections (by colouring) of abyss zones and karstic springs, and expert judgement were used.

The next phase will also be related to designation or the volumes of groundwater bodies by implementation of appropriate analyses.

Basic classification of the groundwater bodies is, depending on aquifer type and ways of flowing, or the discharge, defined as:

- completely separated (non-connected) groundwater bodies (GWB's), as the case is with aquifers of intergranular porosity, which are, dominantly, recharging from watercourses along which they were created,
- connected groundwater bodies like, mainly, in aquifers of karstic-fissure porosity, which are dominantly recharged by precipitation waters or karstic watercourses through fissure zones, and discharge through several springs or spring zones,
- GWB of sub-artesian, artesian or combined type.

Such classification was conducted not only because of systematic approach, but also, and in the first place, for creation of grounds for further development of plans for integral management of water resources in the basin.

In this sense, marked basic directions for connecting these waterbodies with pressures on them (water abstraction, water pollution ...), risks for the achievement of good quality, transboundary influences and influences on the water regime in other (orographic) basins, etc., will be in this report.

Such approach is especially important in the GWB's with karstic-fissure porosity and due to both: their ecological and development importance for BA, as well as due to their sensitivity to possible, mostly hidden, influences that are coming from the broad zone of the places and ways of pollution.

There are 22 large GWB's in BA:

- Eight groundwater bodies in the inter-granular porosity aquifer: Lijevče polje, Prijedorsko polje, Posavina I, Posavina II, Semberija, Krekanski bazen, Sprečko polje, Sarajevsko polje;
- Fourteen groundwater bodies in the karst-fissure porosity aquifer: Sjeverna Majevica, Devetak-Romanija-Sjemeč, Jahorina-Ravna planina, Treskavica-Zelengora-Lelija-Maglić, Borogovo region, Udrč region, Manjača-Vlašić-Čemernica, Grmeč-Srnetica-Vitorog, Unac, Plješevica, Velika Kladuša-Cazin, Vranica, Igman-Bjelašnica, Stupari.

Croatia

Initial characterization of groundwater bodies in the Republic of Croatia was carried out on the basis of Basic Geological map of HR, in scale 1:100,000; Hydrogeological map, in scale 1:200,000; Hydrogeological map, in scale 1:300,000; Hydropedological map, in scale 1:300,000, and numerous other published and unpublished works.

The basis for identification of the groundwater bodies was the analysis of the following elements:

- geological composition of the terrain (lithostratigraphic units and structural/tectonic relations),
- porosity (intergranular, fracture, fracture-cavernous),
- geochemical composition (silicate, carbonate),
- hydrogeological characteristics (hydrogeological units according to the porosity, hydraulic conductivity and aquifer transmissivity),
- direction of the groundwater flow – analysis of groundwater tracing in the karst,
- yields of springs and wells,
- groundwater recharge,
- relation with surface waters,
- position of groundwater bodies within river basins defined in the Strategy of Water Management of HR.

The criterion used for identification of the GW bodies was the requirement from the WFD – yield of over 10 m^3 per day (0.1 l/s). In this manner, on the basis of the performed analysis according to the previously stated indicators, 363 groundwater bodies were isolated in the Black Sea RB, all of which were placed into the category of one aquifer in the vertical cross-section. In the Adriatic RB, a total of 86 groundwater bodies were isolated on the mainland, and 12 on major islands.

Grouping of the groundwater bodies. Since the WFD enables the grouping of the GWBs for purposes to achieve the ecological goals, i.e. achievement of good groundwater status and establishment of surveillance monitoring, the grouping was carried out by taking into account the potential groundwater uses and protection. As the optimum grouping method, under our conditions, the UK model was applied, i.e. aquifers were divided into three types: primary aquifers (from which groundwater is significantly used and which are vital to groundwater ecosystems' survival); secondary aquifers (with important role in groundwater supply, which also, due to their hydrogeological and hydraulic characteristics, can lead to overexploitation) and unproductive aquifers.

In the area of the Black Sea RB, three aquifer types were found, on basis of which the grouping of groundwater bodies was performed, as follows:

- primary aquifers:
    - Quaternary aquifers of intergranular porosity in the Sava River valleys with marked hydraulic characteristics, which either provide water for the majority of public water supply in northern Croatia or are planned for water supply (aquifer in the area of Zagreb, cone deposits of the Sava River right tributaries, alluvial aquifer in the area of Karlovac)
    - Carbonate aquifers of fracture-cavernous porosity and high permeability in high karst zones, i.e. Kupa and Una River Basins, from which groundwater surfaces in high-yield springs,
- secondary aquifers:
    - Quaternary aquifers of intergranular porosity in the Sava River Basin with somewhat lower hydraulic characteristics, used for water supply, with yields generally under 20 l/s
    - Carbonate (Triassic) aquifers of fissure porosity and medium permeability in northern Croatia (Zagorje and Slavonia mountains, Žumberak-Samobor mountains, Mt. Medvednica)

  - Carbonate aquifers of fracture-cavernous porosity in shallow karst zones, i.e. Kupa River Basin, virtually with no significant springs,
- unproductive aquifers:
  - mostly limited to Neogene deposits (exchanges of marls, silts, clays, sand, occasionally carbonates), Quaternary deposits with poor hydraulic characteristics and/or small thickness, and metamorphic rocks (permeable only in a shallow segment below the terrain surface), which generally cannot yield water quantities over 5 l/s.

Serbia

Delineation Criteria - During the process of delineation of groundwater bodies the principle criteria has been the geological characterization of the rock mass, hydrogeological borders, exploitation and pressures identification. On basis of the previously mentioned criteria, two water bodies and one group of water bodies of groundwater have been identified in the Sava River Basin.

Geological structure - identified water bodies have been formed in the aquifer of inter-granulated porosity. Aquifers consist of the sand-gravel quaternary sediment and sand-gravel Pliocene sediment.

Groundwater exploitation - Groundwater of identified groundwater bodies is used for public water supply of inhabitants and industry.

Criteria of significant groundwater bodies - above mentioned groundwater bodies have been identified as significant because of exploitation. They are used for public water supply of inhabitants and industry with the quantity larger than 100 m^3/day in accordance with the limit given by the WFD.

Delineation of the national ground water bodies is under the execution.

Description of significant groundwater bodies

The „East Srem OVK" Groundwater Body (MS Code RS_SA_GW_I_2)
The „East Srem OVK" groundwater body is located in the area of the alluvial plain (floodplain and river terrace) and the upper terrace 2-4 m above the alluvial plain. The absolute elevations of the terrain are: 73-83 m a.s.l. (alluvial plain) and from 84 to approx. 100 m a.s.l. (upper terrace). A major portion of the groundwater body belongs to the Sava River Basin, and a minor portion to the Danube River Basin. The southern boundary of the groundwater body is the Sava River, which is either in direct hydraulic contact with the body or features a somewhat reduced hydraulic conductance due to clogging of the riverbed and, partly, due to partially eroded semi-pervious silty sands of the riverbed. Along the stretch of the Sava upstream from Jarak to Zasavica, where the Sava River is not incised into the aquifer (i.e. where the river channel lies in the overlying, virtually impervious strata), the groundwater body is in direct hydraulic contact with the groundwater body in the region of Mačva. The eastern/north-eastern boundary of the groundwater body is the Danube River. The northern boundary of the groundwater body is the aquifer boundary (i.e. it coincides with the edge of the upper terrace along the Šid-Ruma-Stara Pazova line). It is hydrodynamically defined by the groundwater flow from the „Srem Series" to the said aquifer. The surface area of the groundwater body within the above-mentioned boundaries in the territory of the Republic of Serbia is roughly 1,557 km^2.

The aquifer in which the body is found is an intergranular porosity aquifer. The lower portion of the aquifer is characterized by polycyclic riverine (riverine-lacustrine) sediments, which present an Eopleistocene sequence generally comprised of sands and gravels in the eastern part of Southern Srem (east of the Klenak-Ruma line), and of gravelly sands and gravels in the western part of Southern Srem. The upper portion of the aquifer is generally comprised of sandy deposits, with subordinate sandy-gravelly Middle Pleistocene riverine/bog deposits. The sandy-gravelly strata, which constitute the lower and upper portions of the aquifer, are in direct contact in the alluvial plain of the Sava, while in the upper terrace area they are separated by silt and silty clay interlayers and lenses. The total thickness of the aquifer is between 16 m and roughly 50 m.

The groundwater body is recharged through infiltration of water from the Sava River at high stages, infiltration from the primary canal network at low piezometric levels of the groundwater body, and indirect infiltration of atmospheric precipitation through overlying semi-pervious strata into the aquifer. A certain degree of groundwater flow from the Srem Series into the aquifer cannot be ruled out.

Groundwater is discharged from the body into the Sava River and the primary canal network, when their water levels are low, as well as indirectly, through evapotranspiration of groundwater from the overlying semi-pervious strata. A major portion of the aquifer discharge is attributable to the groundwater abstraction from the body for public and private drinking-water supply for population and several industries.

The „West Srem Pliocene" Groundwater Body (MS Code RS_SA_GW_I_6)

The „East Srem Pliocene" Groundwater Body (MS Code RS_SA_GW_I_7)

The „Mačva Pliocene" Groundwater Body (MS Code RS_SA_GW_I_8)

The „West Srem Pliocene", „East Srem Pliocene" and „Mačva Pliocene" Groundwater Bodies are the the parts of the Srem-Mačva group of the groundwater bodies, located between the southern slopes of Mt. Fruška Gora in the north and northern slopes of Mt. Cer in the south (i.e. in the region comprised of Srem, Mačva and Pocerina).

In Mačva, Pliocene aquifers are found at depth of roughly 60-196 m, in the zone of Crna Bara-Bogatić, Belotić-Tabanović, and at depth of 50-170 m in the zone of Ravnje-Crna Bara. The aquifer in the upper portion of the terrain is continuous, while in the deeper portions of the terrain there are irregular lateral and vertical interchanges with semi-pervious and virtually impervious silts, silty clays and marly clays. Aquifer thicknesses range from below 2 m to some 30 m. Larger thicknesses are found in the western (Badovinci-Crna Bara-Crnobarski Salaš-Ravnje) and central (Belotić-Bogatić) parts of Mačva, where they are 18-30 m, unlike in the northeastern part, northeast of the Tabanović-Glušci line, where aquifer thicknesses are up to 12 m.

In Srem and Mačva (in the single hydrogeological basin of the Sava trench), each aquifer/aquifer package includes groundwater reservoirs, which are hydraulically linked into two groundwater bodies, either directly or indirectly through the semi-pervious silts and silty sands. These two groundwater bodies are separated by thick semi-pervious or virtually impervious deposits. The first body is comprised of the groundwater reservoirs formed in Paludine aquifers, while those of the second body are formed in Upper Pontian aquifers.

The boundaries of the groundwater bodies coincide. The southern and northern boundaries are defined by the areal extent of the aquifer to the slopes of Mt. Fruška Gora and Mt. Cer, while the eastern and western boundaries are open toward Banat and the Croatian portion of Srem, respectively. At this time, it is not possible to define the boundaries along the northern and southern edges accurately, especially along the slopes of Mt. Fruška Gora, where Pliocene sediments are covered by the Srem Series and loess. Probable boundary in this area runs along the Novi Karlovac-D. Maradik-Pavlovci-Čalma-Šid line. The boundary of the bodies in the Mt. Cer area roughly coincides with the Pliocene strata boundary.

The aquifers of both these bodies are recharged through infiltration of precipitation in the Mt. Cer area, where the aquifers are exposed, and to a significantly lesser extent along the southern slopes of Mt. Fruška Gora, where recharge by infiltration is indirect, through the Srem Series and loess. No data are available for an assessment of the extent of recharge of the groundwater bodies.

Under natural conditions, the aquifers were discharged through the flow from deeper to shallower aquifers, especially from the first body to Quaternary aquifers. Today, a major portion of the discharge is attributable to groundwater abstraction from both bodies for public water supply for six towns and about 36 villages. Groundwater abstracted from the Pliocene aquifers in Mačva is used for rural water supply via „public wells", as well as for private and public agricultural, and a few industrial facilities.

The bodies are subject to moderate quantitative pressures only in the areas of sources of water supply (at the Batrovci water source in Šid, the pressure is slightly higher than moderate). The permanent drawdown in the eastern part of Srem is about 10 m, and more than 15 m in the western part of Srem. There is possible risk of not achieving the WFD Article 4 related to environmental goals.

Slovenia – no data submitted.

2.1.2. Important groundwater bodies in the Sava River Basin

Countries in the Sava RB have reported 42 important groundwater bodies in the Sava River Basin.

The national breakdown of the GWBs related to size and number is indicated in Figures II-49 and II-50.

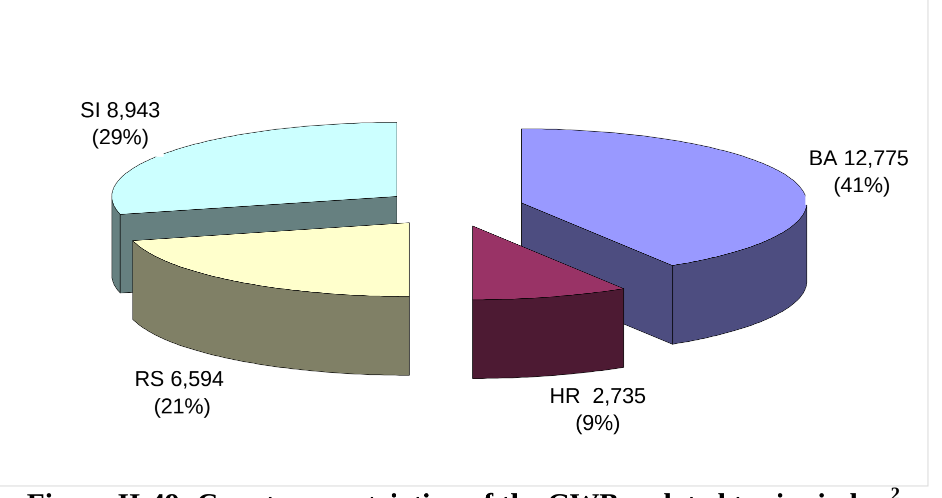


Figure II-49: Country repatriation of the GWBs related to size in km²

Figure II-50: Country repatriation of the GWBs related to number of GWBs

2.2. Risk of failure to reach the environmental objectives

2.2.1. Methodology of risk assessment of the GWBs

Bosnia and Herzegovina

Most important chemical influences on groundwater are identified as:

- Use of natural and artificial fertilizers in agriculture,
- Discharge of wastewater from towns and industry, as well as the farm wastewater through septic tanks and wells,
- Discharge of wastewater from towns and industry, as well as the farm wastewater into the surface waters that feed aquifers, or into the sinking streams (in the karst regions),
- Leakage waters from waste dumps (towns and industry), which do not meet even a minimum sanitary requirements for waste depositing,
- Waters from mines and coal separation.

Unfortunately, there is no organized monitoring of polluters, as well as the groundwater quality monitoring, with data necessary for forecasting influence of these polluters on the ecosystems.

Therefore, the risk assessment of not reaching the aims for certain groundwater bodies was performed mostly during the usage of that water, and based on available data and investigation works, which defined protection measures for ground waters. In those cases, the most common criteria were time of the water held in the ground (for aquifers with intergranular porosity), i.e. results of coloring which represent the direct link of the surface and groundwater (for aquifers with karstic-fissure porosity) and time of the water held in the ground.

According to 1991 data, water consumption (with network losses) for the needs of the population (maximum consumption) was approx. 15.5 m^3/s. The fact that this quantity was secured in approximate degree of 38 % from intergranular type groundwater and 51 % from sources of karst-fissure type (remainder was secured from open streams), points to the pressure on groundwater bodies (exploitation) becoming ever higher.

So far, such situation has been reached by aquifers of Sarajevo Field and Novoselije groundwaters, which are being artificially recharging from the open watercourse waters due to extensive exploitation.

A high-quality estimate of anthropological influence on groundwater based on the so far collected data, till 2005, is not possible.

Influence of exploitation on ecological status of groundwater is estimated as insignificant, because the water capacity of groundwater exploitation is far lower compared to the total estimated aquifer richness (excluding the above-stated and other minor cases) for most identified groundwater bodies.

However, the possible future influence of groundwater exploitation on some water bodies demands additional, more precise risk assessment.

As far as influence on chemical water composition estimate is concerned, high-quality risk assessment requires establishment of a monitoring network for regular follow-up of the quality of groundwater, therefore only preliminary estimate of the chemical water status was performed, based on the expert judgment.

Croatia

Aquifer vulnerability: When defining natural vulnerability of Quaternary aquifers in the Sava RB, the most important data were related to thickness and lithological aquitard composition, which play the main role in natural aquifer protection. Following the analysis of lithological aquitard composition, their thickness and mapping of aquitard favourability for aquifer protection, the aquifer vulnerability maps were prepared.

Natural vulnerability in the Black Sea RB is divided into 5 categories:

- no vulnerability: in the Sava RB, these are areas with unproductive aquifers and aquifers with aquitard depths of over 20 m;
- low vulnerability: areas with aquifers of aquitards achieving even higher thickness, but where aquifer recharge areas are poorly aquitard-protected;
- medium vulnerability: in the Sava RB, these are areas with aquifers whose aquitard thickness reaches 20 m, but where aquifer recharge areas are poorly aquitard-protected;
- high vulnerability: in the Sava RB, these are areas with aquifers whose aquitard thickness reaches 10 m, but where aquitard thickness in aquifer recharge areas is significantly less than 5 m; open carbonate (Triassic) aquifers of fracture-cavernous porosity and medium permeability in northern Croatia and open carbonate aquifers of fracture-cavernous porosity in the Kupa, Korana and Una RBs, partly due to aquitards made of clastic deposits of varying thickness or great depth to groundwater;
- very high vulnerability: Zagreb areas where aquitard thickness is generally under 5 m, and open carbonate aquifers of fracture-cavernous porosity and high permeability in high karst zones of the Kupa and Una RBs.

Groundwater quality. Initial identification of the natural groundwater quality was made on basis of the monitoring raw water quality at water abstraction sites and systematic monitoring on state waters. According to the legislation, monitoring of the groundwater quality is mandatory on all water abstraction sites inluded in the public water supply; however, this scope rarely satisfies the criteria stipulated by the *Regulation on sanitary quality of drinking water* (OG 46/1994). Water quality is observed only on the water abstraction sites used for public water supply, and mostly in abstraction structures (wells or springs). In all recharge areas in the Sava RB the groundwater quality monitoring is carried out only on major abstraction sites (Zagreb), where alluvial aquifers are captured. For initial groundwater chemical and quality status, i.e. selection of indicators for present monitoring, the following are selected:

- groundwater temperature;
- redox conditions in groundwater;
- mineralization/salinity;
- groundwater acidity status (alkalinity, pH);
- contents of nutrient N (NO_3^-,NO_2^-,NH_3) and P (total P, orthophosphates) salts - anthropogenic impacts (agriculture, industries, households, solid waste disposals, etc.);
- heavy metals – Fe – indicator of both natural and anthropogenic pollution;
- chemical oxygen demand (COD);
- chlorides – proof of impacts form agriculture and use of mineral and natural fertilizers, wastewater from roads, households, agriculture;
- other indicators – suspended solids, turbidity, microbiological indicators, contents of mineral oils.

The arithmetic mean reflects the general condition of individual GW bodies very well, and the reflection of such state which does not exceed 50 % of the GW body area, but only if monitoring points are evenly distributed. It is, however, unreliable in cases of uneven pollution by a local or diffuse source, or in aquifers of fracture-cavernous porosity. It is selected for initial characterization of GWBs. The main characteristic of natural groundwater quality in aquifers of intergranular porosity in northern Croatia are increased contents of iron, manganese, ammonium and their associated elements, arsenic in particular, as recorded in eastern Slavonia. This is a consequence of natural, reductive conditions in the aquifer, and not of anthropogenic influence. Groundwater with increased concentrations of heavy metals is generally related to deep aquifers of northern Croatia’s eastern areas. Groundwater quality from carbonate aquifers in northern Croatia is exceptionally good, since they are located in forested mountain areas, thus there are no sources of pollution in their recharge areas. In the areas comprised of carbonate rocks, the natural state of groundwater quality is very good. At times of medium to low water levels, groundwater quality in natural conditions is very good; however, in periods of high precipitation, water turbidity occurs in springs, but lasts only for several days.

Groundwater quality in deeper sections of the alluvial Zagreb aquifer reflects natural geochemical conditions, while several shallower areas of the aquifer are under anthropogenic influence of varying intensity. Groundwater quality in the Zagreb area mostly satisfies the requirements from the *Regulation on sanitary quality of drinking water* (OG 46/94 and 49/97). However, although they generally do not exceed maximum allowed concentrations for drinking water, the presence of nitrates, total and mineral oils, highly volatile hydrocarbons and bacteriological pollution indicates that degradation of groundwater quality is consequential to anthropogenic influence. Groundwater quality in the analyzed springs in the littoral area of Croatia and in Lika is of extraordinary good quality. All analyzed indicators are below maximum allowed concentrations for drinking water, with the exception of microbiological indicators, which, in accordance with the Regulation, can place water into I and II classes. Springs in Lika have only occasional problems with bacteriological indicators.

Pressures: As part of pressure analyses (with regard to legal use, i.e. pressures on groundwater), the following analyses were conducted:

- Analysis of pressures on groundwater quantity status (abstraction, lowering of water levels and irrigation),

- Analysis of pressures on groundwater quality (point sources of pollution: industries, discharges from wastewater systems, solid waste disposals; diffuse sources of pollution: agriculture (total nitrogen, phosphorus and potassium), data on traffic-related pollution).

Problems with determination of pressures were caused by undefined indicators and not updated data bases.

Pressure on groundwater quantity status: Status of groundwater quantity in the Sava RB is satisfactory. There is virtually no regional negative impact on permanent lowering of groundwater levels in aquifers of intergranular porosity, with the exception of the western part of the Sava. However, this lowering of groundwater levels is not attributed only to groundwater overexploitation, but also to other factors, such as construction of hydropower facilities in Slovenia, regulation of the Sava tributaries and torrential flows as well as the regulation of the Sava River bed and gravel exploitation, etc. Negative influence on groundwater quantity status in karst aquifers has not been determined to date.

Pressure on groundwater quality: Data on point sources of pollution were not quite sufficient for a detailed analysis. Pressures, in particular point sources of pollution, were identified: industries, discharges from wastewater systems and solid waste disposals. Pressure analysis includes identification and impact assessment of groundwater quality on all accessible monitoring points (abstraction sites, sources, piezometers).

As part of the impact analysis of diffuse sources of pollution, data were used on terrain coverage with agricultural surfaces (fields) and their pressure in terms of nitrogen, potassium and phosphorus as products of fertilizer use for cultivation of various agricultural crops. The highest quantities of nitrogen, potassium and phosphorus in the Sava RB are in Hrvatsko zagorje, in the valleys of Ilova and Pakra Rivers and in the Požega depression.

Serbia

Pressures and impacts - generally the data about pressures on groundwater are missing, because there is no adequate monitoring of the water quality of identified groundwater water bodies.

The criteria used for the quantity risk assessment were based on the history of alterations of piezometric levels from 1960 observed at a limited number of monitoring stations, on the data collected from operators of groundwater sources on level alterations and quantities of the abstracted water, as well as on the developed regional hydrodynamic groundwater model used for the estimation of future trends of piezometric levels for several scenarios of future groundwater abstraction.

The criteria used for the (quality) chemical risk assessment were based on the thickness, hydraulic conductivity of overlying layers as natural protection of the groundwater body, the results of the quality analysis of chemical monitoring and identification of possible upward trends, as well as on the presence of anthropogenic pressures on chemical status.

Slovenia – no data submitted.

2.2.2. Results of the risk assessment of the GWBs

The risk classification is distinguished between three classes: GWBs 'at risk', GWBs 'possibly at risk' and GWBs 'not at risk'. A GWB is classified as being 'at risk', if the nationally applied risk criteria are fulfilled. In cases of insufficient data, GWBs have been classified as being 'possibly at risk' until more detailed information is available.

Countries have implemented the risk assessment concerning the quality (chemical) status and quantity status of all important GWBs in the Sava RB except in BA which has not reported on the risk assessment for 4 identified GWBs (Krekanski bazen, Sprečko polje, Sarajevsko polje and Sjeverna Majevica) with the size of 221 km^2 which represents 0.6 % of the total area of important GWBs in the Sava RB.

Following tables and figures present the status of the risk assessment of the GWBs in the Sava RB concerning the quantity and quality.

Table II-63: Status of the risk assessment of the GWBs in the Sava RB related to size in km²

		Risk			Risk		
		Quantity			Quality		
	Size	Yes	Possible	No	Yes	Possible	No
	km²	km²	km²	km²	km²	km²	km²
BA	12,775	1,834		10,720	4,264		8,290
HR	2,735	175	153	2,408			2,735
RS	6,594		6,594			1,594	5,000
SI	8,943			8,943			8,943
	31,047	2,009	6,747	22,071	4,264	1,594	24,969
% of total size		6	22	71	14	5	80

Table II-64: Status of the risk assessment of the GWBs in the Sava RB related to number of the GWBs

		Risk			Risk		
		Quantity			Quality		
	No of WBs	Yes	Possible	No	Yes	Possible	No
BA	22	4		14	5		13
HR	11	3	2	6			11
RS	4		4			1	3
SI	5			5			5
Sava RB	42	7	6	25	5	1	32

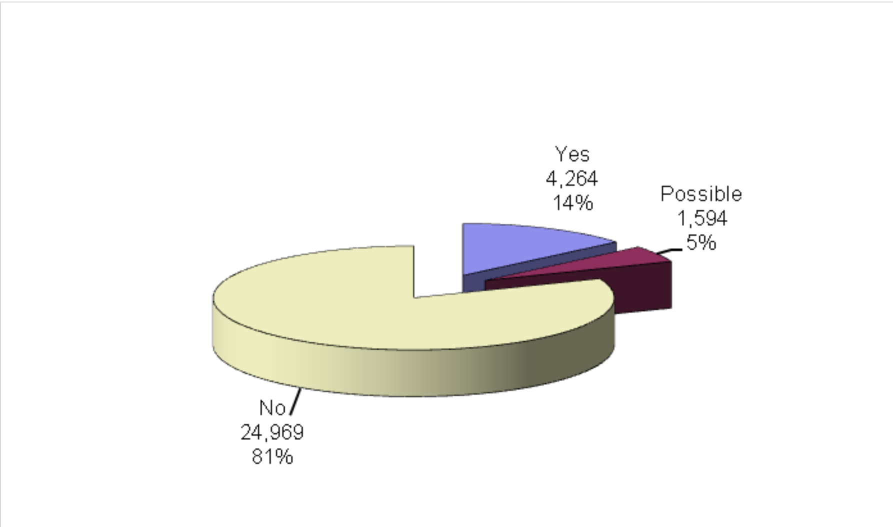


Figure II-51: Risk assessment of the quality (chemical) status of important GWBs in the Sava RB

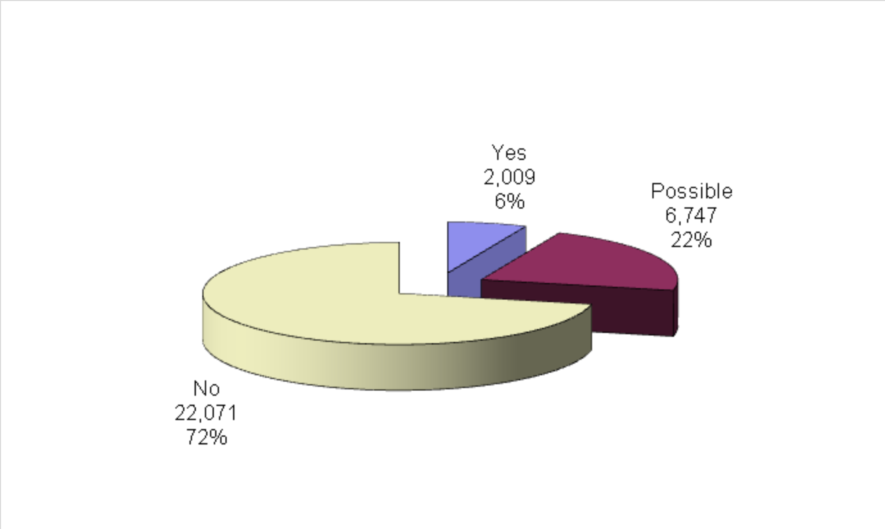


Figure II-52: Risk assessment of the quantity status of important GWBs in the Sava RB

2.3. Monitoring of groundwater

According to the Article 8 of the EU WFD, the Member States shall ensure the establishment of programmes for the monitoring of water status […] for groundwaters, and such programmes shall cover monitoring of the chemical and quantitative status.

Chemical groundwater monitoring programmes are required to provide a coherent and comprehensive overview of the water status within each river basin, to detect the presence of long-term anthropogenically induced trends in pollutant concentrations and ensure compliance with the Protected Area objectives.

A quantitative monitoring network is required to assist in characterisation, to determine the quantitative status of groundwater bodies, to support the chemical status assessment and trend analysis, and to support the design and evaluation of the programme of measures.

Regarding the national monitoring network, there are 17 groundwater stations (only data from HR and RS are available) on the main groundwater bodies in the Sava River Basin.

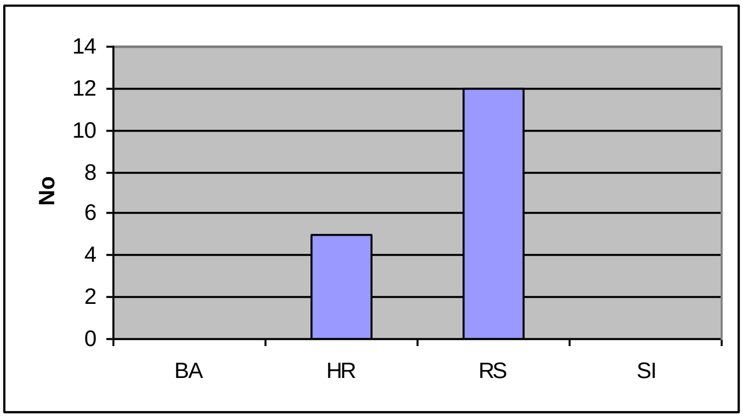


Figure II-53: Groundwater monitoring stations on main groundwater bodies in the Sava River Basin

2.4. Identification of data gaps and uncertainties

Table II-65: Summary table of data gaps and uncertainties

Gap	BA	HR	RS	SI	Remarks
Lack of groundwater quality and quantity data	x	x			
Lack of data on drinking water supply systems and protection zones	x				Especially for small settlements
Lack of data on water balance groundwater	x	x	x		
Lack of data on GWBs connections	x		x		
Lack of data on influence of different pressures to the GWBs	x		x		Especially diffuse pollution

Bosnia and Herzegovina

Data for the required quantity and quality identification of the groundwater have different level of processing for certain aquifers. Data for aquifers exploited for water supply needs of municipal centres exist in most cases, while there are almost no data for smaller water-supply systems (village and individual).

Only several municipalities performed the harmonization of drinking water source sanitary protection with the new legislation.

Other municipalities have sanitary protection zones defined based on partial investigation works or based on decisions by the municipality that exploits the source.

Therefore, the data on aquifer characteristics are either incomplete or unknown for reasons of:

- Spatial and time variation of the groundwater (GW) level, because there is no systematic surveillance of the GW level at the source,
- Lack of data on influence of extensive exploitation on the GW quality (there are no systematic measurements),
- Lack of data on hydraulic connections between the surface and groundwater and influence of agricultural (diffuse) pollution on the GW quality, as well as the influence of concentrated polluters on the GW quality,
- Lack of data on hydraulic connections and influence of agricultural (diffuse) pollution on the GW quality, as well as influence of the concentrated polluters on the GW quality, in karst regions which are very sensitive, especially the smaller GWBs.

Croatia

Future activities within the WFD implementation are: further characterization of the water bodies for the risk of failure to maintain a good water status was determined, establishment of adequate monitoring (of qualitative and quantitative status of groundwater), determination of indicators of water quality, harmonization of the Regulation on water classification with the *Regulation on sanitary quality of drinking water*, updating data bases on point and diffuse sources of pollution, isolation of the water bodies intended for present and future water supply, isolation of water bodies for which, for justifiable reasons, lower requirements should be established. Under way is the preparation of the river basin management plans, analysis of potential transboundary aquifers, definition of transboundary water bodies and establishment of bilateral cooperation with neighbouring countries for harmonization of data on such aquifers. When delineation and characterization have been started, it has been realized that many data are missing due to the inadequate monitoring. Monitoring is performed at water abstraction sites and there is no national programme for groundwater quality monitoring.

Serbia

Data gaps **-** Data to determinate the balance of groundwater bodies are missing. Data on hydrodynamic characteristics of aquifer are known only in the zones of potable water sources, for other locations are estimated. Pressures to water bodies are not completely considered, only the data on existing and potential polluters exist without any quantification.

Slovenia – no information provided.

There is no data about water quality of groundwater.

Part III: Water Quantity

1. Elements of water balance in the Sava River Basin[5]

1.1. Climate

1.1.1. General types of the climate in the Basin

The climate in the Sava River Basin is not uniform, actually it considerably changes over the basin. Its variations are the result of land and sea distribution and closeness, as well as of various orographic features. As it is mentioned in Part I of this report the climatic conditions in the basin can roughly be classified into three general types:

- Alpine climate;
- Moderate continental climate;
- Moderate continental (mid-European) climate.

Three main elements of the climate that significantly affect the water availability and present grounds for development, use and conservation of this resource are air temperature, precipitation and evapotranspiration.

1.1.2. Air temperatures

With regard to air temperatures, it can be roughly assessed that the within-the-year variations exhibit a common pattern for majority of the catchments. Winter temperatures (December to February) are low, while high temperatures occur during the summer season (June – September).

Average annual air temperature for the whole Sava Basin was estimated to about 9.5 ^{o}C. Mean monthly temperature in January falls to about -1.5 ^{o}C, whilst in July it reaches almost 20 ^{o}C. These figures decrease as the altitude grows higher. In earlier studies it was asserted that the average annual temperatures drop about 5 ^{o}C at each 1,000 m of elevation increase. This temperature gradient is somewhat larger for July (6 ^{o}C) and considerably less for January (about 3 ^{o}C).

Average annual temperatures in the region vary in a wide boundaries depending, in the first place, on elevation. The lowest long-term annual average temperatures at measured points take place on the mountain ridges that divide the Sava River and the Adriatic Sea watersheds. According to available documentation the lowest estimated value is 4.7 ^{o}C at Žabljak (ME).

Warmest weather appears at lowlands along the Sava River where this parameter rises to about 10.0 – 12.0 ^{o}C (Belgrade, Zagreb, Slavonski Brod). Illustration of the temperature regime in the considered region is provided in Table III-1, based on the estimates originating from various documentation.

[5] Detailed *Hydrology report for the Sava RB Analysis* with appended tables, figures and maps forms a background document of this Report.

Table III-1: Monthly and Annual Average Air Temperature in the Sava River Basin

Location	MONTH												Mean
	1	2	3	4	5	6	7	8	9	10	11	12	
Ljubljana	-1.8	0.2	4.8	9.9	14.2	18.0	19.7	18.8	15.4	10.0	5.1	0.2	9.5
Žabljak	-4.4	-3.7	-1.0	3.2	8.3	12.0	14.1	13.7	10.2	5.5	1.2	-2.4	4.7
Sarajevo	-0.9	1.5	5.1	9.4	14.1	16.9	18.9	18.5	15.1	10.4	5.3	0.3	9.6
Banja Luka	-0.7	1.9	6.1	10.9	15.6	18.9	20.6	19.7	15.9	10.8	5.9	1.2	10.6
Zagreb	-1.3	0.5	5.4	11.0	15.2	18.6	20.7	19.9	16.2	10.6	5.9	1.0	10.3
Slav. Brod	-0.9	0.9	6.1	11.9	16.2	19.8	21.7	21.0	17.2	11.5	6.6	1.4	11.1
Sremska Mitrovica	-0.7	1.3	6.0	11.6	16.4	19.5	21.0	20.4	16.8	11.1	5.9	1.4	10.9
Beograd	0.4	1.4	6.9	12.4	17.1	20.2	22.0	21.7	18.0	12.3	7.0	2.6	11.9

1.1.3. Precipitation, evapotranspiration and runoff

Precipitation amount and its annual distribution are very variable within the basin. It, however, can roughly be asserted that the form of precipitation has a common feature: rainfall and snowfall of different duration are likely to occur all over the whole catchment. Average annual rainfall over the Sava River Basin was estimated at about P = 1,100 mm. The long-term average discharge of the Sava River at the mouth near Belgrade is about Q = 1,700 m^3/s. This is equivalent to effective rainfall of about h = 570 mm/year. Accordingly, it can be concluded that the average evapotranspiration for the whole catchment is about E = 530 mm/year.

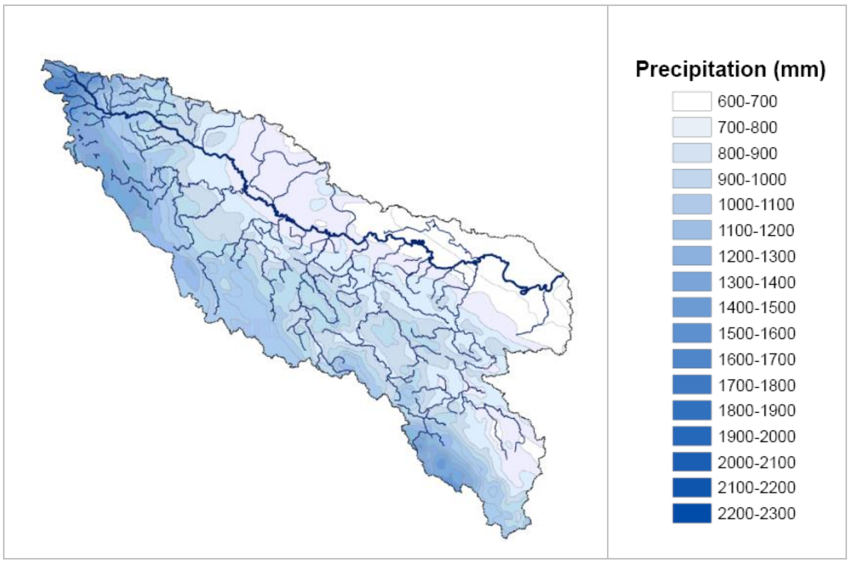


Figure III-1: Mean annual precipitation in the Sava River Basin (*The Danube and its Basin – Hydrological Monograph*, 2006)

Considerably more precipitation occures in mountainous parts of the basin than in the northern regions where low mountains, hilly terrain and plains dominate.

Average annual precipitation over the Sava River Basin in Slovenia is about 1,100 mm. At gauged points in this area it varies between 1,000 mm (at exit of the Sava River from Slovenia) and 3,000 mm (at mountains). These values, however, can be even higher at some particular places. The considered area can receive noticeably larger precipitation in some rainy years.

Variations of average monthly precipitation are not particularly large within the year. Nevertheless, most precipitation occurs in summer season or during autumn. Significant portion of precipitation falls in form of snow so that relatively long periods with snow cover are common characteristic of the region. This causes relatively high spring - to early summer runoff.

Average annual evapotranspiration in the upper Sava River drainage is not highly variable: it was estimated to range between 500 and 600 mm.

Mountainous region south of the Sava River, where most right tributaries originate, belongs to the region where moderate continental climate prevails. Yet, due to closeness of the Adriatic Sea, it is under influence of the Mediterranean.

As previously stated, a part of the drainage situated north of the Sava River, which constitutes a smaller part of the basin, belongs to the Pannonian plains. Climatic conditions in this region are governed by orographic features as well as by closeness and openness to central- and east European part of the Continent. The Pannonian climate, with hot summers and cold winters, prevails in Slavonia, and Vojvodina whose smaller part is drained towards the Sava River. This climate also extends south of the Sava River course into northern Bosnia and Serbia.

Precipitation in this region is relatively low. It ranges from about 650 mm/year to 1,000 mm/year in areas with somewhat higher altitudes. Most precipitation occurs in warmer part of the year (vegetation season) than in colder. This characteristic is favorable to agricultural activities. Snow fall is regular feature every year.

Evapotranspiration is relatively high owing to high summer temperatures and water availability.

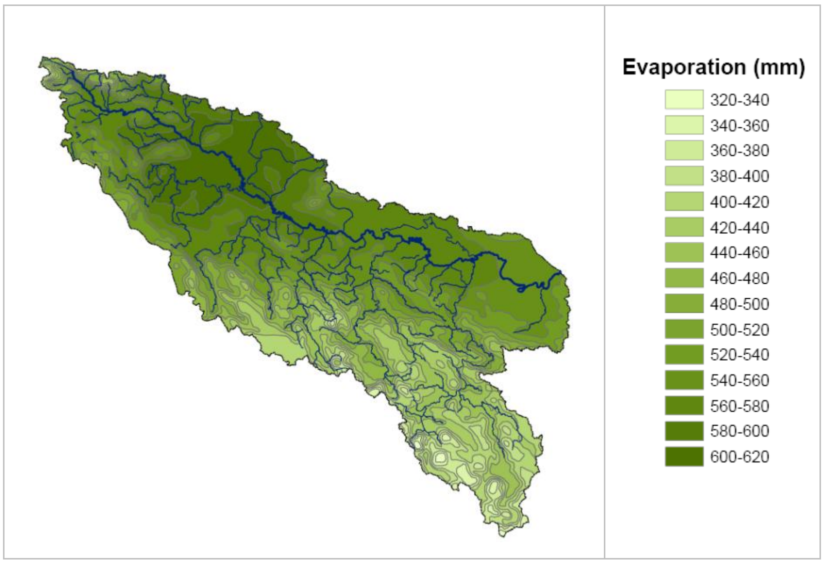


Figure III-2: Mean annual evapotranspiration in the Sava River Basin (*The Danube and its Basin – Hydrological Monograph*, 2006)

Due to the previously stated characteristics the contribution of this part of the catchment to the Sava River flow is much less significant than that coming from the mountainous regions, which are present in the upper and southern drainages.

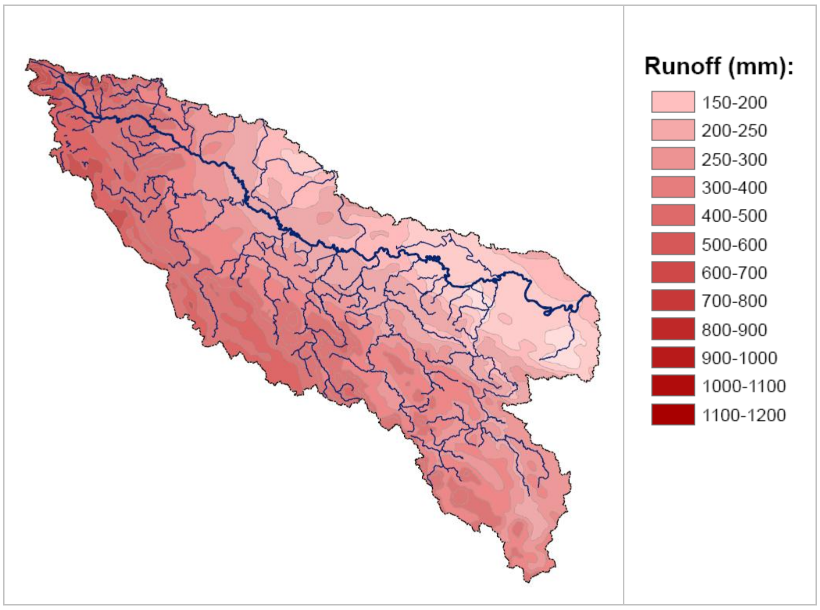


Figure III-3: Mean annual runoff in the Sava River Basin (*The Danube and its Basin – Hydrological Monograph*, 2006)

1.2. Hydrologic characteristics of the Sava River Basin

1.2.1. The Sava River and its main tributaries

Average discharge of the Sava River at the confluence (Belgrade, Serbia) is about 1,700 m^3/s, which results in long-term average unit-area-runoff for the complete catchment of about 18 $l/s/km^2$.

Torrential nature (steep channel's slope, high water velocity and rapids) characterizes the most important Sava tributaries in the upper Sava River Basin in Slovenia. The area is characterized by very high precipitation, with annual averages, occasionally, even over 2,500 mm. For that reason water yield, originating from both rainfall and snow melt, is high and commonly exceeds 30 $l/s/km^2$, while in some limited areas can go as high as 70 $l/s/km^2$.

In general, the right tributaries of the Sava River are characterized by much higher water yield than the left tributaries. The Una River is rich in runoff: its long-term annual average at the mouth exceeds 23 $l/s/km^2$. Water abundance in case of the rivers Vrbas and Bosna is relatively high and long-term values for the whole catchments range between 15 and 19 $l/s/km^2$ as the annual average. Rivers Ukrina, Brka and Tinja, due to less rainfall in their region, are characterized by considerably smaller unit-area-runoff – up to 12 $l/s/km^2$.

The Drina River, as the largest and most important among all tributaries of the Sava River, due to high precipitation (long term annual average is over 2,000 mm) has a very high water yield: between 40 and 50 $l/s/km^2$.

The left tributaries, except in the upper part of the catchment (in Slovenia), drain mostly the flat areas and low hills of the Pannonian Basin. The most important rivers are the Krapina, Lonja and Orljava in Croatia, and Bosut in Croatia and Serbia.

Precipitation in this region is considerably less as compared to the upper Sava River Basin or the mountainous region of Bosnia and Herzegovina and Montenegro. Most of the area gets annually 700 – 1,000 mm of rain. Relatively big evapotranspiration reduces unit-area runoff to few $l/s/km^2$, which at the hilly regions can rise to 12 $l/s/km^2$.

1.2.2. Characteristic flows in the Sava River Basin

Using the results from from thirteen previously prepared studies, the longitudinal presentation of annual average flows along the Sava River has been prepared (Figure III-4). In order to appraise the range of flow estimates given in various documentation only the boundaries (largest and smallest estimated values) are depicted in this graphical presentation.

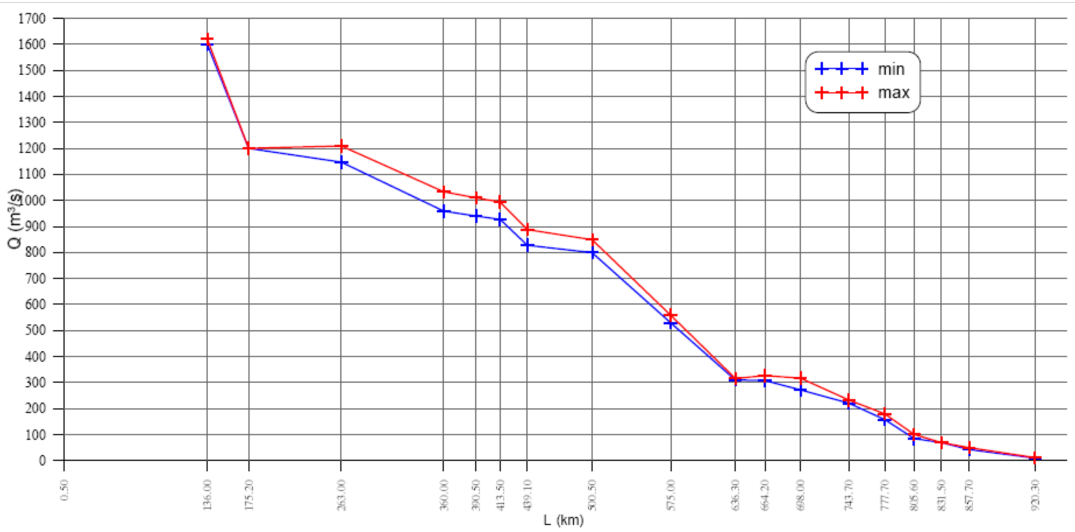


Figure III-4: Spectrum of mean annual discharges along the Sava River

Analyses of the graphical presentation indicate that the estimated annual average value stay in a reasonable agreement along the Sava River course. Some smaller discrepancies of the estimates (up to 10 %) lean toward a conclusion that the existing estimates are acceptable.

Graphical presentation of low flows (Figure III-5) characterized with 100-years return period has been made along the Sava River, which depict only extreme values (maximum and minimum) This graphical presentation leads to conclusion that deviations among results taken from different studies are significant. Reasons for these deviations can be found in different periods of the analyzed time series, different methods of calculations (types of theoretical probability distribution curves) and uncertainty whether the data were used from the same sources.

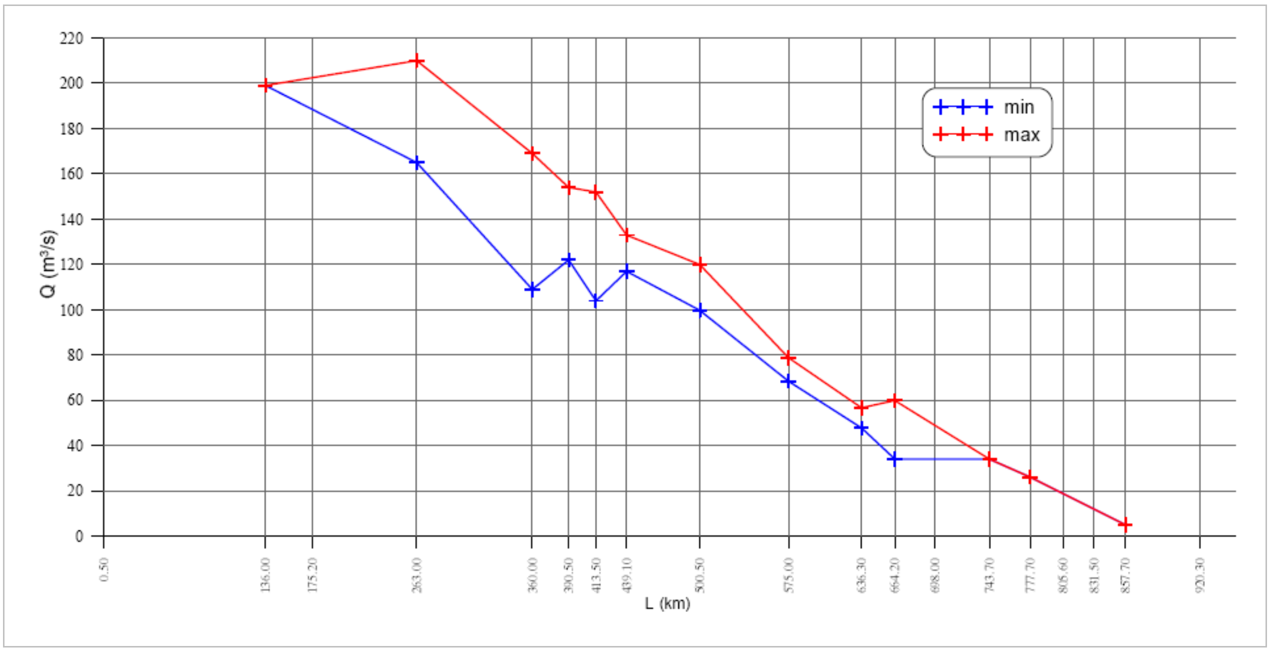


Figure III-5: Spectrum of 100-year minimum annual discharges along the Sava River

Based on the values of maximum annual discharge, derived from the hydrology studies analyzed in the *Hydrology report*, a graphical illustration of the range (maximum and minimum values determined in various studies) has been prepared along the Sava River (Figure III-6). This presentation gives an insight into differences of the calculated results in the reviewed studies related to the Sava River Basin. This graphical presentation implies that discrepancies of the results can be significant due to the reasons described in the section concerning low flows.

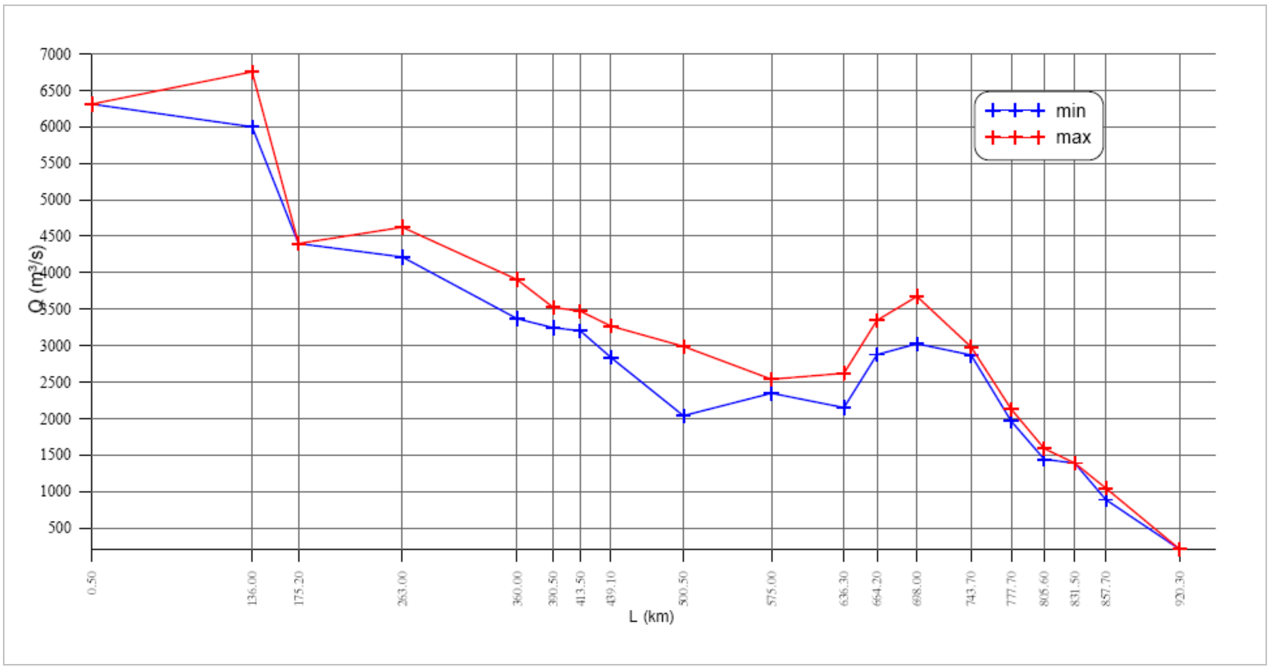


Figure III-6: Spectrum of 100-year maximum annual discharges along the Sava River

1.3. Water balance in the Sava River Basin

Hydrologic balance is very heterogeneous over the catchments of the Sava River Basin.

Hydrologic balance, i.e. input and output of water over a given area, depends primarily on climatic conditions and physical features of the catchments where the process takes place. Relation among elements of the balance (precipitation, river runoff and evapotranspiration) for given geographical conditions is stable on a long run. This relation defines water availability within the considered area.

Maps compiled in the hydrology report demonstrate elements of hydrological balance from the oldest reviewed study (*Hydrological Study of the Sava River Catchment*, Belgrade, 1969) and the most recent study (*The Danube and its Basin – Hydrological Monograph*, Follow-up Volume VIII, *Basin-Wide Water Balance in the Danube River Basin*, Regional Cooperation of the Danube Countries in the Frame of the International Hydrological Programme of UNESCO and Water Research Institute Bratislava, Slovakia, 2006).

Comparative analysis of the maps from the two studies presenting the isolines, in other words, elemental spread of the catchment, which are correspondent to precipitation diapason and discharge from two analyzed hydrological studies, have shown that there are significant differences in the size of the selected catchments and space distribution. There are numerous reasons for this, such as analysis period, input data volume, number of used stations, analysis methodologies applied and accuracy of the basic data from earlier and recent period. It is obvious that a new hydrological study for the Sava River Basin, which should address all these problems, is an imperative.

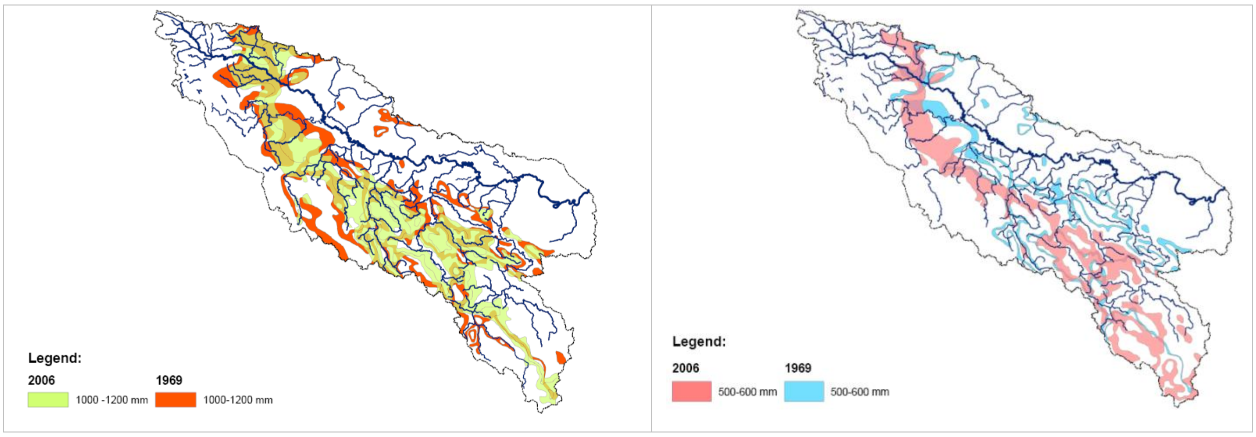


Figure III-7: Comparative maps of mean annual precipitation and runoff (study 1969 – 2006)

Overall conclusion is that spatial distribution of elements of hydrologic balance is heterogeneous. Long-term average annual precipitation range between 600 mm (in Srem and the Kolubara River catchments) and 2,300 mm in far western catchments (the Rivers Sava Dolinka and Sava Bohinjka) as well as in far southern parts (the Rivers Piva, Tara and Lim). Obviously, precipitation increases at the higher altitudes. Consequently, the largest precipitations take place at upper parts of catchments of the Rivers Kupa, Piva, Tara, Una, Vrbas and Drina. Areas with smallest precipitation, in addition to the mentioned regions, are found in Slavonia and Semberia.

Spatial distribution of unit-area-runoff largely follows pattern of spatial distribution of precipitation. This element of water balance is spatially heterogeneous as well: it varies from 150 mm/year (under 5 $l/s/km^2$) up to 1,200 mm/year (almost 40 $l/s/km^2$). Lowest water yields take place within catchments of the rivers Bosut and Kolubara, as well as along lower parts of catchments of the Sava River tributaries (Posavina, Semberija, and Mačva). Upper catchments of the Sava River in Slovenia, as well as of its tributaries (the Rivers Kupa, Una, Vrbas, Bosna, Piva, Tara) are characterized by high water yield.

Spatial distribution of evapotranspiration is heterogeneous, too. Its variation is significant over the area, yet not as large as the other two components. Long term evapo-transpiration ranges between 320 and 620 mm/year. Highest values appear in the Middle Posavina and catchments of the Rivers Lonja, Ilova and Kupa. Lowest value of evapo-transpiration is present in upper parts of catchments of the Rivers Drina, Bosna and Vrbas. Areas with relatively small evapo-transpiration are the upper Sava drainage (in Slovenia) as well as the upper catchments of the Rivers Kupa and Una. Average evapo-transpiration experience Srem and Kolubara River catchments.

1.4. Extreme events: floods and droughts

1.4.1. Floods

Based on the results of several important hydrological studies prepared for the Sava River Basin, floods in the basin usually appear in the spring and in the autumn. Spring floods are the result of snow melting, while autumn floods are caused by heavy rainfall. Depending on the cause, these types of flood exhibit different features. Spring floods last longer and they do not have large maximum discharges, while autumn floods are of shorter duration and have very high extreme flows, when floods go over the river bank they last longer periods of time and become more flat.

Flood duration depends on the flood volume hydrograph and the size of the catchment. Flood duration of the Sava River near Zagreb (HR) is 10-20 days and 40-70 days near Sremska Mitrovica (RS).

A significant difference in the **flood traveling time** on the Sava River between the earliest (1933, 1934) and subsequent (1962, 1964) floods are noticed. Former floods have routing periods of 8-9 days, while subsequent ones have considerably shorter travel time - only 4-5 days.

Shorter routing periods are the result of embankments construction along the Sava River, which led to shorter concentration times and larger maximum discharge in the channel.

By reviewing the data from the flood hydrograph it can be asserted that **intensive floods occur over limited space**. Most floodprone areas are regions called Donje Posavlje, downstream of Županja, or Srednje Posavlje, from Zagreb to Županja, or upstream from Zagreb. The only floods ever to overtake the whole region from Belgrade to Zagreb occurred in 1933, 1937, 1940 and 1947. Most severe floods occurred in 1932, 1942 and 1970 in the Lower Sava region, and in 1937, 1944 and 1974 in the Middle Sava region. These data are for constant durations of 60 days. However, for other durations, floods are different in terms of their significance, which must be kept in mind for future hydrological research. Similar conclusions can be derived based on the flood volume above predetermined threshold flow.

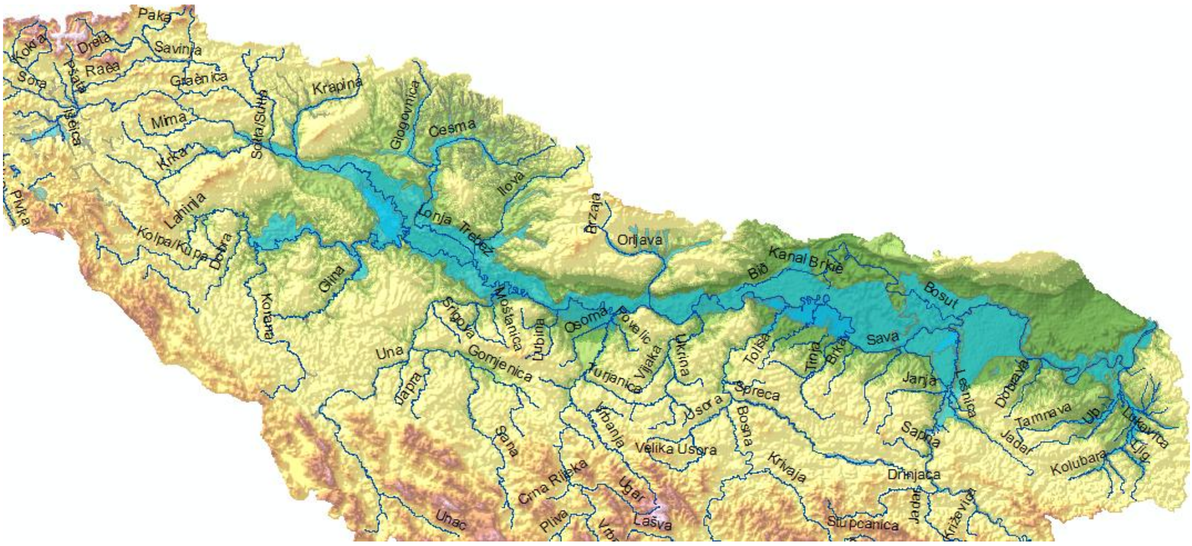


Figure III-8: Indicative map of important flood prone areas along Sava River

Intensive elaboration of significant flood events, flood defense structures, as well as of flood management in the Sava countries can be found in Annex II to this Report.

1.4.2. Droughts

Droughts are non-homogenous over the Sava River catchment, since they cover only certain sub-regions. Nevertheless, as compared to floods, the droughts have larger spatial coverage, which implies that they are governed by global causes and have multidimensional character giving them the larger scale.

Most severe historical droughts in the Sava River Basin occurred in 1946, 1947, 1949 and 1950. Last significant drought happened in 1971, in the upper part of the Sava catchment. This does not imply that there has been no droughts eversince. Actually, there is a strong feeling that very severe droughts have taken place in last twenty years. However, droughts were not comprehensively analyzed since 1974. Keeping in mind that 35 years passed since the last data was analyzed, it is clear that a new hydrological study of historical drought should be undertaken. It should use longer time series, including recent years. In that way, the results of this study will represent an important hydrological parameter in water balance management.

2. Water use and demands

2.1. Water use

Generally, **water use** refers to use of water by households, industry, agriculture, for energy production, environmental protection, etc. including so called in-stream uses such as fishing, recreation, transportation, etc.

A use of water is called **consumptive** if the part of water withdrawn is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment.

To identify if the water use in the Sava River Basin could represent a major pressure on aquatic and other water dependent ecosystems, a rough estimate of water use in Sava River Basin countries is performed, based on the data supplied by countries. The level of confidence of the data is relatively low, because of the problems with gathering data in most of the countries in the Sava River Basin due to various reasons. Nevertheless, this analysis is important step in identification if the water use is significant water management issue in the Sava River Basin.

The overview of various types of water uses in the Sava River Basin is given in Table III-2.

Table III-2: Estimation of total water use in the Sava River Basin

Water use in the Sava RB	Public water supply		Industry		Thermal plants		Irrigation		Other agricultural		Sum
Country	10^6 m^3		10^6 m^3		10^6 m^3		10^6 m^3		10^6 m^3		10^6 m^3
BA	330.5		122.0		39.4	**	6.2	**	66.4	**	564.5
HR	113.4	*	57.2	*	n/a		3.1		201.0		374.7
RS	233.0		40.1		1,722.0		14.2		68.0		2,077.3
SI	106.2		69.9		1,517.0		4.4		182.8		1,880.3
SUM	783.1		289.2		3,278.4		27.9		518.2		4,896.9
%	16.0		5.9		66.9		0.6		10.6		100.0

n/a data not available
* only data for water invoiced available
** data for Fed BA not available

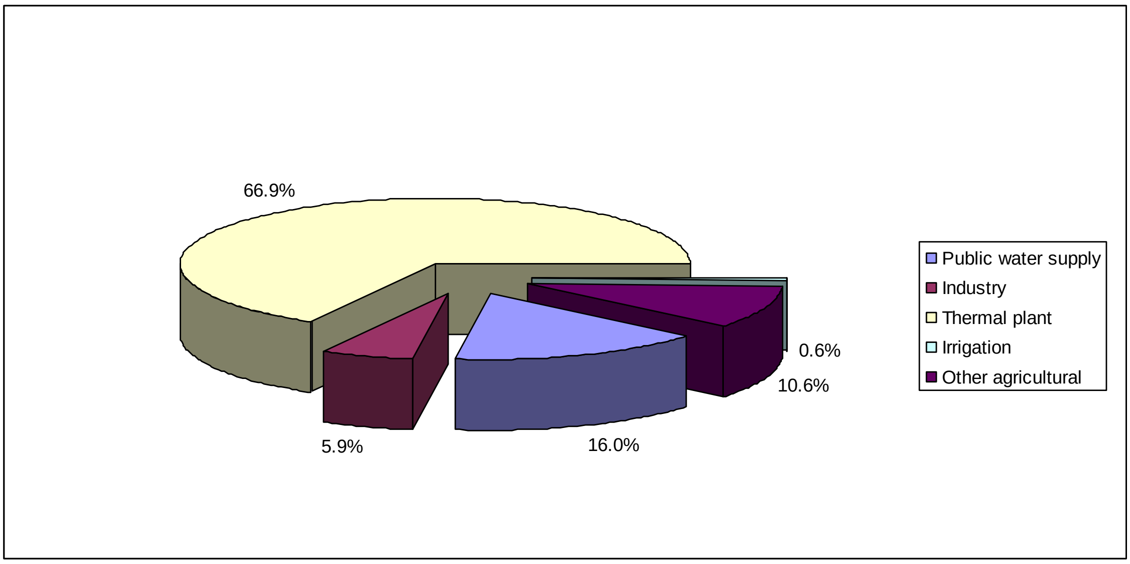


Figure III-9: Estimation of total water use in the Sava River Basin

The total annual water use in the Sava River Basin is estimated at about 4.8 billion m^3/year.

The total annual use of water for **public water supply** (households, industry connected on municipal water systems, etc.) is about 783 million m^3/year. Most of the water used for public water supply comes from groundwater sources, approximately 77 %. Only small part of the water use for public water supply (10-20 %) can be considered as consumptive use.

The total annual use of water for **industry** with separate water sources is about 289 million m^3/year. The fact that the water use for industry is relatively low represents the economic situation in the most of the countries of the Sava River Basin. Most of the water use for industrial process, except for cooling, can be considered as non-consumptive use.

Thermal and nuclear power plant cooling represents the major use of water in the Sava River Basin – about 3.3 billion m^3/year. Major plants in the Sava River Basin are: NPP Krško, TPP Obrenovac 1 and 2, TPP Nikola Tesla A, etc. Cooling systems of TPP and NPP generally can be with and without recirculation. Cooling systems with recirculation are using specifically much less water, but represent a large consumptive user. It is not possible to specify the consumptive use of the water for thermal and nuclear power plant cooling at this moment. Most of the water for this purpose comes from rivers and reservoirs. It can also be noted that thermal pollution of the rivers downstream of major plants could be problem during the low water periods.

Irrigation is major consumptive use of the water in the world, but in the Sava River Basin the total annual use of water for irrigation in the Sava River Basin is less than 30 million m^3. The reason for very small use of irrigation in the Sava River Basin in comparison to other river basins is, in general, inadequate status of agriculture in most of the countries in the Sava River Basin.

Use of water for **other agricultural uses** in the Sava River Basin (i.e. fish production, livestock farms, or other uses) is relatively high, but most of the water is used for fish production and does not represent the consumptive use.

Data for use of water for **other purposes** (tourism, recreation, etc.) are scarce. Since this kind of use does not represent the consumptive use, it could be concluded that this type of use could be only interesting with regard to the quality of the waters needed for such uses.

There are 18 **hydropower plants** in the Sava River Basin larger than 10 MW. In Slovenia, most of the plants are located on the Sava River, but in other countries on major tributaries (Drina, Vrbas, etc.). There is a large number of small and micro hydropower plants in Slovenia. The total installed capacity of the plants is 41,542 MW with yearly production of 2.497 GWh/year. Basic data on existing power plants is given in Table III-3.

Table III-3: Basic data on hydropower plants in the Sava River Basin

	Name	River	Installed capacity (MW)	Installed discharge (m3/s)	Average yearly production in the last 3 years (GWh/year)	Remark
BA	Jajce I	Pliva	60.0	74.0	259.0	
BA	Jajce II	Vrbas	30.0	80.0	181.0	
BA	Bočac	Vrbas	110.0	240.0	307.5	
BA	Višegrad	Drina	315.0	800.0	1,120.0	
HR	HE Gojak	Donja Dobra	55.8	50.0	192.0	
ME	Mratinje	Piva	360.0	240.0	750.0	
RS	Zvornik	Drina	96.0	620.0	515.0	
RS	Uvac	Uvac	36.0	43.0	72.0	
RS	Kokin Brod	Uvac	39,559.0	37.3	60.0	
RS	Bistrica	Uvac	102.6	36.0	370.0	

	Name	River	Installed capacity (MW)	Installed discharge (m3/s)	Average yearly production in the last 3 years (GWh/year)	Remark
RS	Bajina Bašta	Drina	360.0	644.0	1,691.0	
RS	Potpeć	Lim	51.0	165.0	201.0	
RS	RHE Bajina Bašta	Drina	614.0	129.0		
SI	Moste	Sava	21.0	34.5	59.0	
SI	Mavčiče	Sava	38.0	260.0	60.0	
SI	Medvode	Sava	26.4	150.0	77.5	
SI	Vrhovo	Sava	34.2	500.0	126.0	
SI	Boštanj	Sava	33.0	500.0	115.0	
SI	mHE*			cca 350		302 mHE*
Total			41,902.0	4,602.8	6,156.0	

mHE* small and micro hydropower plant (Sava river basin)

Use of water for **navigation** could be seen from the perspective of minimum flows required for navigational purposes in different cross sections of the Sava River.

In conclusion of the analysis of present state of water use in the Sava River Basin it can be noted that at the moment it is not possible to specify which part of total use of water in the Sava River Basin is exactly consumptive, but since use of water for irrigation, as major consumptive use of water is very low in comparison to minimum flows, the water use could not be considered as significant water management issue.

2.2. Scenario for 2015 – water demand

On the basis of the existing national plans, an attempt to estimate future water demand for 2015 was prepared for all important water uses in the Sava River Basin. The estimated demand for water is given in Table III-4 and Figure III-10.

Table III-4: Estimation of total water demand in the Sava River Basin

Water demand in the Sava RB / Country	Public water supply 10^6 m^3	Industry 10^6 m^3	Thermal plant 10^6 m^3	Irrigation 10^6 m^3	Other agricultural 10^6 m^3	Sum 10^6 m^3
BA	414.7	76.2	59.1 *	55.9 *	82.7 *	688.7
HR	n/a	n/a	n/a	n/a	n/a	
RS	264.0	84.4	1,732.6	72.7	90.5	2,244.1
SI	84.0	80.5	1,699.0	0.8	248.5	2,112.8
SUM	762.7	241.0	3,490.7	129.4	421.6	5,045.6
%	15.1	4.8	69.2	2.6	8.4	

n/a data not available
* data not available for FBA

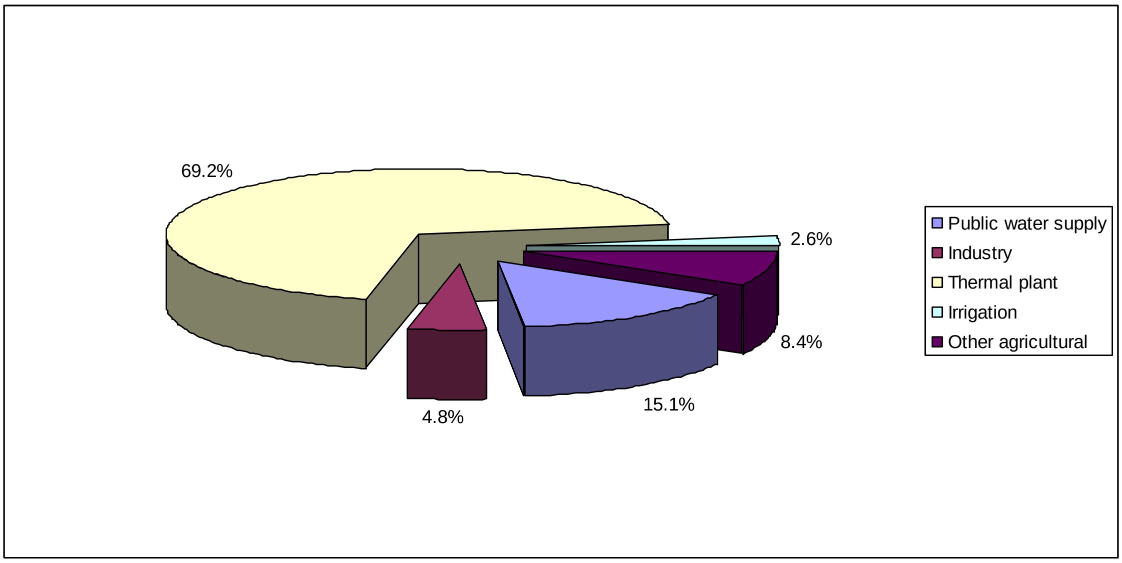


Figure III-10: Estimation of total water demand between water users for 2015 in the Sava River Basin

It has to be noticed that the confidence of such analysis is low due to the fact already specified in the previous chapter, but also for the fact that such predictions in rapidly changing political and economic conditions are very problematic. Some of the countries, or parts of them, were not able to perform such analysis.

The available data lead to conclusion, that generally, an increase of water use may be foreseen, particularly for irrigation, but it has to be noted that the latter will also depend on general economic situation in the region.

In conclusion of the analysis of water demand in the Sava River Basin, in spite of the fact that very little data were available for such analysis, it can be noted that it is to expect that the water use could not be considered as significant water management issue in the Sava River Basin until 2015.

The ratio between water use/demand is indicated in Figure III-11.

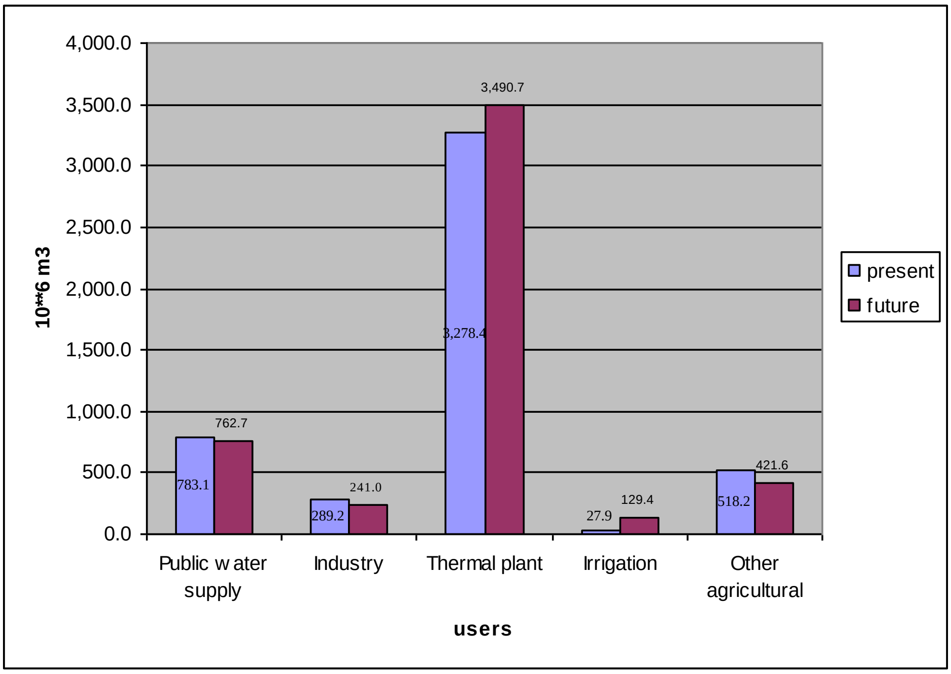


Figure III-11: The ratio between water use/demand in the Sava River Basin

New hydropower plants are planned in Slovenia on the Sava River and in Bosnia and Herzegovina on the Sava tributaries. A reconstruction of the existing power plant (HE Moste) in Slovenia is foreseen. No new power plans are foreseen in Croatia and Serbia until 2015. No data for ME is available. The planned future increase of hydropower capacities in the Sava River Basin is nearly 450 MW, with planned yearly production of more than 1,500 GWh/year.

Table III-5: Basic data on new hydropower plants in the Sava River Basin

Country	Name	River	Planned installed capacity (MW)	Planned installed discharge (m^3/s)	Planned average yearly production (GWh/year)
BA	Ustikolina	Drina	59.0		255.0
BA	Vranduk	Bosna	22.0		103.2
BA	Unac	Unac	71.0		250.0
BA	Ugar usce	Ugar	15.0		60.0
BA	Vrletna Kosa	Ugar	25.0		63.0
BA	Vrhpolje	Sana	68.0		157.4
BA	Vlasenica	Jadar	0.9	0.7	6.9
BA	Bogatić	Željeznica	8.0	5.5	33.0
BA	Mesići	Prača	3.1	8.0	16.0
BA	Tišća	Tišća	2.1	0.7	10.0
HR	Lešće	Dobra	42.0		94.0
RS					
SI	HE Blanca	Sava	42.5		160.0
SI	HE Krško	Sava	41.5		145.0
SI	HE Brežice	Sava	41.5		161.0
SI	To add to the old one HE Moste	Sava	49.9		98.0
Total			491.5	14.9	1,612.5

3. Economic analysis of water use in the Sava River Basin

The EU *Water Framework Directive* (WFD) under Article 5 and Annex III stipulates an economic analysis of water use by demonstrating the main economic characteristics and importance of the water therein and demonstrating the economic capacity of different economic sectors. It provides the river basin's economic profile in terms of general socio-economic indicators and main characteristics of water users and water services in the Sava River Basin.

The socio-economic analysis begins with a global overview of productive activities in the Sava River Basin. The analysis developed in this section should present a general view of different sectors of the economic activity pertaining to the part of the country lying in the Sava River Basin, valuing the evolution of the Gross Value Added (hereinafter called: GVA), Gross Domestic Product - overall/per capita (hereinafter called: GDP), population and employed persons – per economic sector, generated by each sector and its general tendencies. The analysis ends with analysis of water use, according to the economic activities in the Sava River Basin.

The reference year for the data collected is 2005.

The **population** of the Sava River Basin is 8,176,000, which represents 46 % of the total population of all countries. Particularly, the population of the Sava River Basin in Bosnia and Herzegovina[6] is 75 % of the total population in that country, in Croatia[7] 50 %, in Serbia 25 % and in Slovenia 61 %.

Economic activities developed in the Sava River Basin, generate more than 2,379,000 employed people. That is 29 % of all inhabitants in the Sava River Basin and 45 % of all employed people in the countries.

Table III-6: Population and number of employees in the Sava River Basin per country (in 1,000s)

Country	Total population whole country	Population in the Sava RB	Share of total population (%)	Emloyees in whole country	Employees in the Sava RB	Share of emloyees in whole country (%)
1	2	3	4(3/2)	5	6	7(6/5)
B&H[8]	3,843	2,882	75	811	608	75
Croatia[9]	4,442	2,210	50	1,496	781	52
Serbia[10]	7,441	1,854	25	2,069	397	19
Slovenia	2,003	1,230	61	921	593	64
Total	**17,729**	**8,176**	**46**	**5,297**	**2,379**	**45**

As for **employment**, the industry and other activities sector (construction, wholesale and retail trade, hotels and restaurants, transport, storage and communication, financial intermediation, real estate, renting and business activities) remain the greatest producers of jobs. 31% of all employed people in the Sava River Basin work in the other activities sector, 27% work in the industry sector, 29% work in the public sector, 12% work in the agriculture and 1% work in the energy sector.

[6] As the Sava River Basin covers 75 % of the whole territory of B&H, all presented data for the Sava River Basin in this chapter are estimated as 75 % of the statistical data for the whole country.
[7] Aggregation of data for counties belonging to the Sava River Basin, for partly enclosed county extrapolation according to the share of employees.
[8] Population and employees in whole country. Sources: *Labour Force Survey 2006*, Agency for Statistics of B&H.
[9] Population and employees in whole country. Source: Central Bureau of Statistics (CBS) of the Republic of Croatia.
[10] Data source: Statistical office of the Republic of Serbia.

Table III-7: Number of employees in the Sava River Basin per sector and country (in 1,000s)

Country	Employed people in the Sava RB by sectors					Total of employees in the Sava RB
	Agriculture	Industry	Energy	Other activities	Public services	
B&H	125	187	n/a	n/a	296	608
Croatia	97	157	13	358	156	781
Serbia	11	138	12	118	117	397
Slovenia	51	155	7	253	127	593
Total	284	637	32	729	696	**2,379**

Of all employed people in the Sava River Basin, the number of employees in agricultural sector is the highest in Bosnia and Herzegovina, as well as industry and public sector as shown in Figure III-12. Number of employees in the industry sector in Slovenia and Croatia is almost the same.

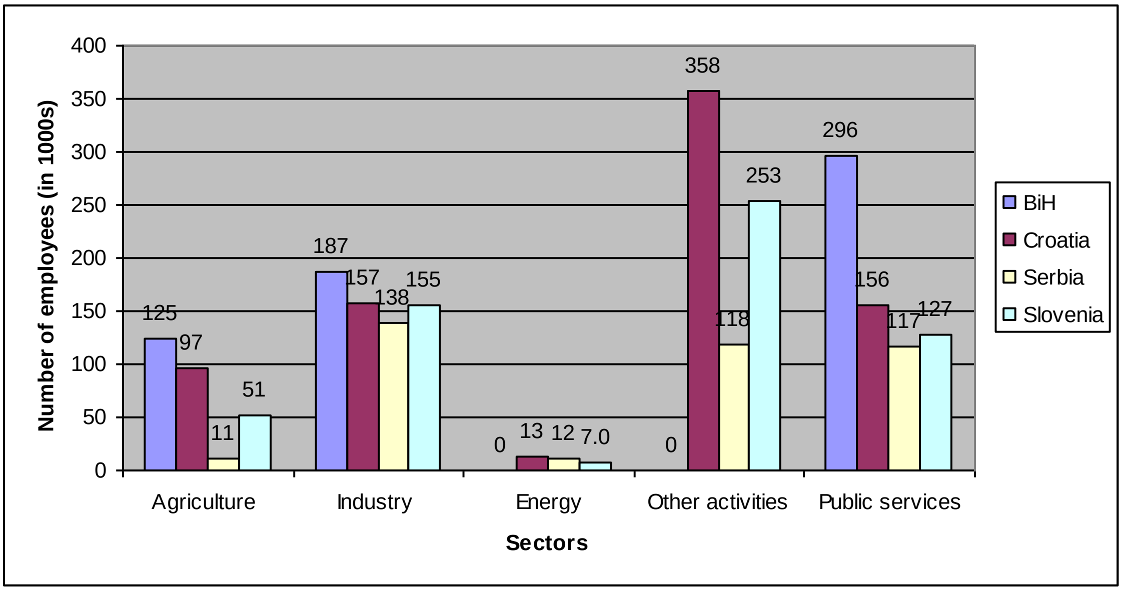


Figure III-12: Number of employees in the Sava River Basin by sector and country (in 1,000s)

Main economic activities in the Sava River Basin in year 2005 are given in Table III-8 and Figure III-13. The total GVA of the Sava River Basin is 40.039 million euros. The sector that contributes the most to the total GVA in value and in growth is the other activities sector (51 %). Industry is the second greatest sector and it represents 22 % of the total GVA in the Sava River Basin. It is followed by the public service sector with 17 %, the agricultural sector holding 6 % and, finally, the energy sector with 4 % of the total GVA in the Sava River Basin.

Table III-8: GVA by sectors and country in the Sava River Basin (in million EUR)

Country	GVA by sectors					In whole, the Sava River Basin
	Agriculture	Industry	Energy	Other activities	Public services	
B&H	563	601	332	3,454	550	5,500
Croatia	950	3,331	372	7,347	2,279	14,279
Serbia	431	663	165	1,659	398	3,316
Slovenia	383	4,015	537	8,480	3,438	16,944
Total	**2,327**	**8,610**	**1,406**	**20,940**	**6,665**	**40,039**

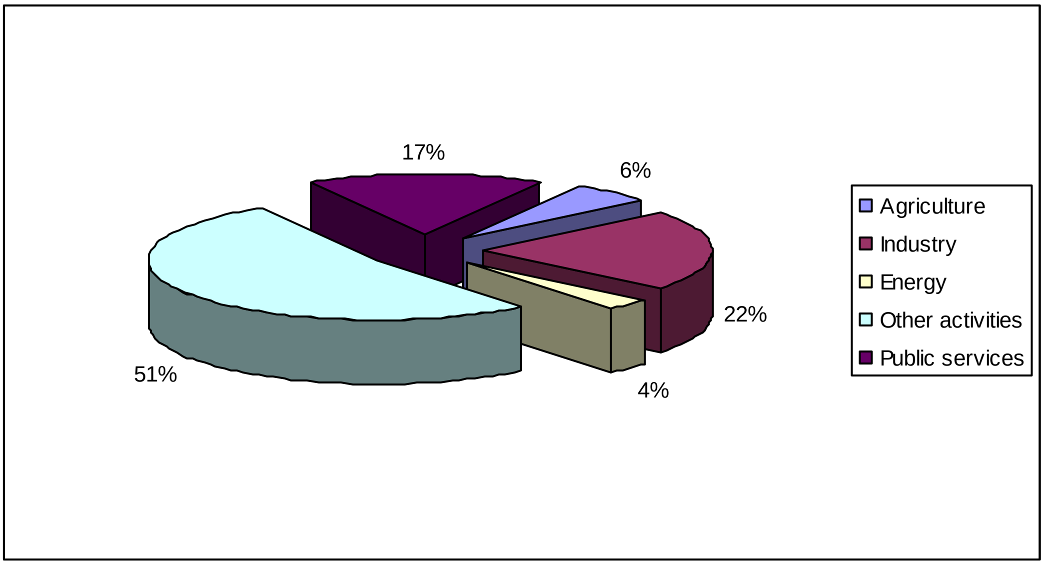


Figure III-13: Main economic activities in the Sava River Basin - GVA (2005)

GDP for the Sava River Basin was calculated on basis of the regional data provided. Share of the GDP in the Sava River Basin reaches a very significant 53 % of the GDP of all countries. The following table shows the GDP of each country separately.

Table III-9: GDP and GPD per capita for the Sava River Basin and each country

Country	GDP for the whole country	GDP in Sava RB	Share of whole countries GDP	GDP per capita for the whole country	GDP per capita in Sava RB
	(million EUR)	(million EUR)	(%)	(EUR/capita)	(EUR/capita)
1	2	3	4(3/2)	5	6
B&H[11]	8,654	6,490	75	2,252	2,252
Croatia[12]	31,255	17,212	55	7,036	7,788
Serbia[13]	20,358	3,913	19	2,736	2,110
Slovenia	28,704	19,331	67	14,328	15,711
Total	**88,971**	**46,946**	**53**	**5,018**	**5,742**

The importance of economic activities in the Sava River Basin is obvious, as e.g. in the part of Slovenia belonging to the Sava River Basin where GDP reaches 67 % respectively, of the total country GDP and also in Croatia where GDP reaches 55 % of the total Croatian GDP.

As a measure for the general **productivity** of each of the analyzed sectors, the GVA/employed person variable has been calculated and shown in Figure III-14. It gains a much greater value in the energy sector (especially in Slovenia), far away from the one gained in the public service and the agriculture sector.

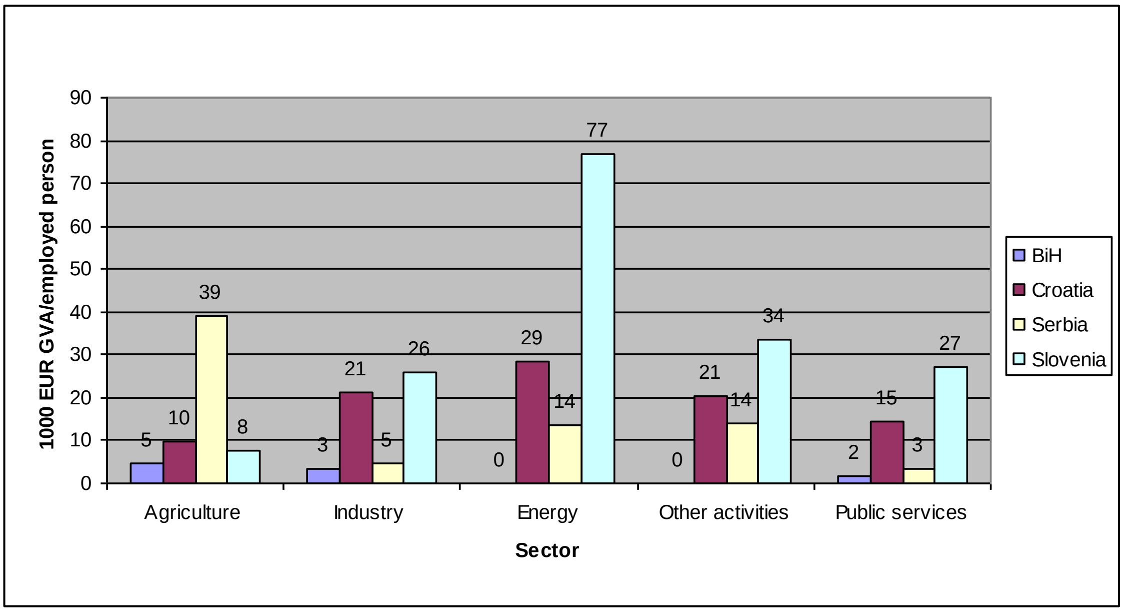


Figure III-14: Productivity according to the economic activities in the Sava River Basin

[11] GDP and GDP per capita for whole country. Source: *Gross domestic product of B&H 2007*, First results, Agency for Statistics of B&H.
[12] GDP and GDP per capita for whole country. Source: Central Bureau of Statistics (CBS), First release on Gross Domestic Product for Republic of Croatia and Counties, 2001-2003, 2004, 2005-2006.
[13] GDP and GDP per capita for whole country. Source: Statistical office of the Republic of Serbia.

Annexes

Annex I - Navigation issues

1. Introduction

Inland waters have multiple functions such as transport, leisure, water management and environment. The most commonly known utilization of inland waterways is for the transport of cargo and related therewith the handling of cargo in river ports.

As a result of growing overseas trade and EU enlargement towards Central and Eastern Europe, freight transport volumes in Europe are expected to increase by one third until 2015. Present patterns of transport growth and its reliance on road transport have become a synonym to congestion and pollution, the cost of which are expected to double to 1% of Europe’s annual GDP by 2010.

Congestion, capacity problems and delays affect mobility and economic competitiveness and are detrimental to the environment and quality of life. The EU has committed itself to pursue the goal of shifting transport to less energy-intensive, cleaner and safer transport modes. Inland waterway transport is an obvious choice to play a more prominent role in reaching these targets.

Together with rail and short sea shipping, inland waterway transport can contribute to the sustainability of the transport system.

In some regions inland shipping has already conquered a modal share of more than 40 % (e.g. in catchment areas of major seaports). Moreover, between 1997 and 2004 impressive traffic growth rates (in tonne-km) in Belgium of more than 50 % and in France of more than 35 % have been achieved. Today the sector is made of some 12 500 vessels, corresponding to a loading capacity of 440 000 trucks. Inland navigation has the best performance in terms of external costs, in particular pollution and safety (2.5 times better than road), and has a huge capacity to deploy. Today only 10 % of the capacity of the Danube is utilised. Modal share accounts for 6 % whereas in the United States navigation on the Mississippi alone accounts for 12% of the modal share in the US.

An increase in inland navigation can lead to significant transport cost reductions. The availability of low-cost inland waterway transport services proves to be a decisive location factor for European industry. It significantly contributes to the preservation of Europe’s industrial employment. In Germany alone some 400 000 jobs directly or indirectly depend on the inland waterway sector and related companies.

Moreover, inland waterway transport is by far safer than other modes. The number of yearly fatalities caused by accidents in the Netherlands, which has the highest density of inland waterway traffic in Europe, is next to zero.

Inland navigation has also been shown to be the most environmentally friendly land transport mode with total external costs currently calculated at 10 Euro per 1,000 tonne-kilometres (by comparison: 35 Euro for road and 15 Euro for rail transport).

Taking into account above mentioned facts and wery suitable geo-political position of the Sava River which links four SEE countries and can be transport link beetween Adriatic and Danube, the Sava countries committed themselves to the sustainable development of the inland anvigation on the Sava River. This is one of the principal objectives of the *Framework Agreement on the Sava River Basin* (FASRB), which is a foundation for the cooperation of the countries, and which is being implemented under the coordinating role of the International Sava River Basin Commission (Sava Commission). To this end, the Sava Commission has undertaken a wide range of actions, including the preparation of studies necessary for the rehabilitation and development of the Sava River waterway, such as the *Feasibility Study and Project Documentation for the Rehabilitation and Development of the Transport and Navigation on the Sava River Waterway*, a set of rules and requirements for the improvement of navigation safety, as well as the re-establishment of the waterway marking system on the Sava River, which are described in the following text.

2. Present status of navigation

2.1. Description of navigation system

In accordance with the FASRB the Sava River and tributaries are open for international navigation as follows:

- Sava River, from rkm 0 (Belgrade) to rkm 586 (Sisak),
- Kolubara River, from rkm 0 to rkm 5,
- Drina River, from rkm 0 to rkm 15,
- Bosna River, from rkm 0 to rkm 5,
- Vrbas River, from rkm 0 to rkm 3,
- Una River, from rkm 0 to rkm 15,
- Kupa River, from rkm 0 to rkm 5.

The Sava River is centrally located in the east-west and north-south Core Transportation Network for South East Europe and could complement the road and rail corridors as well as the European waterway corridor focusing the Danube River.

The strength of the Sava River Waterway Transport System (SRWTS) is however not only defined by the true connectivity with two principal corridors of the SEE Core Transportation Network, but also, and even more by the complementary road and railway infrastructure providing additional and efficient links with principal consumption and production centers in the riparian states.

The network design (Figure A1-1) which also considers interconnectivity via non-core road and rail links makes the Sava River an integral part of a regional transport infrastructure that connects the industries and consumption centers of the region by road, rail and sea with Europe and the rest of the world.

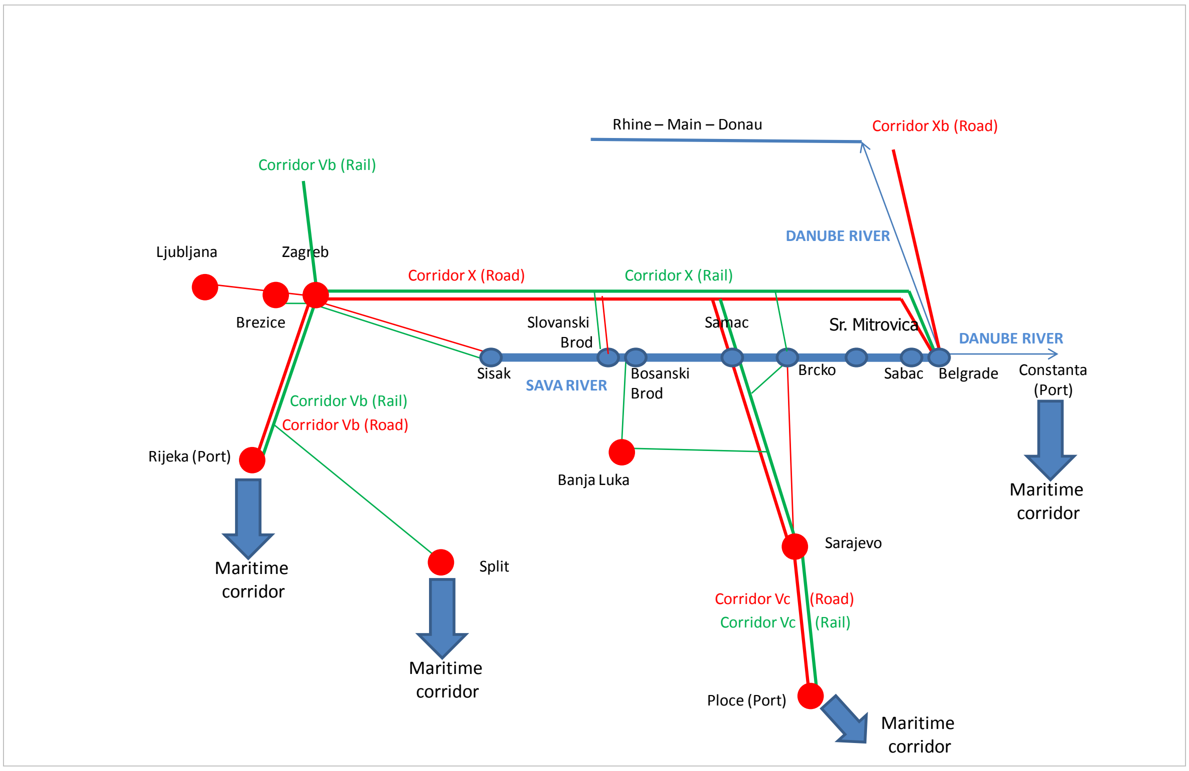


Figure A1-1: SRWTS integrated and multimodal network (concept vision)

Source: *Feasibility Study and Project Documentation for the Rehabilitation and Development of the Transport and Navigation on the Sava River Waterway* on the basis of the SEETO *South-East Europe Core Regional Transport Network Development Plan - Five Year Multi Annual Plan 2008 to 2012*.

Figure A1-2: History: Tug on the Kupa River in the middle of the 20th century

In former Socialist Federal Republic of Yugoslavia (SFRY), Sava River was not open for the international traffic (only vessels under the flag of the SFRY were allowed to navigate on the Sava River) but nevertheless the Sava used to be an important lifeline in the former Yugoslavia and was regularly used for Inland Waterway Transport. However, the break-up of Yugoslavia and the economic decline in the 1980-ies and 1990-ies caused a strong decrease of transport and navigation on the Sava. In the present day, the Sava is hardly used for river transport. Other transport modes are (slowly) recovering but Inland Waterway Transport is still at a low level.

Transport on the Sava (including Croatia, Bosnia and Herzegovina and Serbia) was around 9.5 million tons in 1982 and decreased to 5.7 million tons in 1990. The war of 1991 – 1995 destroyed a lot of the economic activities and the river (and port) infrastructure. For this reason the cargo handled in ports of the Serbian part of the Sava was down to less than 25 thousand tons and in ports in Bosnia and Herzegovina and Croatia down to less than 1 million tons. A closer look at the latter ports for a more recent year gives the following table:

Table A1-1: Cargo handled in the ports on the Sava River (in tons)

Port	2006	2007
Sisak	0	0
Sisak oil terminal	160,000	140,000
Slavonski Brod	160,000	140,000
Bosanski Brod	0	0
Šamac	17,000	60,000
Brčko	81,000	52,000
Sremska Mitrovica	5,000	1,000
Šabac industrial port	27,000	15,000
Šabac Free Zone	0	0
Total Sava River ports	**464,000**	**408,000**

Note: sand and gravel is excluded.

Port of Sisak (the oil terminal of Crnac)

In the past years (2001 – 2005) the terminal received between 160 and 220 thousand tons of crude oil shipped from the port of Slavonski Brod oil terminal at Ruščica. There are no other activities.

Port of Sisak (on the Kupa River)

The only activity is the unloading of a few thousand tons of sand and gravel from dredging activities.

Figure A1-3: Port of Sisak (on the Kupa River)

Port of Slavonski Brod

The main activity at present in the port area is the unloading of sand and gravel from dredging activities. This amounts to 432 thousand tons in 2003, 546 thousand tons in 2004 and even 2,206 thousand tons in 2005. At the oil terminal (Ruščica) 160 – 220 thousand tons of crude oil is loaded for Sisak. Other activities amount to 0 tons in 2003, 23 thousand tons in 2004 and 14 thousand tons in 2005.

Port of Šamac

According to information received in interviews the transhipment in this port (in 2005 / 2006) amounts to some 17 thousand tons per year.

Port of Brčko

According to information received in interviews the transhipment in this port (in 2006) amounts to some 80 thousand tons.

Such low performance in ports is direct result of the present condition of the waterway. The actual classification of the Sava River in accordance with the Sava Commission's Decision 19/08 is presented in Table A1-2.

Table A1-2: Classification of the Sava River Waterway

Section of the Sava River		Length (km)	Waterway Class
downstream (rkm)	upstream (rkm)		
0.0 Sava river mouth	**86.0** Kamičak	86.0	IV
86.0 Kamičak	**102.0** Mišar	16.0	III
102.0 Mišar	**107.0** Šabac	5.0	IV
107.0 Šabac	**111.8** Kalovica	4.8	III
111.8 Kalovica	**176.0** Mlinsko ostrvo	64.2	IV
176.0 Mlinsko ostrvo	**185.0** Sremska Rača	9.0	III
185.0 Sremska Rača	**305.7** Slavonski Šamac Bosanski Šamac	124.7*	IV
305.7 Slavonski Šamac Bosanski Šamac	**330.2** Oprisavci Rit kanal	24.5	III
330.2 Oprisavci Rit kanal	**363.2** Slavonski Brod Bosanski Brod	33.0	IV
363.2 Slavonski Brod Bosanski Brod	**586.0** Sisak	219.8	III

* Difference of 4 km of the marked and the actual mileage is a result of two doubled kilometre signs (kilometres 206 and 207 on the river are twice marked) and the newly designed waterway.

Remarks:

(1) The river mileage in the table is referent and names of settlements are used illustratively.

(2) The river mileage from 0.0 to 209.5 is defined based on the newly designed waterway and there are discrepancies from the kilometre signs in the field.

The quality of the Sava River as a transport mode mostly depends on the availability of sufficient depth for navigation. In line with Sava Commission Classification (SCC) regulations, the Sava Commission applies two standards:

- Navigation must be possible with a reduced draft 95 % of the time;
- Navigation with maximum draft must be possible 65 % of the time.

According to SCC for class IV waterways, this means that the fairway should have a depth of 2.3 m, 95 % of the time, and a depth of 3.3 m, 65 % of the time. The width of the fairway for 2 lane traffic should be 55 m in straight sections and 75 m in curves, measured along the river bed center line of the curve.

The situation in the field is far from meeting these requirements. The shallow sections in Serbia and around the Drina confluence make it at present very difficult to reach Croatia / Bosnia for SCC Class IV categorized vessels, presumable for less than 50 % of the year. The situation in Croatia is slightly better where category Class III vessels can navigate with full draft around 65 % of the time. But important improvement works are also required on this section of the river to increase the availability of the fairway for fully loaded vessels and for SCC Class IV categorized vessels.

Figure A1-4: Drina confluent

The Sava Commission and Sava countries aim at rehabilitation and development of the waterway on the Sava River between Belgrade and Sisak, along the stretch km 0 to km 586, to minimum SCC Class IV waterway and SCC Class Va on sectors where it is possible and feasible. The extension of the navigability upstream Sisak is planned for the later phase in accordance with the development of the economic and transport activities.

In this regard, the Sava Commission finished the project *Feasibility Study and Project Documentation for the Rehabilitation and Development of the Transport and Navigation on the Sava River Waterway*. The project is based on the preliminary designs for the waterway and on several previously done studies and is a basic document for further activities.

2.2. Current state of the fairway conditions

Detailed surveys during the *Feasibility Study and Project Documentation for the Rehabilitation and Development of Transport and Navigation on the Sava River Waterway*, finalized in November 2008, indicated that there is at present a navigable fairway of modest quality on the Sava River between Sisak and Belgrade and on the 5 rkm of the Kupa River, but overall navigation conditions are poor and unfavourable mostly related to:

- Limited draft during large periods;
- Limited width of the fairway;
- Sharp river bends limiting the length and width of vessels and convoys.

Other substantial problems for navigation are:

- Limited height under bridges;
- Insufficient marking;
- Sunken vessels or objects;
- UXO presence.

In accordance with the field survey and reports of the relevant authorities, the following stretches have insufficient width and/or depth:

- From km 0 till approximately km 70 the river is relatively wide and has a fairway width of more than 80 m; also the water depth is sufficient;
- Near km 70 a narrow section is present having a width of 60 m;

- A long shallow reach downstream of Šabac extending approximately from km 84 to 110 is difficult to pass during lower water levels;
- Relatively narrow sections occur between km 130 and 150 for example around km 136 the fairway width is reduced to 70 m;
- Sufficient water depth and fairway width are not available on the stretch between km 170 and 180, thus confirming the problems at the Drina confluence, km 175.4. One lane traffic with a draft of 1 m is only possible at this stretch. Combined with the high flow velocities between 0.7 and 2.2 m/s this stretch causes severe problems for navigation;
- Between the confluence with the Drina (km 175) and the border with Croatia, the river is shallow. The minimum available fairway depth varies between 1.3 and 2.4 m.
- Around Šamac (km 300.0 – km 340.0);
- At the stretch between Slavonski Brod and Slavonski Kobaš (km 380.0 – km 420.0);
- Near Mačkovac (km 450.0 – km 460.0);
- Downstream of Sisak (km 560.0 – km 600.0).

General conclusion is that navigation infrastructure (including training structures and marking system) suffers of aging, lack of maintenance and incompleteness.

2.3. Navigation safety and technical standards

In order to improve the navigation safety, taking into account the present poor condition of the fairway on the Sava River, the Sava Commission started with the upgrading of the regulations in the field of navigation and, at the same time, support the Parties in the re-establishement of the waterway marking system.

According to the *FASRB*, as well as the *Protocol on the navigation regime to the FASRB*, the unification of rules in the field of navigation is one of the main activities stipulated in the *Strategy on implementation of the FASRB*, with the aim to establish an unified regulatory system in the Sava River Basin, which will be harmonized with the rules on European level.

Using the legal capacity given by Article 16(1a) of the *FASRB*, the Sava Commission, based on the proposal of the Permanent Expert Group for Navigation (PEG NAV), passed the following decisions in the field of navigation safety:

- Decision 30/07 on adoption of the *Navigation Rules on the Sava River Basin*;
- Decision 31/07 on adoption of the *Rules for Waterway Marking on the Sava River Basin*;
- Decision 32/07 on adoption of the *Rules on Minimum Requirements for the Issuance of Boatmaster's Licenses on the Sava River Basin*, and
- Decision 33/07 on adoption of the *Rules on Minimum Manning Requirements for the Vessels on the Sava River Basin*.

The decisions entered into force on December 13, 2007.

The Rules are presented to representatives of the competent authorities of the Parties on regular meetings of captains from the Sava Port Master Offices and the Sava Commission follows implementation of the decisions in the Parties with the aim to improve the content of the documents based on the inputs from the field.

The Sava Commission, jointly with the navigation commissions for the Rhine, Danube and Mosel, as well as UNECE and Austria, started the process of comparing the existing navigation rules on European level, in order to improve the *European Code for Inland Navigation* (*CEVNI*) and harmonize the rules in different river basins. There is also a joint work on the establishment of criteria for mutual recognition of boatmaster certificates, with the aim to minimize administrative obstacles for the development of inland navigation.

As for the technical requirements for inland waterway vessels, the Sava Commission developed the *Draft Technical Rules for the Vessels on the Sava River Basin* and the *Draft Rules for the Transport of the Dangerous Goods in the Sava River Basin*. Both documents are currently under discussion in the framework of the PEG NAV.

The *Draft Technical Rules for the Vessels on the Sava River Basin* are based on the EU Directive 2006/87/EC, laying down technical requirements for inland waterway vessels, while the *Draft Rules for the Transport of the Dangerous Goods in the Sava River Basin* propose application of the *European Agreement concerning the International Carriage of Dangerous Goods by Inland Waterways* (*ADN*). Adoption of these rules will be a basis for introduction of highest technical standards in the shipbuilding and the transport of dangerous goods, and will significantly contribute to improvement of navigation safety and environmental protection.

All above mentioned Rules represent a basic set of regulations for the establishment of an unique system of navigation in the Sava River Basin, and are fully harmonized with the requirements of the Danube and Rhine navigation commissions, the UNECE and EU.

In accordance with Article 10(4) of the *FASRB* and Article 9 of the *Protocol on the navigation regime to the FASRB*, the Sava Commission coordinated and supported activities of the Parties on the waterway marking and, in this respect, adopted the following decisions:

- Decision 29/07 on adoption of the *Marking Plan for the Sava River and its Navigable Tributaries for Year 2008*;
- Decision 37/08 on Amendments to the Decision 29/07 on adoption of the *Marking Plan for the Sava River and its Navigable Tributaries for Year 2008*; and
- Decision 02/09 on adoption of the *Marking Plan for the Sava River and its Navigable Tributaries for Year 2009*.

The *Detailed Design of the Marking System of the Sava River Waterway on the B&H Marking Sector* was prepared in the framework of the Sava Commission. The project, financed by B&H, is the basis for rehabilitation of the marking system on this river sector.

The Parties have made significant progress in the re-establishment of the waterway marking system through various activities:

- Republic of Croatia improved the existing marking system on its sector of responsibility;
- Republic of Serbia re-established the marking system on cca 150 rkm;
- B&H completed demining activities in the area of the signs, finished the tendering process for the marking activities, and started with the marking;
- B&H, Republic of Croatia and Republic of Serbia jointly solved the problem of the double river kilometer marks (there were several doubled river kilometer marks).

The re-establishment of the whole marking system will be finalized until the end of 2009, which will significantly contribute to the improvement of navigation safety.

3. Competent authorities in the Sava countries, national policies and regulations

3.1. Institutional arrangements in B&H

Being a decentralized country, Bosnia and Herzegovina has three ministerial levels (state level, Federation B&H level and the Republika Srpska level) for almost all governmental sectors.

The transport sector of Bosnia and Herzegovina is regulated by three ministries and one transport department:

- Ministry of Communications and Transport of Bosnia and Herzegovina;

- Ministry of Transport and Communication of the Federation of Bosnia and Herzegovina;
- Ministry of Transport and Communications ofthe Republika Srpska; and
- Brčko Administrative District Transport Department.

The Ministry of Communications and Transport of Bosnia and Herzegovina is the state level governmental institution responsible for the transport sector. Its main responsibilities are:

- Policy and regulation of common and international communication devices, international and inter-entity transport and infrastructure;
- Development of contracts, agreements and other acts that fall within international and inter-entity communications and transport;
- Relations with international organizations whose functioning fall within international and inter-entity communications and transport;
- Preparation and development of strategic and planning documents that fall within international and inter-entity communications, transport, infrastructure and information technologies; and
- Issues of control of unimpeded transport in international transport; civil aviation and civil transport control.

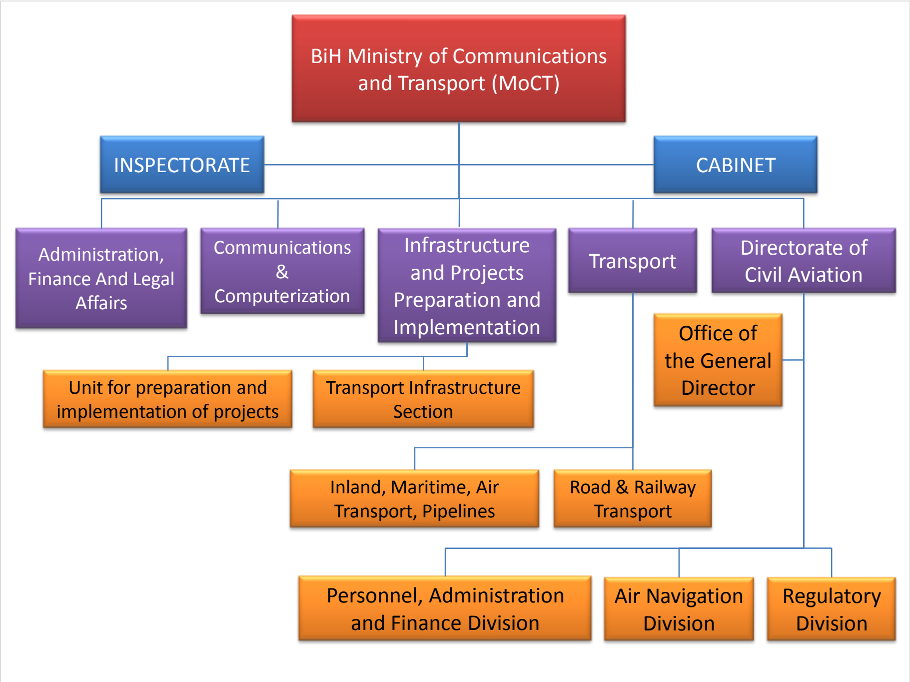


Figure A1-5: Organogram, transport ministry of B&H (state level)

The Sector for Transport and the Sector for Infrastructure and Projects Preparation and Implementation are each responsible for certain aspects of inland navigation.

The **Federal Ministry of Transport and Communications** is the one entity level institution responsible for the transport sector.

The department responsible for inland navigation is the „Department for rail, inland waterway and combined transport" which activities include: monitoring of development status of rail, inland waterway and combined transport, monitoring of safety status of rail, inland waterway and combined transport and undertaking measures for enhancement of safety level, initiation and cooperation in production of development plans and maintenance programs for rail, inland waterway and combined transport and monitoring of implementation, initiation of conclusion of international contracts, conventions, agreements and other acts and monitoring of enforcement, cooperation with state, entity and canton ministries form the transport sector, cooperation with transport inspectors and participation in preparation of laws and regulations and recommendation of amendments which concern transport sector.

The **Ministry of Transport and Communications (Republika Srpska)** is the second entity level institution responsible for the transport sector.

The Ministry is responsible for management and other expert works related to activities, road traffic and public roads, railway traffic and safety of railway traffic, air traffic, sea, river and lake traffic, safety of sea, river and lake traffic, reloading services, communication system, radio communications, mail, telegraph and telephone transport, telecommunication, telecom infrastructure, coordination policy management, inspection supervision of public roads, road traffic, railway traffic, PTT traffic with telecommunications and other works put under its jurisdiction.

3.1.1. National regulations

At present there is no state-level law which regulates inland waterway transport. A draft *Maritime and Inland Waterways Law* (year 2007 version) is in the process of adaptation and is expected to become a formal law in the near future. The future law is also expected to integrate recent developments in the inland waterway sector.

Both entities have legislation for inland waterway transport. The *Law on Internal Navigation of the Republika Srpska* (*Official Gazette* RS 58/01) and the *Law on Internal and Maritime Navigation of the Federation of Bosnia and Herzegovina* (*Official Gazette* FB&H 73/05) are harmonized and contain the same provisions regarding inland navigation. The provisions of both laws are applicable to all vessels (including military) and to inland waterways in the two entities.

3.1.2. National policies

The *Transport Master Plan for B&H* from 2001 became a starting point for the institutional development of the transport sector in B&H.

In a next important step, a comprehensive *Medium Term Development Strategy PRSP* (2004 – 2007) was developed in March 2004 by a large team of various governmental and individual experts.

The B&H *Medium Term Development Strategy PRSP* (2004 – 2007) was updated in 2006 and mentions regarding infrastructure the following objectives in addition to the above:

- By developing river transport in the future a better valorization of the advantages of available natural geographical can be obtained;
- River transport needs to be upgraded up to pre-war levels and the Sava Agreement needs to be put in use, but the lack of funds impede the development of the river transport; and
- To enhance the opening of B&H towards the neighboring countries for which international agreements and contracts are required.

3.2. Institutional arrangements in Croatia

The inland waterway sector in Croatia is presently very well regulated, with clearly divided responsibilities among various governmental institutions.

The Ministry of the Sea, Transport and Infrastructure is the ministry directly responsible for inland waterway transport.

The organization structure dealing directly with the inland waterways is visualized in Figure A1-6.

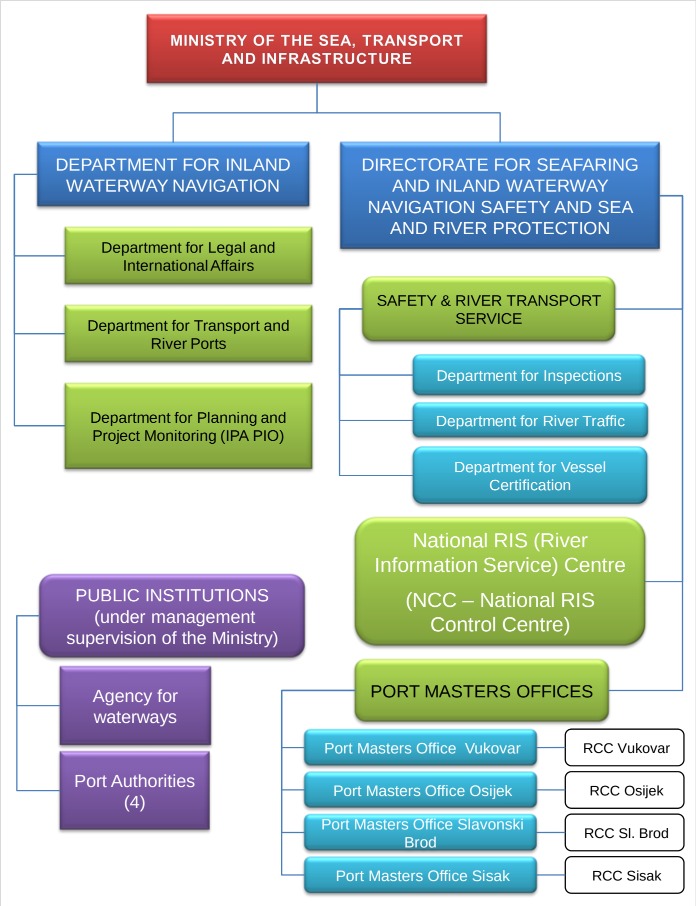


Figure A1-6: Organogram, transport ministry of Croatia (only parts dealing directly with inland navigation)

The Ministry handles administrative and other affairs which concern the following aspects of inland navigation:

- Domestic and international inland waterway transport with respective infrastructure;
- Development strategies of inland waterway transport;
- Inland waterway ports;
- Means of transport;
- Inspectional affairs;
- Safety of inland waterway navigation; and
- Organization and control of relevant infrastructural projects of great significance regarding water management and transport on inland waters.

Other institutions relevant for inland navigation which are under direct authority of the Ministry are: Port Authorities, Agency for Waterways and the Croatian Register of Shipping.

3.2.1. National regulation

The *Inland Navigation and Inland Waterway Ports Act* (*Zakon o plovidbi i lukama unutarnjih voda*, NN (*Official Gazette*) 107/07, 132/07) was adopted by Croatian Parliament in October 2007 and incorporates two previous laws which were regulating inland navigation in Croatia: (1) The *Inland Navigation Act* (*Zakon o plovidbi unutarnjim vodama*, NN (*Official Gazette*) 19/98 and NN (*Official Gazette*) 151/03); and (2) The *Inland Waterway Ports Act* (*Zakon o lukama unutarnjih voda*, NN (*Official Gazette*) 142/98 and NN (*Official Gazette*) 65/02).

The new law represents the harmonization of Croatian regulations with EU Directives for the inland waterway sector in following issues: liberalization of transport market between domestic ports and right for foreign shippers to access the ports; recognition of diplomas, certificates and other evidence of formal training for access to shipping profession; requirements for ship registration; recognition of boatmasters' certificates; procedure for determining ships' capability for navigation and recognition of navigation licenses; establishment of River Information Services (RIS) and jurisdiction for RIS.

A range of regulations and ordinances were adopted on the basis of the *Inland Navigation Act* and of the *Act on Inland Waterway Ports*.

3.2.2. National policies

The *Transport Development Strategy* (*Strategija prometnog razvitka Republike Hrvatske*, NN (*Official Gazette* 139/1999) was adopted by Croatian Parliament in November 1999. The Strategy refers to all modes of transport and covers the period from 2000 to 2020. According to the inland waterway transport part of the Strategy the priorities are construction of inland waterways, ports, and terminals.

The *River Transport Development Strategy in the Republic of Croatia - 2008-2018* (*Strategija razvitka riječnog prometa u Republici Hrvatskoj – 2008.-2018.*, NN 65/2008) was adopted by Croatian Parliament in May 2008. The Strategy refers to six main fields: safety of navigation and environmental protection, market, shipping industry and education, infrastructure, promotion and administrative capacities.

The *Mid-term development plan of the waterways and ports on the inland waters of the Republic of Croatia – 2009-2016* (*Srednjoročni plan razvitka vodnih putova i luka unutarnjih voda Republike Hrvatske 2009.-2016.*) analyses current inland waterway network and port system in Croatia, gives an overview of present situation and problems, and determines future plans. According to this plan, expected activities in the Sava River Basin are upgrading of the Sava River waterway up to class IV, the construction of Danube – Sava canal and investments in rehabilitation and development of the ports Sisak and Slavonski Brod.

3.3. Institutional arrangements in Serbia

The Ministry for Infrastructure is the ministry directly responsible for inland waterway transport (Figure A1-7).

The Sector directly responsible for inland navigation is the Sector for water transport and safety of navigation which has following main competences:

- Establishment of marking and regulation systems of inland waterways;
- Production of electronic navigation charts and establishment of river information services;
- Construction, reconstruction and maintenance of hydro-technical objects and all types of regulation works for establishment of required dimensions of the waterways for the safe navigation, which concerns both international (Danube, Sava) and interstate (Tisza and other rivers in Republic of Serbia) waterways;
- Reconstruction of terminals and ports of international importance and construction of combined transport terminals;
- Reconstruction and maintenance of navigable canals (Begej and Danube-Tisza-Danube (DTD) canal system) and locks which are not part of the hydropower systems;
- Establishment of radio connection on inland waterways of Republic Serbia;
- Development strategy for marinas;
- Acquisition of certain international standards, requirements and recommendations in accordance with provisions and principles of EU;
- Participation in the work of international organization;
- Drafting of development strategy of water transport and legislation on inland navigation.

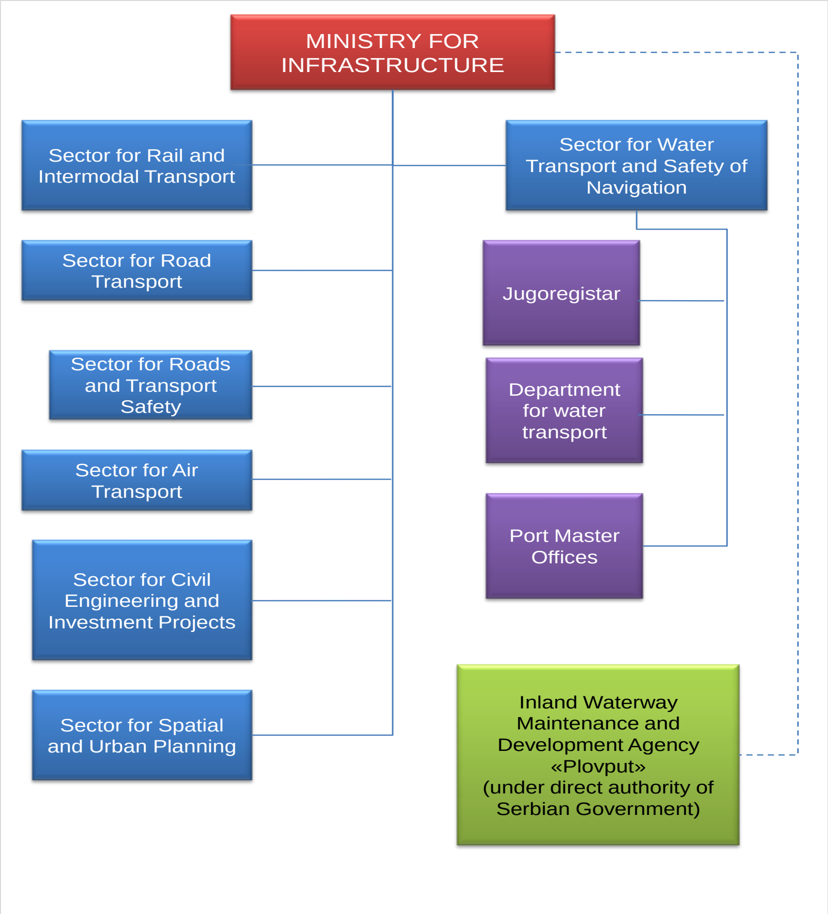


Figure A1-7: Organogram, transport ministry of Serbia

3.3.1. National regulations

The *Maritime and Inland Navigation Act*

The *Maritime and Inland Navigation Act* (*Zakon o pomorskoj i unutrašnjoj plovidbi – Službeni list* SRJ (*Official Gazette of Federal Republic of Yugoslavia*) 12/98, 44/99, 74/99, 73/00) is the law regulating maritime and inland navigation on the entire territory of former state, the Federal Republic of Yugoslavia and is still in force in the Republic of Serbia.

This act regulates the safety of navigation on the sea and inland waters of the Federal Republic of Yugoslavia, navigable waterways in coastal waters and inland waters, right of flag, identification and registration of the ship, basic ownership relations regarding ships, shippers, obligation rights regarding ships, navigation accidents, procedure of execution and security on the ships, relevant law and court competence for legal disputes of international character.

The new *Maritime and Inland Navigation Act* is in the process of drafting and it is expected to be harmonized with EU regulations regarding inland navigation.

The *Inland Navigation Act*

The *Inland Navigation Act* (*Zakon o unutrašnjoj plovidbi* – Službeni glasnik SRS 54/90 and Službeni glasnik RS 46/91, 53/93, 67/93, 48/94) is the law regulating inland navigation in former Federal Republic of Serbia which was the part of former Federal Republic of Yugoslavia and Act is also still in force in the Republic of Serbia. This Act gives provisions on:

- Inland waterways;
- Terminals, winter harbors and anchorages;

- Boats and floating devices;
- Crew of the boat;
- Radio connection;
- Transport in inland navigation;
- Navigation accidents;
- Inspection, and
- Port Master Offices.

3.3.2. National policies

In 2004, the report *Transport Policy and Strategy* was made as an attempt to harmonize the existing transport policy with EU *White Paper*. The report took four years to be adopted as the official *Strategy for rail, road, water, air and intermodal transport of Republic of Serbia (2008-2015)*.

The *Strategy for rail, road, water, air and intermodal transport of Republic of Serbia (2008-2015)* analyses the current situation in the water transport in Serbia and presents priorities and future plans for the sector. According to the Strategy, Serbia has favorable economic and technical conditions for cargo, passenger and tourist navigation on inland waterways. The potential of inland waterways in Serbia is substantial but the infrastructure is in very poor condition.

The Strategy emphasizes, among others, the following priorities:

- Enhancement of navigation conditions on Danube, Sava and Tisza waterways, as well as DTD canal system, in accordance with European development plans regarding inland waterway transport;
- River Sava, which is an international waterway, and Tisza which has an international navigation regime, have to be rehabilitated in accordance with bilateral and multilateral agreements.

3.4. Institutional arrangements in Slovenia

The Republic of Slovenia is the only Sava riparian state which is already a member of the European Union. Slovenia joined the EU in 2004 and became a member of the Euro zone in 2007.

The Ministry of Transport is the highest governmental institution directly involved in inland waterway transport in Slovenia. The Ministry has responsibilities in the fields of railway transport, air transport, maritime and inland waterway transport, and road transport (with the exception of road transport safety control) as well as in the field of transport infrastructure and cableway installations.

The Ministry is structured into the following offices (Figure A1-8):

- Transport Directorate,
- International Affairs Directorate,
- Roads Directorate,
- Railways and Cableways Directorate,
- Civil Aviation Directorate,
- Maritime Directorate.

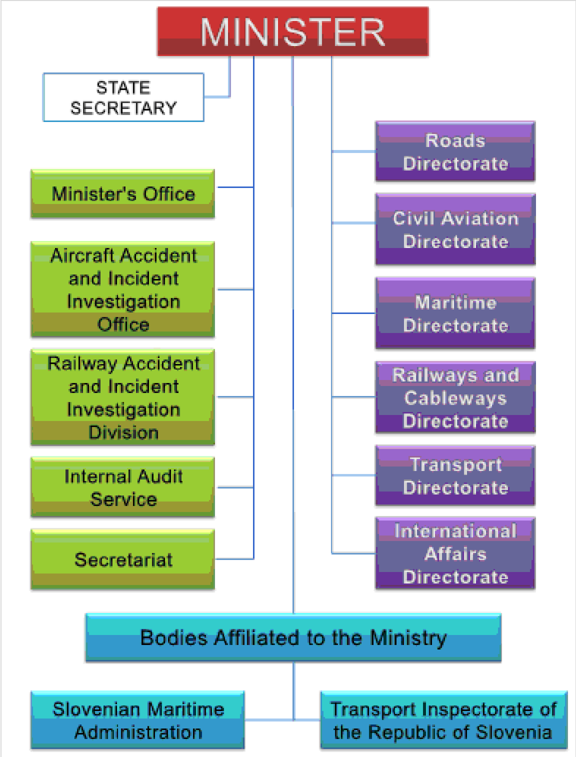


Figure A1-8: Organogram, transport ministry of Slovenia

Each of these offices performs duties falling within the competencies of the Ministry.

The mission of the Ministry is to provide conditions for high-speed, reliable and economically efficient transport of passengers and goods from the source to the destination of traffic flows while maintaining the utmost degree of safety and in order to realize its mission, the Ministry has to provide coordinated, reliable and cost-effective functioning of the overall transport system.

Direct responsibilities of the Ministry regarding inland navigation include the adaptation of implementation rules on the basis of the *Law on Navigation on Inland Waters*. The Ministry is responsible for issuing licenses to institutions that engage in the control and assessment of vessels for navigation. According to a decision of the Ministry, the institution at present licensed for the inspection and assessment of vessels for navigation are the Slovenian Maritime Administration and Transport Inspectorate of the Republic of Slovenia.

The Maritime Directorate is the section of the Ministry which is directly responsible for maritime transport and inland navigation. Most important activities of the Maritime Directorate include:

- Navigation safety control,
- Development of port capacity and port infrastructure,
- Hydrographic surveys of Slovenian waters, issuing nautical charts of Slovenian waters and publications and studies,
- Cooperation in drawing up international agreements and cooperation in international organizations in the area of maritime transport,
- Involvement and participation in European institutions formulating and guiding the development of maritime sector.

3.4.1. National regulations

Slovenia has a law that regulates the navigation on the rivers. Because commercial cargo transport on the Slovenian part of Sava River is rare, this law concentrates on other aspects of inland navigation (tourist, sport, recreational, military vessels).

The *Law on Navigation on Inland Waters* (*Zakon o plovbi po celinskih vodah* – ZPCV, Ur.l.RS 67/2002) regulates the safety of inland navigation, required conditions of navigable areas, vessels and floating devices, persons responsible for navigation of the vessels, wharfs and other places used for the access to navigable area, registration of vessels and floating devices, taking out of sunken goods and inspection of safety of inland navigation.

All issues concerning navigation safety that are not regulated by *Law on Navigation on Inland Waters* are regulated by the *Maritime Code* (*Pomorski zakonik*, Ur.l.RS 37/2004). Relevant issues include: technique of vessel measurement, ship's logs, identification of vessels, vessel's crew exams and certificates, procedure for registration of vessels and shipping accidents.

3.4.2. National policies

In 2006 Slovenian Parliament adopted a *Resolution on Slovenian Transport Policy* (*Resolucijo o prometni politiki Republike Slovenije* – RePPRS, Ur.l.RS 58/2006) in an effort to harmonize Slovenian transport policy according to the EU *White Paper* (European Transport Policy for 2010: Time to Decide, 2001).

The emphasis is given to enhancement of intermodality in the Slovenian transport sector. In spite the importance of inland waterway transport in the European transport policy, the text does not express the Slovenian opinion on a possible development of inland navigation and potential investments in this sector, from which can be concluded that inland navigation is not of strategic importance for Slovenia.

The *Spatial Development Strategy of Slovenia* (Ur.l.RS 76/2004) is the basic strategic spatial development document and an integrated planning document which implements the concept of sustainable spatial development. In the section analyzing the development of public infrastructure it is states that a river port shall be developed on the Sava River at the border between the Republic of Slovenia and the Republic of Croatia, provided that the Sava River from its outflow to the Danube River to the border between the Republic of Slovenia and the Republic of Croatia is made navigable.

3.5. International Sava River Basin Commission

The process, known as the Sava Initiative, was formally initiated with the *Letter of Intent concerning the International Sava River Basin Commission Initiative*, signed in Sarajevo on November 29, 2001 by the Ministers of Foreign Affairs of Republic of Croatia, the Republic of Slovenia, the Federal Republic of Yugoslavia, and by the Minister for Civil Affairs and Communications of Bosnia and Herzegovina.

The four riparian countries subsequently signed, on December 3, 2002, the *Framework Agreement on the Sava River Basin* (FASRB) in Kranjska Gora (Slovenia), after the successful completion of negotiations run under the „umbrella" of the Stability Pact for South-Eastern Europe.

The Agreement entered into force on December 29, 2004, 30 days after the Depositary of the Agreement (Republic of Slovenia) notified the signatories on reception of the last instrument for the ratification procedure. Accordingly, the Constitutional Session of the Sava Commission was held on June 27-29, 2005, in Zagreb.

The FASRB is a legal base for the constitution and functioning of the Sava Commission.

One of the three main objectives of the FASRB is the cooperation of the Parties in order **to establish an international navigation regime on the Sava River and its navigable tributaries**.

Regarding the navigation regime, the *Agreement* stipulates that navigation on the Sava River is free for trade vessels of all States, identical to the regulation for the Danube River under the *Convention on the navigation regime*. Trade vessels have a right to free entrance into ports on the part of the Sava River waterway from Sisak to its estuary into the Danube as well as on all navigable parts of the Sava River tributaries, and this for purpose of loading, discharging, supply, and similar actions. Trade vessels should in their activities respect national regulations of the Parties on whose territory the port is located. Parties will therefore undertake all necessary measures for maintenance of the waterways in their territory to guarantee a navigable state-of-condition as well as to undertake measures on improvement of the navigation conditions, and will not prevent or cause any obstacles to navigation.

The Parties also agree to regulate by a separate *Protocol on the Regime of Navigation* all issues regarding navigation, such as institutional arrangements (rules of navigation, technical rules for vessels, marking of navigable waterways etc.) and expenses relating to the maintenance of the navigable waterways and the regime of navigation. The *Protocol on the Navigation Regime* was agreed between the Parties pursuant to the provisions referred to in Article 10, Paragraph 6 of the *Framework Agreement on the Sava River Basin* and entered into force also on December 29, 2004.

In the field of navigation, the Sava Commission has international legal capacity necessary for making decisions:

- aimed to provide conditions for safe navigations;
- on the conditions for financing construction of navigable waterways and their maintenance.

Decisions of the Sava Commission are obligatory for the Parties.

4. Future status of navigation

4.1. Transport needs

A cease of the transport activities on the Sava River and economic changes in the region during the last two decades caused a significant drop of the cargo transport on the Sava River.

However, the expected growth in river traffic is notable and clearly warrants the investments and initiatives. An issue that has been investigated in detail was the question whether the rehabilitation efforts should concentrate on upgrading to Class IV or directly to Class Va.

The cargo forecasts after upgrading to Class IV on the sector between Belgrade and Sisak confirm the growing positive appreciation regarding traffic volumes on the Sava River between now and the year 2027. During the year 2012 (representative of post-upgrading of the Sava River to Class IV navigation), commercial cargo traffic is expected to reach between 3.5 million and 7.9 million tonnes, depending on realization of low or high economic growth scenarios. These volumes are likely to increase to 6.1 million and 15.3 million tonnes in 2022, and to ultimately reach between 7 million and 18.7 million tonnes during year 2027, again depending on the low and high growth scenarios, respectively. This positive future is not a consequence of the progress of one particular port along the Sava River, but the results of a combined strong performance of all river ports.

From a purely traffic volume perspective, the immediate upgrading to Class Va has a notable additional positive effect on the estimated future cargo volumes.

Keeping the same evaluation base, the total additional cargo volume that is generated during the reference period and via an immediate upgrading to Class Va ranges from 1.5 million additional tones in the high growth scenario to 2.5 million tonnes in the low growth scenario.

Assuming possible benefits obtained from economies-of-scale equaling respectively 5 % and 10 % on total base traffic, the benefits markedly increase under all economic scenarios and the pattern of benefits also increases in time. For example, with a 5 % traffic benefit, the immediate upgrading would lead to 3.4 million tonnes of additional cargo in 2012 according to the low growth scenario, increasing to 6.2 million additional tonnes of cargo in 2027 according to the high growth scenario. Assuming a 10 % scale benefit, the benefits of an immediate upgrading to Class Va would reach 4.3 million tonnes in 2012 according to the low growth scenario, climbing to almost 11 million tonnes by 2027 assuming a high growth scenario.

The traffic estimates after rehabilitation to Class Va suggest that for the year 2027 high growth scenario without any economies-of-scale benefits taken into consideration, 20 million tonnes may be transported along the highest activity segment (between Danube River and Šabac International Port). Figure A1-9 presents the range according to minimum and maximum economic growth scenario of potential cargo volumes per river section in year 2027.

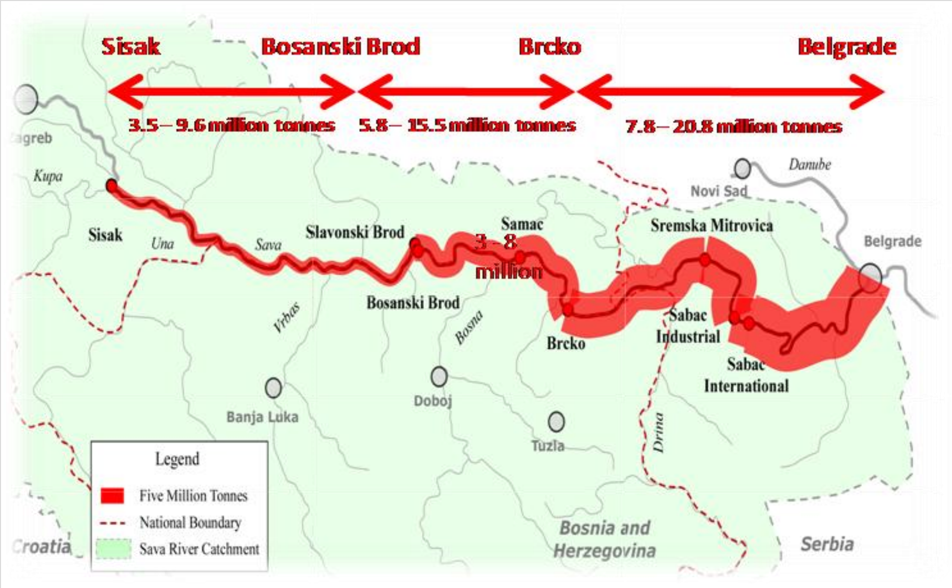


Figure A1-9: Cumulative traffic volume per main segment (minimum and maximum estimated volumes for year 2027)

In terms of ton kilometers, based on river kilometers within the Sava River, the year 2027, high growth scenario for Class Va suggests that, on a cumulative basis, some 5,605 million ton kilometers may be expended along the highest activity segment (between Danube River and Šabac International Port). This would increase to the order of 6,177 million ton kilometers under the base condition plus 10 percent commercial cargo scenario.

The number of ships passing along any given segment of the Sava River is a critical determinant of operational sufficiency. Several considerations influence this calculation and the analysis of vessel movements should be for a „fail safe" condition; that is, the „worst case" demand. Loadings on all Sava River segments, under 2,000 ton average loads, base case plus 10 percent demand scenario, and high economic growth range from 66 for the Šabac International – Danube River segment of the Sava River, to 23 for the short (one kilometer) Slavonski Brod – Bosanski Brod segment. The total number of vessel movements is less than the upstream Sisak – Slavonski Brod segment since the latter, which extends over roughly 220 river kilometers, has a much higher net level of dredging activity. Hourly one-way peak directional vessel movements for the Šabac International – Danube River segment, under an equivalent 22 hour day, and 60 percent directional peak hour factor, would be 1.8 vessels per hour; that is, in the peak hourly direction, a ship every 33 minutes. Similar headways for the medium and low economic growth scenarios would be a ship every 50 and 85 minutes, respectively.

The issue of commercial navigation upstream Sisak has until now never been seriously investigated and no assessment was ever made of the potential volumes river traffic could capture on the river section upstream Sisak. This first effort in estimating possible cargo volumes of river transport upstream Sisak is subject to a number of preliminary observations.

Results for year 2027, under the high economic scenario, indicate a potential Brežice activity of some one million tons (but considerably less under other growth scenarios) and near two million tons for Zagreb / Rugvica (Table A1-3).

Table A1-3: Forecast Throughput: new ports of Zagreb (Rugvica) and Brežice

Economic scenario	Thousand Tons per Annum			
	2012	2017	2022	2027
Brežice				
Low	100	150	180	210
Medium	210	300	370	440
High	450	690	870	1,060
Zagreb (Rugvica)				
Low	190	280	340	380
Medium	390	550	680	810
High	850	1,280	1,620	1,980

Note: Totals exclude sand and gravel.

These findings raise several implications. There exists an argument (although not an overly dominating one) for implementing Rugvica Port, depending on adopted economic growth rates. However, some of the Rugvica throughput would (more than likely) be at the expense of Sisak Port and Slavonski Brod Port. Justification for implementing a commercial cargo-based port at Brežice is highly questionable except under the highest economic growth scenarios if one accepts an industry benchmark that 500,000 annual tonnes are needed to support any sort of port. However, there exist and undeniable nautical tourism potential that calls for the appropriate infrastructure to accommodate high-order nautical tourism by means of locks for the planned hydroelectric dams and guaranteed Class II or Class III navigability, concurrently low-order commercial services (perhaps) are possible.

4.2. Design/construction criteria

The Sava Commission has adopted and made decissions on *Detailed Parameters on Waterway Classification* and *Classification of the Sava River Waterway* (see Chapter 2.1) which define design criteria.

Since the conclusion of the *Feasibility Study and Project Documentation for the Rehabilitation and Development of Transport and Navigation on the Sava River Waterway* is that the Sava River waterway should be improved to a Class Va, only this criteria will be presented and compared to Class IV. The differences are rather small and still not yet completely clear (depends on various factors) if the Class Va will be apply on a whole stretch of Sava River.

The design requirements for the fairway dimensions and safety clearances for improving the Sava to a SCC Class Va waterway are almost similar to the design requirements for a SCC Class IV waterway (Figure A1-10).

The differences are:

- The depth of the fairway is 2.4 m for SCC Class Va and 2.3 m for SCC Class IV (at low navigable water level).
- The width of the waterway in bends is 90 m for SCC Class Va instead of 75 m for SCC Class IV; and
- The horizontal clearance below bridges is 55 m for SCC Class Va and 45 m for Class IV.

STUDY		Feasibility study 2008 (present study)	Feasibility study 2008 (present study)
WATERWAY	classification system	SCC	SCC
	class	IV	Va
MOTOR VESSELS AND BARGES	length (m)	80-85 70 (when pushed)	95-110 76.5-85.0 (when pushed)
	beam (m)	9.5 9.5 (when pushed)	11.4 11.4 (when pushed)
	maximum draught (m)	2.5 2.5 - 2.8 (when pushed)	2.5 - 2.8 2.5 - 4.5 (when pushed)
	tonnage (t)	1000 - 1500	1500 - 3000 1600 - 3000 (when pushed)
PUSHED CONVOYS	Convoy type		
	length (m)	85	95 - 110
	beam (m)	9.5	11.4
	maximum draught (m)	2.5 - 2.8	2.5 - 4.5
	tonnage (t)	1250 - 1450	1600 - 3000
DIMENSIONS OF FAIRWAY	Depth of fairway (m) (in case of reduced draught and for a water level that is exceeded 95% of the time)	2.3	2.4
	Depth of fairway (m) (in case of maximum draught and for a water level that is exceeded 65% of the time)	3.3	3.4
	Width of waterway in a stream (m)	55	55
	Width of waterway in a curve (m)	75	85 (for vessels with min length) 90 (for vessels with max length)
	minimal radius of curvature (m)	360	360
SAFETY CLEARANCES	Vertical clearance under bridged (m) (for water level that is exceeded 1% of the time)	7	7
	Horizontal clearance under bridges (m)	45	55
	Vertical clearance under the power lines (m) up to 110 kV up to 250 kV up to 400 kV	15.00 15.75 17.00	15.00 15.75 17.00
	Vertical clearance under cables (m)	12	12
	Horizontal clearance for cables and power lines (m)	width between river banks at high water levels	width between river banks at high water levels

Figure A1-10: SCC requirements for a class IV and class Va waterway

4.3. Further development of planned works

The *Feasibility Study* recognized that 21 stretches required dredging and training works, 20 stretches required bands improvement, 3 bridges have to be reconstructed in order to meet SCC Class Va requirements and marking system have to be completed (in spring 2009 river section from rkm 335 to rkm 150 is not marked, but it is expected that fully operational marking system on the whole Sava River, including navigable part of Kupa River, will be established).

Beside of these „basic" requirements, the following miscellaneous works can significantly improve the state of fairway conditions:

- Removal of ship wrecks or obstacles (total of 3 ship wrecks have to be removed);
- Cleaning of areas from UXO (unexploded ordnance);
- Implementation of River Information Services;
- Upgrading of winter ports.

The general lines of the development of waterway on Sava River are schematized in Figure A1-11.

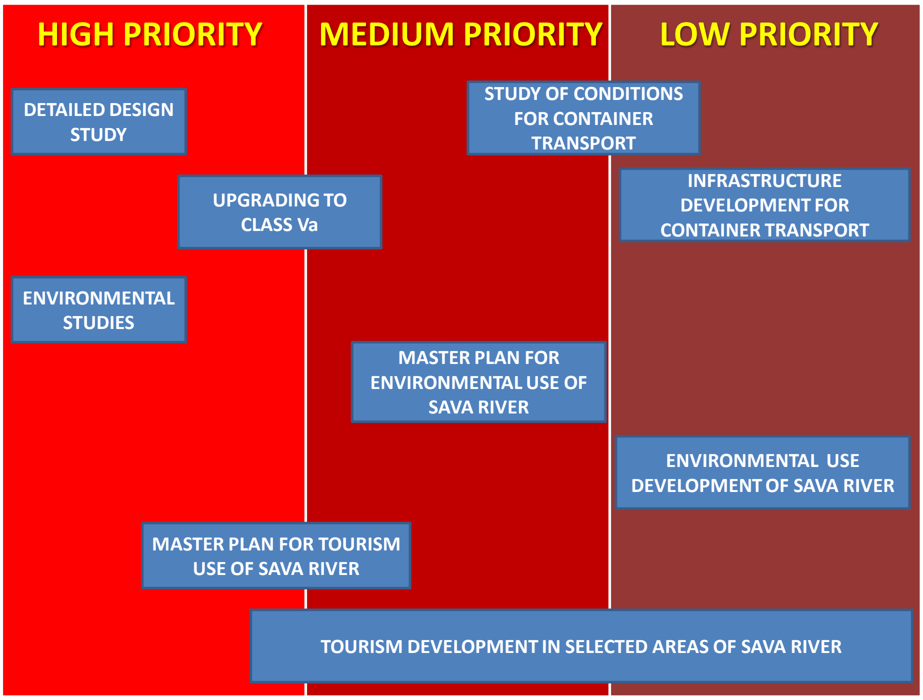


Figure A1-11: General Action Plan implementation lines

The comprehensive rehabilitation program for the Belgrade – Brežice section of the Sava River can be divided into two principal groups of initiatives. The first group is associated with the restoration of commercial navigation on the river section between Belgrade and Sisak. The second group of works involves the development of alternative river utilizations, principally focusing tourism and recreation and is coupled to the river section between Sisak and Brežice.

However, above characteristic distinction between the two river sections is not exclusive, given that several sections of the river offer opportunities for integrated developments:

- The river section between Sisak and Rugvica (Zagreb), where a policy decision is possible to develop a river port in Rugvica, hence necessitating the development of commercial traffic. Such evolution could emerge in addition to the opportunities for tourism development and the high environmental value of that river section; and
- Several cities along the Sava River already have developed, have started to develop, or offer high development potential for waterfront landscaping and for the creation of tourism and recreational water-based infrastructures, improving the link between river and city.

The realization of a comprehensive river development program, covering transport, tourism / recreation and environment, is a long-term initiative comprising a range of concrete actions and projects, each having its own characteristics, dynamic and timeframe.

A wide range of projects, studies and policy actions emerged from the *Feasibility Study* and are listed in Table A1-4.

The list of initiatives is ranked in accordance with the estimated priority of the initiative and reflects not only the intervention logic which imposes a certain sequential order, but also considers the possible economic, environmental or social value of specific actions.

It should be emphasized that several of these initiatives, in particular when considering policy actions, are closely inter-related and could be combined under the „project preparation" label.

Table A1-4: Prioritized list of projects, studies and policy actions

Group	Intervention name / description	Intervention type	Priority
1	Approval of Feasibility Study results	Policy action	High
2	Agreement on management and coordination structures	Policy action	High
	Financial sources and donors	Policy action	High
3	Detailed Design Study	Study	High
	Environmental Impact Study	Study	High
	Marking (Study) of fairway	Study/ Physical works	High
	RIS Final Design Study	Study	High
4	Financing rehabilitation works	Policy action	High
	Preparation rehabilitation works (tendering, selection)	Policy action	High
5	Rehabilitation works (dredging and training)	Physical works	High
	Other infrastructure works	Physical works	Medium
	RIS development	Physical works	Medium
6	Sava River Tourism Master Plan	Study	Medium
	Sava River Environmental Master Plan	Study	Medium
	Sector Development Plan	Study	Medium
	Sava River Port development	Policy action	Medium
7	Sava River Tourism development	Policy action	Medium/ low
	Sava River Environmental development	Policy action	Medium/ low
8	Regional development	Policy action	Low
	Container transport development	Policy action	Low

4.4. Economy indicators

In accordance with the *Feasibility Study and Project Documentation for the Rehabilitation and Development of the Transport and Navigation on the Sava River Waterway*, total cost for upgrading Sava River from Belgrade to Sisak to Class IV equals 63,799,200 Euros (excluding contingencies and project costs) compared to 68,313,600 Euros (idem) for immediate upgrading to Class Va. The difference in total cost, just over 7 %, originates in large majority from increased dredging and training cost and higher environmental costs. All other costs remain relatively equal for both options.

Table A1-5: Comparative summary of rehabilitation costs

	Total for SCC Class IV (Euro)	Total for SCC Class Va (Euro)	Difference (Euro)	Difference %
Dredging and training works	34,929,200	39,108,600	4,179,400	12.0
Environmental costs	1,005,000	1,340,000	335,000	33.3
Bridge replacements	8,880,000	8,880,000	0	0.0
River bend improvements (total)	11,360,000	11,360,000	0	0.0
Markings and sunken vessels	1,835,000	1,835,000	0	0.0
RIS	5,790,000	5,790,000	0	0.0
Net cost	63,799,200	68,313,600	4,514,400	7.1
Including contingencies (+10%)	70,179,120	75,144,960	4,965,840	7.1
TOTAL project costs (+15%)	80,705,988	86,416,704	5,710,716	7.1

As the river gradually diminishes its size in upstream direction the demanded work to comply with a SCC Class IV navigation channel increases. As a result of this, upgrading of the Sava from Rugvica to Brežice needs from the river engineering point of view, to be done with dams and locks.

Most ideally from the environmental and river engineering point of view is the implementation of a series of small dams with locks at close internal spacing. Because locks are notoriously expensive this is usually not feasible and the absolute minimum amount of dams has to be used as alternative solution.

Table A1-6 presents the infrastructure costs and the operation and maintenance costs depending on the types of alternatives and the approach used to assess these costs.

Table A1-6: Overall cost overview for rehabilitation of section Sisak - Brežice

Project	Investment costs (Euro)	Operation and maintenance costs (Euro)
Section 1: Sisak – Rugvica:		
Approach 1	22,785,000	56,950
Approach 2	32,816,883	56,950
Section 2: Rugvica – Brežice:		
Alternative 2 dams	299,046,000	4,476,000
Alternative 2 dams + Mokrice dam	324,346,000	5,476,000
Alternative 5 dams	353,947,000	7,144,000
Alternative 5 dams + Mokrice dam	379,247,000	8,144,000
Combined:		
Minimum	321,831,000	4,532,950
Maximum	412,063,883	8,200,950

Furthermore, the Cost Benefit Analysis clearly demonstrated that the investment performance for immediate upgrading of the section between Belgrade and Sisak to SCC Class Va are very positive and is even better as the already positive appreciation of upgrading the river to Class IV. Especially the performance of the project at low transport volumes improves significantly, meaning that the immediate upgrading to Class Va has less investment risk in case of lower than expected traffic / cargo volumes.

The river section between km 0 and km 362 shows the best socio-economic performance in case of upgrading to Class Va while the stretch between 362 and 583 (Slavonski Brod – Sisak) is not yet positive at the end of the appraisal period in the year 2028, but calculation will break even in 2031, therewith showing clear potential in the longer term future.

The profitability of investments is substantially better for the upgrading to Class Va than to Class IV, which already were very positive, and the internal rates of return (IRR) are clearly better for SCC Class Va. Compared to the higher level of benefits when comparing the upgrading to Class IV with upgrading to Class Va, the increase in costs remains moderate at a 15 % increase, discounted over 20 years. As a result, the Net Present Values are much higher for upgrading to SCC Class Va as compared to SCC Class IV. Also the benefits for the transport industry show big increases of about +55 % compared to upgrading to Class IV and there is furthermore a notable increase of +20 % on the external benefits.

Overall, the reference medium volume scenario shows an internal rate of return of 20 % which is very good. The Net Present Value at 6 % discount rate is 157.9 million Euro and the Benefit/Cost ratio is 2.68. These figures illustrate that the project clearly provides an added value for the industry and society. Furthermore one should bear in mind that the appraisal period is short (20 years) and sand and gravel transport by IWT have been disregarded in the analysis. Therefore the results shall be considered to be robust and rather conservative.

Comparing the river rehabilitation costs and benefits for river section Sisak – Brezice with the results for upgrading the section Belgrade – Sisak, both to SCC Class IV, the immediate and logical conclusion is that the extension of navigability upstream Sisak generates a clear negative CBA result. An increase on the cost-side could be observed of 270 % up to 290 % while the benefits only increased between 2.4 % and 3.3 %. Since the relative change of costs is much bigger than the relative increase of benefits, the benefit/cost ratio is strongly negative.

There is no doubt that extension of navigability upstream Sisak does not provide sufficient benefits to compensate for the huge investments. Even when integrating the investment into the development of Sava River downstream Sisak, the benefit/cost ratio for the combined investment is 0.60, meaning that only 60 % of the total investments are recovered by internal and external transport benefits. However, once the investments are completed and there are only operations and maintenance costs, there is a positive annual cash flow and the balance between benefits and costs is improving during the years 2019 and 2028.

In respect of the above economic analysis and associated results, two specific comments should be made:

- The CBA has been conducted according to a specific assumed timetable. Possible changes in this timetable could change the outcomes of the CBA. This is in particular true if the capital costs are moved forward significantly, reducing the profitability of the project.
- The CBA has assumed a sequential implementation of the rehabilitation works, starting in Belgrade and proceeding upstream towards Sisak. The CBA does not consider impacts related to alternative development scenarios which could have an impact on the outcome of the CBA.

The CBA has been realized using realistic assumptions and taking conservative positions. Given the limitations caused by the level of detail of available information, the investigation provided sufficiently robust information to recommend:

- The immediate implementation of rehabilitation works to upgrade Sava River to Class Va between Belgrade and Sisak.
- To abandon the idea of upgrading that section to Class IV and in the future upgrade to Class Va if demand warrants such additional investment;
- Formally abandon the idea of upgrading Sava River upstream Zagreb for commercial river transport and concentrate on tourism development and energy production; and
- In principle abandon the idea of introducing commercial traffic on the section Sisak – Rugvica because there is no economic or financial rationale for the investment.

Meanwhile, based on a careful consideration of the findings presented in the *Study*, as well as all other relevant inputs, the Sava Commission has decided on the navigation class of the future Sava River waterway. Namely, according to Decision 21/09, further activities should be performed in accordance with the parameters for the Class Va on the section from the river mouth (rkm 0) to Brčko (rkm 234), and in accordance with the parameters for the Class IV on the section from Brčko (rkm 234) to Sisak (rkm 586).

Figure A1-12: Towed convoy on the Sava River

4.5. River Information Services (RIS)

RIS is a widely accepted European platform for improvement of safety and efficiency of the inland navigation sector because it is based on modern information and communication technologies.

The legal basis for the development of River Information Services (among several others), strongly promoted by the European Commission is *Directive* 2005/44/EC of the European Parliament and of the Council of September 7, 2005, *on harmonized river information services (RIS) on inland waterways in the Community*, Official Journal L 255, 30/09/2005 P. 0152 – 0159.

The *RIS Directive* applies to all European Inland Waterways of class IV or above connected to the European Inland Waterway Network as well as to all international ports. Every EU member state and all candidate countries should implement this Directive, transpose it into national legislation and subsequently establish RIS according to the approved standards.

The process of RIS implementation has already started in some riparian countries focusing primarily the Danube River and all initiatives taken in these processes should be taken into account when developing the RIS for Sava River.

Taking into account that RIS considerably improves safety and efficiency in inland navigation, it should be established on the Sava River as soon as possible, but most likely after full river rehabilitation (at the moment the fairway has been marked and commercial traffic has reached sufficiently relevant volumes).

Additionally, RIS should be established at the first stage on the whole stretch of the waterway between Sisak (HR) and Belgrade (SR).

There are 4 basic and 2 additional services that should be implemented:

- Fairway Information Service with ENC and Inland ECDIS feature;
- Tracking and Tracing of the vessels by means of AIS network;
- Notices to Skippers (NtS);
- VHF voice direct radio link with shore-ship service messages feature;
- Electronic Ship Reporting (ERI) - additional service;

- Calamity abatement - additional service.

The services should be implemented in a harmonized way based on existing technologies and system solutions developed in Croatia and Serbia for RIS implementation on the Danube River. This systematic approach should be used for both, system and service design.

Institutional framework and administrative capacity

For a successful implementation of RIS it is very important to establish an institutional framework and to appoint the competent authorities for the development and physical construction of the RIS infrastructure, hardware and software. After the construction process is completed, competent authorities should be appointed for the maintenance, administration and operation of the RIS services. The establishment of such institutional framework is under jurisdiction of riparian states; however there is an important role of the Sava Commission too, in order to assure the harmonized development and implementation of a RIS on the Sava River.

Implementation and costs

The implementation of RIS on the Sava River consists of three main category tasks or levels of implementation that can be schematized as an implementation triangle (Figure A1-13). There is one more important issue, which is implementation on commercial level as well, which is obligation of users to use the equipment on board the vessel. However, this task has already been covered under legal and technical group task line.

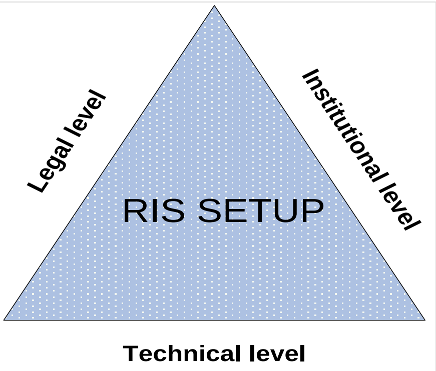


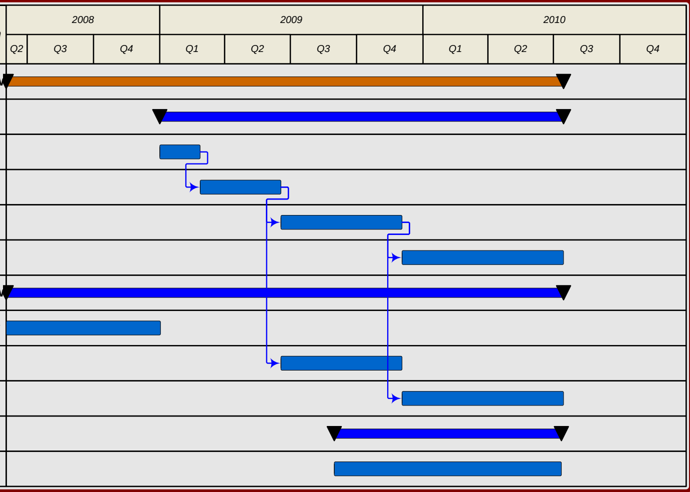
Figure A1-13: RIS implementation triangle

All these category tasks should be incorporated in the *Implementation Plan for River Information Service on the Sava River*. All present activities of the riparian states regarding RIS development on the Danube River and other tributaries, as well as the ongoing RIS implementation activities on the Sava River, should be taken into account in that plan. Activities of the Rhine Commission and the Danube Commission, as well as activities of the European Commission especially in the regulatory segment of implementation should be carefully considered.

The implementation timetable is presented in Table A1-7. It is foreseen that implementation of key services would last for about 2 years.

Table A1-7: RIS implementation timetable

ID	Tasks	Beginning	End	Duration
1	**RIS IMPLEMENTATION**	**2.6.2008**	**14.7.2010**	**110,43w**
2	**TECHNICAL & TECHNOLOGICAL DEVELOPMENT**	**1.1.2009**	**14.7.2010**	**80w**
3	SITE SURVEY AND RANGE TEST	1.1.2009	25.2.2009	8w
4	SYSTEM AND SERVICE DESIGN	26.2.2009	17.6.2009	16w
5	PRODUCTION AND SUPPLY	18.6.2009	2.12.2009	24w
6	TESTING	3.12.2009	14.7.2010	32w
7	**LEGAL FRAMEWORK DEFINITION**	**2.6.2008**	**14.7.2010**	**110,43w**
8	ADOPTION OF RIS STANDARDS	2.6.2008	1.1.2009	30,57w
9	APPOINTMENT OF COMPETENT AUTHORITIES	18.6.2009	2.12.2009	24w
10	SUPPORTING PROGRAMME FOR ONBOARD EQUIPMENT SUPPLY	3.12.2009	14.7.2010	32w
11	**INSTITUTIONAL SETUP**	**31.8.2009**	**11.7.2010**	**45w**
12	RECRUITMENT AND START UP	31.8.2009	11.7.2010	45w



It should be pointed out that each country is competent and responsible for the implementation on their territory of RIS and the progress in the development of RIS varies from country to country.

Table A1-8: Preliminary cost estimates for RIS implementation (EURO)

DEVELOPMENT	HR	SRB	B&H	All
AIS Base station, controller, hardware	200,000	75,000	100,000	
AIS Communication links to RCC	80,000	40,000	40,000	
AIS Integration software	100,000	100,000	100,000	
RCC Hardware (server clients)	40,000	20,000	20,000	
NRCC	10,000	10,000	10,000	
NTS	0	0	5,000	
Total Phase I	430,000	245,000	275,000	950,000
ERI+HDB+Gateway	0	350,000	350,000	
Total Phase I+II	430,000	595,000	625,000	1,650,000
MAINTENANCE (annually)	HR	SRB	BIH	All
AIS Network	96,000	36,000	48,000	
RCC links and software	1,260	630	630	
NCC links and software	0	0	10,000	
ENC update	15,000	15,000	15,000	
NTS update	5,000	5,000	5,000	
ERI update	20,000	20,000	20,000	
Supervision and control	50,000	25,000	25,000	
Total maintenance	187,260	101,630	123,630	412,520

Role of the Sava Commission

The efficient development of RIS on Sava River is in principle the responsibility of each of the riparian countries individually and is limited to their respective territories. Furthermore, non-EU and non-Candidate countries are not under the obligation to implement RIS in accordance to EU rules and regulations (*RIS Directive*). This situation could lead to a fragmented development of RIS on Sava River and to utilization of different and not always compatible technologies.

It is for that reason imperative that a common platform for cooperation between countries and competent authorities is established within the Sava Commission and that the implementation of RIS services on Sava River is coordinated and structured via the Sava Commission.

5. Environmental considerations

In order to take actions toward sustainable water management by taking appropriate measures to, at least, maintain and, where possible, improve the environmental conditions in the Sava River Basin, the Sava Commission has put a special importance on sustainable and environmentally friendly development of navigation on the Sava River.

In this respect rehabilitation and improvement of the Sava River waterway needs to be in agreement with the main objectives of the *Framework Agreement on the Sava River Basin*:

- Restoring navigation on the Sava River and its tributaries;
- Promoting integrated river basin management of water quality and environmental conservation;
- Coordination of risk protection (flood, drought, pollution);
- Supporting sustainable, ecologically and socially responsible economic development.

Furthermore due to the fact that IWT plans and projects have environmental implications, there is the need to carry out environmental assessments before decisions are made. This is required by the *Strategic Environmental* (SEA) *Directive* (2001/42/EC) for qualifying plans, programmes and policies and required by the *Environmental Impact Assessment* (EIA) *Directive* (85/337/EEC) for qualifying projects. Under these procedures, the public can give its opinion and results are taken into account in the authorisation procedure for the projects.

It is also important to emphasize that, to achieve „good ecological status” or „good ecological potential” for all surface waters and to prevent deterioration of the ecological status - as required by the EU WFD – an integrated planning philosophy is needed. Multi-use riverine landscapes should be the goal (including for example providing for fauna and flora habitats, flood protection, inland navigation, fisheries, tourism).

The Sava Commission, together with the ICPDR and Danube Commission, was one of the main driving forces in the process of drafting the *Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin* and, accordinfly, this document has been taken into account from the beginning of the Project. According to the *Joint Statement*, future approach needs balancing between navigation and ecological needs. To enable them to function, both IWT and ecological integrity have certain basic needs. In order to develop mutually acceptable solutions - such needs must first be clearly defined. However, not all needs are fulfilled in all cases. The implementation of a new, integrated planning philosophy would aim to put this right and will help ensure both sustainable development of IWT and the achievement of all required environmental objectives. Further, relevant environmental mitigation or restoration measures, should be proposed to prevent the deterioration of the ecological status and ensure the achievement of the environmental objectives. Both pressures and measures should be identified via a common understanding. This goal should be achieved by an interdisciplinary process. Opportunities to improve both the environmental and navigation conditions through a joint approach to projects need to be identified.

Taking into account all above mentioned principles, the Sava Commission included environmental experts in the development of the *Prefeasibility Study for the Rehabilitation and Improvement of the Sava River Waterway* and *Feasibility Study and Project Documentation for the Rehabilitation and Development of Transport and Navigation on the Sava River Waterway*, which is the very first phase of rehabilitation and development of the Sava River waterway.

The *Prefeasibility Study* has a special chapter on EIA, and in the *Feasibility Study*, a separate report on environmental impact assessment was done for the each phase of the rehabilitation and development of the waterway.

These reports present a pre-phase in the EIA report preparation. This document is a basis for EIA reports preparation (which will folow), it gives a general overview of the intervention location, possible impacts and measures to be conducted. EIA reports and EIA process in accordance with the *EIA Directive* and national regulations will be prepared and conducted during the following phase of project preparation.

In this respect development of the full EIA for the interventions on the part of the Sava River from km 207 to km 586 is in process and will be finished in 2009. B&H and Serbia started with preliminary actions for the EIA development for the stretch from km 0 to km 207 and it is expected to start in the second half of 2009.

In order to present whole project and relevant studies to the stakeholders, the Sava Commission organized several workshops and presentations and all relevant documentation are available on the web. From the very beginig of the project, interdisciplinary team of expert is engaged on the project and the stakeholders informed and included in the planning process. Already in this pre-phase of planning the process is very transparent thanks to the presentations of the project, informing the stakeholder and availability of the informations on the planned actions and the prepared documents to the public (via web). This step already complies with the guidelines mentioned above. All the required ecological and planning guidelines mentioned above will be as well met during the following steps of planning. As the following stages include the EIA process and the preparation of the designs and EIA reports in each involved country, all of the mentioned guidelines are to be taken into account during those phases.

On the other side, taking into account the existing navigation on the Sava River and trying to improve regulation regarding the water protection, the Sava Commission in 2007 developed the *Protocol on prevention of water pollution caused by navigation to the FASRB*, which was signed at the Second Meeting of the Parties to the FASRB, held on June 1, 2009, in Belgrade. This *Protocol* is aimed at prevention, control and reduction of pollution originating from vessels, establishment of technical requirements for the equipment of port facilities, and other reception stations, development of the best available techniques, informing, development of spill response measures and monitoring of water quality. Transboundary cooperation should include actions to prevent pollution from vessels by developing a joint action programme, since water quality monitoring requires a network of national institutions for monitoring and inspection. The *Protocol* underlines the importance of set-up of the institutional framework, establishment of joint body for determination of reasons and facts relating to the accident, and impact to the environment.

At the same time, the Sava Commission is involved in the recently launched project *Waste Management for Inland Navigation on the Danube – WANDA*, which is aimed to develop proposal for the establishment of the harmonized waste management system for the Danube River. Through participation in the project, the Sava Commission will be able to receive the most recent information on this issue, to contribute to the project with its expertise, to provide feedback on a strategic level and make use of the project results for further activities in this regard.

6. Conclusions

Present status of waterway is very poor and waterway infrastructure suffers of aging, lack of maintenance and incompleteness. Such status has negative impact on the safety of navigation and increase possibility for accidents with potential adverse impacts on environment.

Rehabilitation and development of the waterway of the Sava River seems to be a project with clear positive socio-economic effects and the future activities should therefore focus on an efficient completion of the studies and design, and the execution of works on the waterway rehabilitation.

The infrastructure rehabilitation is only a first step in the establishment of a modern river transport sector and in this regard, following the approach of the NAIADES program, the next actions are of particular importance:

- The transposition of all EU rules and regulations for inland waterway transport is realized as quickly as possible with full transparency and following the principles of good governance;
- Further work on the harmonization of the rules and regulations on the European level;

- The necessary strategies are developed for the realization of a public support program for the restoration / creation of a competitive river transport sector, within the limitations of the EU rules and regulations on state aid;
- In time, river transport and Sava River become part of the region's transport systems and attention is paid to the introduction of modern techniques and technologies and to container transport;
- The development of the sector and the modernization of IWT should be strengthened by a sustainable and modern marketing campaign, on the one hand to attract private investments and on the other hand to increase the demand for and use of IWT, and
- The creation of a comprehensive expertise building program will be required and should be developed following a benchmark of existing knowledge levels with best practices.

All the required ecological and planning regulations and guidelines such as EU Directives and *Joint Statement on Guiding Principles for the Development of Inland Navigation and Environmental Protection in the Danube River Basin* shall be as well met during the following steps of project.

Annex II: Flood Management in the Sava River Basin

1. Introduction

As the largest by discharge and the third longest tributary to the Danube, on its way from the spring in Slovenian Alps until its mouth to the Danube River in Belgrade, the Sava River connects the four states. The large complex of preserved alluvial wetlands in the middle of the basin, called Central Posavina makes the Sava River Basin unique for the outstanding biological and landscape diversity, as well as for a good functioning flood retention system.

In the times of the Socialist Federal Republic of Yugoslavia, the efforts have been made to treat the water management in the Sava River Basin in an integrated manner. The *Study on Planning and Regulation of the Sava River* has been developed in the frames of the United Nations Development Programme (UNDP) and performed by the consultants Polytechna-Hydroprojekt (Prague, Czech Republic) and Carlo Lotti and Associati (Rome, Italy) in 1972. In this study, as a part of the water management plan on the Sava River Basin level, flood protection and water use plans, mathematical modeling, as well as proposal of measures with economic indicators have been elaborated. The mentioned study is even at present the most complete document on the water management concerning the whole Sava River Basin.

Nowadays the four countries, signatories to the *Framework Agreement on the Sava River Basin* (FASRB), are promoting a coordinated sustainable flood protection on the Sava River Basin level. The flood risk management and the water quality management are considered as a part of integrated river basin management, basing on the Directive 2007/60/EC (*Directive on the assessment and management of flood risks*, hereinafter the *Flood Directive*) and taking into account the *Action Programme on Sustainable Flood Protection in the Danube River Basin* adopted in 2004. Both documents suggest common approaches to the flood risk management, coordinated planning and action within river basins and sub-basins, while considering the interests of all the partners involved.

1.1. Basic information on prone areas and threats

The Sava River valley, especially its middle part from Zagreb to Županja, and the lower part, downstream of Županja, as well as the lower parts of the Sava tributaries are prone to flooding. The floods occur generally in spring, after the snow melt and in autumn, after the heavy rainfall. The wide floodplanes and the natural lowland areas act as detentions and retentions of flood waves.

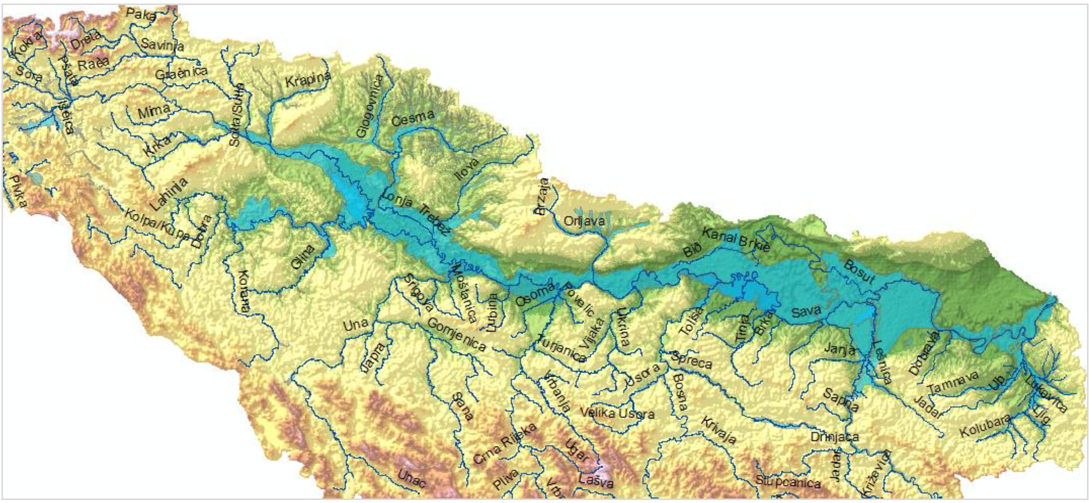


Figure A2-1: Indicative map of important floodprone areas along the Sava River

Table A2-1: List of important flood prone areas of the Sava River

No.	Flood prone area name	River name	Area (km^2)	Protected (Y/N)	Country	Bank Side L/R	Comments
1	Middle Sava Tacen-Šentjakob-Beričevo	Sava River	12.4	Y/N	SI	L/R	Q_{100}
2	Middle Sava Dolsko-Litija	Sava River	13.4	N	SI	L/R	
3	Lower Sava, Krško polje	Sava River	17.3	Y/N	SI	L/R	Q_{100}
4	Lower Sava, Brežiško polje	Sava River	12.4	N	SI	L/R	
5	Lower Sava, Čateško polje	Sava River	3.9	Y/N	SI	L/R	Q_{100}
6	Lower Sava Dobovsko polje	Sava River	11.4	N	SI	L/R	
7	Grad Zagreb	Sava River	57.0	N	HR	L/R	
8	Grad Zagreb	Sava River	82.0	Y	HR	L/R	Q_{1000}
9	Odransko polje	Sava River	289.0	Y	HR	R	Q_{100}
10	Sisačko-Banijsko područje (area)	Sava River	152.0	N	HR	R	Zelenik retention storage
11	Sisačko-Banijsko područje (area)	Sava River	73.0	Y	HR	R	Q_{100}
12	Črnec polje	Sava River	57.0	N	HR	L	Žutica retention storage
	Črnec polje	Sava River	294.0	Y	HR	L	Q_{100}
13	Lonjsko polje	Sava River	390.0	N	HR	L	Retention storages (Lonjsko p., Mokro p., Opeka and Trstik)
	Lonjsko polje	Sava River	366.0	Y	HR	L	Q_{100}
14	Crnac polje	Sava River	177.0	Y	HR	L	Q_{100}
15	Jelaš polje	Sava River	203.0	Y	HR	L	Q_{100}
16	Biđ-Bosutsko polje[14]	Sava River	1,127.0	Y	HR	L	Q_{100}
17	Dubička ravan	Sava – Una River	67.6	Y	BA-RS	R	Q_{100}
18	Lijevče Polje	Sava – Vrbas River	210.05	Y	BA-RS	R	Q_{100}
19	Srbačko-Nožička ravan	Sava – Vrbas River	29.5	Y	BA-RS	R	Q_{100}
20	Ivanjsko Polje	Sava River	149.6	Y	BA (FB&H - RS)	R	Q_{100}

[14] Inclusive the flood prone area of the tributary Bosut River in Croatia.

No.	Flood prone area name	River name	Area (km^2)	Protected (Y/N)	Country	Bank Side L/R	Comments
21	Odžačka Posavina	Sava – Bosna River	87.0	Y	BA-FB&H	R	Q_{100}
22	Srednja Posavina – Orašje	Sava – Tinja River	131.0	Y	BA-FB&H	R	Q_{100}
23	Srednja Posavina	Sava - Tinja River	92.17	Y	BA-RS	R	Q_{100}
24	Semberija	Sava -_Drina River	153.0	Y	BA-RS	R	Q_{100}
25	Gornji Srem[15]	Sava + Eastern Periph. Canal	564.0	Y	RS	L	Q_{100}
26	Sremska Mitrovica	Sava + Eastern Periph. Canal	12.0	Y	RS	L	Q_{100}
27	Hrtkovci-Sremska Mitrovica	Sava River	16.0	N	RS	L	
28	Hrtkovci	Sava River	12.0	Y	RS	L	Q_{100}
29	Klenak-Hrtkovci	Sava River	11.0	N	RS	L	
30	Klenak	Sava River	5.0	Y	RS	L	Q_{100}
31	Kupinovo-Klenak	Sava River	107.0	N	RS	L	
32	Kupinovo II	Sava River	13.0	N	RS	L	Ongoing construction - new levee not finished
33	Kupinovo I	Sava River	6.0	Y	RS	L	Q_{100}
34	Donji Srem	Nova Galovica + Sava River	121.0	Y	RS	L	Q_{100}
35	Novi Beograd	Danube River + Sava River + Nova Galovica	24.0	Y	RS	L	Q_{100}
36	Mačva	Sava + Drina	437.0	Y	RS	R	Q_{100}
37	Orasac	Sava + Dobrava	3.0	Y	RS	R	Q_{100}
38	Mrdjenovac-Ladjenik	Sava + Dobrava	17.0	Y	RS	R	Q_{100}
39	Provo-Orlača	Sava River	16.0	Y	RS	R	Q_{100}
40	Obrenovac	Sava + Kolubara + Periphery Gravity Canal	96.0	Y	RS	R	Q_{100}
41	Mislodjin Barič	Sava + Kolubara + Barička Reka	5.0	Y	RS	R	Q_{100}
42	Mali Makiš	Sava River	3.0	Y	RS	R	Q_{100}
43	Veliki Makiš-Ada Ciganlija	Sava River + Ostružnička r.	31.0	Y	RS	R	Q_{100}

[15] Inclusive the flood prone area of the tributary Bosut River in Serbia.

No.	Flood prone area name	River name	Area (km^2)	Protected (Y/N)	Country	Bank Side L/R	Comments
		+ Železnička r. + Topčider. r.					
44	Beograd	Sava River + Topčiderska r.	2.0	Y	RS	R	Q_{100}

Table A2-2: List of important flood prone areas of the transboundary tributaries to the Sava River

No.	Flood prone area name	River name	Area (km^2)	Protected (Y/ N)	Country	Comment
Left side transboundary tributaries						
1	Middle Sotla	Sotla River	8.4	N	SI	
2	Sutla River Basin	Sutla River	7.3	N	HR	
3	Bosut River Basin	Bosut River		Y	HR, RS	Q_{100}
Right side transboundary tributaries						
4	Kupa RB (without Glina R.) in Croatia	Kupa, Odra R., canal Kupa-Kupa River	143.4	Y	HR	Q_{25}-Q_{50}
	Kupa River Basin	Kupa River Basin	462.3	N	HR	
5	Glina RB in Croatia	Glina River	52.6	N	HR	
6	Una River Basin in Croatia	Una River	22.2	Y	HR	Q_{100}
7	Korana R. in FBA and lower course of Mutnica River	Korana River	2.95	N	BA-FBA	
8	Glina R. in FBA and lower courses of Glinica River Kladušnice	Glina River	2.55 1.57	N	BA-FBA	
9	Kulen Vakuf town region	Una River	2.41	N	BA-FBA	
10	Bihać region (from Ripač to Pokoj)	Una River	13.67	N	BA-FBA	
11	Bosanska Krupa region	Una River	2.40	N	BA-FBA	
12	Bosanski Otok region	Una River	1.43	N	BA-FBA	
13	Goražde town region and Vitkovići	Drina River	3.04	Y/N	BA-FBA	Q100

1.2. Historical flood events on the Sava River

During the last century, several large floods occurred on the Sava River, the largest covering the whole region from Zagreb to Belgrade in 1933, 1937, 1940, 1947 and 1974. The Upper Sava Region (Slovenia) suffered on floods in the last decades in 1990, 1998, 2005 and recently in 2007, when besides enormous economic damage, six human lives were lost. In the Middle Sava region, the most severe floods occurred in 1923, 1925, 1926, 1964, 1966, 1970, 1990 and 1998, while in 1915, 1924, 1932, 1940, 1944, 1952, 1962, 1970, 1981, and 2006 in the Lower Sava region. The large flood that hit Zagreb in 1964, resulted in loss of 17 human lives, loss of homes for tens of thousands of people and huge damages.

Some more information on historic floods on the Sava River and its tributaries in the whole Sava River Basin can be seen in the national reports, in the Appendices I, II and III.

2. Existing Flood Management

2.1. Commanding responsibilities

2.1.1. Institutional arrangements in Bosnia and Herzegovina

In Bosnia and Herzegovina the water management lies under the entity-level competence.

2.1.1.1. Republika Srpska

The main legal instrument which determines the protection against harmful water affects is the *Water Law of Republika Srpska*. This law is in compliance with *Water Law of FBA* and EU WFD as well as with EU *Flood Directive (Official Gazette of RS, No. 55/06).*

Institutions responsible for the law implementation:

- Ministry of agriculture, forestry and water management, Banja Luka
- Republic Directorate for waters (as of February 13, 2009, the Agency for waters for Sava River Basin district), Bijeljina
- Republic administration of civil protection, Banja Luka.

The implementation of *Water law* and flood protection is enforced also by public utilities for Sava (Gradiška), Sava (Brod), Posavina (Vukosavje), Ušće Bosne (Šamac), Srednja Posavina (Lončari), Semberija (Bijeljina), Drina (Zvornik) and Gornja Bosna (Foča).

Furthermore, by the *Law on civil protection*, measures and activities of the Civil protection Center on prevention and protection of human and capital assets in case of flooding is determined.

Civil protection is managed by the Republic administration of civil protection, directly supervised by the Government, i.e. Parliament of the RS-B&H. Implementation is done through regional departments in Banja Luka, Doboj, Bijeljina and Sokolac.

Relevant Ministry of agriculture, forestry and water management determines authorities in charge for flood protection and their responsibilities. Ministry and the RS-B&H Government cover also the expenses of the flood protection costs.

Republic Institutes for hydrometeorology are in charge for: supervision, measuring, collecting and analyzing hydro meteorological data as well as for weather forecasting.

2.1.1.2. Federation Bosnia and Herzegovina

Water law of Federation B&H defines protection against harmful water effects. This law is completely harmonized with EU WFD and compliant to the RS-B&H water law. In order to regulate the flood protection plans, flood protection activities and competences in accordance with the EU law, the existing *Decree on flood protection plans (Official Gazette of FB&H, Nr. 3/02)* is going to be substituted by a new Decree, which fulfills the EU requirements and is in the process of adoption.

Moreover, *Decree on people and capital assets protection measures organization, content and implementation*, enacted by FB&H Government *(Official Gazette of FB&H 27/08)* envisages organization, preparation activities, as well as protection measures against danger and consequences of natural disasters, including floods.

Civil protection for Sava River Basin area is in FB&H divided on two flooded areas, namely Odžačka and Srednja Posavina. Inclusion of municipal civil protection headquarters in flood protection activities ensures prompt response.

Institutional set-up for implementation of the above described legal framework is the following:

- Federal Ministry of Agriculture, Water Management and Forestry, Sarajevo;
- Agency for Sava River catchment, Sarajevo;
- Federal civil protection headquarters, Sarajevo.

In addition, specialized organizations designated by the Main flood protection operational measures plan, are in charge for flood protection on individual flood prone areas.

Main plan of flood protection operational measures in FB&H also defines municipal civil protection headquarters, responsible for implementation of civil protection activities on the two flood prone areas. These are civil protection headquarters in municipalities of Odžak, Domaljevac - Bosanski Šamac, Orašje and Gradačac.

Flood protection institutions' competences and responsibilities are prescribed by Federal Ministry of Agriculture, Water Management and Forestry (FMAWMF) through the *Decree on flood protection plans*. The Agency and FMAWMF cover the implementation costs.

Federal Meteorological Institute also plays an important role in the flood protection as it is obligated to update regularly data on precipitations, river water levels, the snow cover status and weather forecast. Relevant data are submitted to the Water Agencies competent for flood protection of the individual areas.

More information can be seen in the national report, in Appendix 1.

2.1.1.3. Brčko district

Protection against harmful effects of water in the Brčko district is based on the *Water Law of Republika Srpska (Official Gazette of RS, No. 10/98).*

As institution responsible for the law implementation, the Department of Agriculture, Forestry and Water Management of the Government of Brčko District B&H entitles the registered and qualified companies to be engaged in flood protection in the areas where the flood protection structures egsist, according to the law of the Brčko district.

Civil protection is managed by the Headquaters of civil protection of Brčko district B&H, appointed by the mayor. The Headquaters of civil protection guides the civil protection, company employees and members of other organisations in case of flood defense.

2.1.2. Institutional arrangements in Croatia

Legal framework regulating flood protection in the Republic of Croatia consists of the *Water Act* and the *Water Management Financing Act.* Ministry of Regional Development, Forestry and Water Management, as a state administration body and Hrvatske vode, as a state agency are the competent bodies for the flood protection issues.

Water Management Strategy is the main water management document. The *Water Management Strategy* is adopted by the Croatian Parliament *(Official Gazette, No. 91/08*) with the aim to establish an integrated and coordinated water regime on the whole national territory. This regime encompasses the provision of sufficient and adequate water for economic purposes, protection of people and assets against floods and other adverse effects of water and of aquatic on water dependent ecosystems:

Croatian *Water Management Strategy* is fully compliant with the UN/ECE *Guidelines on Sustainable Flood Prevention*, the principles of EFD and the *Action Programme for Sustainable Flood Protection in the Danube River Basin*.

The *State Flood Defence Plan*, adopted by the Croatian Government, defines operative flood defence on state water. Operative flood defence on local waters is carried out on the basis of the flood defence plans for catchment areas, which are adopted by county assemblies according to the proposals made by Hrvatske vode.

Based on these plans, operative flood defence on state waters is established in river basin districts, while on local waters, the operative flood defence is established in catchment areas.

In the Sava River Basin, Hrvatske vode as a state agency, undertakes operative flood defence through its Head Office: the Department of Protection against Adverse Effects of Water and through Service for protection against adverse effects of water, within the Water Management Department for the Sava River Basin District (Sava WMD). Twelve (12) water management branch offices (WMBO) of the Croatian Waters in the catchment areas also take part. Legal entities approved by the Ministry and registered by the court are used for the interventions during operative flood defence. This entities provide their own machinery, equipment and skilled labour, while Hrvatske vode provide of materials and basic tools.

State Hydro-meteorological Service is responsible for monitoring, measuring, collecting and analyzing of meteorological data. Systematic monitoring and forecasting of water levels and flows in the Sava River Basin is conducted by Hrvatske vode, providing efficient implementation of flood defence measures.

More information can be seen in the national report, in Appendix 2.

2.1.3. Institutional arrangements in Serbia

Proceedings and measures for flood and ice protection are in Serbia envisaged by the *Water Law (Official Gazette of the Republic of Serbia 46/91).*

Flood defence is carried out by:

- Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Republic Directorate for Water;
- Public Water Management Companies:
  - „Srbijavode" – Belgrade (in charge for flood protection along the right bank of the Sava River, and the Drina and the Kolubara River Basins),
  - „Vode Vojvodine" – Novi Sad (in charge for flood protection along the left bank of the Sava River and the Bosut River), and
  - „Beograd vode" for the territory of the Belgrade city,
- Local water management companies, and
- State Hydro-meteorological Service (HMS).

Responsibilities are defined in the *General Flood Defence Plan* and the *Flood Defence Action Plan*, while the Ministry provides for the financial sources.

Public Water Management Companies (PWMC) are important actor in overall flood protection activities. They cover the provision of relevant assessments and studies, construction and maintenance of protection structures, technical documentation related to flood defence, staff, equipment and warning system. PWMC ensure local participation and control during the period of flood defence.

State Hydro-meteorological Service is responsible for monitoring, measuring, collecting and analyzing hydrologic and meteorological data, as well as for providing relevant forecasts and information from domestic and foreign territories to all the flood defence participants. Ministry of Agriculture, Forestry and

Water Management compiles *Flood Defence Action Plan* for one-year period. *Flood Defence Action Plan* determines the flood control organization, managers, and criteria for regular and emergency flood defence.

More information can be seen in the national report, in Appendix 3.

2.1.4. Institutional arrangements in Slovenia

Flood risk management is in Slovenia defined by:

- The *Water Act* (adopted in 2002, amended in 2008)
  - Rules on methodology to define flood risk areas and erosion areas connected to floods and classification of plots into risk classes (adopted in 2007),
  - Decree on conditions and limitations for constructions and activities on flood risk areas (adopted in 2008),
  - Decree on the detailed content and method of drawing up a water management plan (adopted in 2006),
- The *Natural and Other Disasters Protection Act* (adopted in 2006),
  - Decree on the contents and drawing up of protection and rescue plans (adopted in 2006),
  - Protection and rescue plan in case of floods (adopted in 2004).

The transposition of the EU *Flood Directive* will be completed in 2009, with the adoption of *Regulation on detailed content and mode of preparation of the Flood Risk Management Plan* (FRMP).

The institutions responsible for flood risk management/defence are:

- Ministry of the environment and spatial planning, Environment directorate, Department of waters with its Environmental Agency;
- Ministry of Defence, Administration of the Republic of Slovenia for Civil Protection and Disaster Relief and Inspectorate for Protection Against Natural and Other Disasters.

National FRM work programme for 2009-2015 will contribute to more operational coordinated tasks in the process of the EU *Flood Directive* implementation.

2.2. Design/construction criteria, system and state of the flood protection structures

The flood protection system in the Middle and Lower Sava Basin relies mostly on the natural retention areas and the flood protection levees. Generally, the main levees are designed for the 100-year return period floods, with freeboard of 0.5 - 1.2 m, while in urban settlements for the 1000-year flood. The Sava River flood protection system is significant for the rarely preserved large natural retentions (Lonjsko polje, Mokro polje, Kupčina, Zelenik and Jantak) which have, together with the system of relief canals, a large positive impact on the flood regime as in Croatia, so in the downstream countries. The nature park and Ramsar site Lonjsko Polje, covering some 500 km^2 presents a great ecological value. Obedska bara is one of the biggest wild bird nature reserves.

However, the situation is specific. In the recent decades, due to the political disputes and war, the water management has been neglected during some intervals in several parts of the Sava River Basin. The hydraulic structures have not been maintained, some have been damaged and monitoring processes have been interrupted. Many reconstruction works are still to be done.

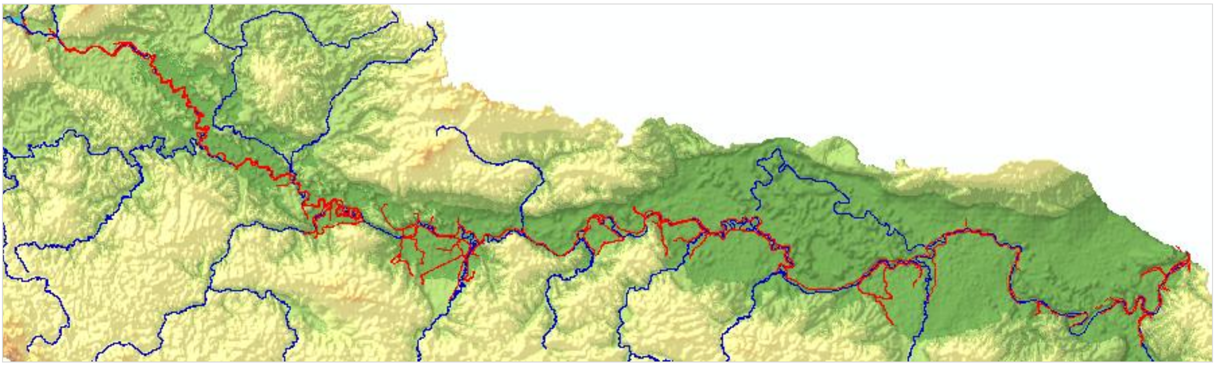


Figure A2-2: Levee system along the Sava River

2.2.1. Bosnia and Herzegovina

In Bosnia and Herzegovina, on the right bank of the Sava River, the flood zones are divided into seven polders, so called „kazete": Dubička ravan, Lijevče polje, Srbačko-Nožička ravan, Ivanjsko polje, Odžačka Posavina, Srednja Posavina and Semberija. The polders are independently protected against floods by levees. The sections without protection are still inundation zones with a limited retention function. 23 pump stations and the system of canals (main boundary canals for external waters and the network of the main canal for collecting inland waters) support the drainage and the flood protection. Una, Vrbas and Bosna River are all protected until the area where the Sava backwater reaches. Many settlements on the tributaries are not protected. Drina River has, according to the steeper river basin smaller prone areas. The construction of the Mratinje reservoir on the Piva River had a positive impact of decreasing the flood risk of the settlements in vicinity.

More information can be seen in the national report, in Appendix 1.

2.2.2. Croatia

In Croatia, the flood protection system in the Central Posavina relies on five large lowland retention areas: Lonjsko Polje, Mokro polje, Kupčina, Zelenik and Jantak, two basic water distribution facilities, Prevlaka and Trebež1 sluices and the three relief canals (Odra, Lonja-Strug and Kupa-Kupa). This flood defence system has not yet been finished. The construction works have been executed just in 40 % of the value of the planned investment, however a large positive impact on the flood regime has been achieved as in Croatia, so in the downstream countries. Generally, the flood protection works helped to reduce the areas potentially flooded by 100-year high water of the Sava River and its tributaries by 65 %. However, the Sava section upstream of Zagreb to the Slovenian border is still unprotected.

More information can be seen in the national report, in Appendix 2.

2.2.3. Serbia

In Serbia, the levee reconstruction to so called „Sava levee profile" started in 1980-ies. The reconstructed levees within the backwater zone of the „Iron Gate 1" HPP are being completed with a ballast on the protected side. However, reconstruction of the flood defence lines along the Sava River and its tributaries in the mouth sections has not been completed so far. A dense network of channels discharges drainage water into the Sava River by gravity or pumping.

The left-bank levees of the Sava River protect the lowland area of Srem. The defence line is not continuous. The downstream sector of the lower Srem and Belgrade area and the upstream sector reaching the Croatian border are mostly protected, while 80 km long middle sector, where the nature reserve Obedska bara is located, is prone to floods.

On the right Sava bank, the lowest and the upper sector are protected by levees, while on 40 km long middle part only local flood protection structures were built. The quay walls and levees in central Belgrade area do not satisfy the required safety level. In the upper part (the Mačva region) levees need to be reconstructed or upgraded to the required safety level and many sluices and pumping stations have to be restored.

Flood defence structures along the Drina River and its tributaries were constructed mainly for protection of larger settlements and significant industrial facilities. Protection of agricultural land is present only at the most downstream section of the Drina River (the Mačva region), and on some tributaries. Dams and reservoirs at Drina, Lim and Uvac River are also part of the flood protection system.

Flood protection structures along the Kolubara River were constructed for protection of settlements, industrial facilities and agricultural land. Different types of flood protection structures were used, depending on land use in the protected area and location of structures.

The Bosut River discharges into the Sava River through the Bosut sluice, located on the left Sava levee. During high waters of the Sava River the sluice is closed, and water is being pumped by the „Bosut" pumping station. Both structures need major overhaul.

More information can be seen in the national report, in Appendix 3.

2.2.4. Slovenia

In Slovenia, the important impact on current flood protection level can be caused by:

- too few reliable data about impact of climate changes on flows,
- large pressure to land use change,
- lack of non-structural measures.

In the present time there are ongoing State spatial plans for reduction of the flood risk:

- in the Ljubljanica River Basin, on tributary Gradaščica (Mali graben), reducing the flood risk on southwest of Ljubljana,
- in the Savinja River Basin, reducing the flood risk in Celje and some smaller settlements near Savinja River and tributary Bolska River,
- in the Savinja River Basin, reducing the flood risk in smaller settlements near Savinja River on section Ločica – Letuš,
- in the Sora River Basin, reducing the flood risk in Železniki.

Almost all proposal solutions include the preservation of natural retention areas and construction of new detention reservoirs on areas where the flood hazard already exists, combined with regulation of the river course or/and dikes. In spatial planning procedures, important principle lies in preservation of the existing flood hazard areas.

Construction of hydropower stations on lower section of the Sava River involved maintenance, restoration, improvement and construction of new structural flood defences (dikes, detention reservoirs) for flood protection of existing settlements.

The most important non-structural instrument is defined by the *Decree on conditions and limitations for constructions and activities on flood risk areas* and can be considered as the most important preventive measure in line with flood risk management plan. The goal of this decree is to prevent and limit the land use which is generating new flood risk potentials.

2.3. Long term flood protection strategies

The common long term flood protection strategy in the Sava River Basin has clear goals, like development of the *Flood Risk Management Plan* in order to minimize the risk from flooding. On one hand, for efficient flood protection various structural and nonstructural measures have to be provided. On the other hand, the process of growing of structures and valuable objects in the vicinity of water courses is evident and difficult to manage. Thus, the exposure to risk and vulnerability in flood prone areas is growing constantly.

2.3.1. Bosnia and Herzegovina

In Bosnia and Herzegovina, the flood protection problems are quite complex; large flood prone areas, partially still damaged constructions and flood protection systems, relatively small financial resources for prevention, investments and post flood activities. Through the *Study of present flood protection level estimation for Federation B&H*, an optimal strategy has been determined for selection of optimal flood protection development for the territory of the entire FB&H. The Study includes also the selection of location for priority investment intervention and identification of optimal technical parameters for structures and flood protection systems that should be constructed in the next period.

Planning of spatial use in river valleys as flood prone areas, protection of natural retentions on Sava River are priority for all the countries.

2.3.2. Croatia

In Croatia, through the *Water Management Strategy*, the targets for effective flood protection are determined. As priority of the first order for the flood protection, the larger towns, potentially at risk from the Sava and Kupa River, are set, then other settlements along the Sava, Kupa and Una River. As next goal, reconstruction of dykes and further construction of the Central Posavina flood protection system are foreseen.

Moreover, performing of operative flood defence, together with competent services from the neighboring countries, presents an important goal.

2.3.3. Serbia

In Serbia, the long term flood protection strategy is defined in the *Water Management Master Plan of the Republic of Serbia*, with a goal of maintenance of existing flood protection structures, and reconstruction or/and construction of the flood protection structures. The priority projects are the protection of Belgrade (left and right bank key walls should be reconstructed) and Mačva region (reconstruction of right Sava and Drina levees). Further actions will depend on set priorities for flood protection (first priority are areas with 20,000 inhabitants, large and significant industrial and other facilities, etc.).

More information can be seen in the national reports, in the Appendices 1, 2 and 3.

2.3.4. Slovenia

By the *Water Act* (adopted in 2002, amended in 2008), Slovenia put legal frame for overall water management within the river basin districts, which includes protection of water, water use and water regulation, as well as protection against the adverse effects of water.

The legislative implementation of the EU *Flood Directive* has in Slovenia been done through the *Water Act* and *Rules on methodology to define flood risk areas and erosion areas connected to floods, as well as classification of floods into the risk classes*. Further implementation will be done through the national *Flood Risk Management* (FRM) *work programme for 2009-2015*.

The goal in FRM (Framework Programme) is to limit the constructions and the activities in flood hazard areas and to reduce the existing flood risk. The *Decree on conditions and limitations for constructions and activities on flood risk areas* (adopted in 2008), can be considered as a part of FRM Plan. The conditions and limitations for construction and activities on flood hazard areas are based on expert studies, based on uniform methodology with *Rules on methodology to define flood risk areas and erosion* *areas connected to floods, and classification of floods into the risk classes* (adopted in 2007). The major impact of this decree is on spatial planning, by defining the restrictions that must be accepted in the planning process.

The conditions and limitations stated in the *Water Act*, namely that worsening of the high water regime by the human activities is not allowed, force the planers to reserve the additional areas for flood retention, or to undertake other measures in order to reach the conditions determined by the Water act and to reduce existing flood risk.

The process of involvement the insurance company's policy in the flood risk management is in progress.

Furthermore, the „user pays principle" and the public-private partnership should be considered more in financing of the flood protection infrastructure.

2.4. National Flood Prediction and Warning Practices

Adequate hydrologic information, flood prediction and warning system is needed for an integrated water resources management and flood risk management in the Sava River Basin. Furthermore, a strong cooperation in sharing data and information among the riparian states present the key factors.

2.4.1. National Flood Prediction and Warning Practices in Bosnia and Herzegovina

Law on Ministries and *Water Law* define the role of the entity Hydro-meteorological Institutes (HMS) in Bosnia and Herzegovina. Two departments of HMS, the Hydrology Department and the Meteorology Department, are included in flood forecasting and monitoring.

The HMS Forecast Office collects hydrological and meteorological data and distributes information to the Ministry of Agriculture, Forestry and Water Management, Public Water Companies and to the Entity information centre.

At the moment, the data available on the territory of B&H are inadequate for or an effective warning and forecast system, as only daily and short-term meteorological forecasts are available. Information network for early warning system with 99 automatic real-time stations for water level measuring is under construction and expected by the end of 2009.

The HMS issues warning and forecasting information which include daily information on rainfall, air and water temperature, water level, water flow and ice, daily information on water levels and water flows, together with relevant warning about the development of flood on the upper river parts and forecast on extreme water levels.

2.4.2. National Flood Prediction and Warning Practices in Croatia

"Hrvatske vode" has established a system of on-line monitoring stations to ensure a more efficient operative flood defence. There are, 62 automatic stations in Croatia located in the Sava River Basin. The collected information on real-time monitored water levels is published at the website http://www.voda.hr and on the teletext of Croatian Television (HTV).

Systematic forecasting of water levels and flows in the Sava River Basin is conducted at the majority of water gauge profiles in the Sava and Kupa River, which are relevant for the implementation of flood defence measures under the *National Flood Defence Plan*.

"Hrvatske vode" is also building a comprehensive hydrologic data collection and dissemination system for internal use while the improvement of the existing flood forecasting models and integration of the on line meteorological data is expected for the future. National Protection and Rescue Directorate and public will also have access to collected data after the test phase.

More information can be seen in the national report, in Appendix 2.

2.4.3. National Flood Prediction and Warning Practices in Serbia

The role of the State Hydro-meteorological Service of Serbia (HMS) in flood defence is defined by a number of laws (*Law on Ministries*, *Water Law*, *Law on Protection Against Natural and Other Major Disasters*), and by-laws (*General Flood Defence Plan* and *Flood Defence Action Plan*). Two departments, namely the Hydrology Department and the Meteorology Department of the HMS Serbia participate in flood forecasting and monitoring.

The HMS Forecast Office collects and distributes hydrological and meteorological data and transmits hydrological warnings to the Ministry of Agriculture, Forestry and Water Management of Serbia – the Republic Directorate for Water, the Public Water Companies and to the State centre for observation and information, which distributes this information to the endangered communities. Hydrological data are collected from 13 stations in the Sava River Basin and reported in real time, via radio, telephone and automatically via GSM. Meteorological data are collected from 61 stations.

Currently, the data available on the territory of Serbia do not provide a sufficient basis for the delivery of warnings and forecasts. Main reason stems from the fact that floods on major rivers, such as Sava and Drina River originate beyond Serbian borders. Therefore, information from upstream countries is indispensable. Data from neighboring countries (8 stations in Croatia) are collected via GTS (Global Telecommunications System) and by e-mail, and for 5 stations in the Republika Srpska by phone.

Various methods, ranging from the simplest graphical correlations to the most sophisticated models describing the physical processes that take place within the river basin and the river network are used for hydrological forecasting. For all of these methods and models, it is important to have the access to accurate data. For the time being, only nowcasts and short-term meteorological forecasts can be used successfully.

Hydrological data are collected daily by the HMS from 5 hydrologic stations within the territory of Serbia and 10 external hydrologic stations. Water level and/or discharge forecasts are prepared daily and exchanged internationally, The Forecast Office of the HMS issues warning and forecasting information, which encompass, among others:

- daily information on rainfall, air and water temperature, water level, water flow and ice,
- daily water level forecasts for 1 or 2 days in advance;
- warning about the development of flood on the upper river parts;
- forecast on extreme water level (forecast of ice phenomena) for next 7 days and approximate forecasts for next 30 days.

In addition, plans have been prepared to improve warning and forecasting procedures and to incorporate more extensively radar surveillance for those rivers on which flood waves rise within $T_p \leq 10$ hours.

2.4.4. National Flood Prediction and Warning Practices in Slovenia

Environmental Agency of the Republic of Slovenia, Hydrology Forecasting Department is responsible for forecasting hydrological events on the national level and launching flood warnings to the Notification Centre of the Republic of Slovenia. Since 2005 the operative practices in national forecasting department improved with forecasting tools based on international cooperation. In the time period from 2005 to 2007, the national hydrological forecasting service became a full member of EFAS (European Flood Alert System) and MAP D-Phase (Mesoscale Alpine Programme), covering forecasts up to 10 days ahead.

Hydrological observing network in the in Slovenia consists of 196 hydrological stations, among them 18 automatic stations in the Sava RB. The daily data on water levels and discharges and hourly data on recording gauges are available in the database of Environmental Agency of the Republic of Slovenia.

Hydrological Forecasting Division is responsible for the real-time data acquisition, data management, processing and hydrological forecasting and warning. Excellent cooperation between the Weather and Hydrological forecasting staff within the Environmental Agency has proven to be extremely beneficial in preparing and issuing hydrological forecasts and flood/drought warnings.

2.5. Cooperation and common efforts in the Sava River Basin

The Parties to the FASRB (Bosnia and Herzegovina, Croatia, Serbia and Slovenia) are promoting a common approach to the flood risk management, coordinated planning and action within the Sava River Basin and consideration of all the Parties involved.

2.5.1. Activities under the lead of the Sava Commission

Since the start of work of the International Sava River Basin Commission in 2006, the sustainable flood protection in the Sava River Basin is coordinated by the Permanent Expert Group for Flood Protection (PEG FP) on the basin-wide level. The most important document prepared by the PEG FP is the proposed *Protocol on Flood Protection to the FASRB*, which should serve as the ground document for all the common activities in the Sava River Basin. By adoption of this Protocol, the riparian countries agree, while taking into account the FASRB, the EU *Flood Directive* and the *Action Programme for Sustainable Flood Protection in the Danube River Basin*, on cooperation in:

- Preparation of the *Program for Development of the Flood Risk Management Plan in the Sava River Basin*,
- Undertaking of the Preliminary Flood Risk Assessment,
- Preparation of the Flood Hazard and Flood Risk Maps,
- Development of the *Flood Risk Management Plan in the Sava River Basin*,
- Establishment of the Flood Forecasting, Warning and Alarm System in the Sava River Basin,
- Exchange of information significant for sustainable flood protection.

The *Protocol on Flood Protection to the FASRB* has been distributed to the Parties. Adoption and ratification of the Protocol are expected in due course. In the frame of the program quoted under the item (a), the Permanent Expert Group for Flood Protection is designating a detailed *Road map for the preparation of the Flood Risk Management Plan in the Sava River Basin*.

In the whole process of undertaking of Preliminary Flood Risk Assessment, preparation of the Flood Hazard and Flood Risk Maps, the Sava Commission will be a coordinating body for the data exchange between the countries.

As the first step towards the future flood risk analyses in the Sava River Basin, an assessment of the hydrological analyses on the Sava River and tributaries to date, the *Hydrology Report for the Sava River Basin*, has been prepared. According to the fact, that the last common hydrology study in the Sava River Basin has been made some thirty-five years ago, a programme for a new detailed *Hydrological Study* on the basin-wide level has been elaborated. The initiative for a common hydrology study has been fully supported by the newly constituted *Ad hoc* Hydrometeorological Expert Group (*Ah* HM EG), as well as by the PEG FP. According to the programme, the new study should comprise collection and analyses of data at meteorological and hydrological gauging stations at the asin-wide level, evaluate flood characteristics and drought properties in meteorological and hydrological aspects, flow forecasting and climate change.

The second project on the priority list of the PEG FP is the joint *Flood Mapping Study for the Sava River*, basing on the information on existing analyses and data availability collected through the ISRBC.

Common activities related to the establishment of the Flood Forecasting, Warning and Alarm System in the Sava River Basin, are described in the next chapter.

2.5.1.1. The Hydrometeorological Information and Flood Forecasting/Warning System in the Sava River Basin (HMIFFWS)

Development of a Hydrometeorological Information and Flood Forecasting/Warning System (HMIFFWS) *for the Sava River Basin*, as a basis for the integrated water resources management and sustainable navigation presents one of the goals of the ISRBC. As stipulated in the FASRB (2002), the Parties to the FASRB shall „establish a coordinated or joint system of measures, activities, warnings and alarms in the Sava River Basin for extraordinary impacts on the water regime". Furthermore, in the *Strategy on Implementation of the FASRB* (2008), (item 2.6), development of joint or integrated flood forecasting and warning system in the Sava River Basin is foreseen, based on the assessment of the existing national systems. The leading body in this process is PEG FP of the Sava Commission, supported by the *Ah* HM EG, in close cooperation with the National Hydrometeorological Services (NHMSs) of the Sava countries.

The initiative for the establishment of a joint or integrated HMIFFWS on the Sava River in a transboundary context came in 2003, by a meeting of the hydrological experts from the Sava RB in Geneva. The NHMS representatives from the Sava countries, signatories to the FASRB, supported the idea of a common hydrometeorological project in the Sava RB, the NHMS from Montenegro and Albania also joined the initiative. ISRBC overtook the role of the coordinating body in the process. In 2005, the *Skeleton of the Sava Project Proposal for Development and Upgrading of Hydrometeorological Information and Forecasting System for the Sava River Basin* has been prepared. The WMO and the World Bank supported the initiative.

Finally, in 2007, a new project proposal for *Development and Upgrading of the Hydrometeorological Information and Flood Forecasting/Warning System in the Sava River Basin* (HMIFFWS), the so called *Sava Project*, has been prepared by M. Anđelić and J. Roškar. The project aims at building on and reinforcing further the existing NMHSs of the Sava riparian states in the area of assessment of status of the resource, river flow simulation, forecasting and flood warning in the Sava RB. Furthermore, the hydrological and meteorological real-time observing networks and database management should be supported, and a state of the art hydrological forecasting system for the Sava River Basin should be developed. The ultimate goal is to reinforce the Sava RB countries' capability to manage the common Sava River Basin water resources and to reduce the disaster risks caused by floods and droughts in the region. ISRBC is expected to play a significant role in the project implementation, while the WMO is proposed to be the executing agency of the project.

The implementation of the *Sava Project* is going to be divided into several phases, in order not to be too large and too expensive if implemented in its original form.

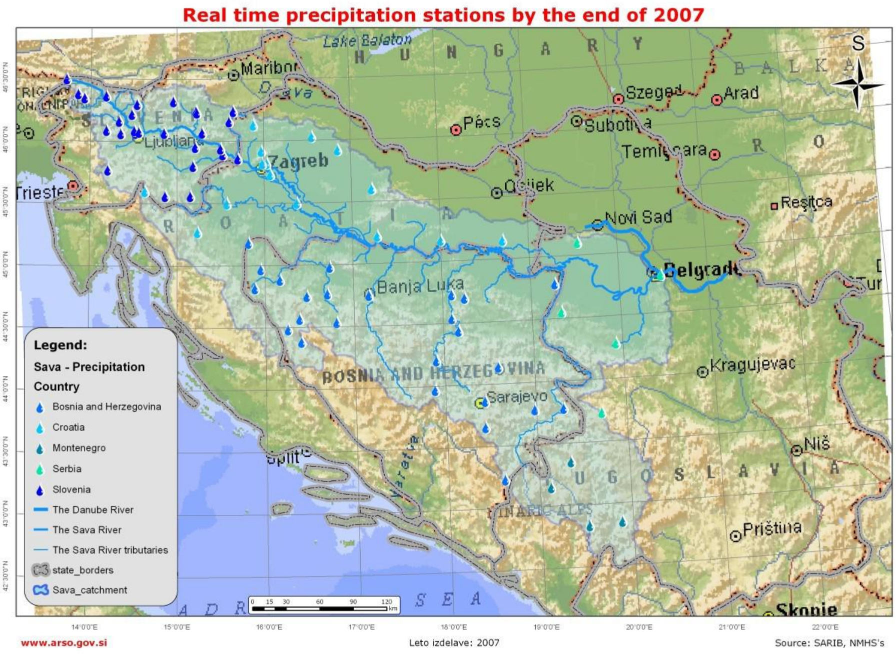


Figure A2-3: Precipitation stations in the Sava River Basin by the end of 2007 (source SARIB, NHMSs)

Figure A2-4: Hydrological stations in the Sava River Basin by the end of 2007 (source SARIB, NHMSs)

Accordingly, the first phase of the new *Sava-HYCOS*[16] project, a part of the South East Europe Disaster Management Initiative (SEEDRMI) should concentrate on the reinforcement of the observation and telecommunication network, strengthening the forecasting capabilities of the NHMSs and development of a hydrological forecasting system for the Sava River. In this sense, a set of new observing stations in the Sava RB will be suggested.

[16] Hydrological Cycle Observing System.

2.6. Recommendations on further regional cooperation in flood management

Bosnia and Herzegovina, Croatia, Slovenia and Serbia are going to cooperate in planning and implementation of measures, works and activities in flood management on the Sava River and its tributaries on principles set up in the EU *Flood Directive*, taking into account the *Action Program for Sustainable Flood Protection in the Danube River Basin*, as well as the existing good practices in cooperation in the Sava River Basin, in accordance with the „no harm" principle. The measures foreseen in the *Flood Risk Management Plan* for any Party should not increase the flood risk on the territory of the other Party. The cooperation will be based on a joint or harmonized Flood Forecasting, Warning and Alarm System and information exchange. Measures for flood defence emergency situations, for establishment of preparedness and measures for mitigation of transboundary impacts are foreseen. Interested public should be actively involved in the process of the development of the *Flood Risk Management Plan* and its up-date.

Appendices

Appendix I: Flood Management in Bosnia and Herzegovina

BRIEF CHARACTERIZATION, REVIEW AND ASSESSMENT IN FLOOD MANAGEMENT IN SAVA COUNTRIES

- Sava River Basin in Bosnia and Herzegovina -

REPUBLIKA SRPSKA

MINISTRY OF AGRICULTURE, FORESTRY AND WATER MANAGEMENT

BANJA LUKA

AGENCY FOR WATERS OF SAVA RIVER BASIN DISTRICT

BIJELJINA

FEDERAL MINISTRY OF AGRICULTURE, WATER MANAGEMENT AND FORESTRY - SARAJEVO

AGENCY FOR SAVA RIVER CATCHMENT

SARAJEVO

April, 2009

1. Introduction

Bosnia and Herzegovina is situated between 42° 26' – 45° 15' North latitude and 15° 45' – 19° 41' East longitude, on total area of 51,129 km^2. By its administration organization, it is divided on two entities: Republika Srpska (RS-B&H) and Federation of Bosnia and Herzegovina (FB&H).

Table Ap1-1: Area of administration units

Administration unit	Area [km^2]
Bosnia and Herzegovina	51,129
Republika Srpska	25,053
Federation B&H	26,076

B&H is mostly hilly and mountainous with lowlands in the Sava River Basin and in lower parts of the Sava River tributaries.

Table Ap1-2: Terrain types in B&H and RS-B&H

Terrain types in B&H	Total area in B&H		Sava RB in B&H	
	Area [km^2]	Perc. [%]	Area [km^2]	Perc. [%]
Lowlands < 200 m a.s.l.	6,899	13.5	5,862	15.31
Hilly 200 – 500 m a.s.l.	13,241	25.9	11,276	29.45
Hilly-mountainous 500 - 800 m a.s.l.	10,502	20.5	8,121	21.21
Mountainous > 800 m a.s.l.	20,487	40.1	13,029	34.03
Total:	51,129	100.0	38,288	100.00

The Sava River Basin in B&H creates ca. 38,288 km^2 or 74.9 % of the total B&H area, what means 39.2 % of the total Sava River Basin (97,713 km^2).

The Sava River Basin in B&H is created by primary river basins of Una, Vrbas, Ukrina, Bosna Rivers and the direct Sava River Basin.

Table Ap1-3: Areas of primary river basins in Bosnia and Herzegovina

Danube Basin	Basic basins in B&H	Distance from Sava mouth [rkm]	River basin area [km^2]	Sava RB area in B&H [km^2]	Sava RB area in B&H [%]
Sava River	Una	507	9,368	8,137	8.33
	Vrbas	419	6,274	6,274	6.42
	Ukrina	373	1,500	1,500	1.54
	Bosna	306	10,810	10,810	11.06
	Drina	175	19,570	7,068	7.23
	Direct Sava Basin	-	3,786	3,786	3.87
	Korana and Glina (Kupa)	-	-	713	0.73
Total basins in B&H		332	51,308	38,288	39.18
Other basins in Sava RB		-	46,405	59,425	60.82
Grand Total:		**-**	**97,713**	**136,001**	**100.00**

Total length of the Sava River in B&H is 332 km, from the border with Croatia (Una River mouth to the Sava River on rkm 507) to the border with Serbia (Drina River mouth on rkm 175).

Sava River forms natural border with Croatia, Serbia on the left river bank, and border with B&H on the right river bank.

This means that all Sava River tributaries that are coming from B&H are the right tributaries.

Beside mentioned, the border between B&H and Croatia is created also by the Una River and border between B&H and Serbia – by the Drina River.

Table Ap1-4: Basic hydrological characteristics of Sava River tributaries in Bosnia and Herzegovina

River	Location	Basin area [km^2]	Q_{min} 95% [m^3/s]	Q_{mean} [m^3/s]
Sava	Sava - mouth of Una River – upstream	29,585	117.3	643.6
Sava	Sava - mouth of Drina River – downstream	84,939	262.1	1,606.7
Una	mouth of Una	9,368	37.0	216.4
Vrbas	mouth of Vrbas	6,274	26.3	113.0
Ukrina	mouth of Ukrina	1,500	0.94	19.8
Bosna	mouth of Bosna	10,810	24.2	157.0
Sava	Direct Sava Basin	3,786	-	-
Kupa	Korana and Glina in B&H	-	-	-
Drina	mouth of Drina	19,570	55.5	395.0
Total:	**Tributaries in B&H**	**19,570**	**55.5**	**395.0**

The land use in B&H is presented within the Table Ap1-5. Total area of RS-B&H without Brčko District is 2,446,800 ha (24,468 km^2). Out of total agricultural land, the land intended for cultivation is 893,540 ha, out of that only 1 % is irrigated via constructed irrigation systems.

Table Ap1-5: Land use in B&H

Land use	Sava RB in B&H
	B&H [ha]
Total area	3,820,428
Other (forestry, ...)	1,647,219
Agricultural land	2,203,424
Land under cultivation	971,257
Plowmas	1,101,505
Orchards	130,248
Vineyards	414,000
Meadows	439,226
Pastures	662,279
Fish farms	-
Wetlands	-
Agricultural land per resident	0.79
Plowmas per resident	0.35

1.1. Sava River

Sava River enters B&H from Croatia on the river km 507 (from the mouth), at the Una River mouth, and leaves B&H on river km 175, on the Drina River mouth. Along its entire course through B&H, in total length of 332 km, it creates the state border between B&H and Croatia and B&H and Serbia. Main right tributaries of Sava River in B&H are: Drina River (mouth at 175 rkm of the Sava River), Bosna River (306 rkm), Vrbas River (419 rkm) and Una River (507 rkm).

Along the Sava River bed, there are dikes for protection against Sava River flood waters in total length of 175 km, i.e. ca. 52.7 % of the total river course length, since the most fertile agricultural RS and FB&H land is situated in this area.

Beside this, almost along the entire Sava River course and along its main tributary mouths, there are significant flood protection systems against external (upland) and inland waters, whose total area in direct Sava River Basin is ca. 109,000 km^2, and in entire Sava River Basin it is ca. 133,000 km^2. Flood protection system against inland and external waters are made of: dikes for defense against river flood waters, canal network and drainage systems for protection against external and inland waters and systems of 23 pump stations for pumping the external and inland waters out to the Sava River. Total capacity of pump stations for flood protection is 135.25 m^3/s.

The most important systems for flood protection against inland and external waters are: area of Semberija, Gnjica-Lukavac, Tinja-Brka-Brezovo polje, Srednja Posavina, Odžačka Posavina, Ivanjsko Polje, Srbačko-Nožička ravan, Lijevče polje and Dubička ravan.

There are three sections of Sava River course identified, between the mouths of its main tributaries, and they are as follows:

From Drina River mouth (175 km) to the Bosna River mouth (306 km), total length 131 km.

In this section, Sava River has all characteristics of a very large lowland river. Total length of dike in this section (in B&H) is ca. 78 km. Flood protection dikes are situated 200-1000 m away from the main river bed, in order to provide the required flow profile for the Sava River flood waters. On the locations of the natural flood water retentive areas, the distance of flood protection dikes is even up to 4,000 m. The main port on this section is Brčko port. This port restarted its work in 2005 with decreased operation capacity.

Figure Ap1-1: Sava River (Rača River bridge) **Figure Ap1-2: Sava dike (Rača River bridge)**

Beside the Sava River dikes, there are reclamation systems also constructed on this section, as follows: Semberija (19,000 ha), Gnjica – Lukavac (2,800 ha), Tinja-Brka-Brezovo Polje (7,500 ha) and Srednja Posavina (24,500 ha), in total area of ca. 53,800 ha. For the needs of pumping the external and inland waters into the Sava River, 7 pump stations have been constructed with the total capacity of 57.55 m^3/s. On the area of Republika Srpska, there are pump stations Begov Put, Domuz Skela, Topolovac I, Topolovac II, Šamac and Đurići (Brčko District) with total capacity of 41.35 m^3/s, and in Federation B&H Tolisa and Grad in total capacity of 15.8 m^3/s.

From Bosna River mouth (306 km) to Vrbas River mouth (419 km), total length 113 km.

On this section, Sava River has all characteristics of very large lowland river. The total length of the dikes in this area (in B&H) is ca. 50.03 km. Sava River is navigable along this whole section.

There are following flood protection systems against inland and external waters constructed at this section of the Sava River: Odžačka Posavina (10,000 ha), Ivanjsko Polje (7,000 ha) and Srbačko-Nožička Ravan (6,000 ha), with total area of ca. 23,000 ha. There are 4 pump stations with total capacity of 32.2 m^3/s for the needs of pumping the external and inland waters into the Sava River.

In the area of Republika Srpska, there are pump stations Ivanjsko polje I, II and Ina, with total capacity of 12.2 m^3/s, and in FB&H pump stations Svilaj, Zorice I and Zorice II, with total capacity of 20.0 m^3/s.

Figure Ap1-3: Flood protection pump station machine room

From Vrbas River mouth (419 km) to Una River mouth (507 km), total length of 88 km.

On this section, Sava River has all characteristics of a large lowland river. Total dike length on this section (in B&H) is ca. 46.4 km. Along the whole section, Sava River is navigable.

Figure Ap1-4: Sava River (quay – Gradiška bridge)

At this section of the Sava River course, there are following flood protection systems constructed against inland and external waters: Lijevče polje (36,500 ha) and Dubička Ravan (6,500 ha), with total surface of 43,000 ha. There are 8 pump stations with capacity of 45.5 m^3/s constructed for the needs of pumping the external and inland waters into the Sava River. All pump stations are located on the area of Republika Srpska: Bajinci, Matura, Dolina, Kej, Liman, Orahova, Glavinac and Dubica.

Figure Ap1-5: Pump station structure Liman (Lijevče polje)

From the descriptions stated above, it can be seen that Sava River is a typical very large lowland river, with its entire course within B&H. The direct Sava River Basin is most fertile land in Republika Srpska and Bosnia and Herzegovina, with relatively high population rate, so that flood protection systems are relatively very long. Total length of protection dikes is 175 km. Beside this, river bed is highly modified with various bank protections (Brčko, Šamac, Brod, Srbac, Gradiška and Kozarska Dubica, towns with constructed harbors and banks strengthened with bank protections).

Total difference in elevation of the Sava River bottom from the Una River mouth to the Drina River mouth is 14.5 m, on the entire section in the total length of 332 km, so that the average river bed slope is 0.04 m/km.

1.2. Una River

Una River is the right Sava River tributary, with the mouth at the 507 rkm.

With the catchment area of 9,368 km^2, Una River is the third biggest Sava River tributary in B&H.

Una River spring is in the Suvaja mountain plinth, 214.7 rkm, with spring level at 420 m a.s.l. Total difference in elevation from the spring to the mouth is 335 m (85.0 m.a.s.l), and average river bed slope is 1.56 m/km.

Main left Una River tributaries are: Klokog and Žirovac.

Main right Una River tributaries are: Unac, Krušnica and Sana, Mlječnica and Moštanica River.

Ca. 35.7 % of the Una River Basin (3,346 km^2) is located on RS territory, ca. 49.3 % (4,613 km^2) on FB&H territory and ca. 15.0 % (1,409 km^2) on HR territory.

Una River Basin belongs to the moderate continental climate zone, with average annual precipitation of 1,245-1,400 mm, total precipitation of 11,663 hm^3 and average runoff of 6,824 hm^3.

Lower Una River course is the section from Novi Grad to Kozarska Dubica, in total length of 75 km (mouth of right tributary – Sana River, 112 m a.s.l.) with total difference in elevation of ca. 27.5 m and average river bed slope of 0.47 ‰. At this section, Una River is a huge lowland river with lot of meanders and islands, with variable both - river bed width and water depth. At this section, the towns Novi Grad, Kostajnica and Kozarska Dubica are situated.

Upper Una River

Spring area of Una River consists of several springs in karst formations. Main springs are Unsko Vrelo and springs Velika Neteka and Mala Neteka, in the area south from the Suvaja Mountain. First important Una River tributary is Srebrenica River with mouth immediately under Suvaja Mountain. Downstream of the waterfalls at Martin Brod lies the mouth of the right Una River tributary - Unac River. From Martin Brod to Bihać, Una River has no significant tributaries, except for springs in karst area, nearby Kulen Vakuf.

Figure Ap1-6 and **Figure Ap1-7: Una River – details from the upper course**

At this section, Una River is abound with natural cut-off trenches, thus forming smaller and bigger waterfalls and cascades and nearby Strbacki Buk it is creating a big waterfall.

Very steep slopes at the small distances are characteristic for the upper course (from the spring to Bihać). Total fall from the spring to the water meter station Bihać is 151.8 m, and the length of this section is 66.8 km.

Middle and lower Una River

On the middle course, from Bihać to Novi Grad, Una River is an upland-lowland river with a significant river bed slope. Total slope from Bihać to Novi Grad is 104.0 m at the length of 71.0 km. North of Bosanska Krupa, Una River has its right tributary, Krušnica.

Figure Ap1-8: Una River – middle course **Figure Ap1-9: Una River – middle course**

From Novi Grad to the mouth into the Sava River, Una River has all characteristics of a lowland river, with total fall of 29.3 m at the length of 71.5 km; average slope is 0.41 m/km. The largest right tributary to the Una River - Sana River is being discharged in Novi Grad, and a little lower from Novi Grad, there is a left tributary Žirovac. Total fall of Una River from Bihać to Novi Grad is 104.0 m at the length of 71.0 km.

Section from Dubica to the Una River mouth into the Sava River, represents a part of reclamation system Dubička ravan, so that flood protection dike is being constructed on the both rivers sides, at the length of ca. 12.5 km, for protection against Una and Sana River flood waters.

Figure Ap1-10: Una River – lower course (Novi Grad – upstream from the Sana River mouth)

1.3. Vrbas River

Vrbas River is the Sava River right tributary, being discharged at the 419 rkm.

With catchment area of 6,386 km^2, Vrbas is the smallest Sava River tributary in B&H.

Vrbas River spring is in the Vranica mountain plinth, 235 rkm, with spring level at 1,715 m a.s.l. Total difference in altitude from the source to the spring (88 m a.s.l.) is 1,627 m, and average river bed slope is 6.92 m/km.

Main left Vrbas River tributaries are: Pliva and Krupa River.

Main right Vrbas River tributaries are: Bistrica, Ugar, Svrakava, Vrbanja, Turjanica and Povelić.

About 63 % of the Vrbas River Basin (4,008 km^2) belongs to RS and ca. 37 % (2,378 km^2) is located in FB&H.

Upper Vrbas River

In the upper course, larger tributaries to the Vrbas River are Dragučina, Rijeka and Pliva River – as the most important tributary. Upper course of spring to Han Skela (km 145.1) has an average river bed slope of 7.8 m/km. This section is characterized with big falls and low water quantities.

Figure Ap1-11: Vrbas River – upper course

Middle Vrbas River

Middle Vrbas River course is the section from Jajce to Banja Luka, with total length of 72.5 km, total difference in elevation of ca. 165 m, with average longitudinal slope of the river bed of ca. 2.27 m/km. There are HPP Bočac (RS), HPP Jajce I (FB&H), and HPP Jajce II (FB&H). Those accumulations have a significant impact on the hydraulic regime of the water course.

Figure Ap1-12: Vrbas River – middle course

Lower Vrbas River

Lower Vrbas is the section from Banja Luka to the Vrbas River mouth (Srbac), in total length of ca. 70 km, with total difference in altitude of ca. 65 m and average river bed fall of 0.9 m/km.

At this section, Vrbas has all characteristics of a large lowland river. In this area, several towns developed, as follows: Banja Luka, Laktaši and Srbac (mouth) with significant industrial structures.

Section from Povelić – Razboj tributary mouth (15 rkm) to the Vrbas River mouth in the Sava River is used as natural retention for flood waters of Vrbas and Sava River, so that dikes are constructed at this section on the both river sides. At the Vrbas River right bank, at this section the reclamation system Srbačko-Nožička Ravan is constructed for protection against inland and external waters (6,100 ha). Inland waters are partially pumped by pump station Povelić into the Vrbas River and partially by the Ina pump station into the Sava River.

Figure Ap1-13: Vrbas River – lower course

1.4. Bosna River

Bosna River is the Sava River right tributary, being discharged into the Sava River at 306 rkm in Šamac.

With catchment area of 10,457 km^2, Bosna River is the second biggest tributary of the Sava River in B&H. Ca. 3,043 km^2 (29 % of the total river basin area) is located on the RS territory and ca. 7,414 km^2 (71 %) on FB&H territory.

Bosna River spring is located in Sarajevsko polje, in Igman mountain plinth, 272.5 rkm, with spring level on 494.7 m a.s.l. Total difference in altitude from the spring to the south (76.4 m a.s.l.) is 418.2 m and average river bed slope is 1.53 m/km.

Main left tributaries of the Bosna River are: Fojnica, Lašva and Usora River.

Main right tributaries of Bosna River are: Željeznica, Miljacka, Stavnja, Krivaja and Spreča River.

Upper Bosna River course

Bosna River gains its headwaters from karst springs in village Vrutci nearby Ilidža in Igman mountain plinth on 494.7 m a.s.l.

Figure Ap1-14: Bosna River spring

Figure Ap1-15: Bosna River in Zenica

Significant tributaries in upper Bosna River course are Željeznica, Miljacka, Zujevina, Dobrinja, Stavnja, Fojnica and Lašva River. Total area of upper Bosna River course is 4.120 km^2. Entire upper Bosna River course is 77.5 km long, with total fall of 174 m. Bosna River bed slope varies in range of 1.5 – 2.2 m/km. In the heavily populated valleys in this part of the river course, the towns Sarajevo, Visoko, Kakanj and Zenica have been developed.

Željeznica River, that is considered as the Bosna River main course extension, is performing drainage of Jahorina, Treskavica and Bjelašnica Mountain.

Middle and lower course of Bosna River

In its middle course, Bosna River is creating water cushions and rapids on several points. Average slope is 1.45 m/km. Significant Bosna River tributaries in the middle course are: Gostović, Krivaja and Usora River.

The largest towns in this part of the river basin are: Zavidovići, Žepče and Maglaj.

Lower course of Bosna River is the section from Doboj to the mouth into the Sava River, with total length of 76.3 km.

Figure Ap1-16: Bosna River – lower course (Modriča)

Figure Ap1-17: Bosna River (mouth into the Sava River – bridge in Šamac)

Figure Ap1-18: Bosna River – lower course (Bosna River mouth into Sava – Šamac port)

On the territory of Republika Srpska, Bosna River is a large lowland river.

Total difference in elevation from the left tributary Usora River mouth (139 m a.s.l.) to the Bosna River mouth is ca. 62.6 m, and average river bed slope is ca. 0.82 m/km.

Following towns with important industrial capacities have been developed on this part of the Bosna River course: Doboj, Modriča and Šamac. Section from Modriča to Šamac is a natural retention for Sava and Bosna River flood waters. Due to that fact, the flood protection dikes were constructed along entire river course in length of 40 km on the both banks of the Bosna River. Inland waters are being pumped into the Bosna and Sava River.

1.5. Drina River

Drina River is the largest right tributary of the Sava River, with the total river basin surface of 19,570 km^2, with the mouth into the Sava River (175 rkm) and the total course to Šćepan Polje (345.9 rkm), of 346 km.

According to the size, Drina River Basin is the forth biggest river basin on the territory of the former Yugoslavia, next to the Sava, Morava and Vardar River Basin. With the total runoff of 120,000 hm^3/year, Drina River Basin covers 11.2 % (13,000 hm^3/year).

Total length of Drina River is ca. 346 km and the total difference in elevation from Šćepan Polje to the mouth is 366 m, so that the average river bed slope is ca. 1.06 m/km. Total length of Drina River together with Tara River is 496 km.

Drina River is created of two rivers: Piva and Tara River, originating from Montenegro, with confluence on location Bastasi (Šćepan Polje), rkm 345.

Total surface of Drina River Basin (with Piva and Tara River) belongs to the following states: Bosnia and Herzegovina - 37.1 %, Serbia - 30.5 %, Montenegro - 31.6 % and Albania - 0.8 %.

Significant left Drina River tributaries are: Janja, Drinjača, Žepa, Prača, Bistrica, Sutjeska and Piva River.

Significant right Drina River tributaries are: Jadar, Lim, Rzav, Ćehotina and Tara River.

Lim River is the most important Drina River tributary, with the river basin surface of 5,717 km^2 (29.2 % of the total river basin).

Upper Drina River course

In its upper course, Drina River is averagely large upland river.

Upper course of the river is the section from Šćepan Polje (345.9 rkm) to the Lim River mouth (264.3 rkm), total length 82 km, with total fall of 138 m. Drina River bed slope in this part ranges from 1.5 – 1.9 m/km, and average slope is 1.67 m/km. In the narrow valleys of Drina River in this part following towns are developed: Foča, Goražde and Višegrad.

Piva River

Tara River | Drina River

Figure Ap1-19: Confluence of Tara and Piva River – Drina River (Šćepan Polje – Bastasi)

Middle Drina River course

In its middle course, Drina River is large and mostly hilly river.

Middle course of Drina River and section from Lim River mouth (264.3 rkm) to Zvornik (90.0 km), total length of 174 km with total fall of 161 m. The Drina River bed slopes range from 0.5 – 1.35 m/km, and average slope is 0.94 m/km. In this part of the basin are towns Bratunac and Zvornik. There are also 3 HPPs with the reservoirs (accumulation lakes) constructed in this middle course of Drina River:

- HPP Višegrad, chainage 255 km, accumulation volume 161,000 hm^3,
- HPP Bajina Bašta, chainage 200 km, accumulation volume 340,000 hm^3,
- HPP Zvornik, chainage 82.6 km, accumulation volume 47,500 hm^3.

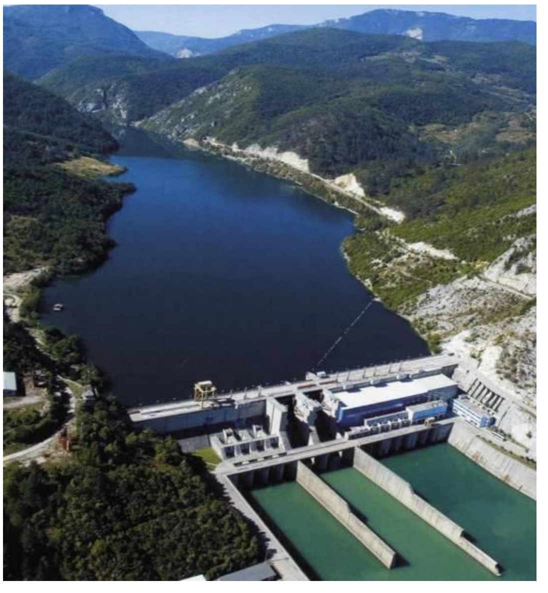


Figure Ap1-20: HPP Višegrad – RS-B&H

Figure Ap1-21: Višegrad (Mehmed Paša Sokolović Bridge, under UNESCO protection)

Figure Ap1-22: Zvornik (Divič – HPP Zvornik) – RS-B&H

Figure Ap1-23: Zvornik (Divič - Zvornik reservoir)

Lower Drina River course

In its lower course, Drina River is getting all characteristics of a large lowland river.

The lower section of Drina River course stretches from Zvornik (chainage 90.0 km) to the mouth into the Sava River (chainage 0.0), with total length of 82.6 km and total fall of 59.4 m. Drina River belongs in its lower course to the category of lowland rivers. River bed slope ranges from 0.5 – 0.7 m/km, and average slope is 0.7 m/km. The river section along the Sava River mouth (area of Semberija) is characterized by very deep layers of alluvial deposit, namely 40-80 m deep and 20 km long. This area is extremely rich in ground water, mostly originating from Drina River. Zvornik and Bijeljina are larger towns developed at this section. Along the Sava River mouth, the section is ca. 15 km long. Along the Drina River course, there are dikes and bank protection against floods from Drina and Sava River, as well as the system for protection from inland waters – reclamation system Semberija. As shown in the Figure Ap1-24, Drina River is mostly a large lowland river at this section.

Figure Ap1-24: Drina River - Semberija

2. Basic characteristics of the Sava River Basin in B&H

As it was stated in the introduction, the main flood protection systems are located in the Sava River valley and in the zone of main tributary mouths in B&H.

The most fertile agricultural land in RS and B&H is located in this area. Furthermore, this is the area with the highest population rate and most of the settlements and industrial capacities have been constructed here.

Flood areas are mostly lowlands in lower river courses on altitude of 85-160 m a.s.l. with exception of Podrašničko polje (Mrkonjić Grad), since this is a high karst field with altitude of ca. 730 m a.s.l.

Middle (hilly) river courses with altitude of 200-500 m a.s.l., as well as mountain courses with altitude higher then 500 m a.s.l., are occurring with very rare floods, as a consequence of torrents or extremely high precipitations. Agricultural land zones are very small in this area and settlements are small too, so damages caused by floods are very low compared to the damages in lowland parts of the basin.

Main drainage pattern, flood zones, module of land use and topographic characteristics of terrain are given in Attachments 1, 2, 3 and 4.

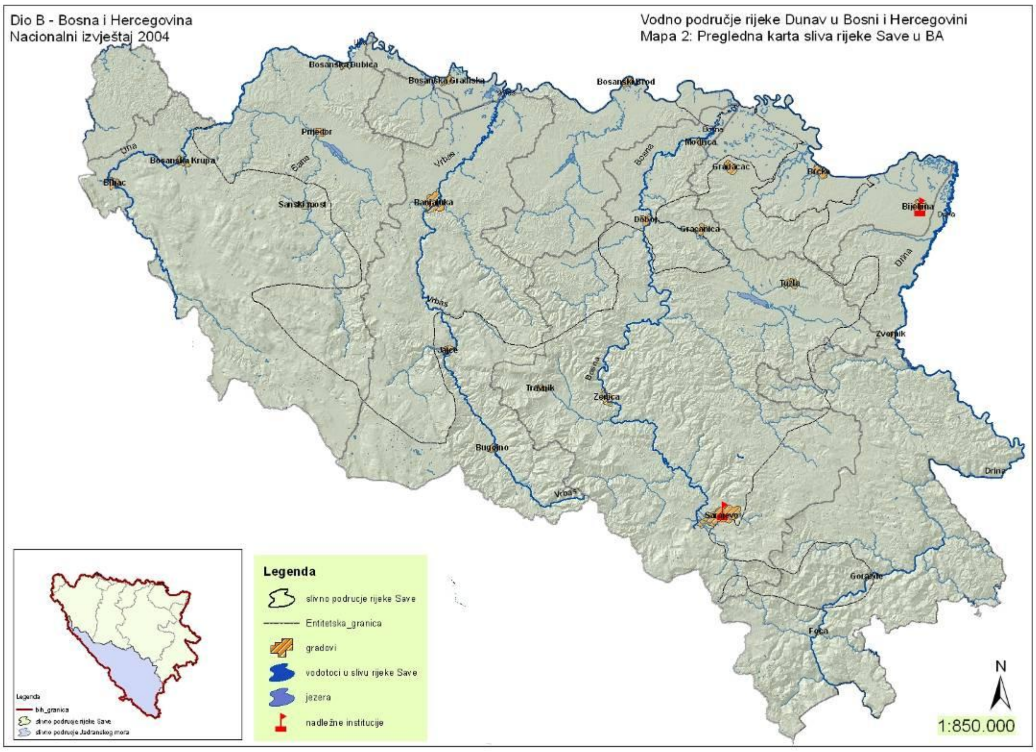


Figure Ap1-25: River network and administrative units in the Sava RB in B&H

Table Ap1-6: Sava River Basin in B&H

River	Location	Basin area [km^2]	Q_{min} 95% [m^3/s]	Q_{mean} [m^3/s]
Sava	Sava mouth of Una – upstream	29,585	117.3	643.6
Sava	Sava mouth of Drina – downstream	84,939	262.1	1,606.7
Una	mouth of Una	9,368	37.0	216.4
Vrbas	mouth of Vrbas	6,274	26.3	113.0
Ukrina	mouth of Ukrina	1,500	0.94	19.8
Bosna	mouth of Bosna	10,810	24.2	157.0
Sava	Direct Sava Basin	3,786	-	-
Kupa	Korana and Glina in B&H	-	-	-
Drina	mouth of Drina	19,570	55.5	395.0
Total:	**Tributaries in B&H**	**19,570**	**55.5**	**395.0**

2.1. Topographic characteristics of terrain of the Sava RB in B&H

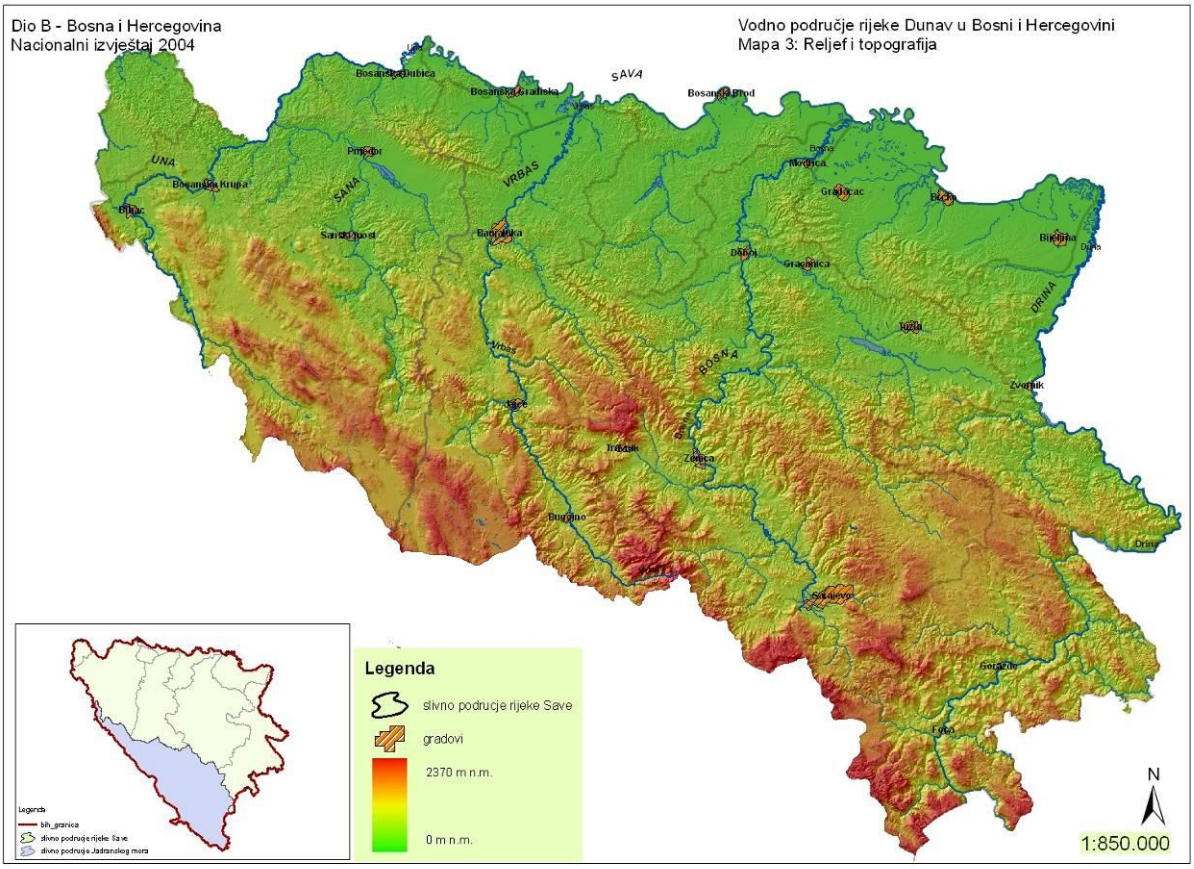


Figure Ap1-26: Terrain chracteristics of the Sava RB in B&H

Table Ap1-7: Terrain types in B&H

	Total area in B&H		Sava RB in B&H	
	Area [km²]	Perc. [%]	Area [km²]	Perc. [%]
Lowlands < 200 m a.s.l.	6,899	13.5	5,862	15.31
Hilly 200 - 500 m a.s.l.	13,241	25.9	11,276	29.45
Hilly-mountainous 500 - 800 m a.s.l.	10,502	20.5	8,121	21.21
Mountainous > 800 m a.s.l.	20,487	40.1	13,029	34.03
Total:	51,129	100.0	38,288	100.00

2.2. Land use

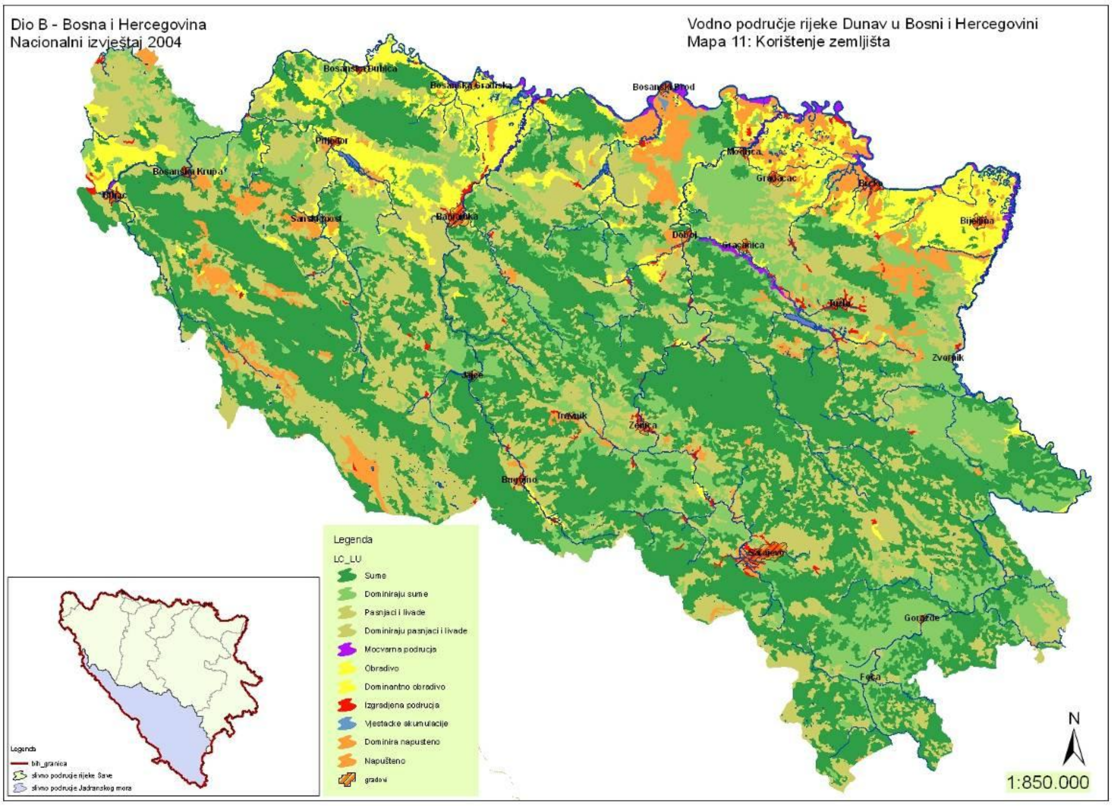


Figure Ap1-27: Land use in the Sava RB in B&H

Table Ap1-8: Land use characteristics in the Sava River Basin in B&H

Land use	Sava RB in B&H [ha]
Total area	3,820,428
Other (forestry,...)	1,647,219
Agricultural land	2,203,424
Land under cultivation Plowmas Orchards Vineyards Meadows Pastures	971,257 1,101,505 130,248 414 439,226 662,279
Fish farms	-
Wetlands	-
Agricultural land per resident	0.79
Plowmas per resident	0.35

3. Historical floods

Historical data on floods are originating from 1822, when first regulation/control works were initiated in Herzegovina. Systematic observation and flood monitoring on B&H territory started in 1878, when first construction works were initiated on flood protection dikes in the Sava River valley.

Floods occur in the Sava River Basin in autumn and spring, with approximately same volume of floods and damages caused by floods.

Largest flood was recorded in period September 20, 1878 to January 4, 1879, when in just 106 days in the Sava River Basin there was ca. 1381 mm rainfall. According to the data from water gauge in Sisak, in that period water level went over 900 cm twice and over 800 cm even nine times.

On the Drina River, a catastrophic flood was recorded in 1896, when water level went 100 cm over fence on the bridge of Omer Paša Sokolović. Entire Podrinje was impacted by this flood with catastrophic consequences even along entire Sava River course in Semberija and Serbia. This flood has entirely destroyed settlements Bosanska and Sremska Rača. Settlement Sremska Rača was displaced to present location, while settlement Bosanska Rača has never been restored.

By constructing reservoirs of HPP Mratinje, HPP Višegrad, HPP Bajina Bašta and HPP Zvornik, probability of occurrence of such catastrophic wave was significantly decreased.

After construction of dikes on the Sava River right bank in the period of 1934-1941, damages caused by floods were considerably decreased. Beside those dikes along the Sava River, the construction of dikes along the main Sava tributaries Una, Vrbas and Bosna, as well as Drina River side started in B&H.

In 1964, a long term flooding event occurred in Middle Posavina with huge damages on agricultural land. Unfortunately, there is no more precise data on damages.

Floods of similar scope occurred during 1965 and 1966, covering entire area of Posavina and lowland parts of tributaries in B&H.

On December 19, 1968, large flood was recorded in Sarajevsko polje, when Bosna River overflowed the bridge on water meter station in Reljevo, with depth of 30-40 cm and took away the road outlet and part of the local road on right bank in length of ca. 80 m.

In period of 1972-1974, floods have covered entire lowland area in B&H (Posavina with tributaries Una, Sana, Vrbas, Bosna, Tinja, Brka and Drina River).

Entire period from 1981 to 1991 is characterized by flood events with different volume, covering more or less even upper Sava River tributary courses.

In 1996, on September 23-24, due to very high precipitations in Vrbas River Basin there was a flood wave formed, causing floods on entire Vrbas River course downstream of Banja Luka.

In 1999, big flood event was recorded in Tuzla, Bosna River Basin, when small River Jala caused great flooding.

In 2004, Srbac suffered significant damages in the area of Vrbas and Povelić River mouth, causing great damages in upper river course of Povelić River.

By construction of a dike along the Sava River, the flood wave propagation from the Una River mouth to Sremska Mitrovica has been decreased from previously 8-9 days to 4-5 days, as a direct consequence of a reduction of inundation areas in Posavina.

4. Existing flood management

4.1. Commanding responsibilites

Water management in Bosnia and Herzegovina is under the entity-level competence.

Republika Srpska

Protection against harmful water effects, meaning protection against river flood waters, protection against upland external waters, protection against inland flood waters, protection against torrential waters and protection against erosion, is determined by *Water Law of Republika Srpska*, which is completely harmonized with *Water Law of FB&H* and EU WFD as well as with the EU *Flood Directive* (*Official Gazette of RS,* No. 55/06).

Beside this, *Law on civil protection* determines measures and activities of Civil protection Center on human and capital assets prevention and protection in case of flooding and flood occurrence. In that sense, civil protection is organized in 5 regional departments of Republic administration of civil protection as follows: ORUCZ Banja Luka, ORUCZ Doboj, ORUCZ Bijeljina and ORUCZ Sokolac. Civil protection actions are managed by Republic administration of civil protection which is under direct management of the Government, i.e. Parliament of RS-B&H.

Institutions in charge for above mentioned laws implementation are as follows:

- Ministry of Agriculture, Forestry and Water Management, Banja Luka;
- Republic Directorate for waters (as of February 13, 2009, the Agency for Waters for Sava River Basin District), Bijeljina;
- Republic administration of civil protection, Banja Luka.

Beside mentioned Republic authorities, implementation of *Water Law* and flood protection are enforced by following public and partially privatized utilities as follows:

- JP Sava, Gradiška;
- JP Sava, Brod;
- JP Posavina, Vukosavlje;
- JP Ušće Bosne, Šamac – privatized;
- JP Srednja Posavina, Lončari – privatized;
- JP Semberija, Bijeljina;
- JP Drina, Zvornik – privatized;
- JP Gornja Bosna, Foča.

For civil protection implementation, following regional departments are in charge:

- ORUCZ Banja Luka,
- ORUCZ Doboj,
- ORUCZ Bijeljina,
- ORUCZ Sokolac.

Responsibilities and authorities within flood protection are defined by the Decree of relevant Ministry of agriculture, forestry and water management, while flood protection costs are borne by relevant Ministry and the Government of RS-B&H.

Flood protection is implemented on three basic protection levels (degrees):

- Level of flood awareness – for the water level when water is being discharged from the natural river bed,
- Level of regular protection – when flood water level wets toe of the dike, and
- Level of emergency protection – when flood water level comes to 0.5-1.0 m above the dike toe with further growth trend.

Actual flood defense level differs for different protection zones and depends on dike condition, dike height and imiportance of the protected area.

Actual defense level is being proclaimed by the relevant Ministry, while for the Regional administration of civil protection, by the RS-B&H Government.

The role of district water management utilities is very important in flood protection system, since, by relevant Ministry Decree, they have been proclaimed as competent and in charge for the following issues:

- Maintenance and rehabilitation of flood protection structures (dikes, weirs and PS);
- River deposit exploitation with the purpose of designed water course profile maintenance and especially for navigable path maintenance;
- Required mechanization for flood structure maintenance and rehabilitation, as well as for the maintenance of mechanization itself;
- In emergency situations organization of additional personnel and equipment from local companies via Republic administration of civil protection headquarters;
- Coordination of all terrain activities related to the flood protection and direct flood protection management activities in the field, for the flood area of which they are in charge. In that sense, they are directly managing and making decisions on proclaiming defense needs and level against external upland drainage waters.

For the purpose of most efficient flood protection, flood protection areas are divided into dike sectors (sections) where Sector flood protection managers are in charge for flood protection.

Flood protection level is defined per each sector based on the water level measured on water gauge for each sector and section of the dike, individually.

The role of MoAFWM and Agency for Waters for Sava River Basin District is as follows:

- Providing of required Studies and Design documents related to the flood protection systems on entire area of RS-B&H, and in coordination with MoAFWM and Agency for waters from Federation of Bosnia and Herzegovina for entire B&H;
- Developing Action plans and river basin management plans;
- Developing flood protection plans for individual sectors;
- Providing financing for new structures construction and for maintenance of existing ones, as well as for the monitoring system, system for early warning and supervision system for collecting and exchange of information related to the meteorological conditions and water levels;
- Planning and coordination of flood protection and flood risk mitigation activities by involving municipal civil protection headquarters in charge for flood protection.

Republic Institutes for hydrometeorology are in charge for: supervision, measuring, collecting and analyzing hydro meteorological data, as well as for weather forecasting.

On RS-B&H territory, within the Sava River Basin, monitoring and measuring of meteorological parameters have been performed on 23 stations, hydrological parameters were registered on 7 stations and continuous water level monitoring is been performed on 22 automatic stations (additional 14 automatic stations are in process of installation). Total number of automatic stations in B&H is 99.

Plans for unforeseen and emergency situations are not a part of the *General flood protection plan* for RS-B&H. For time being, this planning activity is under Republic association of civil protection competence and they are in charge for evacuation plans and activities that are not part of the *Flood protection plan*.

General flood protection plan is not enacted and adopted for RS-B&H. The *Framework plan for water management development in RS-B&H until 2015* and *Action plan* for implementation of this plan determine the guidelines and the time schedule for preparation of the new *Flood protection plan*.

For now, *Annual flood protection plans* are being enacted, based on relevant Ministry decree and based on the *Flood protection plan* that was in force until 1992 (Flood protection plan in force until the war).

Legal base for *Flood protection plan* implementation within RS-B&H are *Water law* and *Civil protection law* and their by-laws.

Annual flood protection plan is enacted annually, based on relevant ministry Decree.

Constituent part of the *Annual flood protection plan* is the *Main flood protection operational plan* for relevant year and it contains data on:

- Flood area (flood area mark, data on Sectoral flood protection manager and its deputies, data on Public Utility in charge for the named area);
- Characteristic water levels for flooded area (relevant water meter staff, maximal observed water level, water level for proclaiming regular flood protection level, water level for proclaiming emergency flood protection level);
- Flood sector (name and detail description of the sector, data on sector flood protection manager and its depute);
- Nomination of Head manager for RS-B&H flood protection;
- Nomination of Head manager deputy for RS-B&H flood protection.

Regional and sector managers for flood protection are in charge for preparation of appropriate flood protection plans under their competences – plans that contain data on:

- Competent municipal civil protection headquarters;
- Settlements to be mobilized for flood protection;
- Other data on regular and emergency flood protection participants.

Federation of Bosnia and Herzegovina

Protection against harmful water effects means implementation of activities and measures on mitigating or preventing harmful water effects and its consequences on people and capital assets and it is related to flood protection and protection against ice on water courses and protection against erosion and torrents. Protection against harmful water effects covers also protection measures and mitigating its consequences caused by emergency water pollution and it is proscribed by *Water law of Federation B&H*, which is completely harmonized with RS-B&H *Water law* and EU WFD. Also, it should be pointed out, that types and content of flood protection plans and flood protection activities are defined by *Decree on flood protection plans* (*Official Gazette of FB&H*, Nr.: 3/02). This Decree also determined structure and competences of each subject participating in flood protection. Since this Decree was not harmonized with relevant EU Directive, there was a new Decree on types and content of flood and ice protection plans developed, which is completely harmonized with relevant Directive and it is in process of adoption. The old Decree has dealt just with flood protection structures in FB&H ownership, while the new Decree deals with all water courses of the 1st category, except flood protection structures.

Beside all mentioned, *Decree on people and capital assets protection measures organization, content and implementation,* enacted by FB&H Government (*Official Gazette of FB&H* 27/08), determines organization, content and preparation activities, as well as protection measures implementation module against danger and consequences of natural disasters, technological, ecological and other accidental events, where floods also belong. In article 15, paragraph 1, item 7, in connection with articles 43-46, protection and rescuing on the water surface and under the water, it reads: Protection and rescuing on and under the water is to be implemented by: citizens under self-protection, utilities and other legal persons competent by its basic field of activities or if they are somehow connected to sea, rivers and lakes, as well as sport organizations dealing with sport performed on or under the water and services equipped and enabled for this type of protection and rescuing, civil protection units for protection and rescuing on and under the water, and administration authorities and services for administration in charge with water management.

Main flood protection operational measures plan enacted each year, amongst other issues determines also tasks, persons leading actions and unique and harmonized module of actions during preparation and implementation of activities and protection as well as the rescuing measures, in case of emergency flood protection on the territory of FB&H.

In that sense, the civil protection for the Sava River Basin area is organized on two flooded areas Odžačka and Srednja Posavina and the municipal civil protection headquarters are involved in flood protection activities.

Institutions in charge for the above-mentioned laws implementation are as follows:

- Federal Ministry of agriculture, water management and forestry, Sarajevo;
- Agency for Sava River catchment, Sarajevo;
- Federal civil protection headquarters, Sarajevo.

Beside mentioned bodies, *Water law* and flood protection activities are provided by specialized organizations, nominated through the *Main flood protection operational measures plan*, in charge for flood protection on individual flood prone areas.

For the implementation of the civil protection activities according to the *Main plan of flood protection operational measures in FB&H*, on the two flood prone areas, there are following municipal civil protection headquarters in charge:

- OŠCZ Odžak,
- OŠCZ Domaljevac - Bosanski Šamac,
- OŠCZ Orašje,
- OŠCZ Gradačac.

Responsibilities and competences of flood protection institutions are defined by *Decree on flood protection plans*, proscribed by Federal Ministry of Agriculture, Water Management and Forestry (FMAWMF), while costs of implementation are borne by Agency and FMAWMF.

Flood protection activities are implemented on two basic protection levels (degrees):

- Regular flood protection, when flood water level reaches the level on water meter staff, proscribed by the decree for that flood prone area,
- Emergency flood protection, when flood water level reaches the level on water meter staff, proscribed by decree for that flood prone area.

The start and the termination of regular and emergency flood defense for individual flood prone area is being proclaimed by regional flood protection manager who immediately informs the federal flood protection manager according to the *Decree on flood protection plans*.

Role of specialized organizations is very important in flood protection system, since those organizations are being nominated through the *Main plan of flood protection operational measures*, as competent organizations and in charge for:

- Maintenance and rehabilitation of flood protection structures (dikes, dams and PS);
- River deposit exploitation with the purpose of designed water course profile maintenance and especially when navigable path is in question;
- Required mechanization for flood structure maintenance and rehabilitation and maintenance of mechanization itself;
- In emergency situations organization of additional personnel and equipment from local companies via Republic administration of civil protection headquarters;
- Coordination of all terrain activities connected to flood protection and direct flood protection management activities on the field for the flood area they are in charge with. In that sense, they are directly managing and making decision on proclaiming protection need and level against external upland drainage waters.

For the purpose of most efficient flood protection, flood protection areas are divided into dike sectors (sections) where Sector flood protection managers are in charge for flood protection.

Flood protection level is defined per each sector, based on the water level measured on water meter staff for each sector and section of the dike individually.

Role of the FMAWMF and the Agency for the Sava River catchment is as follows:

- Providing the required Studies and Design documents related to flood protection systems on entire area of FB&H, and in coordination with MoAFWM and Agency for waters from RS-B&H for entire B&H;
- Developing river basin management plans;
- Developing flood protection plans for individual sectors according to *Decree on flood protection plans*;
- Providing financing for new structures construction and for maintenance of existing ones as well as for monitoring system, system for early warning and supervision system for collecting and exchange of information related to meteorological conditions and water levels;
- Planning and coordination of flood protection and flood risk mitigation activities by involving municipal civil protection headquarters in charge for flood protection.

Federal Meteorological institute is obligated to continuously submit data on precipitation, river water levels, status of the snow cover and weather forecasts and to submit them to the water management information centers of competent Water Agencies for the individual flood protected areas. Main operational plan determines the hydrological and meteorological stations which will deliver the mentioned data.

Federal meteorological institute submits to the Water management information center for Sava catchment the information received from 15 hydrological and 13 meteorological stations.

On the FB&H territory, in the Sava River Basin, under the Agency for Sava River catchment, Sarajevo competence, monitoring and measuring of meteorological parameters on 14 automatic stations, hydrological-meteorological on 5 automatic stations and hydrological parameters is carried out on 42 automatic stations. Design documentation for installation of additional 30 hydrological automatic stations in Bosna River Basin is under preparation.

Main prevention plan for flood protection in FB&H is prepared in accordance with decree in force, but it is not yet adopted. Considering the fact that the new decree on types and content of flood and ice protection plans is in adoption procedure and completely harmonized with the EU *Flood Directive*, the former plan is not going to be adopted anyhow, at least not in the originally prepared form. New *Decree on flood protection* determines directions and time schedule for new Flood protection plans preparation.

In FB&H, the legal base for *Flood protection plan* implementation is the FB&H *Water law* and *Law on civil protection*, as well as the appropriate by-laws.

Main plan of flood protection operational measures is enacted each year by the FB&H Government on the FMAWMF proposal and contains data on:

- Flood area (flood area mark, data on Sector flood protection manager and its deputies, data on Public Utility in charge for this area, municipal civil protection headquarters);
- Characteristic water levels for flooded area (institution for issuing data, relevant water meter staff, maximal observed water level, water level for proclaiming regular flood protection level, water level for proclaiming emergency flood protection level);
- Flood sector (name and detail description of the sector, data on sector flood protection manager and its depute);
- Nomination of Head manager for FB&H flood protection;
- Nomination of Head manager deputy for FB&H flood protection.

Regional and sector managers for flood protection are in charge for preparation of appropriate flood protection plans under their competences – plans that contain data on:

- Competent municipal civil protection headquarters,
- Settlements to be mobilized for flood protection,
- Other data on regular and emergency flood protection participants.

Except those flood and ice protection plans, it was planned to prepare erosion and accidental pollution plans according to the FB&H *Water Law*.

Brčko district

Protection against harmful effects of water in Brčko district is based on the *Water Law of Republika Srpska* (*Official Gazette of RS, No. 10/98*).

The Department of Agriculture, Forestry and Water Management of the Government of Brčko District B&H, as the institution responsible for implementation of law, entitles the registered and qualified companies, to be engaged on flood protection in the areas where the flood protection structures egsist, according to the law of Brčko district.

Civil protection is managed by the Headquaters of civil protection of Brčko district B&H, entitled by the mayor. The Headquaters of civil protection guide the civil protection, company employees and members of other organisations in case of flood defense.

4.2. System and state of the flood protection structures

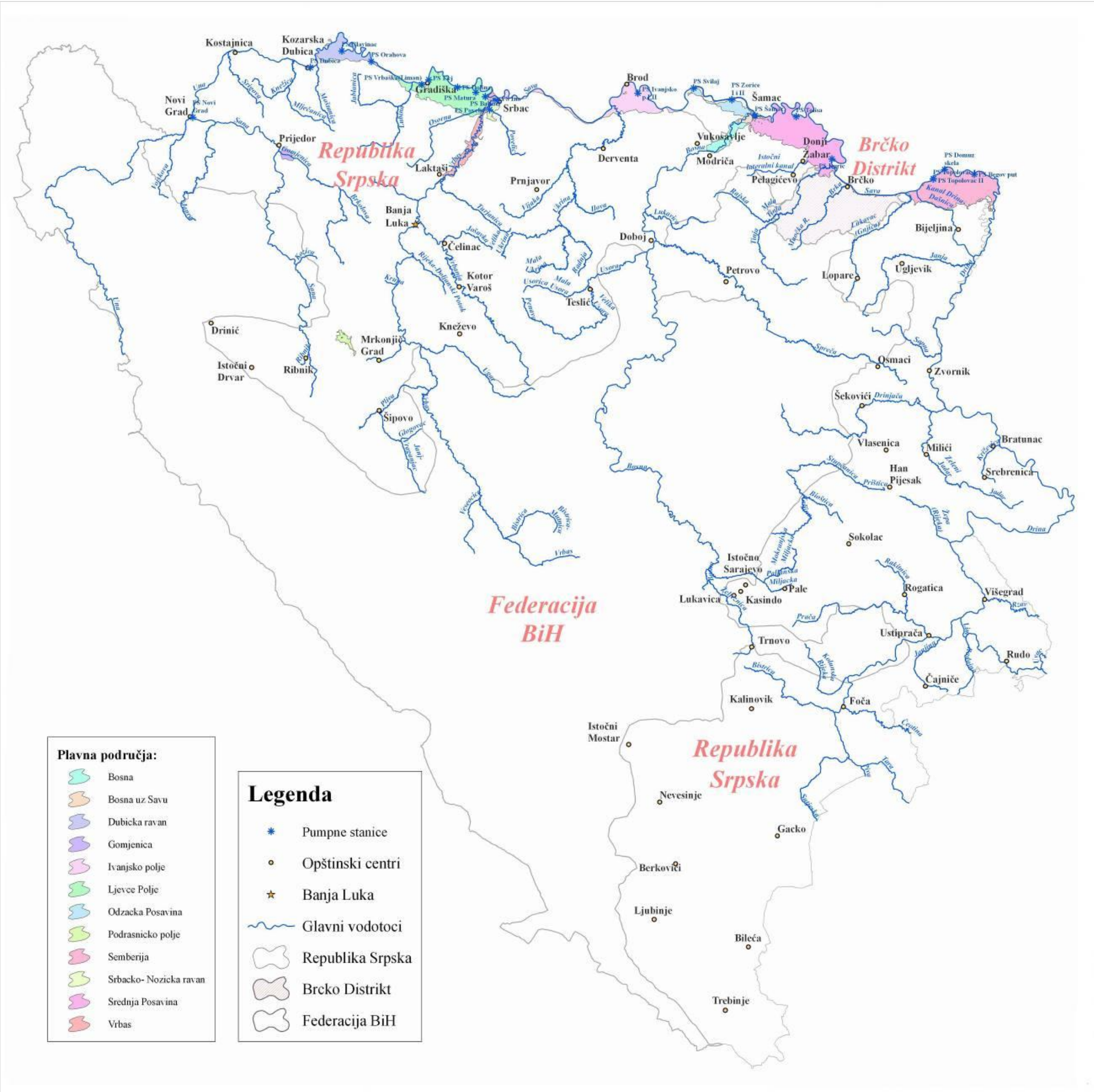


Figure Ap1-28: Flood prone areas in B&H – Sava River

For the purpose of estimating the Sava flood protection system importance, together with the flood protection systems along the main tributaries, hereby we present tabular review of population and infrastructure within the flood prone area.

Based on the data on the damage estimation, it was concluded, that the annual damages are for 3-10 times higher then investment value of the flood protection system, depending on the area and flood prone surface.

Table Ap1-9: Settlements and infrastructural facilities in flood prone area – Sava River in B&H

No of settlements	Population [according to census 1991]	Other local road network [km]	Local road network [km]	Magistral road network [km]	Railway network [km]
89	122,956	183.1	565.5	179.6	26.6

Sava River

Constructed flood protection systems along the Sava River in RS-B&H and FB&H consist of Sava River dikes and dikes along Sava River tributaries in lower (flood prone) part of the course. Flood zones were formed in polders, so called „kasete" which are independently protected against floods. There are sections without flood protection and those are inundation zones along Sava River, thus still remaining (limited) natural function of accepting and transforming part of the flood wave volume. Basically, inundation zones are accepting Sava River flood waters so its retention capacity is relatively small.

Table Ap1-10: Flood prone areas in RS-B&H and B&H

Flood prone area	Area [km^2]	Length of dikes [km]	No of pumping stations	Q_{mean} [m^3/s]	Protected
Dubička ravan – Sava	67.60	19.104	3	13.05	Yes
Lijevče polje – Sava	210.05	31.846	5	32.66	Yes
Srbačko-Nožička ravan – Sava	29.50	19.104	2	11.50	Yes
Ivanjsko polje – Sava	149.59	26.410	1	10.70	Yes
Odžačka posavina – Sava	87.00	26.980	2	11.60	Yes
Srednja posavina – Sava	223.17	52.720	3	29.00	Yes
Semberija – Sava	153.00	26.684	3	27.85	Yes
Total Sava system:	919.91	202.848	19	136.36	Yes
Gomijenica – Sana	9.64	-	-	-	No
Vrbas – Vrbas	55.53	26.225	-	-	Yes
Bosna – Bosna	35.47	27.525	-	-	No
Podrašničko polje – Ponor - Vrbas	11.34	-	-	-	No
Total:	1951.8	53.75	-	-	-
Total B&H	3903.6	256.598	19	136.36	-

Dikes on the right bank of the Sava River are protecting lowland area of Posavina. Protection line is not continuous. Flood protection system is divided into seven polders (sectors):

Dubička ravan (rkm 507.4 – Una River mouth to rkm 475.7) protection line 19.1 km long is continuous and protects area of Dubička ravan, i.e. ca. 6760 ha of agricultural land and Kozarska Dubica town. Dikes are providing flood protection against Sava River flood waters of 100-years return period, with banking of 1.2 m. Beside the Sava River dike protection, 17.5 km of dike is also provided for this polder along the

Una River, from Una River mouth to 27.2 rkm. In urban part of the town, there are bank protections in function of traffic road with shelf retaining wall in total length of 650 m. The remaining right part of the Una dike was constructed as classic dike.

Protection against external upland waters and inland waters is provided by 3 pump stations in total capacity of 13.05 m^3/s. PS Dubica with the capacity of 2.95 m^3/s, is performing pumping from both part of Una River inland waters and rain waters of Dubica. There is also PS for inland waters of direct Sava River Basin - PS Orahova with capacity of 3.0 m^3/s and PS Glavinac I and II, with total capacity of 7.1 m^3/s.

For collection of the external (upland drainage waters) and for collection of the own (inland) waters in zone of protected area, there was canal network constructed, 74.18 km long. Main protection is provided by main boundary canals: Upper boundary canal 8.7 km long, Hatinovac canal 2.57 km long, Lower boundary canal 12.5 km long with network of secondary canals 34.64 km long, Stara Rakovica canal 5.54 km long, with network of secondary canals 4.45 km long and Virovska canal 4.01 km long with network of secondary canals in total length of 2.71 km.

Lijevče polje (rkm 463 – mouth of Jablanica River to rkm 421.9 – Vrbas River mouth), protection line 31.8 km long continues and protects areas of Lijevče polje, i.e. ca. 21,005 ha of fertile agricultural land and Gradiška town. In urban area, dikes are mostly also performing role of traffic roads with shelf retaining wall in total length of 950 m. Dikes are providing protection against Sava River flood waters of 100 years return period, with banking of 1.2 m. Beside this Sava dike, protection for this polder is provided also with a 14.6 km long dike along the left Vrbas River bank – zone of Sava River backwaters, from Vrbas River mouth to 15.0 rkm.

Protection against external upland waters and inland waters is provided by 5 pump stations with total capacity of 32.66 m^3/s: PS „Bainci", capacity 5.0 m^3/s, PS „Dolina", capacity 8.61 m^3/s, PS „Matura", capacity 8.55 m^3/s, PS „Kej", capacity 1.0 m^3/s and PS „Liman", capacity 9.50 m^3/s.

For collection of the own (inland) waters in the zone of protected area, a canal network was constructed in total length of 91.65 km. Main protection is provided by canals: Osorna-Borna-Lijevče - total length of 25.6 km with secondary network 12.6 km long, Lukavac - total length of 3.7 km, with secondary network in total length of 4.6 km, Jurkovica-Jablanica canal - 10.8 km long, with secondary network - 22.43 km long, Topola-Jablanica canal - 11.65 km long, with secondary network of 22.15 km.

Srbačko-Nožička ravan (rkm 419.2 – Vrbas River mouth to rkm 411.8) protection line 19.1 km long is continuous and protects area of Srbačko-Nožička ravan, i.e. 2950 ha of fertile land and Srbac town. Dikes are protecting against the Sava River flood waters of 100-years return period, with banking of 1.2 m.

Protection against external upland waters and inland waters is provided by 2 pump stations in total capacity of 6.00 m^3/s: PS „Povelić" - capacity of 4.0 m^3/s and PS „Ina" - capacity of 2.00 m^3/s.

Beside Sava dike, protection for this polder is provided also by 14.6 km long dike along the Vrbas River-area of Sava backwaters, from Vrbas River mouth to 15.0 rkm. Protection against external upland and inland waters is provided by canals: Povelić canal - 4.86 km long, with a secondary canal network in total length of 3.88 km and main canal Ina - 9.995 km long, with secondary canal network of 13.2 km.

Ivanjsko polje (rkm 373.5 to rkm 341.1) protection line of 26.41 km is continuous and protects Ivanjsko polje, i.e. 14,959 ha of fertile land and Brod town. Dikes are providing protection against Sava River flood waters of 100-years return period, with banking of 1.2 m.

Protection against external upland waters and inland waters is provided by PS „Ivanjsko polje I and II", with capacity of 10.7 m^3/s.

Protection against external upland and inland waters is provided by canals, in total 59.91 km long. Main boundary canal is 17.18 km long and Middle boundary canal 3.87 km long with secondary canal network in total length of 38.86 km.

Odžačka Posavina – FB&H (rkm 334.5 to rkm 306.0 – Bosna River mouth) protection line is 26.41 km long and it is continuous and protects 8,700 ha of fertile land and settlements Svilaj, N. Grad, Gornja and

Donja Dubica and Prud. Dikes are providing protection against Sava River flood waters of 100-years return period, with banking of 1.2 m.

Protection against external upland and inland waters is provided by PS „Zorice I and II” with the capacity of 4.0 m^3/s.

Protection against inland waters is provided by canals in total length of 68.61 km: Srnotače canal, 12.94 km long with secondary canal network in total length of 8.59 km; Kamenica canal, 5.89 km, with secondary canal network in total length of 1.26 km; Berek canal - 8.04 km long with secondary canal network in total length of 1.82 km, Bukovica canal - 11.72 km long, with secondary canal network in total length of 7.79 km and Main collection canal - 6.13 km long, with secondary canal network in total length of 4.43 km. Main canal mouths are also protected with dikes.

Flood protection system for Odžačka Posavina area is organized by forming two polders:

Svilaj polder – area of 1,240 ha is situated between Sava protection dike and Upper boundary canal, Lower boundary canal and Svilaj-Potočani boundary canal. When Sava River flood waters occur, then inland waters are being pumped out by PS Svilaj - capacity 2 m^3/s.

Area between the Sava protection dike, dikes along the Bosna River, boundary canal Svilaj-Potočani and Bosna – Bukovica are creating Odžak – Novi Grad polder. Total surface of polder is 8,900 ha. When the Sava River flood waters occur, inland waters are being pumped out by PS „Zorice I” – capacity 5.5 m^3/s and „Zorice II” – capacity 4.1 m^3/s.

There are following significant structures constructed on this area which form polder:

- Dikes for protection against external waters:
- Along the Sava River – Sava protection dike „Prud-Kadar” – 27.1 km long,
- Along Bosna River - „Prud-Neteka” – 6.9 km long.

Boundary canal for protection against upland waters:

- „Svilaj – Potočani” – 13 km long (gravitation drainage of upland waters into Sava River) with adjacent dikes,
- „Bosna – Bukovica” – 6.5 km,
- Upper boundary canal 2.4 km long,
- Lower boundary canal 3.3 km long.

Sava protection dike is damaged along whole its length because bins and shelters were constructed in the dike body. Dikes are mined, especially watery side and inundations, so that de-mining of terrain is important precondition for rehabilitation works. Lack of maintenance for longer time has caused growth of vegetation, which additionally damages dikes with its roots.

Inland drainage of Odžačka Posavina is performed gravitationally by canal network when water levels in Sava River are low. When Sava River flood waters occur, then they are being pumped out into the Sava River from Odžak – Novi Grad polder (8,900 ha) or Svilaj polder (1,240 ha).

Srednja Posavina – RS-B&H and FB&H (rkm 306.0 – Bosna River mouth to rkm 228 – Tinja River Basin) the protection line, 52.7 km long, is discontinuous and protects 22317 ha of fertile land and settlements Šamac, Orašje and Brčko. Dikes are protecting against Sava River flood waters of 100-years return period, with banking of 1.2 m.

In Orašje urban area, dike is a traffic road, combined with shelf retaining wall in total length of 300 m. In Brcko urban area, there are dikes, with shelf retaining walls in total length of 350 m.

Beside Sava dike, along tributaries, there are dikes constructed in area of Sava River backwaters - Right dike of Bosna River - 1.5 km long and right dike of Tinja River - 1.6 km long.

Protection against upland waters and inland waters is provided by 3 pump stations in total capacity of 29.0 m^3/s: PS „Duga” (Šamac), capacity 6.0 m^3/s, PS „Tolisa”, capacity 15.5 m^3/s and PS „Đurić”, capacity 7.5 m^3/s.

Protection against inland waters is provided by canals in total length of 197.07 km. Eastern lateral canal - 21.79 km long, with secondary network - 14.15 km long, Tinja-Tolisa canal - 15.95 km long with secondary network - 14.15 km long, Dušine canal - 14.23 km long with secondary network - 39.37 km, main boundary canal Svilaj-Potočani - 13.60 km long with secondary network - 20.61 km long.

Land reclamation area of Srednja Posavina is a plane located between Sava, Bosna and Tinja Rivers, and Trebava and Majevica mountains hillsides. There is already a constructed flood protection system on this location.

Flood protection of reclamation area of Srednja Posavina is performed by Sava protection dike 45.7 km long, dike lies between village Krepšić and Bosanski Šamac. 37.66 km of the dike are located in the area of FB&H.

Protection against upland flood waters consists of a constructed system of boundary canals ca. 56 km long, while protection against inland waters is represented by system of canal network.

The area of Srednja Posavina with the total surface of 48,400 ha is, according to the terrain configuration, divided into 4 separate areas, as follows:

Area drained gravitationally:

- polder „Zapad”, surface of 10,244 ha,
- polder „Istok”, surface of 15,546 ha.
- polder areas out of which water is pumped out during the Sava River flood waters:
- polder „Sjever”, surface of 12,300 ha,
- polder „Objeda”, surface of 10,333 ha.

Generally, it can be said that the protection level in the Srednja Posavina area was not on satisfactory level. Dikes were providing various protection level for tributaries, since protection banking varied from section to section, thus not providing the adequate protection level. Partial reconstruction of dikes on urgent sections (the ones with lowest protection level or lowest security of dike slopes) was initiated, due to the above mentioned reason.

Semberija (rkm 203.6 – GOK mouth to rkm 175 – Drina River mouth) protection line 26.684 km long is continuous and protects 15,300 ha of fertile land and Bijeljina town. Dikes are providing protection against Sava River flood waters of 100-year return period, with banking of 1.2 m.

On the section from the Sremska Rača bridge to the Stara Dašnica canal mouth (5.1 km upstream), Sava dike was constructed with banking from 0.1-0.2 m (reconstruction of dike has not been performed). It can be stated, that this section is most critical one in the entire Sava River flood protection system, so reconstruction of this part of protection line will be certainly one of the top priority activities for RS-B&H.

Beside Sava dike along tributary - Drina River, there is left Drina dike in the reach of Sava River backwater, in length of 8.23 km.

Protection against external upland waters and inland waters is provided with 3 pump stations in total capacity of 13.5 m^3/s: PS „Topolovac I and II” - capacity of 9.3 m^3/s, PS „Domuz skela” - capacity of 2.8 m^3/s and PS „Begov put” - capacity of 15.75 m^3/s.

Protection against external and inland waters is provided with canals in total length of 287.8 km: Drina-Glogovac-Dasnica canal in length 9.73 with secondary canal network 2.65 km long; Dašnica canal - 10.89 km long with secondary canal network 5.59 km long; Stara Dašnica - 10.89 km with secondary canal network of 44.02 km; Majevički boundary canal – MOK - 12.81 km with secondary canal network of 25.12 km; Main boundary canal – GOK - 13.69 km with secondary canal network of 35.54 km and Selište canal - 13.52 km with secondary canal network of 57.83 km.

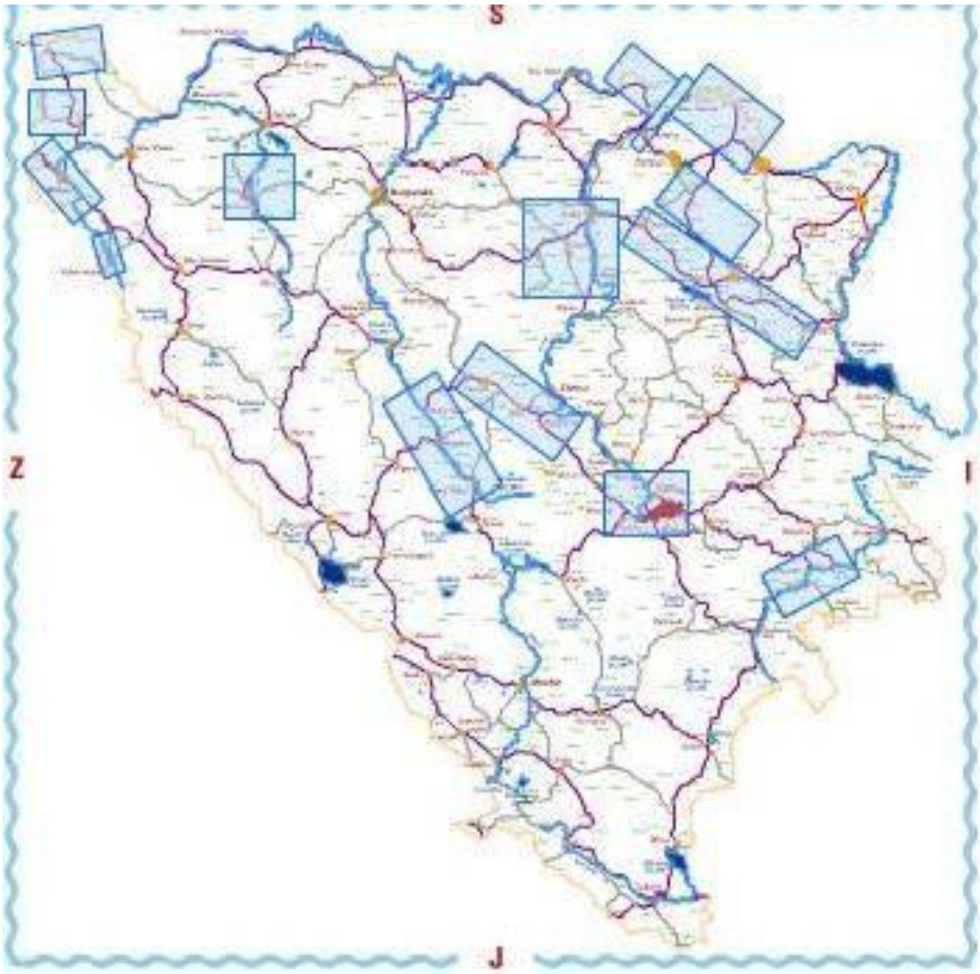


Figure Ap1-29: Flood prone areas in B&H – Sava RB wide-scale

Una River

Protection system against Una River flood waters is constructed on the area of Kozarska Dubica, in zone of Sava River backwaters in total length of 17.5 km. In urban part, right dike of Una River was organized as a shelf retaining wall or a traffic road with, or without concrete shelf retaining walls 0.8 m high. Total length of the shelf retaining walls in urban area is 0.65 km.

From Dubica to Novi Grad there is none protection objects.

In Novi Grad urban area there are protection dikes which are at the same time urban roads combined with shelf retaining concrete walls at the section 2.1 km long. Main purpose of those dikes is protection against Una and Sana River flood waters.

In Prijedor urban area, there is a dike on the right Sana River bank, from Gomjenica River mouth to Sana River old bed in total length of 1.3 km, providing protection against flood of 100-years return period, with banking of 0.8 m.

There are no flood protection structures on the 2.4 km long left river bank in the urban area, so that there is very frequent flooding on the wide area of Tukovi settlement and the entire area on the left river bank.

Gomjenica River is channeled on the section from „Saničani" fishpond to its mouth into the Sana River.

Beside this, upstream from Saničani fishpond, Gomjenica River, as extremely torrential river is flooding entire area frequently and even urban area of Prijedor along the Gomjenica canal.

On Una River area situated in FB&H, inadequate flood protection level is provided for settlements Kulen Vakuf, Bihać, Bosanska Krupa and Bosanska Otoka, as for the coastal agricultural areas on the almost entire water course length.

Flood protection for Kulen Vakuf was partially solved by decreasing of limestone obstacle – sedra (in river bed) located ca. 1.5 km downstream from the settlement. Before the above mentioned obstacle removal, Kulen Vakuf had a great problem dealing with floods, since larger parts of settlement have been flooded for several years.

Bihać is endangered by Una River flood waters and Drobnica water course (coming from Plješevica) flood waters. Drobnica water course was regulated on the section crossing the settlement.

There were no flood protection works performed in Bosanska Krupa and Bosanska Otoka.

Based on the available hydrological data (previously registered maximal flows and water levels), it can be concluded that Una River valley deals with highest flood risk. Up to date, there were no more significant flood protection works and absence of floods in the last twenty years has encouraged construction of structures and settling on river banks. Due to this fact, flood water wave, when occurs, can cause great material damages with possibility of human casualties.

When flood water wave occurs, floods are going to endanger areas downstream from Bihać, more precisely the valley between Ripča and Sokolac and areas nearby Pokojsko polje. Areas in Klokot valley are also endangered, so it is not possible to use great area nearby very interesting big spring Klokot, which is the main potable water source for Bihać.

Areas being flooded by flood waters in Kulen Vakuf are not large, but the problem is that settlement itself is being flooded.

Besides, flood prone are also bank areas of Una River in the middle parts of settlements Bosanska Krupa and Bosanska Otoka, where huge damages could be expected.

Vrbas River

Dikes along Vrbas River, in the area of the Sava River backwaters, are providing flood protection of 100-years return period, with banking of 1.2 m.

But, constructed dikes outside the Sava River impact zone, the left dike in total length of 14.875 km and the right dike in total length of 11.35 km, have no required banking - there is banking of 0.1 – 0.2 m and rehabilitation works are required.

Flooding problems along the Vrbas River in the part going through FB&H occur in Gornji Vakuf and Donji Vakuf.

Project documents are developed for Donji Vakuf for river bed regulation in length of 3.0 km, from the Prusačka River mouth all the way to the exit from the settlement. Up to date, there were river bed regulation works performed on the section from traffic reinforced concrete bridge on the road Donji Vakuf - Bugojno downstream, in length of ca. 1.0 km. Also, there are smaller regulation works performed on Vrbas River tributaries in the area of Donji Vakuf for Oboračka River (in the part crossing the settlement) and Prusačka River, nearby the gypsum factory at the Vrbas River mouth.

Vrbas River bed regulation was performed recently on the curve section going through Gornji Vakuf located upstream of the road bridge, in length of ca. 700 m.

Now, when the flood waters occur in Gornji Vakuf, just smaller areas nearby water course are endangered by floods. Higher damages could be expected in Donji Vakuf, where the planned regulation works have to be finished.

Bosna River

Along the Bosna River, except for the dikes, already described in the Sava River impact area, there are no flood protection systems. For protection of flood prone area, on the section from Šamac to Doboj, it is necessary to construct 19.342 km of the dike on the left river bank and 8.183 km on the right river bank.

Sarajevsko polje is endangered by flood waters of the Bosna River – as the main recipient and its tributaries (Dobrinja, Željeznica, Miljacka, Zujevina and Tilava River).

Since this is a heavily populated area, it is important to protect it against flood waters, since the damages caused by floods are extremely high.

When flood protection works are considered - the ones being performed are just those, connected to the tributary river bed regulation on some individual sections.

On Željeznica River, bed regulation through the settlement Ilidža was performed in length of 1,000 m. River bed regulation was performed on Miljacka River on the part from the mouth into the Bosna River and upstream to the Briješćanski potok (stream) mouth in the length of 1,700 m, on the section where this water course is running beside the urban waste water treatment plant. Miljacka River bed is also regulated at the section going through Sarajevo – from the bridge on Sarajevo - Ploče railway and upstream to the weir on Bentbaša in the length of ca. 10.0 km. For the remaining part of the inter-section, in length of 2,100 m, the project documentation has been prepared.

Criterion of flood waters probability of occurrence of 0.002 (once in 500 years) has been adopted.

Section of the Bosna River running through FB&H is endangered by flooding by its own flood waters, as well as by backwaters caused by Sava River flood waters at the mouth section.

At the Bosna River mouth to the Sava River, there is a dike Prud-Neteka, ca. 6.5 km long. It is an extension of the Sava dike in the area of the Sava River backwaters, and is situated in flood protection system for the Odžak area. Existing dike is not satisfying the required protection level, neither by its height, nor by the length. Final design for rehabilitation of this dike was prepared before the war, with the protection level appropriate for the Sava River waters (1.20 m), but the works were never implemented.

At the considered water course section, from the mouth to the Sava River to the place in Modriča, Bosna River water course is of a lowland type and has no stable course. It is meandering, changing the position of the river bed frequently, thus endangering both, left and right river bank. This meandering of the river course, due to decreased flow velocity, has for a consequence creation of gravel bars along the left or right convex bank, with significant sedimentation quantities, what makes the flow profile narrower, increases water velocity and traction force, and directs stream of the watercourse towards opposite river bank.

Water management structures constructed previously for protection of river banks and river bed stabilization are endangered or completely destroyed.

Those processes are on certain places in such progress, that the course has come to the dike and represents direct threat. The most critical location on the Bosna River left bank is in Prud settlement, where the destroyed river bank lies in the immediate vicinity of the protection dike and its further collapsing endangers directly the dike base and asphalt road Odžak-Prud, and thus also the Prud settlement (when flood waters occur).

War and lack of maintenance for a longer period, have contributed to this status. In this section, this water course forms also the *Dayton Peace Agreement* entity border line, what makes the problem even more complex and postpones the required actions on the river bank protection, what could also have as a consequence the flood protection systems destruction, above all the other damages caused.

At the right river bank, protection line against Bosna and Sava River external waters (backwater) is the road Modriča-Šamac, which is not directly endangered by erosion processes on the right bank since it is on a safe distance.

Drina River

Due to different geo-morphologic characteristics of the Drina River Basin, flood prone areas are significantly smaller compared to those along the Sava River. That is the reason why the protection structures along the Drina River have been constructed just along the Drina River mouth, thus protecting settlements Balatun, Velino Selo, Brodac, Dvorovi and the city of Bijeljina. Protection dikes are mostly constructed in form of roads.

In the area of Zvornik town, flood protection against Drina River is solved by shelf retaining reinforced concrete walls in total length of 1.6 km and in other parts of the town just with bank protections made of stones. Main function of bank protections along the Drina River lower course is protection against erosion, i.e. against the fertile land being taken away.

The only section of the Drina River located in FB&H, is in the area of Goražde and Vitkovići. Entire area of Goražde was flooded in 1896, by the Drina River flood waters. This Drina River flow was significantly higher then the 500-years flood water, which was relevant for the flood protection structures sizing.

By construction of the big Mratinje reservoir (total volume of 880 hm^3) on the Piva River, the Drina River tributary, the flood risk for Goražde has been decreased considerably.

Larger works in Goražde were performed on bank stabilization construction for the purpose of the Drina River bed stabilization.

River bank protection in length of 2,200 m without parapet wall was made on the left bank, thus not providing protection height from waters of 100- and 500-years return period.

Right bank has been protected by a parapet wall in length of 2,700 m and it is not providing adequate protection height for waters of 100- and 500- years return period.

In Vitkovići, left river bank has no protection against floods of 100 and 500-years return period.

Also, there are sections out of the town area, that are flood prone and should be protected. Those are Zupčići and Ahmovići upstream from Goražde, on the right river bank and downstream of Podljutače, on the left river bank and Hubijeri on the right Drina River bank.

4.3. Structure of the drainage system

Constructed flood protection systems along the Sava River in RS-B&H and FB&H consist of Sava River dikes and dikes along the Sava River tributaries in lower (flood prone) part of the course. Flood zones were formed in polders, so called „kasete" which are independently protected against floods.

Protection against external upland waters and inland waters is provided by 19 pump stations in total capacity of 136.4 m^3/s. Total length of the Sava River dikes is 202.85 km.

For collection of external (upland drainage) waters, a system of main boundary canals was constructed, in total length of 223.24 km. For collection of inland waters in zone of the Sava River protected area, a main canal network has been constructed, in length of 230.2 km in total.

Total protected area in Sava River system covers 919.9 km^2.

The above mentioned data on primary flood protection structures in direct Sava River catchement area are given in Table Ap1-11.

Table Ap1-11: Main hydraulic structures for protection against external and inland flood waters

No	Polder (melioraton area)	Water Body (WB)	Canal network				
			Protection of external water – by gravity		Protection of inland water Pumping		
			Main canals (m)	Secondary canals (m)	Main canals (m)	Secondary canals (m)	Name of Pumping Stations and $Q_{inst.}$ (m^3/s)
1.	Semberija	BA_SA_1	Drina - Glogovac 6,900	-			
			Glogovac 2,830	2,650			
			Dašnica 10,890	5,590	canal IV 9,850	28,580	PS „Begov

No	Polder (melioraton area)	Water Body (WB)	Canal network				
			Protection of external water – by gravity		Protection of inland water Pumping		
			Main canals (m)	Secondary canals (m)	Main canals (m)	Secondary canals (m)	Name of Pumping Stations and $Q_{inst.}$ (m^3/s)
			Stara Dašnica 13,860	18,170	canal III 5,510	25,460	put” 15.75
			Majevički lat. canal MOK 12,810	-	canal II 6,810	18,310	
			Main lat. canal GOK 13,690	3,750	canal II 6,450	24,340	PS „Domuz skela” 2.80
			Selište 13,520	-	canal IV 9,420	48,410	PS „Topolov ac I i II” 9.30
2.	Central Posavina	BA_SA_1	Eastern lateral canal (RS) 21,790	-	Ometa - Osatno 7,480	10,730	PS „Đurići” 7.50
					Smrudlja 3,490	9,680	
					Žalta 11,430	14,560	
			Tinja – Tolisa 15,950	7,460	Rain and faecal sewage Orašje		PS „Grad”
					Brijesnica 6,690	-	PS „Tolisa” 13.00
			Canal Dušine 14,230	25,470	GK 4,260	9,640	
					Rain and faecal sewage Šamac (RS)		PS „Šamac” 6.00
		BA_SA_2	Main lateral canal Svilaj - Potočani 13,600	5,420	GK 1 3,950	3,690	PS „Svilaj”
					GK 2 3,000	720	
					GK 3 3,830	-	
3.	Odžačka Posavina (FB&H)	BA_SA_2			Srnotače 12,940	8,590	PS „Zorice I” i „Zorice II” 4.0 m^3
					Kamenica 5,890	1,260	
					Berek 8,040	1,820	
					Bukovica 11,720	7,790	
					Main coll.canal 6,130	4,430	

No	Polder (melioraton area)	Water Body (WB)	Canal network: Protection of external water – by gravity: Main canals (m)	Canal network: Protection of external water – by gravity: Secondary canals (m)	Canal network: Protection of inland water Pumping: Main canals (m)	Canal network: Protection of inland water Pumping: Secondary canals (m)	Canal network: Protection of inland water Pumping: Name of Pumping Stations and $Q_{inst.}$ (m^3/s)
4.	Ivanjsko polje	BA_SA_2	Main lateral canal 17,180	4,960	Mecelj I 4,330	2,330	PS „Ivanjsko polje I i II” 10.70
					Ukrinac II 9,210	-	
			Central lateral canal 3,870		Ukrinac IV 7,410	5,060	
					Canal III 5,560	-	
5.	Srbačko – Nožička ravan	BA_SA_2			Povelic 4,860	3,880	PS „Povelić” 4.00 Vrbas RB
					Main.canal. Ina 9,995	13,200	PS „Ina” 1.50
6.	Lijevče polje	BA_SA_3	Osorna - Borna-Ljevče 25,600	-	Borna 12,600	-	PS „Liman” („Vrbaška ”) 9.50
			Lukavac 3,700	-	Main canal 4,600		
			-	-	Rain and faecal sewage Gradiška		PS „Kej” 1.00
			Jurkovica - Jablanica 10,800	-	Gostinja 8,660	9,890	PP „Dolina” 8.50
					Osorna 3,880		
			Topola - Jablanica 11,650	-	Matura 7,500	10,560	PS „Matura” 8.55
					Brzaja 2,660	1,430	PS „Bajinci” 5.00
7.	Dubička ravan	BA_SA_3	Upper lateral canal 7,800	-	-	-	-
			Hatinovac 2,570	-	Lower later. canal 12,500	34,640	PS „Orahova ” 3.00
			-	-	Stara Rakovica 5,540	4,450	PS „Glavinac ” 7.00
			-	-	Virovska 4,010	2,710	

No	Polder (melioraton area)	Water Body (WB)	Canal network				
			Protection of external water – by gravity		Protection of inland water Pumping		
			Main canals (m)	Secondary canals (m)	Main canals (m)	Secondary canals (m)	Name of Pumping Stations and $Q_{inst.}$ (m^3/s)
			-	-	Rain and feacal. sew. Dubica		PS „Dubica" 2.95
8.	Područje Gomijenice Prijedor	BA_SA_1	Main canal Gomijenica	17,560			
			Sec. canals Gomijenica	10,660			
			Embankments by the Gomijenica	43,100			
			Canal for rain and wastewater	2,970			
			Embankment around the canal for rain and wastewater	2,925			

Table Ap1-12: Agricultural Flooded Areas

River	Area	Agricultural flooded area (ha)		
		P=1/20	P=1/100	P=1/500
1.	2.	3.	4.	5.
Sava	Wider area of Odžak (from Šamac to Svilaj)	4,038.00	4,710.00	5,107.00
Sava	Wider area of Orašje (from Domaljevac to Vučilovac)	8,334.00	8,644.00	9,604.00
Una	Area of the town Kulen Vakuf	158.20	168.80	177.90
Una	Wider area of Bihać (from Ripač to Pokoja)	759.80	1,056.10	1,215.70
Una (P12-P28)	Area of Bosanska Krupa	40.73	92.42	96.49
Una (P1-P12)	Area of Bosanska Otoka	8.92	25.78	38.49
Vrbas	Area of Gornji Vakuf	68.30	109.35	161.80
Vrbas	Area of Donji Vakuf	8.30	31.51	89.86
Bosna	Part of Sarajevsko polje from Plandište to Reljevo	424.80	457.50	458.70
Bosna	Riverine area of the Bosna River downstream of Modriča up to Šamac	377.00	1,362.00	1,772.00
Drina	Area of Goražde and Vitkovići	32.70	37.60	132.20
Glina	Riverine area of the Glina River in FB&H and downstream of Glinica and Kladušnica River	194.08	211.70	228.60
Korana	Riverine area of Korana River in FB&H and downstream of Mutnica River	231.80	268.70	329.50

River	Area	Agricultural flooded area (ha)		
		P=1/20	P=1/100	P=1/500
1.	2.	3.	4.	5.
Spreča 1	Valley downstream of reservoir Modrac (from Lukavac to Brijesnica)	2,613.90	2,802.90	3,096.40
Spreča 2	Valley upstream of reservoir Modrac (from Osmaci to Spreca confluence in reservoir)	3,517.00	4,121.00	4,240.00
Tinja	Area of the Srebrenik town	238.10	274.40	295.80
Tinja	Wider area of Tinja settlement	34.80	50.80	70.30
Usora	Valley of Usora in FB&H from Kaloševici to mouth in Bosna R.	949.20	1,282.80	1,319.70
Sana	Wider area of Sanski Most	333.60	468.55	595.75
Lašva	Travnik town and area of Dolac	4.00	18.50	23.10
Lašva	Area of Vitez	218.00	415.00	575.80

4.4. National flood prediction and warning practices

The role of the Entity Hydro-meteorological Institutes is defined by a *Law on Ministries* and *Water Law*. Two departments of HMS take part in flood forecasting and monitoring: the Hydrology Department and the Meteorology Department.

The HMS Forecast Office is responsible for the collection and distribution of hydrological and meteorological data to: Ministry of Agriculture, Forestry and Water Management, Public Water Companies and to the Entity centre for information.

Data, forecasts and warnings are presented in special bulletins and transmitted via e-mail to Ministry, and all other participants in flood defence activities.

The data available on the territory of B&H at the moment are not sufficient for the warnings and forecasts, because automatic water gauges with real-time data are not conected to information system yet. Information network for early warning system is under construction. Completion of information system with 99 automatic real-time stations for water level mesuring, and some parameters for water quality measuring, is expected at the end of 2009.

At the moment, only daily and short-term meteorological forecasts are available.

The HMS issues warning and forecasting information, providing following data:

- Daily information on rainfall, air and water temperature, water level, water flow and ice, originating from hydrological and meteorological domestic network;
- Daily information on water levels, water flows;
- Warning about the development of flood on the upper river parts;
- Forecast on extreme water level (height and time of appearance).

5. Long-term flood protection strategy

Preparation of *Long term Strategy for flood protection in RS-B&H* is just in initial phase. Basic guidelines for this *Strategy*, given in *Action plan for flood risk management*, are also not yet adopted.

It was planned to adopt those documents by the end of 2012.

Considering the size of flood prone area in B&H, as well as the available resources (human and financial), the implementation of planning documents, and especially the long-term ones, is going to require considerable time.

Problems that should be covered by those documents are as follows:

- Providing of required financial and human resources for regular and good maintenance of existing protection structures, according to appropriate technical criteria and standards. Present maintenance level of existing structures does not provide adequate safety level in flood protection. Maintenance of inundation areas is not performed by organized and adequate measures. Just the main dikes, floodgate structures and pump stations are maintained.
- Providing adequate financial resources required for reconstruction of existing and construction of new flood protection structures will be a long term process, as long as the construction of those.
- Providing required financial funds for construction of planned accumulation on Drina and Vrbas River that would be able to decrease flood waves, is also a big task of long term flood protection strategy that fits quite well into the development strategy of EPC B&H.
- Preparation of a simulation module for optimization of the HPPs on the Sava River tributaries operation with the purpose of maximizing effects in flood protection.
- Based on flood risk assessment, it is necessary to make flood protection measures rank list for the purpose of maximizing effects of measures.
- Improving international cooperation on collecting, exchange and processing of meteorological and hydrological data, as well as on simulation module preparation for entire Sava River Basin for the purpose of defining possible harmful effects and improving flood wave forecasting, as well as damages that could be caused.
- Renewal and rehabilitation of systems of flood protection structures
    - Finalizing flood protection line to meet the level, appropriate for the protected area importance and the volume of damages that could be caused by possible floods by flood waters of certain range of occurrence;
    - Enlarging and construction of protection structures against flood waters from urban area with 30,000 inhabitants.
- Water regime control and new approach in water zones organization
    - Planning and construction of multipurpose systems where flood protection structures effects are manifested on wider area and on larger part of important economic and other structures;
    - Analyzing of solution concept and possibility to apply other prevention measures (operational, regulation) that would mitigate flood damages;
    - Determination of priority areas for actions with the purpose of identifying endangered flood prone areas, flood danger maps and flood risk maps.
- Establishing hydrologic forecasting system and system of early warning
    - Establishing data base and flexible monitoring system with the purpose of delivering data on water levels, flows and precipitations and establishing flow forecasting module and accumulation management module.
- Coordinated competence and role of other participants in flood protection and public awareness
    - Coordinated participation of all relevant participants and specialized services as well (meteorological, accumulation users, spatial planners, services for protection and rescuing people) in the water management process on potentially endangered areas.
- Mitigating erosion processes
    - Participation of representatives from water management sector in Erosion protection Program and Strategy;
    - Implementing general measures against erosion;
    - Rehabilitation of erosion damages.
- Solving the inland waters issue
    - Coordinated activities of water and agricultural sector on rehabilitating existing reclamation systems and enabling their development, according to plans and agricultural consumers needs and needs for settlements protection against inland waters negative effects.

- Solving the problem of lack of water
    - Taking participation of water sector in preparation of Plan of activities for lack of water.
- Coordination of water and soil management system
    - Mutual participation of water and soil management sectors in management plans for those resources.
- Prevention and readiness in case of disasters – collapsing or overflowing of dams
    - For new dams and protection dikes construction, one should strictly apply regulations, rules and technical standards. Preparation of studies of status and stability of constructed structures in function;
    - Preparation of Early warning Studies for warning people on flood wave occurrence, and installation of automatic measuring stations and water level indicators for all bigger water courses and downstream from dams.

6. Possible impacts on present flood protection level

Estimated most important factors that can decrease flood protection system safety on the Sava River Basin area in B&H are as follows:

- Flood waters increasing trend due to anthropogenic factors impact in the basin (disconnecting of flow and decreasing existing inundation, construction activities on inundation terrains).
- Uncontrolled felling of forest especially in upper parts of river basin (those that generate flood wave) can have big harmful effects on downstream area.
- New regulations which as a consequence have decrease of natural retention areas in the Sava River Basin or decreasing the flood wave travel time on tributaries, can also have harmful effects on downstream areas.
- It is well known that retention areas in Srednja Posavina have crucial impact on flood wave size and duration time on downstream area of the Sava River Basin. It was shown, that complete disconnection of retentions would increase the Sava River peak discharge nearby Sremska Mitrovica for over 10 %.
- Existing natural inundation along Donja Drina River (downstream of Zvornik dam) have significant impact on the Drina River flood waters. Construction of dikes on both river banks (as planned under hydro-power use project) could increase $Q_{1\%}$ at the mouth for 5-10 %.
- Down to the Drina River mouth, the flood wave is coming before the Sava River flood wave. Uncontrolled accumulation management on Drina River and in retention areas in Srednja Posavina can bring to superposition of wave and make the conditions in downstream areas worse.
- Climate change, analyzed under LISFLOOD project, can have significant harmful or positive effects on water regime in the Sava River Basin.
- Lots of structures and systems are damaged, thus remained without proper function and organization of activities before, during and after flood event is disturbed. Material basis and human capacities in all institutions engaged in flood protection has weakened. What is especially important, they have such small financial resources for prevention, investments and post flood activities.
- In the last decade, significant process of coming down to valleys and constructing the structures in the water courses vicinity is evident. Especially in the last ten years, number of very valuable objects have been constructed in inundation of natural river beds, what makes the situation even more complicated. Due to that reason, and especially because of neglecting maintenance activities-cleaning of the river beds - we have critical conditions in a lot of river valleys in B&H. If appropriate measures are not undertaken emergently, we can expect huge material damages and even human casualities.
- Planning of space use in river valleys with strict appreciation of flood prone areas level of impairness becomes very important. In some zones, where residential and economic structures are

constructed, it is not possible to provide adequate flood protection level in short period, due to the lack of investment funds or unprofitable investment actions on bigger protection systems or structures. Required technical parameters should be identified on those areas (specific altitude etc.) for temporary implementation of strategy „living with floods".

Detailed analyses conducted through the *Study of present flood protection level estimation for Federation B&H*, clearly indicates that flood protection problems in FBA are considerable, very specific and complex. It was concluded that they have to be solved systematically, gradually, studious and with appropriate optimal strategy application.

Situation is especially complex since lot of structures and systems are largely damaged, thus do not have appropriate functions and because organization of activities before, during and after floods is quite disturbed. Financial base and human capacities have weaken in all institutions engaged in flood protection and especially important is the fact they have such small financial resources for prevention, investments and post flood activities.

In conditions when work on solving flood protection problems was almost minor and when this sector dealt with such small financial resources for investment activities on flood protection rehabilitation and development in last ten years, it is useful to have this kind of Study since strategy for solving this issues was largely defined within.

Under this strategy it is meant that based on appropriate basis and conducted analyses, it would be possible to:

- Select program of optimal flood protection development for the territory of entire FB&H;
- Make selection of location for priority investment interventions, and
- Identify optimal technical parameters for structures and flood protection systems that should be constructed in the next period.

Based on collected hydrological data, conducted hydrological and hydraulic analyses, defined flood prone areas for individual considered areas and based on cadastre of flood protection structures (if exists) it was determined that existing structures are not satisfying basic flood protection convention requirements for various ranges of flood water occurrence. Areas without flood protection system are in more difficult situation, of course.

In the last decades, process of constructing the structures in the water courses vicinity is evident. Especially in last ten years, number of very valuable objects have been constructed in inundation of natural river beds, what makes situation even more complicated. Due to that reason and especially because of neglecting maintenance activities-cleaning the river beds, there are critical conditions in lot of river valleys in B&H. If appropriate measures are not undertaken urgently, huge material damages, even human casualties, can be expected.

Considering through this Study all potential material damages that could occur in agriculture and on structures on considered endangered areas, it can be generally concluded that flood risk is significantly high.

There is another unfavorable circumstance in relation to flood risk. After dry period in last twenty years or so, without significant floods, we have just entered wet period proved by great floods in FB&H in 2001 and 2002 and floods in central and west Europe (Prague, Dresden, earlier in Frankfurt, etc.) then in Poland, Russia, Austria etc. with human casualties and material damages expressed in tens of billion of Euros.

Well known strategies were used in approach used for solving flood protection problems. Based on that, considered areas could be divided into three groups: polders in Posavina, in valleys of water course regulation, dikes or, as potential possibility, control of natural water regime by accumulation construction and in case of karst fields, construction of outlet structures for water in fields. Flood protection systems already exist in Posavina and they require rehabilitation (consequences of war and lack of maintenance) and reconstructed in order to provide required protection level for Sava and Bosna River flood waters. Alternative technical solutions (active and passive protection) were proposed in water course valleys – depending on individual conditions and in several cases mixed as most rational and realistic solutions.

Third alternative solution, whose strategy was estimated as optimal, was considered on water courses where construction in upper river basin was considered in previously prepared documents. But due to complete uncertainty in sense of those structures implementation in recent time, this alternative to the technical solution was considered just as one of the possible solutions.

There are no alternatives for karst fields when strategy in approach of solving the problem of flood protection was considered. Fields are closed and it is all about solution of water evacuation from field and it can be solved just by construction of outlet structure – tunnel with required adjacent structures. Task is being even more complex when we consider problem of such discharged waters acceptance on lower horizons. Alternations were performed with outlet structure capacity in function of flood protection effect in the karst field.

Selection of flood protection solution concept was performed, based on techno-economic analyses, including environmental aspect of solution.

Under this Study, econometric analyses were performed for the first time (as the study level allowed) for all considered areas in FB&H and based on this, along with other relevant factors (technical solution, ecology), selection of proposed flood protection concept for each individual area was performed.

When we consider ecological/environmental impact on selection process, one has been guided by the attitude of consistent application of sustainable development strategy, according to which it should be taken care that negative environmental impacts are minimized and positive maximized.

Zoning of priorities (for groups) was performed based on results of conducted analyses, according to the level of the flood threat and the volume of possible damages, based on investment effects in several areas (econometric analyses). Ranking was performed based on criteria of inland profitability rate, which is considered as appropriate method for implementing analyses on the study level.

It is important to point out the importance of this Study for water management, as one of the foundation documents, which represents first, but at the same time very important step in flood protection rehabilitation and improvement in FB&H. Complex analyses were performed (including econometric ones) for the endangered areas for the first time for entire territory of FB&H, based on high quality maps, considering existing status of structures and flood protection level, size of potential damages, selection of appropriate strategy, proposal of measures (technical solution option), concluded with conducting economic-financial analyses and proposing priority actions, based on achieved results.

This Elaborate is going to enable development of long term time schedule for rehabilitation and flood protection structures and systems construction. In that way, it will be possible to abandon previously applied strategy to act with investment, just after flood is being registered, although the possibility of two extremely high water wave occurrence is relatively small.

Planning and use of space in river valley with strict respect of flood threats level for individual areas becomes very important. Study gives a lot of valuable data that can serve as good base for spatial plans preparation, whose scope will cover area threaten by floods. In some zones where residential and economic structures are constructed, it is not possible to provide adequate flood protection level in short period, due to the lack of investment funds or unprofitable investment actions on bigger protection systems or structures. Required technical parameters should be identified on those areas (specific altitude etc.) for temporary implementation of strategy „living with floods”.

For good management and flood protection management, as part of integral water management, it is necessary to provide information, planning and financial base for timely and quality recommendations for competent institutions for decision making and implementation activities and also it is necessary to provide institution in charge for integral water management with qualified personnel.

After the foreseen presentation of this study is implemented in municipalities and cantons threaten by floods, results of this study could be used for preparation of spatial and town planning documents, for preparation of flood protection plans on municipal and cantonal level and finally for the preparation of *General flood prevention plan* (*Official Gazette of FB&H,* Nr. 3/02).

Appendix II: Flood Management in Croatia

BRIEF CHARACTERISATION, REVIEW AND ASSESSMENT IN FLOOD MANAGEMENT IN SAVA COUNTRIES

- Sava River Basin in the Republic of Croatia -

HRVATSKE VODE

VGO SAVA

Služba razvitka i katastara

Ulica grada Vukovara 220

10 000 Zagreb

February, 2009

1. Basic information on flood prone areas

The Sava Basin in Croatia covers 25,770 km^2 (27.0 % of the whole basin). In Croatia, the Sava flows in the length of 510 km and for the most part constitutes the border with Bosnia and Herzegovina (313 km).

The largest tributaries of the Sava River in Croatia are the Kupa (10,236 km^2), Una (9,368 km^2), Bosut (2,913 km^2), Česma (2,890 km^2), Ilova – Pakra (1,816 km^2), Orljava (1,616 km^2) and Krapina (1,244 km^2).

Parts of the Kupa River in Croatia constitute the state border with Slovenia (total length of the 100 km), while parts of the Una River constitute the state border with Bosnia and Herzegovina (total length of 130 km).

The Sava River and its major tributaries, the Kupa and Una, have snow-rain regime, with high discharges in the period October-December as well as spring discharges (due to snow melting and spring rains). Distinct discharge minimum is in August and September.

The average annual flow of the Sava River at its entry into Croatia (Jesenice) amounts to ca. 300 m^3/s, and to ca. 1,200 m^3/s at its exit from Croatia. At its entry into Croatia the Sava River has torrential character with huge differences between minimum and maximum flows. The highest flow of the Sava at its entry into Croatia happened during a huge water wave in 1990 – the flow amounted to 3,607 m^3/s, which is some 70 times larger flow than the absolute minimum in that profile. The torrential character of the river decreases gradually due to the flattening of water waves in vast lowland retentions of the central Sava River Basin. The ratio of absolute extremes at the exit from Croatia is considerably less (around 18). The highest flow of 4,161 m^3/s at the Županja station was recorded in as far back as 1970.

The Sava River Basin is asymmetric and dispersed, which is why the occurrence of extreme high waters is slightly reduced. The central part of the Sava valley is a depression, which is a particular topographic phenomenon. The average height of the basin in the upper section, in the Zagreb profile, is 540 meters above sea level; on the downstream section, near Gradiška, the average height of the basin is 420 meters above sea level, and 570 meters above sea level at the mouth. These data on the average height along the river point to a certain anomaly, but also to a clear conclusion that this central area is predisposed to flooding.

The area along the Sava River, from Zagreb and Karlovac in the west to Gradiška in the east is commonly known as the Central Posavina.

It comprises of approximately 250 km of the Sava River flow and 140 km of the Kupa River flow, with the accompanying lowland area of about 400,000 ha. This is the region where the large urban centres of Zagreb, Sisak and Karlovac, together with about 400 smaller settlements have developed, which are now home to more than one third of Croatian population, where important traffic corridors have been built, and substantial agricultural surfaces established. For the most part, however, this area has retained its original, natural characteristics even today. It is a very heterogeneous area, with varying degrees of development, population density and lifestyle, starting from the Croatian capital of Zagreb and a number of other, fast developing towns to depopulated rural areas where natural environment is used in traditional ways for mere survival. Parts of the area are protected in accordance with laws and conventions on nature protection (Nature Park and a Ramsar site of Lonjsko polje, a Ramsar site of Crna Mlaka, ornithological reserves of Rakita and Krapje Đol, etc.).

2. Flooding in the Sava River Basin

High flows from the mountainous western part of the basin (the Sava River Basin in Slovenia) and larger right-hand tributaries, wide valleys of lowland watercourses, major cities and valuable assets in potentially threatened areas make Sava River Basin very vulnerable to floods. It is estimated that floods potentially endanger 19 % of the Sava Basin in Croatia (Figure Ap2-1, Table Ap2-1). It can be claimed that the solution of flood protection remains one of the dominant water management tasks as well as the prerequisite for the success of other activities.

Figure Ap2-1: 100-year flood areas in the Sava River Basin prior to the construction of the flood protection system

Table Ap2-1: List of poential flood prone areas in the Sava RB

List of potential flood prone areas in the Sava river basin			
No.	River Basin	River name	Floodprone area (ha)
1	Sava	Sava	326700
2	Sutla	Sutla	730
3	Krapina	Krapina	10510
4	Česma	Česma,connection channel Zelina-Lonja-Glogovnica	54740
5	Ilova	Ilova,Toplica Bijela,Pakra	13930
6	Orljava	Orljava,Londža, Veličanka	16300
7	Una	Una	2220
8	Kupa (without Glina)	Kupa, Odra, relief channel Kupa-Kupa	60570
9	Glina	Glina	5260
Total floodprone area			490960

3. Historical flood events

Natural floods that occur in the Sava River Basin are divided into five main groups:

- river floods caused by heavy rainfall and/or sudden snow melt,
- torrential floods on smaller watercourses caused by short-duration rainfalls of high intensity,
- floods in karst fields caused by heavy rainfall and/or sudden snow melt, as well as insufficient permeability of natural sinkholes,
- internal waters floods in lowland areas,

- ice floods.

Also possible are artificial floods caused by dam/embankment breaks, activation of landslides, inadequate structures, etc.

The largest floods of the Sava River and its major tributaries recorded during the last one hundred years were the following:

- the Sava River floods: in 1923, 1925, 1926, 1933, 1964, 1966, 1970, 1974, 1990 and 1998,
- the Sutla River floods: in 1974, 1987, 1989 and 1998,
- the Krapina River floods: 1974, 1989 and 1998,
- the Kupa River floods: in 1939, 1966, 1972, 1974, 1996 and 1998,
- the Dobra River floods: 1966, 1998 and 1999,
- the Česma River floods: 1969, 1970 and 1973,
- the Ilova River floods: 1951, 1960 and 1972,
- the Una River floods: in 1955, 1970, 1974 and 2004,
- the Orljava River floods: in 1951, 1972, 1987 and 1998,
- the Bosut River floods: in 1926, 1970 and 1974.

The floods that occurred in the first half of the 20th century did not cause major damage because river valleys were not populated yet. The development of the City of Zagreb is a typical example of the development of a town on the area along a river, thus at risk of floods. Back at the beginning of the 20th century Zagreb was situated in higher regions, and hence did not suffer any major damage from the river's floods, even at times of great floods, such as those that occurred in 1923, 1925 and 1926. In the 1920-ies the construction of dikes along the Sava River began, the city spread into the plain, and came closer to the Sava. After World War II, in the 1950-ies and later on, the city spread to the right bank and grew to become a city of nearly a million. The areas beyond the banks became more and more populated, the value of construction was high, and the system of dikes constructed until then gave impression that the protected area was safe.

Unfortunately, the price of ignoring the risk of construction in the floodplain soon became evident, during high water in October 1964. The flood protection system – constructed only partially, inadequate, inconsistent and vulnerable – was not able to withstand a sudden extreme inflow from the Sava River Basin in Slovenia. Around 6,000 hectares of the immediate urban area were flooded, as well as the settlements of Zaprešić, Samobor, Dugo Selo, and Velika Gorica. The consequences of the flood were disastrous: 17 human lives were lost, and material damage was extensive. Some 150,000 people were evacuated, and tens of thousands of people lost their homes.

The towns of Karlovac and Sisak, as well as many settlements along the Kupa River lying between those two towns paid a price of living near a river in December 1966. Around 5,500 housing units were flooded on the area of the town of Karlovac, and a total of 15,600 hectares on the territory of the then municipality of Karlovac, the Karlovac-Zagreb motorway, and many other roads.

Even though the Sava waters were released into the Lonjsko polje retention storage by blowing up the Sava dike near Dubrovčak, assisted by the high waters of the Kupa River, the Sava spilt over the dike in Sisak, flooding the lowest parts of the town.

The middle and lower parts of the Sava River Basin suffered great damage from the Sava flooding in January 1970. Due to a great inflow of the Sava's right-bank tributaries, the Sava flooded an area of 222,640 hectares, inflicting huge damage to agricultural and urbanized areas beyond the banks. Since the high waters of the Sava and the Bosut Rivers coincided, a large part of Biđ-Bosutsko polje was flooded.

The most widespread flooding in the Sava River Basin was recorded during a high water wave in October 1974, when 270,000 hectares were flooded.

The flooding was caused by a simultaneous and long-lasting heavy inflow from almost the entire Sava River Basin. The Sava River spilt over and breached its dikes on several sections downstream of Zagreb (on 7 locations). The dikes were blown up on 3 locations in order to release excess water into Odransko, Lonjsko polje and Mokro polje retention storages. Despite that, numerous villages lying beyond left and right Sava River banks (from Oborovo to Stara Gradiška) were flooded. Even though the erected temporary embankments, in some places as high as 120 cm, managed to protect the area beyond the Sava's dikes on the section from Stara Gradiška to Županja from immediate flooding, intensive rainfall and seepages beneath dikes caused great damage to the agricultural areas of Crnac polje, Jelas polje and Biđ polje.

An area of 9,200 ha was flooded in the Krapina River Basin and 14,600 ha in the Kupa River Basin. The Krapina River and its tributaries flooded Zlatar Bistrica, Pojatno, Bedekovčina and other smaller settlements, the Zagorje highway, and the Zaprešić-Kraljevec railroad. The Kupa flooded parts of Karlovac, Ozalj and 12 smaller settlements, while its tributaries flooded Ogulin, Slunj, Glina and Topusko among the larger settlements and numerous smaller settlements.

Even though flood protection works had been carried out as far back as 1963 in the Una River-Sava River node and on the section of the course of the Una River towards Hrvatska Dubica, parts of the villages of Tanac and Uštica were flooded. The Una River also flooded parts of the town of Dvor.

The floods described above, particularly those in Zagreb in 1964 and in Karlovac and Sisak in 1966, prompted the development of an integrated solution for protecting the lowland area along the Sava from floods, known as the Central Posavina. Reconstruction of the existing dikes and construction of new ones started soon after the 1964 flood. From the mid 1960-ies to the mid 1980-ies, around 40 % of the planned regulation and protection water structures of the Central Posavina flood protection system were constructed. They protect important parts of river valleys, enable certain control of the high water regime of the Sava River and its tributaries, as well as safe use of significant agricultural areas.

That is the reason why the high water waves that occurred in the Sava River in the last thirty or so years have not caused any major flooding, thus confirming the efficiency and functioning of the constructed system. We should particularly stress successful evacuation of a high water wave in the Sava River in November 1990. The height of this wave on the section of the Sava from Radeče, Slovenia to Podsused, Croatia exceeded the disastrous flood wave of 1964. Whereas the 1964 flood had had casualties and inflicted enormous material damage to Zagreb, the 1990 water wave passed through Zagreb and further downstream without any serious damage because the Odra relief canal was activated. Damage was recorded only on the stretch from the Podsused bridge to the mouth of the Sutla River, because there was no flood protection system there.

In the basins of Sava's tributaries flood protection systems are incomplete or do not even exist. In the last twenty years, larger damage was caused by the flooding of the Kupa (1996 and 1998), Krapina (1989), and Gornja Dobra Rivers (1999).

The flood protection solution in the Kupa River Basin is integral part of a comprehensive flood protection solution in the Central Posavina. The constructed structures provide protection from mere 5-year high water to 50-year high water. That is why higher water waves, like the one in November 1998, significantly flooded urbanized and agricultural areas (12,000 ha).

Flooding is also frequent in the town of Ogulin, in whose protection from floods the Gojak hydropower system plays an important role. In July 1999 the flood wave of the Gornja Dobra River occurred during the overhaul of the Gojak HPP, leading to disastrous flooding in Ogulin.

Watercourses in the Krapina River Basin are regulated for 10-25-year high water, but their capacity is even lower because of insufficient maintenance. Many parts of the basin are not even protected from 10-year high water.

The gravest consequences were left in the wake of the water wave of the Krapina River and its tributaries in July 1989. An area of 5,600 hectares was flooded, as well as the settlements of Krapina, Donja Stubica, Zabok, Marija Bistrica, Stubičke Toplice, Kupljenovo, Zaprešić, and some other smaller settlements. The Zagorje highway and a number of local roads were flooded; road traffic was virtually closed, as well as rail traffic between Zagreb and Zagorje.

4. Existing Flood Management

4.1. Commanding responsibilities

Flood protection in the Republic of Croatia has been regulated under the *Water Act* and the *Water Management Financing Act*. The competent bodies for flood protection issues are: the Ministry of Regional Development, Forestry and Water Management as a state administration body and Hrvatske vode as a state agency.

The roof state-level water management document, the implementation of which is provided for under the *Water Act*, is the *Water Management Strategy*, which is prepared by Hrvatske vode and adopted by the Croatian Parliament (*Official Gazette, No. 91/08*). It is a long-term planning document which is systematically harmonized with changes occurring in the water system and socio-economic development, and is also mutually harmonized with the *National Physical Planning Strategy*, *Environmental Protection Strategy*, the state-level forest management planning documents and the planning documents of inland navigation system development.

The basic aim of the *Water Management Strategy* is the establishment of an integrated and coordinated water regime on the national territory, which includes the following:

- Provision of sufficient quantities of drinking water of adequate quality to the population,
- Provision of the required quantities of water of adequate quality for various economic purposes,
- Protection of people and assets against floods and other adverse effects of water,
- Protection and improvement of the status of water and of aquatic and waterdependant ecosystems.

The UN/ECE *Guidelines on Sustainable Flood Prevention*, the principles of EFD and *Action Programme for Sustainable Flood Protection in the Danube River Basin* are included in the *Water Management Strategy*.

Protection of people and assets against floods and other adverse effects of water includes construction and maintenance of water protection structures, carrying out of protective works and flood protection measures.

Operative flood defence on state waters is conducted according to the *State Flood Defence Plan* adopted by the Government of the Republic of Croatia, whereas the carrying out of operative flood defence on local waters is based on flood defence plans for catchment areas, which are adopted by county assemblies on the basis of proposals put forward by Hrvatske vode.

The flood defence plan includes:

- a list of measures to be taken prior to, in case of, and after flood occurrence;
- areas, sectors, and sections of watercourses, and protective water structures subject to flood protection measures;
- water levels at which certain sectors initiate preparation, regular defence, emergency defence or emergency status;
- regulations on the equipment and materials to be prepared for flood defence;
- a list of companies which are to conduct flood defence;
- a list of experts involved in flood defence (names, duties, authorities and responsibilities);
- methods of informing the public on occurrences and measures during flood defence;
- survey of ice protection measures on watercourses.

On the basis of these plans, operative flood defence on state waters is established in river basin districts, and within those in counties, various sectors and on different sections of watercourses. Operative flood defence on local waters is established in catchment areas, and within those in counties, various sectors and on different sections of watercourses.

In the Sava River Basin, operative flood defence is carried out by Hrvatske vode: the Department of Protection against Adverse Effects of Water (Hrvatske vode Head Office), Service for protection against adverse effects of water within the Water Management Department for the Sava River Basin District (Sava WMD), and by employees of Croatian Water branch offices in the catchment areas - 12 water management branch offices (WMBO). The Sava River Basin district flood defence center is located in the seat of river basin district in Zagreb. County flood defence centers are located in county seats. Field flood defence centers for river sections and water watchmen areas have also been established. Activities of protection against adverse effects of water in the Sava River Basin are carried out by approximately 100 permanent employees of Hrvatske vode, with the additional 70 persons temporarily employed when necessary. Interventions during operative flood defence are carried out by the Ministry-approved, court-registered legal entities using their own machinery, equipment and skilled labour. Materials and basic tools for operative flood defence are provided by Hrvatske vode.

4.2. System and state of the flood protection structures

The existing protection systems in the Sava River Basin are very complex and comprise of a large number of regulative and protective water structures. Along national watercourses there are around 1,600 km of protective dikes, whereas local watercourses are protected by around 200 km of protective structures. In cooperation with various water and land users, multipurpose reservoirs were constructed with the total volume of 73 hm^3 and mountain retention storages with the total volume of 2,5 hm^3; partially also 5 large lowland retention storages in the Sava River Basin (Lonjsko polje, Mokro polje, Kupčina, Zelenik and Jantak) with the total volume of 1.590 hm^3. Two basic water distribution facilities, Prevlaka and Trebež1 weirs are built. Canal network in the Sava River Basin is rather developed. There are three major relief canals (Odra, Lonja - Strug and Kupa - Kupa) with a total length of about 65 km, connective canals Zelina - Lonja - Glogovnica - Česma and Ilova - Pakra, and a total of about 534 km of lateral canals for collecting mountain waters on the margins of flood protected areas.

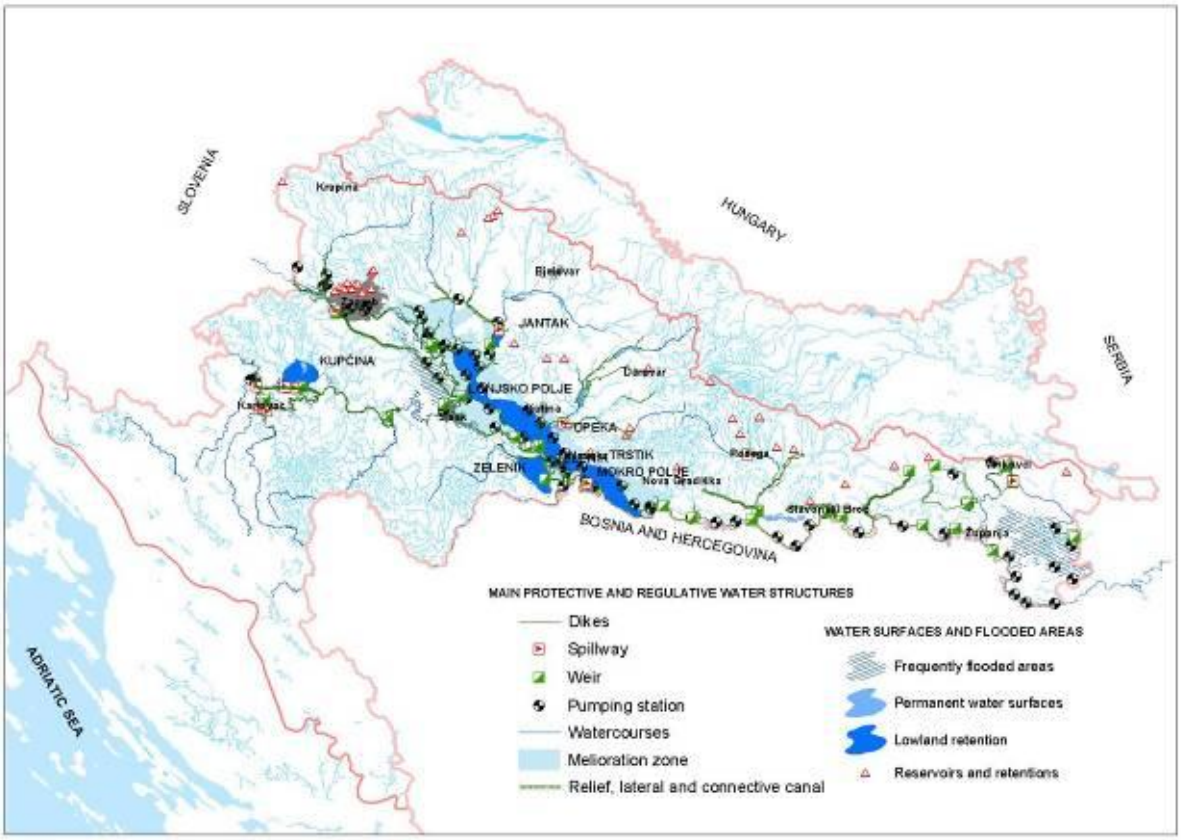


Figure Ap2-2: Status of flood protection in the Sava River Basin in Croatia

The history of works carried out for the purpose of flood protection in the Sava River Basin goes back to the 19th century. As it was already mentioned, floods in 1960-ies, were instrumental in the development of the integrated Central Posavina flood control plan, within the framework of a wider regulation of the Sava River Basin. Economic objectives dominated the concept: the protection of existing goods, the provision of space for new developments (urbanization, agriculture, traffic) and the creation of conditions for navigation, hydropower production, raising of water levels in minor watercourses and other water uses in the area.

The proposed solution was based on the imitation of centuries-old natural flood processes in the Central Posavina, whose lowest parts are naturally suitable for flood retention due to their geomorphologic characteristics (pronounced natural depressions), and also due to the way in which the flood defence system of the Sava was developed - starting downstream and continuing towards the upstream section. Downstream of the town of Stara Gradiška the flood control system was already defined by dikes constructed along the Sava. It was therefore necessary to adopt the postulate that any works or interventions in the Central Posavina area must not deteriorate the flood status of the lower Sava. It is important to point out that this solution has a positive effect on our neighbouring countries, Bosnia and Herzegovina and Serbia, which have to guard against a significantly reduced amount of access water from the Sava.

The core of the solution were the flood storages in the Kupa and Sava lowlands, of sufficient retention capacity for the relief of excess flood waves. 58,800 ha of flood storages were planned (Lonjsko polje, Mokro polje, Zelenik, Kupčina), which provided the required level of protection. Apart from the flood storages, the system comprised of three relief canals (Odra, Lonja-Strug, Kupa-Kupa), which made up for the limited flow rate on some stretches of the main watercourses and redirection of excess water into flood storages, and about 15 structures for water distribution control under flood conditions. Additionally, there were earlier constructed dikes along the larger watercourses, which had to be continuously rebuilt and reconstructed, if necessary. The system was generally designed to provide protection from the predicted 100-year flood, whereas larger urban centres, i.e. Zagreb, Karlovac and Sisak, were defended from 1000-year flood.

The intention was to achieve the maximum possible reduction of floodplains and the complete control of floods. All other parts of the area had to be protected and made suitable for urban or economic purposes through water management works

The implementation of the designed solution soon started and continued until the mid 1980-ies, after which the construction activities generally came to a halt. During 1980-ies and 1990-ies new concepts were analyzed and developed in accordance with the principle of sustainable water management, which takes into account a wide spectrum of needs, including protection of natural ecosystems and maintenance of biodiversity.

The basic difference between the modified solution and the original project lies in the manner how the flood storages of Lonjsko and Mokro polje are established. The original solution anticipated these areas with full flood control, maximally reduced surfaces and higher depths of retained water. The modified solution proposed the following crucial changes:

- enlargement of floodplains at Lonjsko polje by approx. 7,000 ha;
- free flow of relieved flood water along Mokro polje;
- lowering of maximal water depths in the flood storages.

Another important change was related to the design and functioning of the Lonja-Strug canal, which was originally planned along the Lonjsko and Mokro polje in the length of 105 km. At its upstream end, the canal receives waters fed at the sluices of Prevlaka and Palanjek, then waters of numerous minor tributaries, and finally at Stara Gradiška transfers these waters back to the Sava River. The rationalized solution uses the functionality of already constructed canal parts. However, a further construction of this rather sizeable structure, accompanied by high embankments, is abandoned. The natural watercourses of Lonjsko and Mokro polje are used for transport of fed water. The filling of flood storages occurs gradually, and thus achieves the return to almost natural flow regime through these areas. Following figure presents the modified solution of the Central Posavina.

Figure Ap2-3: Rationalized flood control solution

These changes contribute to a better protection of natural values, and are an important step towards environmentally acceptable flood management. Part of the lowland, with an area of about 50,000 ha, was proclaimed the Nature Park of Lonjsko polje in 1990 and is also recognized as a Wetland of International Importance (Ramsar site) since 1993.

The value of constructed Central Posavina defence system facilities is approximately 40 % of the total value of the investment. With the partially constructed Odra, Lonja–Strug and Kupa–Kupa canals, Jankomir, Prevlaka and Trebež control facilities, reconstructed and newly built dikes along the Sava and its tributaries, and existing and newly formed Lonjsko polje and Mokro polje retention areas, the existing retention capacity (natural state) has been increased and the achieved positive effects already have impact on the high water regime. The works carried out have provided essential protection for the vital parts of river valleys, a certain degree of high water control of the Sava and its tributaries, and safe use of valuable agricultural land.

War in Croatia in the early 1990-ies caused massive damages to the previously constructed systems, and generally stopped their development. A delay in the implementation of the previously planned projects was also influenced by economic transition, which changed priorities of water management's principal partners in the field of multipurpose regulation and use of water and land, energy generation and agriculture. Simultaneously, due to general economic conditions, in the period 1990 - 2005 water management had not at its disposal even the funds necessary for regular maintenance of the existing systems. The consequence of such conditions is the current unfavourable status of protection against adverse effects of water, which is characterized by high flood risks in some areas, numerous incomplete or inadequately maintained protection and amelioration systems, and only partially repaired war damages (particularly with regards to de-mining of the mine fields). Croatian water management, in accordance with its current potentials, systematically makes strong efforts to improve currently status of flood protection in Croatia, with priority activities aimed at flood protection of insufficiently protected towns and settlements.

The following table shows current status of flood protection in the whole Sava River Basin.

Table Ap2-2: Present protection status

List of potential flood prone areas in the Sava river basin				Present protection status	
No.	River Basin	River name	Floodprone area (ha)	Protected area (ha)	Unprotected area (ha)
1	Sava	Sava	326700	261100	65600
2	Sutla	Sutla	730		730
3	Krapina	Krapina	10510	3500	7010
4	Česma	Česma,connection channel Zelina-Lonja-Glogovnica	54740	19200	35540
5	Ilova	Ilova,Toplica Bijela,Pakra	13930	11600	2330
6	Orljava	Orljava,Londža, Veličanka	16300	4750	11550
7	Una	Una	2220	2220	
8	Kupa (without Glina)	Kupa, Odra, relief channel Kupa-Kupa	60570	14340	46230
9	Glina	Glina	5260		5260
Total			490960	316710	177450

Data presented in the table show that the flood protection works carried out have helped reduce the areas potentially flooded by 100-year high water of Sava River and its tributaries by 65 %.

Most has been done in the protection against 100-year high water of the Sava River. The only area left unprotected is an area along the Sava upstream of Zagreb towards the Slovenian border (5,700 ha) where protective dikes have not yet been erected. The area of 59,900 ha is retained to receive floodwater (Lonjsko polje with Žutica, Mokro polje, Opeka, Trstik, and Zelenik retention storages). The safety level of the constructed protective system along the Sava River and its tributaries up to the backwater effect of the Sava waters is shown in Table Ap2-3. Figure Ap2-4 shows the overview map of floodprone areas along the Sava River. It can be seen that 72 % of the entire levee length meets the criterion of 1.20-meter freeboard above the design 100-year flood. Other parts have a lower safety level than required: 20 % of the levees have freeboard of 0.60-1.20 m, while 8 % or 51 km of levees are at the same level or only 60 cm above 100-year high water of the Sava River. These are old levees built under different protection criteria: parts of the Sava levee protecting Biđ-bosutsko polje, shorter sections of the left-bank Sava levee from Trebež to Dubrovčak, and shorter sections of the right-bank Sava levee upstream of Sisak. Reconstruction of the above sections is planned, and for some of them project documents have already been prepared.

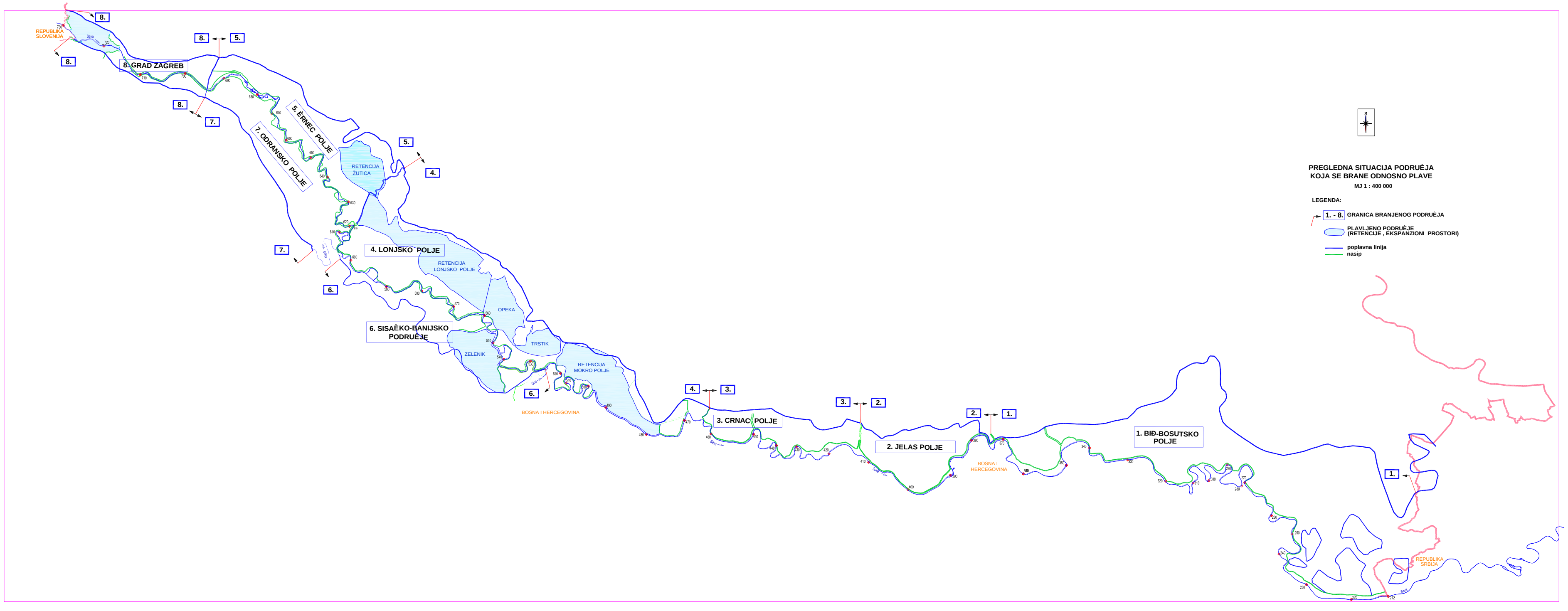


Figure Ap2-4: Flood prone areas (protected and unprotected) along the Sava River

On the area of the City of Zagreb the height of the levees is such that they provide protection from Sava's high waters of 1000-year return period. However, even though 19 mountain retarding basins have been constructed, parts of Zagreb are at risk from torrents from Medvednica Mountain. Zagreb is protected from Mt. Medvednica torrential streams only from floods of 20 to 50-year return periods.

The entire potentially flooded area in the basins of larger tributaries in the event of a flood of 100-year return period covers an area of 1,643 km^2. Only 36 % of the area is protected, while on other sections protective structures have not been constructed yet or their level of protection is significantly lower – they are mostly protected against floods of 5 to 25-year return periods. It is mostly larger settlements and roads that are protected, while agricultural areas continue to be frequently flooded.

Towns and settlements are also inadequately protected from torrential mountain streams, particularly settlements in region of Hrvatsko Zagorje, Požeška kotlina and in the Dobra River Basin.

Table Ap2-3: List of important floodprone areas in HR

List of important flood prone areas (protected and unprotected) in the Sava river basin										
No.	Floodprone area name	River name	Area (ha)	Protected (Y or NO)	Total length of levees	Length of levee with freeboard above the Base Flood Elevation (1 %-annual-chance flood event)			Openings through the levee system	Comments
						1.20 m	0.60-1.20m	0.00-0.60m		
					km	km	km	km		
1	Biđ-Bosutsko polje	Sava	112700	Y	139.1	126.1		13.0		
2	Jelas polje	Sava	20300	Y	41.7	41.7				
3	Crnac polje	Sava	17700	Y	52.0	42.8		9.3		
4	Lonjsko polje	Sava	36600	Y	136.8	112.8	6.3	17.7	spillway, weir	Košutarica, Trebež
	Lonjsko polje	Sava	39000	N						Lonjsko,Mokro polje,Opeka and Trstik retention storages
5	Črnec polje	Sava	29400	Y	73.4	14.8	53.3	5.3	weir	Prevlaka
	Črnec polje	Sava	5700	N						Žutica retention storage
6	Sisačko-banijsko područje	Sava	7300	Y	58.4	34.1	21.3	3.0		
	Sisačko-banijsko područje	Sava	15200	N						Zelenik retention storage
7	Odransko polje	Sava	28900	Y	75.9	30.7	42.2	3.0	spillway	Jankomir
8	Grad Zagreb	Sava	8200	Y	54.4	54.4				
	Grad Zagreb	Sava	5700	N						
TOTAL			326700		631.6	457.4	123.0	51.2		

4.3. Structure of the Drainage System

Amelioration drainage systems are constructed for the purpose of rapid and efficient drainage of excess water from agricultural and other lowland areas. The prerequisite for their construction is previous protection of amelioration areas from the floods of external waters.

The total amelioration area of the Sava River Basin is identified as a lowland and gently rolling area below the top topographic limit of 200 meters above sea level. Its total area is 955,334 hectares, which accounts for around 42 % of the total basin area on the territory of the Republic of Croatia. The area can be divided into 22 natural, traditional or design units defined by the constructed structures of watercourse regulation and flood protection systems (Figure Ap2-5).

Amelioration drainage systems are fully or partially constructed on 348,363 hectares, on 74,919 hectares of which land drainage and regulation are covered by a combined drainage method (surface drainage + underground drainage + agricultural engineering measures). An impressive scope of the constructed structures and amelioration works carried out, particularly intensive in the 1980-ies e.g. a network of main first- and second-category amelioration structures in the length of around 1,696 km – does not have a proper impact on agricultural production within the area and in general on the drainage of the area. The reason for this is, in addition to certain uncompleted systems, poor condition of the constructed structures, which is the result of insufficient funds required for the regular maintenance of the structures, i.e. unresolved land use structure within the constructed systems. In order to improve the efficiency of these systems, a program of clearly required construction measures by which the functionality of basic amelioration structures would be increased by the year 2015 has been prepared. Under that program, Hrvatske vode would have to invest HRK 116 million in the rehabilitation of amelioration watercourses and canals of first and second category, reconstruction and construction of pumping stations, with annual maintenance costs of HRK 50.95 million.

Table Ap2-4: Data on the functionality of the constructed amelioration drainage systems and on the area of the unconstructed part of amelioration areas

Administrative units in the Sava River Basin	Size of the melioration area	State of development level for the melioration drainage systems				
		Surface drainage				Combined drainage
		Completely developed	Partially developed	Total	Undeveloped	
	ha					
BANOVINA	138955	6400	15500	21900	117055	4500
BRODSKA POSAVINA	73802	71900	1902	73802	0	13215
KUPA	71050	8018	0	8018	63032	2008
KRAPINA	17100	0	5400	5400	11700	0
ZELINA-LONJA	33100	7877	150	8027	25073	2161
LONJA-TREBEŽ	48450	38757	0	38757	9693	11035
SUBOCKA-STRUG	25950	0	17000	17000	8950	5000
ČESMA-GLOGOVNICA	123170	19668	0	19668	103502	2008
BIĐ-BOSUT	169810	137931	31879	169810	0	24775
ŠUMETLICA-CRNAC	52520	26709	8444	35153	17367	7171
ILOVA-PARA	61100	3015	0	3015	58085	2046
ORLJAVA-LONĐA	50450	5311	14689	20000	30450	1000
VGO SAVA	865457	325586	94964	420550	444907	74919
GRAD ZAGREB	89877	22777	12200	34977	54900	-
Sava Basin	955.334	348363	107164	455527	499.807	-

Table Ap2-5: Data on the constructed amelioration structures

Administrative units in the Sava River Basin	Canal length				Pumping stations		
	class I canals	class II canals	Total class I +class II canals	Total class III +class IV canals	Number of pumping stations	Total capacity	Total power
	km					m3/s	kw
BANOVINA	15	63	78	1216	4	20.2	2060
BRODSKA POSAVINA	184.92	202.07	386.99	2519.44	4	32.4	2790
KUPA	81.14	55.2	136.34	222.74	0	0	0
KRAPINA	0	106	106	254	0	0	0
ZELINA-LONJA	30.86	54.9	85.76	312.22	2	2.1	132
LONJA-TREBEŽ	132.3	155.32	287.62	1268.78	9	36.3	2310
SUBOCKA-STRUG	89.4	39.1	128.5	230.68	4	8.05	700
ČESMA-GLOGOVNICA	66.88	67.64	134.52	522.19	1	2	150
BIĐ-BOSUT	510.05	182.11	692.16	5024.4	9	46.76	2846
ŠUMETLICA-CRNAC	86.7	237.32	324.02	987.41	4	32.3	2732
ILOVA-PARA	0	39.67	39.67	89.65	0	0	0
ORLJAVA-LONĐA	197.51	81.48	278.99	212.99	0	0	0
VGO SAVA	1394.76	1283.81	2678.57	12860.5	37	180.11	13720
GRAD ZAGREB	301.8	190.1	491.9	-	3	18	1080
Sava Basin	1696.56	1473.91	3170.47	-	40	198.11	14800

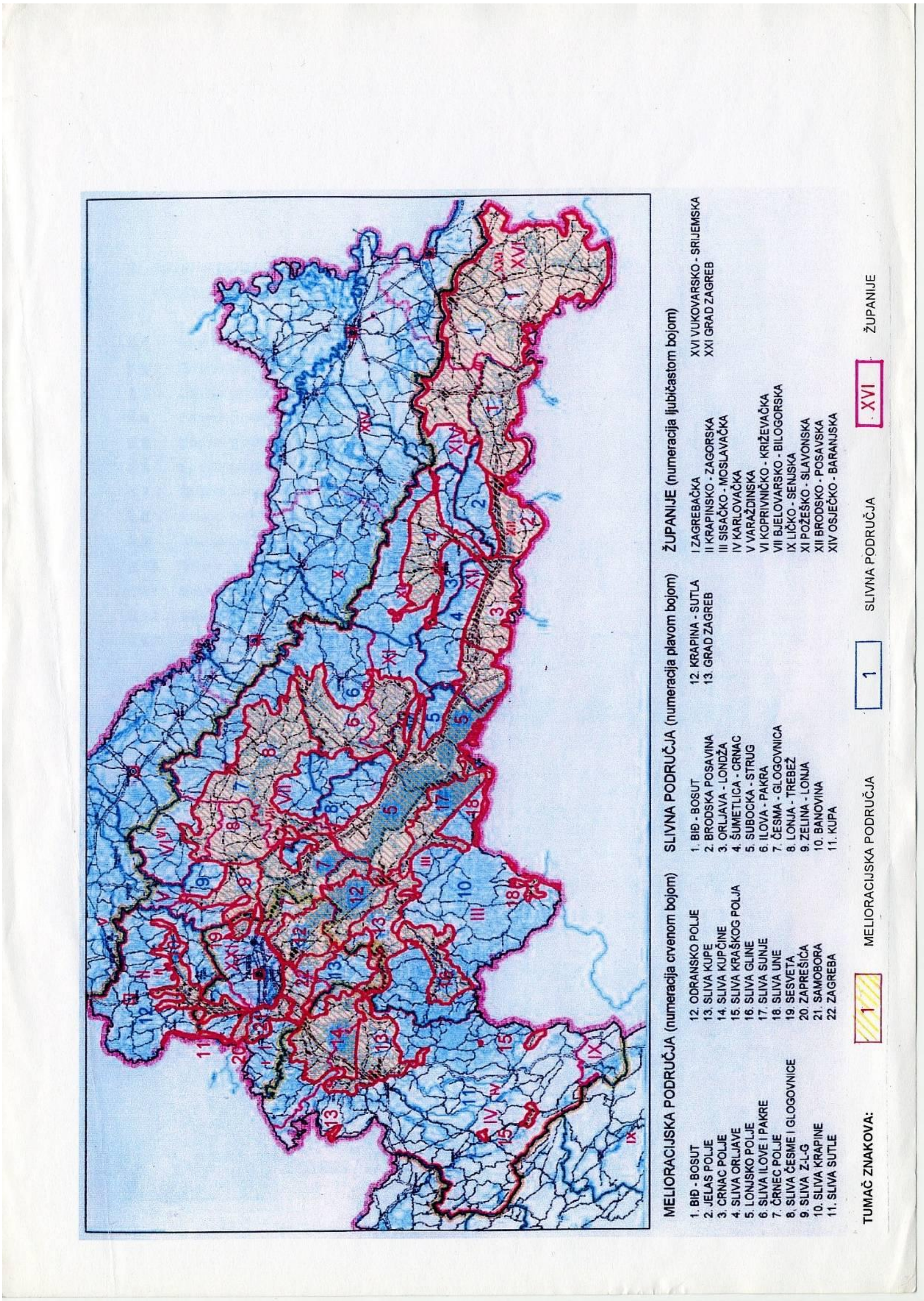


Figure Ap2-5: Amelioration areas and administrative units in the Sava River Basin

4.4. National Flood Prediction and warning practices

For more efficient operative flood defence Hrvatske vode has established a system of on-line monitoring stations. Today, on line data system consists of 103 automatic stations in Croatia. 62 of them are in the Sava River Basin. The real-time monitored water levels can be found on the website http://www.voda.hr or at the same address when using „wap” mobile phones as well as on the teletext of Croatian Television (HTV).

Data on water level obtained from field stations are used for the preparation of forecasts of arrival, propagation, and transformation of a flood wave.

Systematic forecasting of water levels and flows in the Sava River Basin is conducted by Hrvatske vode at the majority of water gauge profiles in the Sava and Kupa Rivers, which are relevant for the implementation of flood defence measures under the *National Flood Defence Plan*.

For the part of the Sava River downstream Jasenovac, it is still not possible to make reliable hydrological forecasts due to the lack of information from the part of Sava River Basin in Bosnia and Herzegovina.

For internal use of Hrvatske vode comprehensive hydrologic data collection and disemenation system is beeing built takeing in consideration not only flood monitoring, forecasting and warning but other requirements of water management as well.

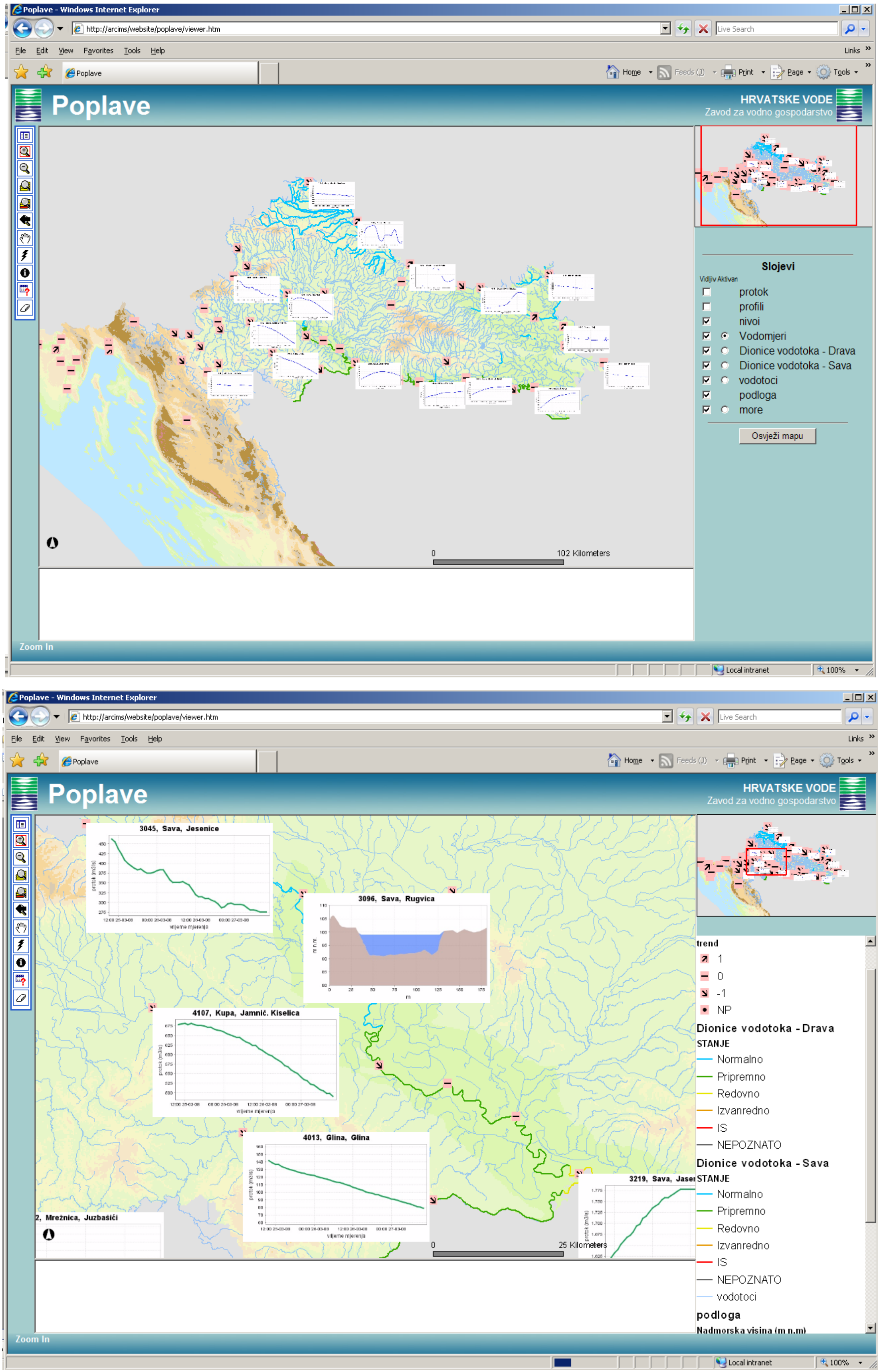


Figure Ap2-6: Hydrologic data collection and disemenation system of Hrvatske vode

In the next phases, improvement of the existing flood forecasting models and inegration of their results is expected as well as integration of on line meteorological data. After the test phase some products will be availabile for other users (National Protection And Rescue Directorate) and public.

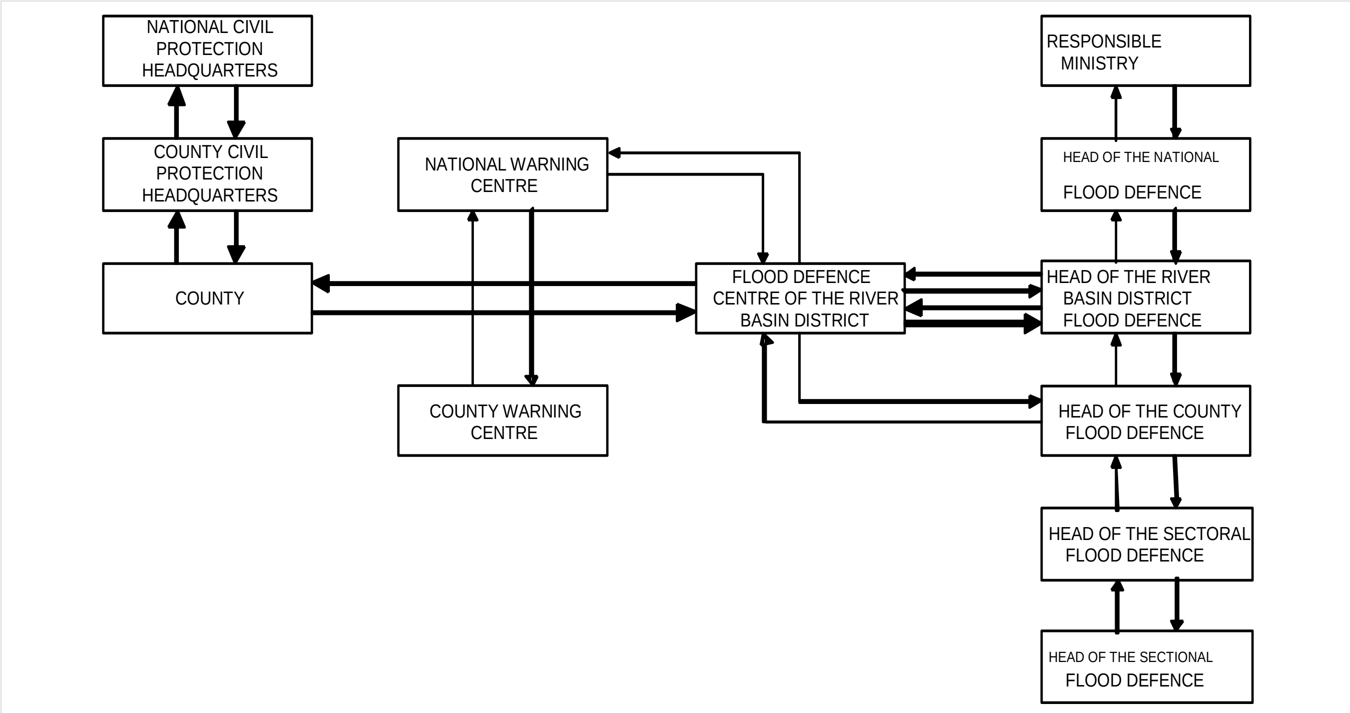


Figure Ap2-7: Scheme of Operative Flood Defence

5. Long-Term Flood Protection Strategy

For the protection of people and assets against floods, the *Water Management Strategy* defines the following targets:

Coordination of authorities and responsibilities. Improvements in flood protection require the application of integrated, systematic, effective and cost-efficient measures together with preventive structural and non-structural activities. The prerequisite for their application is active and coordinated participation of all actors, the water management sector, and of: protection and rescue services, meteorological and hydrological service, health service, physical planning experts, local and regional self-government units, users and managers of multi-purpose water-storage reservoirs, farmers, foresters, environmentalists, scientists and researchers, the media, higher education institutions, interested non-governmental organizations, and citizens and entrepreneurs on the areas potentially at risk.

Identification of the areas for priority action. From the point of view of health, safety and environment, the priorities of first order in preventive flood protection are the areas of large and larger towns with more than 30,000 inhabitants, potentially at risk from major rivers - the Sava and Kupa Rivers. The priorities of second order are other towns and settlements along the Sava, Kupa and Una Rivers. The current dikes at critical sections along major rivers will be gradually reconstructed and extended. Priority works related to further development of the Srednje Posavlje (Central Posavina) system will be carried out. Other activities will be implemented in the order defined on the basis of various criteria, including: the number of defended population, prevented material and other damage, general water management significance, estimated investment costs, etc.

Implementation of structural measures. When planning preventive flood protection measures it is necessary to select an appropriate combination of river basin regulation in order to maintain or increase natural retaining capacities of land and vegetation, and structural measures which affect the reduction of flood wave peak flows and protection of the area behind the riverbanks. It is necessary to bring into balance the demands for further urbanization and economic exploitation of space and land use needs to slow down the run-off and retain water in the basins. Water management systems have to be planned as multi-purpose systems in order to rationalize water and land use, and account has to be taken of their economic justification and their impacts on the environment and nature.

Operative flood defence. A flood defence plan will be drawn up for an integrated water system. Operative flood defence on boundary watercourses is carried out together with competent services from the neighbouring countries.

Monitoring and forecasting of weather phenomena. The efficiency of operative flood defence will be improved through the modernization of current systems for the monitoring and forecasting of weather phenomena (on-line monitoring stations, radars, satellite images, forecasting models, etc.), and current communications systems. Flood forecasting models will be developed, officially adopted and regularly updated, and on international rivers they will be developed and coordinated in the framework of competent international bodies. Systematic monitoring and forecasting of weather phenomena and timely provision of relevant information to the competent services for operative flood defence are the responsibility of hydrological and meteorological services.

Water estate management. The problems related to water estate will be regulated through the adoption of a regulation harmonized with other regulations related to land use, which will define precise criteria for addressing all controversial issues. The water estate on unregulated inundation areas and on large lowland retarding basins of protective flood defence systems will be resolved by the zoning of the terrain and graded restrictions in land use. The priority of the water management sector is the demarcation of the water estate, its registration into land registers, and entry into physical plans, and systematic monitoring of the status of the water estate.

River basin regulation. Maximum flood wave flows, particularly in small- and medium-sized basins, can be partly reduced by preserving and improving the natural retaining capacities of land, watercourses, and floodplains. Natural wetlands and floodplains in the basins therefore need to be preserved, and, where possible and economically justified, reconstructed or extended.

Financial insurance of property against uncovered flood risks. Flood protection systems provide protection against high waters only for those return periods for which they were dimensioned. Flood risks will therefore be more precisely defined. The water management sector is responsible only for the flood damage caused by flood waves of shorter return periods than those for which protective systems had been dimensioned, under the condition of sound maintenance. The remaining risks will be covered by the owners and users of property with appropriate financial insurance. The state should support such insurance. The condition for the implementation of this measure is the existence of flood risk maps and flood damage maps at the areas under potential risk.

The role of other agents in preventive flood protection. The protection and rescue services will ensure proper functioning of regional and local public alert systems; organize the work of the civil protection; prepare strategic, tactical and operative disaster management plans, and, if needed, organize appropriate exercises; organize the evacuation of inhabitants in case of need; organize emergency medical aid to affected population; and organize post-flood terrain recovery. Other agents in flood protection are: science-and-research institutions, the media and interested NGOs with active and constructive participation in the processes of development of planning documents.

The above mentioned targets will be achieved through gradual implementation of a series of activities and measures.

It is possible to estimate implementation costs of individual measures, and to make proposals about the manner of their implementation. The usual 15-year investment cycle has been selected as the planning basis of the goals that can be reasonably achieved.

In the Sava River Basin, it is anticipated that 87-percent functionality of flood protection systems will be achieved by the end of 2023, and 100-percent functionality by the end of 2038. This goal will be achieved through gradual implementation of repair and reconstruction works, and through the implementation of developmental projects.

The average annual investments in the repair, reconstruction, and development of protective systems during the next thirty years will amount to around HRK 170 million.

In order to bring the current systems for the protection against adverse effects of water into a functional condition (repair and reconstruction), it is necessary to invest around HRK 3.8 billion.

Developmental projects for systems for the protection against adverse effects of water require investment in the total amount of around HRK 1.3 billion.

Regular economic and technical maintenance of current protective systems require an investment of HRK 489 million per year.

Appendix III: Flood Management in Serbia

FLOOD MANAGEMENT

- Sava River Basin in the Republic of Serbia -

REPUBLIC OF SERBIA

MINISTRY OF AGRICULTURE, FORESTRY AND WATER MANAGEMENT
REPUBLIC DIRECTORATE FOR WATER

INSTITUTE FOR THE DEVELOPMENT OF WATER RESOURCES „JAROSLAV ČERNI" - BELGRADE

February, 2009

1. Introduction

The Serbian stretch of the Sava River, 209 km long, has characteristics of a typical alluvial watercourse flowing through wide lowlands. Between the mouth of the Drina River (km 177) and the state border with Croatia (km 209) the river is the border line between Serbia (RS) and Bosnia and Herzegovina (B&H).

Sava River tributaries at the Serbian section are:

- The Drina River (right tributary), the most significant both by catchment area (about 19,500 km^2 or 20 %) and flow. The catchment is shared by B&H (37 %), Montenegro (31.5 %), Serbia (30.5 %) and Albania (1 %). There are many transboundary rivers in this river basin (Drina, Lim, Cehotina, Crni Rzav, Beli Rzav). Drina makes the border between B&H and Serbia in its downstream reach. The Drina River Basin is hilly and mountainous, with the average altitude 934 m a.s.l. (from the altitude of 75.4 m a.s.l. at the mouth to over than 2,500 m a.s.l. at the highest mountains).
- Several small right tributaries with catchments located only within the Serbian territory. The largest one is the Kolubara River with catchment area of 3,639 km^2, emptying into the Sava River at km 27.
- The Bosut River at the left with catchment area of 2,913 km^2 whereas 70.7 % belongs to Croatia and 29.3 % to Serbia. The Bosut River flow regime is completely controlled and depends on the outflow from the Vinkovci reservoir (Croatia) and the operation mode of the sluice and pumping station Bosut located at the mouth.

Main characteristics of the Sava River Basin are given in Figure Ap3-1 (river network and administrative units), Figure Ap3-2 (topography), and Figure Ap3-3 (land use).

As presented on Figure Ap3-3, land uses in valleys of the Sava River and tributaries are different. Numerous rural and urban settlements (the most important being Belgrade, Obrenovac, Šabac and Sremska Mitrovica) are developed in the riverine lowlands along the Sava, which are predominantly used for agriculture. Number of settlements in the Kolubara River catchment is smaller, and agricultural land use is dominant. Forests and barren land prevail in the Drina catchment, and a number of settlements is small. The Bosut catchment area is mainly covered by forests. Due to the land use, the most significant are flood risks in the Sava lowlands, while hilly and mountainous areas are endangered by torrent floods and associated phenomena.

The most famous flood in the Sava River Basin occurred in November 1896, as a consequence of an extreme and enduring rainfall in the Drina catchment. According to later consideration, the return period of the event was 10,000 years. This catastrophic flood event initiated construction of flood defence system along the Sava River.

Flood defence system along the Serbian Sava River section is not continual. There are still natural floodplains capable to store and attenuate a part of flood wave (Table Ap3-1, Figure Ap3-4). Due to considerably different geo-morphological characteristics of the Drina River Basin, floodplains are significantly smaller than along the Sava River.

Numerous floods were registered in 20th century on the Sava River (1915, 1924, 1932, 1940, 1944, 1952, 1962, 1970, 1974 and 1981), with permanent increase of flood volume and water levels (e.g. the maximum recorded water level at Sremska Mitrovica station was increased by 1 m in 100 years). The flood wave in October 1974 was the consequence of simultaneous high waters at the Drina and middle Sava. In the springtime 1981 the riparian land along the Sava River was endangered because the Sava flood arrived at high levels at the mouth to Danube. The newest episode was in spring 2006, when only short section in the mouth area was endangered by the Danube backwater. Flood events on smaller rivers in the Kolubara and Drina catchments are more frequent. Especially frequent floods occur on the Jadar River, the most downstream right tributary of the Drina.

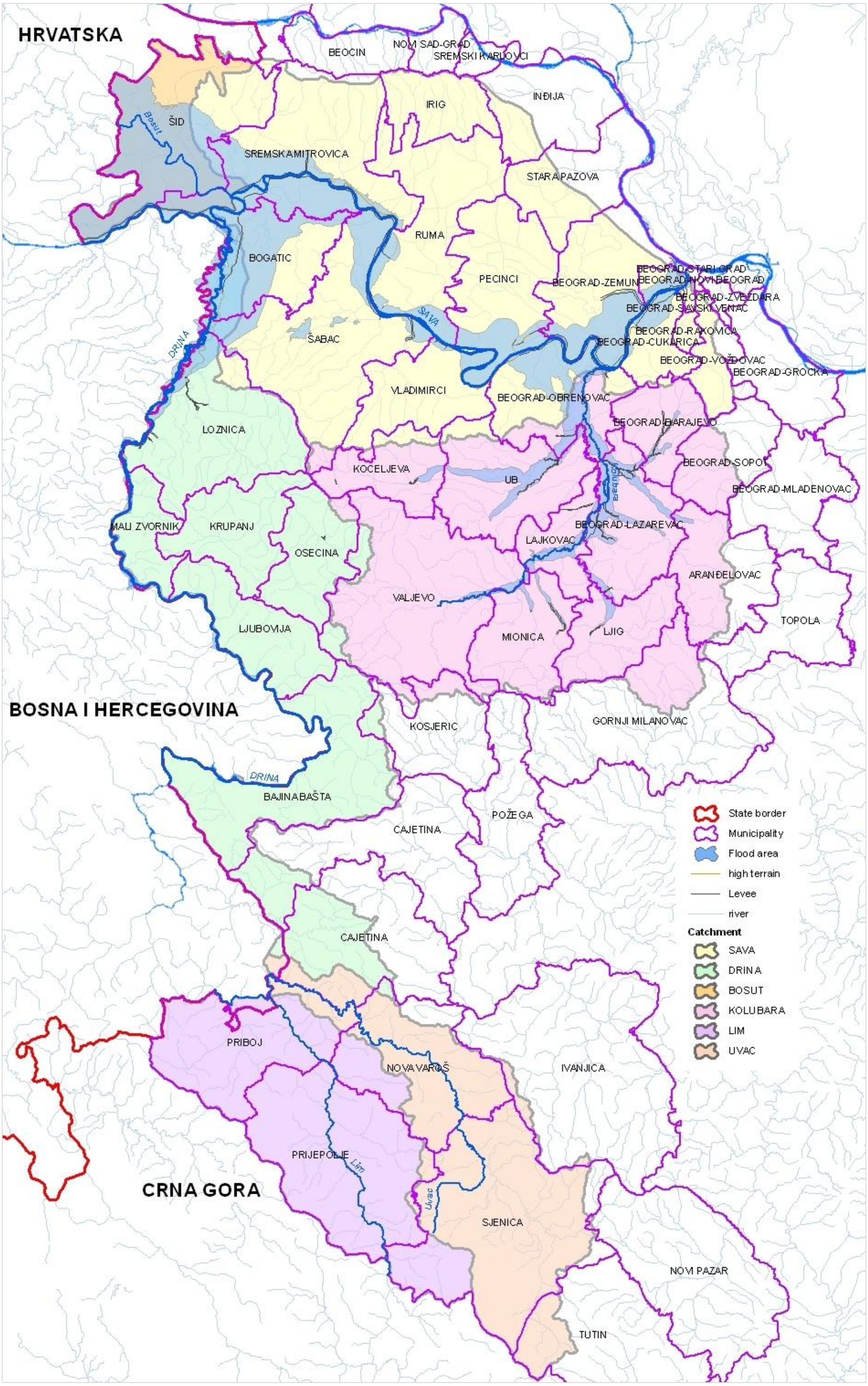


Figure Ap3-1: River network and administrative units in the part of the Sava River Basin in Serbia

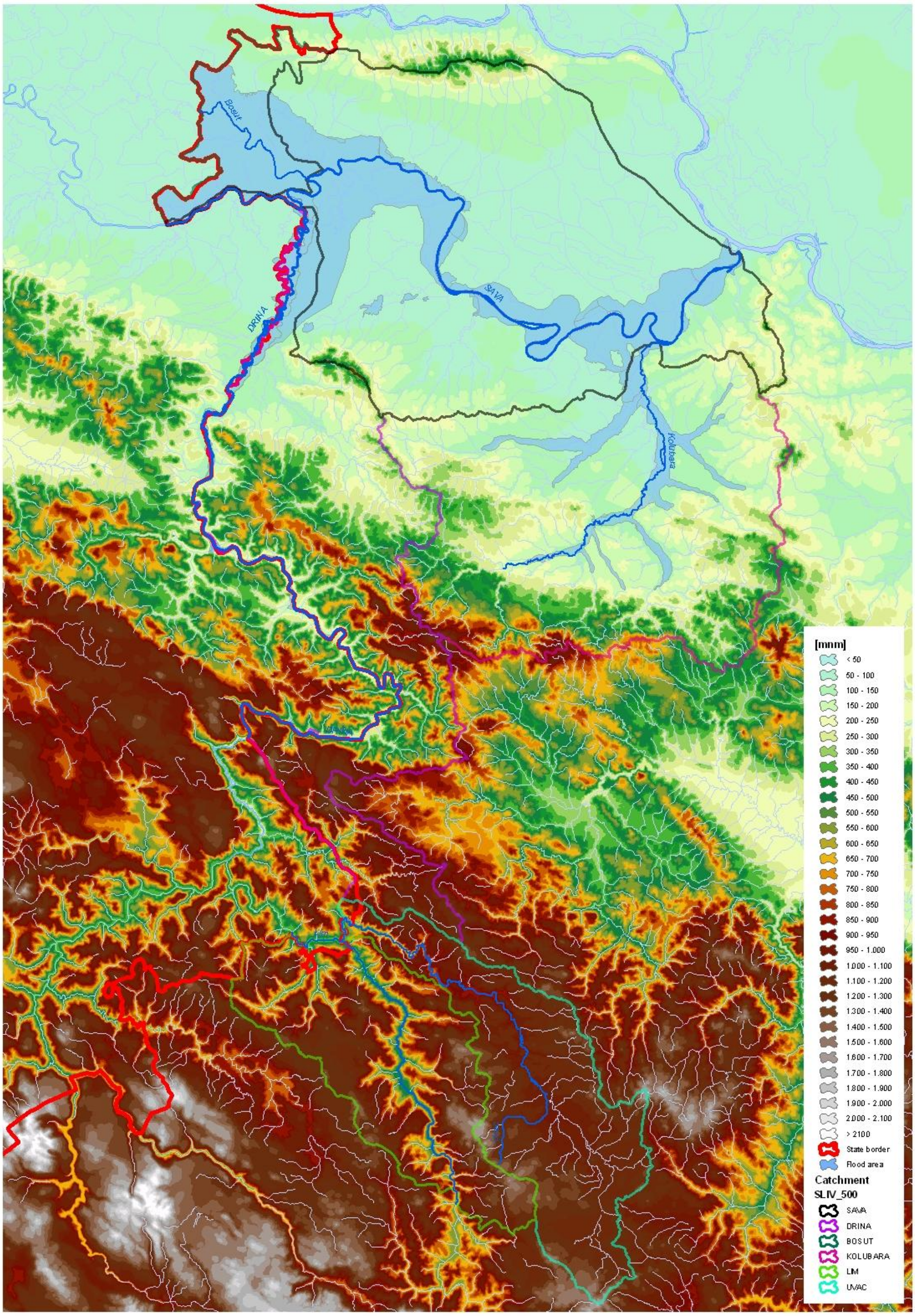


Figure Ap3-2: Topography of the Sava River Basin in Serbia

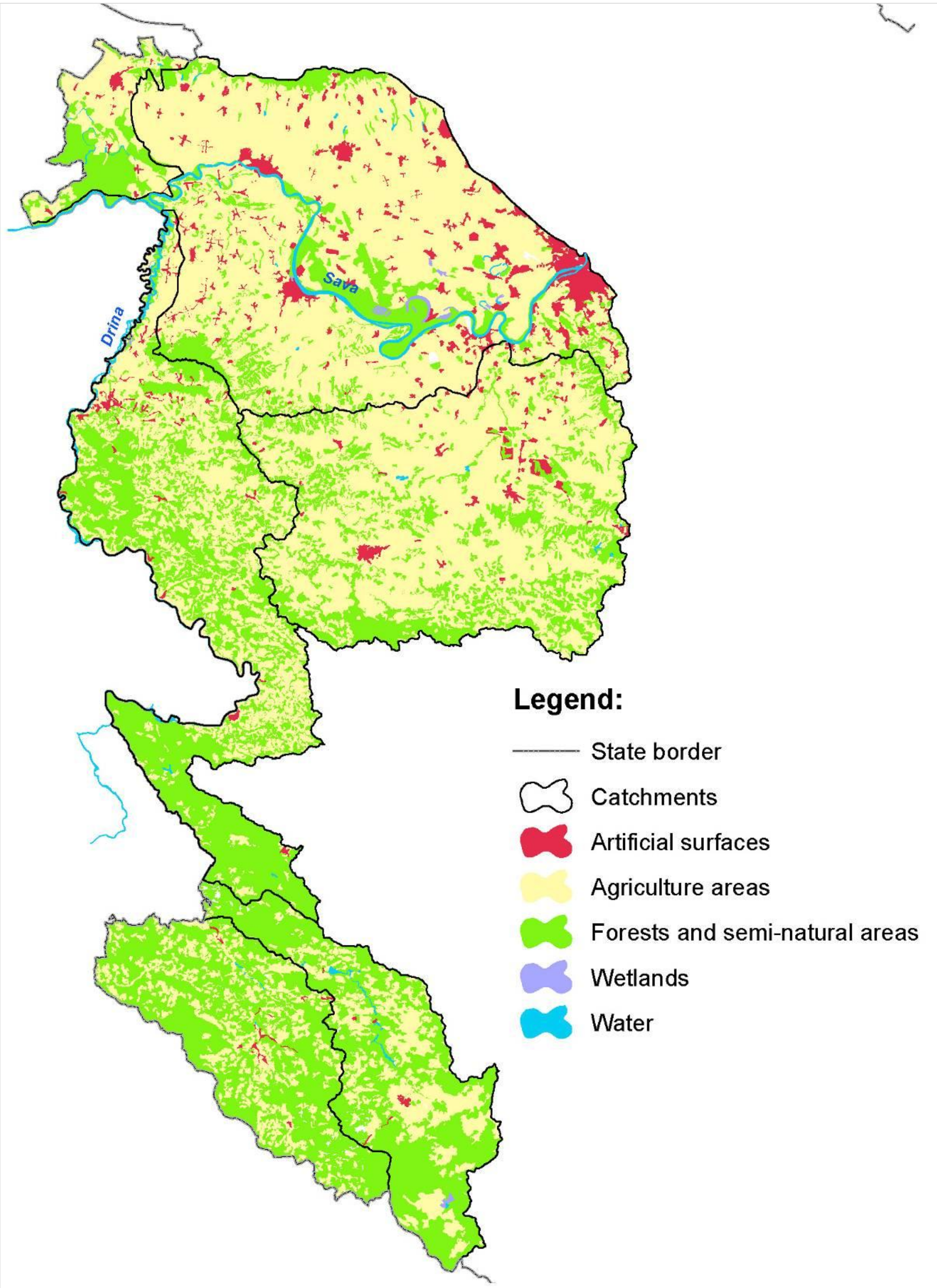


Figure Ap3-3: Land use in the Sava River Basin in Serbia

Table Ap3-1: Flood prone areas (protected and unprotected) along the Sava River

	No.	Flood prone area name	River name	Area (km^2)	ID	Protected (Y or N)
LEFT BANK	1	Novi Beograd	Dunav + Sava + Nova Galovica	24	S.1.1.	Y
	2	Donji Srem	Nova Galovica + Sava	121	S.1.2.	Y
	3	Kupinovo I	Sava	6	S.1.3.	Y
	4	Kupinovo II	Sava	13		N
	5	Kupinovo-Klenak	Sava	107		N
	6	Klenak	Sava	5	S.1.4.	Y
	7	Klenak-Hrtkovci	Sava	11		N
	8	Hrtkovci	Sava	12	S.2.1.	Y
	9	Hrtkovci-Sremska Mitrovica	Sava	16		N
	10	Sremska Mitrovica	Sava + Istočni obodni kanal	12	S.2.2.	Y
	11	Gornji Srem	Sava + Istočni obodni kanal	564	S.2.3.	Y
RIGHT BANK	12	Beograd	Sava + Topčiderska reka	2	S.3.1.	Y
	13	Veliki Makiš-Ada Ciganlija	Sava + Ostružnička reka + Železnička reka + Topčiderska reka	31	S.3.2.	Y
	14	Mali Makiš	Sava	3	S.3.3.	Y
	15	Mislodjin-Barič	Sava + Kolubara + Barička reka	5	S.3.4.	Y
	16	Obrenovac	Sava + Kolubara + Obodni gravitacioni kanal	96	S.3.5.	Y
	17	Provo-Orlača	Sava	16	S.4.1.	Y
	18	Mrdjenovac-Ladjenik	Sava + Dobrava	17	S.4.2.	Y
	19	Orašac	Sava + Dobrava	3	S.4.2.	Y
	20	Mačva	Sava + Drina	437	S.4.5.	Y

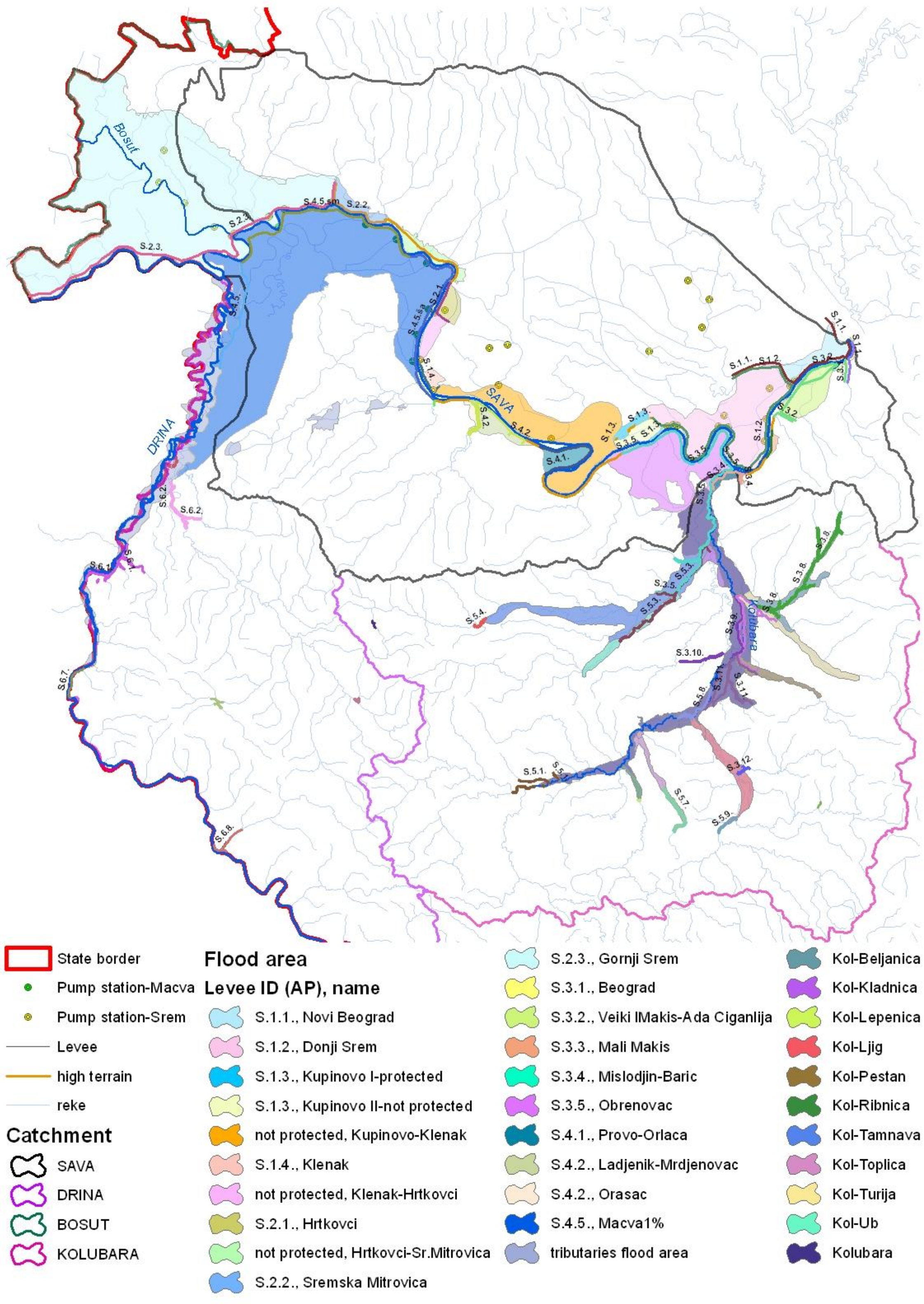


Figure Ap3-4: Flood protection lines and areas potentially prone to flooding along the Sava and its tributaries

2. Existing flood management

2.1. Commanding responsibilities

2.1.1. Institutional arrangements in Serbia

Flood protection is regulated by the *Water Law* (*Official Gazette of the Republic of Serbia* 46/91). The Law arranges proceedings and measures for flood and ice protection, as well as protection from torrents and erosion.

The participants involved in flood defence are:

- Ministry of Agriculture, Forestry and Water Management of the Republic of Serbia – Republic Directorate for Water;
- Public Water Management Companies: „Srbijavode" – Belgrade (in charge for flood protection along the right bank of the Sava River, and the Drina and the Kolubara River Basins), „Vode Vojvodine" – Novi Sad (in charge for flood protection along the left bank of the Sava River and the Bosut River) and „Beograd vode" for the territory of the Belgrade city;
- Local water management companies;
- State Hydro-meteorological Service (HMS).

Responsibilities of participants are determined in the *General Flood Defence Plan* and the *Flood Defence Action Plan*, while the Ministry is providing financial sources.

The flood and ice control actions are organized and carried on in three phases, depending on the hazard degree: preparation, regular and emergency defence. Phases of defence are defined in the *Flood Defence Action Plan*, in relation to the river stage on the adjacent gauging station.

The role of Public Water Management Companies (PWMC) is very important. Apart from defence period, the activities of Companies encompass:

- Provision of relevant studies and designs;
- Construction, reconstruction and maintenance of protection structures;
- Making and updating the technical documentation related to flood defence;
- Preparation of staff, equipment, material, machines and warning system.

During the period of flood defence, the PWMCs engage skilled stuff from local water management companies, organize monitoring to provide hydro-meteorological data from local stations, as well as attending the protection lines. In case when the protection line is endangered, the PWMC should organize prompt action to prevent levee break.

The protection lines are divided to sectors which, as a rule, correspond to territories of local water management companies.

State Hydro-meteorological Service is responsible for monitoring, measuring, collecting and analyzing hydrologic and meteorological data. The Service is also providing relevant information and forecasts from domestic and foreign territories to all the flood defence participants. Within the Serbian part of the Sava River Basin, data are collected on 15 points. In addition, data from the foreign countries are being obtained from 10 stations (in Croatia and B&H).

Measures and procedures for flood protection in the Republic of Serbia are defined in *General Flood Defence Plan* and *Flood Defence Action Plan*. These plans are prepared only for watercourses with the existing flood protection structures. For other areas endangered by floods, but not included in the mentioned plans, local community appoints flood protection measures and proceedings. Also companies which properties are endangered prepare special flood protection plans.

General Flood Defence Plan is proclaimed by the Government of the Republic of Serbia for 5-year periods. The overall strategy of management, as well as the obligations and responsibilities of the main participants are determined in the General Plan. Preparations, monitoring and warning, tasks of personnel in charge, as well as basic scheme of organization are also specified.

General Plan defines:

- The legal framework and mandatory principles;
- Preventive measures beyond flood period;
- Duties, responsibilities and mandates of persons in charge of flood control;
- Duties and responsibilities of legal entities, i.e. companies that organize and implement flood control measures;
- Prerequisites for proclamation of the state of emergency;
- Control of floods caused by internal waters;
- Methods for provision of funds for flood control implementation.

Ministry of Agriculture, Forestry and Water Management retrieves *Flood Defence Action Plan* for one-year period. *Flood Defence Action Plan* affirms organization of flood control, managers, and criteria for proclamation of regular and emergency flood defence. The *Flood Defence Action Plan* accurately defines the organization of flood and ice control on rivers, as it:

- Identifies managers in the Directorate for water, the Public Water Management Companies and other companies and institutions responsible for flood control;
- Enumerates levee sectors and sections, including the name and chainage of each sector and section, relevant water gauges, and criteria for proclaiming regular and emergency flood defence;
- Specifies reporting hydrologic stations, from which the HMS of the Republic of Serbia generates prescribed reports, forecasts, and warnings;
- Lists ice phenomena observation points/localities, the criteria for initiating ice defence, and the required number of ice breakers;
- Provides an overview of hydrologic stations on foreign territories;
- Defines the personnel required for regular and emergency flood and ice defence, and the necessary means (tools, equipment, and machinery) for implementation.

2.2. System and state of the flood protection structures

2.2.1. Flood protection structures in Serbia

Flood protection system along the Sava River

The history of development of the flood protection system along the Sava River is very long, and related to establishment of numerous settlements and agricultural development. The levee reconstruction to so called „Sava levee profile" (Figure Ap3-5) was initiated after extremely difficult and expensive flood defences in 1974 and 1981. Reconstructed levees within the backwater zone of the „Iron Gate 1" HPP have ballast on the protected side. However, reconstruction of the flood defence lines along the Sava and its tributaries in the mouth sections has not been completed so far. The alignment of flood defence structures along the Sava River is presented at Figure Ap3-4.

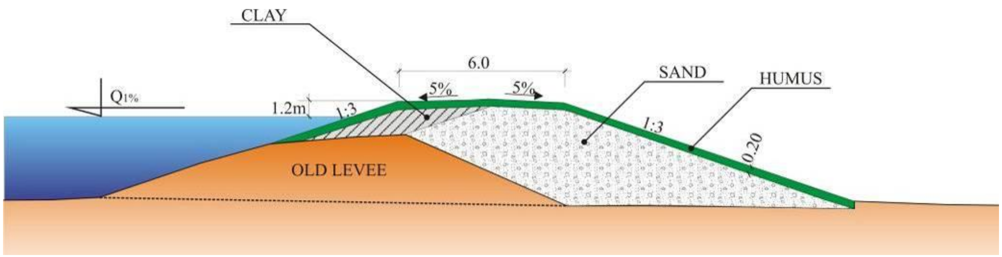


Figure Ap3-5: „Sava levee profile"

The left-bank levees of the Sava River protect the lowland area of Srem. The defence line is not continuous, and three different sectors can be clearly distinguished:

- From the Sava mouth to Kupinovo village (rkm 0 to rkm 56, ID S.1 on Figure Ap3-4), a 51.3 km long protection line is continuous, protecting the area of Lower Srem, i.e. around 13,000 ha of agricultural land, 1,300 ha of urban territory with the Belgrade area, and a few villages. Densely populated area of New Belgrade (S.1.1) is protected by 8.5 km of the quay wall and by levee on a short section. Along the 6.2 km these structures are below design protection level. The levee from New Belgrade to Progar (S.1.2, 51 km long) is mostly reconstructed (except 3.5 km near Progar). There are 7 pumping stations at this section. The most upstream levee section (S.1.3, 5.5 km long) is not reconstructed and does not provide required protection of the Kupinovo village.
- Riparian lands between the Kupinovo village and the city of Sremska Mitrovica (rkm 56 to rkm 135.2) are not protected, except along two short stretches (S.1.4 and S.2.1 on Figure Ap3-4). The terrain is low, and high waters inundate 12,000 ha. The natural reserve Obedska bara is located in this area (near Kupinovo).
- From Sremska Mitrovica to the border with Croatia (rkm 135.2 to rkm 209.8) a 70 km long levee (S.2 on Figure Ap3-4) protects the area of Upper Srem, i.e. around 48,000 ha of fertile agricultural land and forests, city of Sremska Mitrovica and numerous smaller settlements, traffic infrastructure and industry. Drainage water from dense channel network is discharged into the Sava River by gravity or pumping. The most significant structures are pumping station and sluice „Bosut", at the mouth of this river. All levees are reconstructed and ensure suitable safety level.

The flood protection line on the right bank of the Sava River also has three specific sections:

- From the Sava River mouth to Skela (rkm 0 do rkm 55.1, ID S.3 Figure Ap3-4) flood protection line is interrupted by numerous smaller and larger tributaries. The protected area is thus divided into several flood cells protected by levees along the Sava and its tributaries. There are four flood cells downstream of the Kolubara River confluence (S.3.1 – S.3.4, Figure Ap3-4), with the Belgrade urban and suburban areas, industry etc. Quay walls and levees in the central Belgrade area (S.3.1) do not satisfy required safety level. Levees upstream of the Kolubara mouth (S.3.5, Figure Ap3-4) protect 12,000 ha of agricultural land, numerous settlements and part of Obrenovac, industrial facilities and infrastructure.
- Between Skela and Šabac (rkm 70.3 to rkm 101.8) only short levees are built to protect agricultural land and small settlements (S.4.1, S.4.2 and S.4.4 on Figure Ap3-4).
- Between Šabac and the Drina River mouth (rkm 101.8 to rkm 168, S.4.5 on Figure Ap3-4), a 70 km long and continuous defence line protects the Mačva region. It extends 18 km along the Drina River right bank to Badovinci. Within protected area there is a city of Šabac and numerous smaller settlements, 30,000 ha of agricultural land, industrial facilities and infrastructure, and drainage systems. Only about 50 % of levees were reconstructed, while the rest are below required safety level. Numerous sluices and pumping stations are weak points in flood defence system.

<u>Flood protection system along major tributaries</u>

Flood defence structures along **the Drina River and its tributaries** were constructed mainly for protection of larger settlements, where significant industrial facilities are located (Loznica, Bajina Bašta and Ljubovija at the Drina, Priboj and Prijepolje at the Lim River). Protection of agricultural land is present only at the most downstream section of the Drina River (protection of the Mačva region), in the Jadar River valley and on some tributaries.

Different types of flood protection structures were built, depending on land use in the protected area and characteristics of the watercourse. Standard flood defence structures – levees are present at the most downstream section of the Drina and near Loznica and Ljubovija, where the levee is used as a road. Flood protection along the Drina in Zvornik, and along the Lim in Priboj and Prijepolje is provided by bank revetments and quay walls. Along smaller watercourses with torrential flood regime, and only on stretches through settlements (Loznica, Krupanj, Ljubovija, Bajina Bašta, Sjenica, Banja Koviljača, Bela Crkva, Osečina) the „urban-type" river training was done. Dams and reservoirs at the Drina, the Lim and the Uvac Rivers are included in flood protection system.

Flood protection structures along **the Kolubara River and its tributaries** were constructed for protection of settlements, industrial facilities and agricultural land. Different types of flood protection structures were used, depending on land use in the protected area and location of structures: „Sava levee profile" in the Sava backwater zone, „Kolubara levee" (4 m crest width, 1:2 sides slope) along upstream sections of Kolubara, and regulations of „urban" and „rural" types along smaller tributaries.

The Bosut River discharges into the Sava through the „Bosut" sluice, located at km 145.8 of the left bank Sava levee. Sluice controls water levels of the Bosut, except during high waters of the Sava when it must be closed (about 3/4 of the Bosut River watershed is lower than the Sava flood levels). In this period, Bosut water is being pumped by the „Bosut" pumping station. Both structures are in bad condition.

2.3. Structure of drainage system

Significant and organized efforts on reclamation of large wetlands along the Sava River started in 18th and 19th centuries, simultaneously with flood protection works. After the erection of the Iron Gate Dam, riverine areas were protected from the adverse effects of high groundwater levels by suitable structures and systems (i.e. reconstructed old and newly built drainage systems, drainage wells, pumping stations).

Presently, the most dense drainage network is built in the area of Srem: „Galovica" system in Lower Srem covers 194,341 ha, while two separate systems in Upper Srem cover 159,000 ha. These systems are characterized by very long main channels, which have a dual function (drainage and transport of surface waters from the Fruška Gora mountain).

On the right side of the Sava River, drainage is needed in the lowlands of Mačva (and further upstream along the Drina River to Loznica) and in the Kolubara River Basin. Numerous small rivers are collecting drainage water from channel network, while the Cer peripheral channel transports it to the Sava River.

Present drainage conditions within the Sava River Basin are presented in Table Ap3-2, while Table Ap3-3 presents actual state of drainage systems, including the area and number of structures.

Table Ap3-2: Areas endangered by excess waters of different origin (ha)

Area	High levels of surface and groundwater (high frequency of occurrence)	Low levels of surface and groundwater (moderate frequency)	Inland waters in drainage systems (seasonal and local)	Total
Srem	29,728	24,926	46,667	101,321
Podrinjsko - Kolubarsko	41,875	100,675	77,000	219,550
Upper Drina	-	2,500	-	2,500
Total	**71,603**	**128,101**	**123,667**	**323,371**

Table Ap3-3: Present state of drainage systems (areas and structures)

Area	Total area (ha)	Area covered by drainage (ha)	Number of systems	Subsurface drainage (ha)	Number of pumping stations	Length of channels (km)	Density of channel network (m/ha)
Srem	384,500	353,433	33	7,920	27	5,071	14.3
Podrinjsko - Kolubarsko	783,800	159,921	31	1,315	20	1,252	7.8
Upper Drina	41,000	-	-	-	-	-	-
Total	**1,587,300**	**513,354**	**64**	**9,235**	**47**	**6,323**	**12.3**

2.4. Design/construction criteria and the long-term flood protection strategy

Implementing criteria from the *Water Management Master Plan of the Republic of Serbia*, and taking into account the actual flood protection conditions and problems (especially the size of flood prone areas and possible damages), the long term flood protection strategy in the Sava River Basin in Serbia will comprise of:

- Regular maintenance of the flood protection structures, according to criteria, standards and norms.
- Reconstruction or/and construction of the flood protection structures to decrease flood hazard. Protection for the adopted design 100-year flood should be provided along the Sava River. This is an adequate criterion for the protection of the Sava riparian lands, considering the size of the potentially endangered areas, number of inhabitants and infrastructure value. Reconstruction is needed on 19.3 km of the left-bank Sava levee in the Lower Srem, and only 2.1 km on the Upper Srem (near Hrtkovci village). The most urgent and first priority tasks are protection of New Belgrade and Zemun areas, where the reconstruction of kway walls is need along 6.2 km of the Sava and 1.5 km of the Danube. Reconstruction of 13.4 km long the right-bank levees and kway walls downstream of the Kolubara River mouth is needed, especially 4 km of kway walls in Belgrade. Also, the reconstruction of 31.3 km of the Sava and the Drina levees in Mačva region is urgent. Reconstruction of sluice and pumping station Bosut must also be done.
- Flood protection of first-priority areas (flood cells with more than 20,000 inhabitants, large and significant industrial and other facilities) and second-priority areas along the Sava River tributaries (areas with 5,000 to 20,000 inhabitants, medium industrial and other facilities, significant drainage and irrigation systems or water-supply sources) should be provided. Design criteria will be a result of cost-benefit analysis.
- Adequate measures for sediment management and torrent control should be applied. These would encompass anti-erosion watershed management and torrent control measures with optimal combination of biological measures (forestation, forest melioration, pasture melioration, etc.), bio-technical measures (contour trenches, terraces etc.), and technical measures (dams and river-bed training). Also, controlled sand and gravel excavation to preserve channel convaying capacity and flow regime should be applied.
- Gradual and broad implementation of non-structural flood protection measures (as upgrade of the flood forecasting and warning procedures; introduction of flood maps into spatial plans, etc.).
- International cooperation in flood management on rivers which cross or represent the state border (Sava, Drina, Lim and Bosut Rivers).

2.4.1. Possible impacts on a current flood protection level

The most significant impacts on safety of flood defence systems along the Sava River in Serbia are:

- Trend of flood level increase (due to natural or anthropogenic factors as disconnection of floodplains, heightening of levees, constructions in inundated areas, deforestation, etc.)
- It is known that the retentions in the Middle Posavina region have particular influence on extent and time of occurrence of peak flow on downstream section of the Sava River. It was estimated that peak flow at Sremska Mitrovica would increase for more than 10% if floodplains were completely disconnected.
- The existing natural floodplains along the lower Drina (downstream of Zvornik dam) have a significant influence on the Drina floods. Construction of levees on both banks (as planned within the hydropower generation project) could increase Q1% by 5 to 10% at the mouth.
- On the Drina mouth, flood waves usually occur before Sava floods. Uncoordinated operation of the Drina reservoirs and retentions in the middle Posavina could lead to superposition of flood waves and worsen conditions on downstream sector of the Sava.
- Climate change – analyses provided in the LISFLOOD Project (*Impact of climate change to the Sava River flow regime*, JRC).

The *Study of Training and Regulation of the Sava River in Yugoslavia* (Polytechna - Hydroprojekt - Karlo Lotti and Co., 1972.) should be mentioned from the perspective of the integrated flood protection in the Sava River Basin. It was based on the postulate: „*No upstream user of the flood defence structures and measures should be allowed to deteriorate flow regime downstream*".

2.5. National Flood Predicition and Warning Practices

The role of the State Hydro-meteorological service of Serbia (HMS) in flood defence is defined by a number of laws (*Law on Ministries, Water Law, Law on Protection Against Natural and Other Major Disasters*), and by-laws (*General Flood Defence Plan* and *Flood Defence Action Plan*). Two departments of HMS Serbia take part in flood forecasting and monitoring, the Hydrology Department and the Meteorology Department.

The HMS Forecast Office is responsible for the collection and distribution of hydrological and meteorological data. It transmits hydrological warnings to: Ministry of Agriculture, Forestry and Water Management of Serbia – the Republic Directorate for Water, Public Water Companies (which distribute them to responsible personnel), and to the State centre for observation and information, which distributes these information to endangered communities. Data, forecasts and warnings are presented in special bulletins and transmitted via e-mail to Ministry, and all other participants in flood defence activities.

Hydrological data are collected from 13 stations in the Sava River Basin and reported in real time, via radio, telephone and automatically via GSM. Meteorological data are collected from 61 stations.

The data available on the territory of Serbia are not sufficient for the delivery of warnings and forecasts. Namely, floods on major rivers, such as the Sava and the Drina originate beyond RS borders and that is why information from upstream countries is indispensable. Data from neighboring countries (8 in Croatia) are collected via GTS (Global Telecommunications System) and by e-mail. Also data for 5 stations in the Republika Srpska are collected by phone.

Various methods are used for hydrological forecasting, ranging from the simplest graphical correlations to the most sophisticated models which describe the physical processes that take place within the river basin and the river network. For all of these methods and models, it is important to have access to accurate data on the initial conditions of forecasted parameters, and the fundamental impacts. Such data are provided by hydrologic and meteorologic measurements and observations, while precipitation can be the result of meteorological forecasts. For the time being, only nowcasts and short-term meteorological forecasts can be used successfully.

Hydrological data required for hydrologic forecasts, are collected daily by the HMS from 5 hydrologic stations within the territory of Serbia and 10 external hydrologic stations. Water level and/or discharge forecasts are prepared daily and exchanged internationally, along with data from 31 hydrologic stations.

The Forecast Office of the HMS issues warning and forecasting information. The Office activities encompass the delivery of the following data:

- Daily information on rainfall, air and water temperature, water level, water flow and ice, originating from hydrological and meteorological domestic network;
- Daily information on water levels, water flows, ice and water level forecasts, issued by GTS from upstream countries;
- Daily water level forecasts for 1 or 2 days in advance;
- Warning about the development of flood on the upper river parts;
- Forecast on extreme water level (height and time of appearance);
- Forecast of ice phenomena (twice a week) for next 7 days and approximate forecasts for next 30 days (twice a month).
- The following methods are currently operational:
- MANS (nonlinear model of river flow) for the Sava;
- SSARR and TANK for the Kolubara;
- Simple index model for forecasting discrete hydrologic events, i.e. large flood waves on rivers with catchment areas up to 1,500 km^2 (short flood wave travel times and durations).

Plans have been prepared for the ensuing period to improve warning and forecasting procedures and to more extensively incorporate the products of radar surveillance for those rivers on which flood waves rise within $T_p \leq 10$ hours (corresponding to a catchment area up to 300 km^2). At river basins with the surface area up to 2,000 km^2, rainfall/runoff models will be developed. Rainfall/runoff-type models, in combination with computations of flood wave travel and transformation within the river channel, will be used for larger catchments (larger than 2,000 km^2).