### STATUS QUO REPORT ON HYDROGRAPHICAL ACTIVITIES

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<th>Document ID:</th>
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<tr>
<td><strong>Activity:</strong></td>
<td>Improve Methods, Processes and Procedures for Hydrographical and Hydrological Activities</td>
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<tr>
<td><strong>Author / Project Partner:</strong></td>
<td><strong>Date:</strong></td>
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<td>Jasna Muskatirovic, PhD/ Plovput</td>
<td>28 September 2009</td>
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<td>Jasna Muskatirovic, PhD/ Plovput</td>
<td>February 10, 2010</td>
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<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AGN</td>
<td>European Agreement on Main Inland Waterways of International Importance</td>
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<tr>
<td>FDI</td>
<td>Foreign direct investments</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GOS</td>
<td>Global Observation System</td>
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<td>GTS</td>
<td>Global Telecommunications System</td>
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<tr>
<td>HS DTD</td>
<td>Hydro System DTD</td>
</tr>
<tr>
<td>ICPDR</td>
<td>International Commission for the Protection of the Danube River</td>
</tr>
<tr>
<td>IMF</td>
<td>International Monetary Fund</td>
</tr>
<tr>
<td>IWW</td>
<td>Inland waterways</td>
</tr>
<tr>
<td>MMS</td>
<td>Main Meteorological Stations</td>
</tr>
<tr>
<td>MOSS</td>
<td>Meteorological Observation System of Serbia</td>
</tr>
<tr>
<td>RHMZ</td>
<td>Republic Hydrometeorological Service of Serbia</td>
</tr>
<tr>
<td>UTC</td>
<td>Coordinated Universal Time</td>
</tr>
<tr>
<td>WMO</td>
<td>World Meteorological Organization</td>
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Note:
In preparation of this document different texts and reports from the Republic Hydrometeorological Service of Serbia and the Institute for Water Resources “Jaroslav Černi” were used, so the author would like to thank colleagues from these institutions for help.
2 ASSIGNED REGION OF INTEREST – GENERAL INFORMATION

2.1. Geographical position

The Republic of Serbia is located at the crossroads between East and West, between the Balkan Peninsula and the Pannonian Plain. Serbia offers an outstanding potential for river transportation. Although landlocked, there is around 2,000 km of navigable inland waterways, among which the largest are Danube, Sava, Tisza Rivers, as well as system of canals Danube-Tisza-Danube, (Figure 1).

![Figure 1: Danubean countries](image_url)

2.2. Economical position

In the period between 2001 and 2008 Serbia had strong economic growth (real GDP between 5% and 6% per year). That growth a result of reduced inflation, rising domestic demand and export, FDI inflow, and reduction in public debt.
However, the growth based on consumption led to the increase of import, which was more than two times higher than export. Foreign direct investments (FDI) inflow decreased dramatically in 2008, which made Serbia vulnerable to the negative impact of global financial crisis. In 2009 Stand-by arrangement with IMF was signed (of nearly 3 billion EUR), which is a good signal for future investors.

The other problem is that the economic growth in the past 5 years was not followed by the creation of new jobs. Official unemployment rate remains high, focused on youth, older workers, women and minorities. Long-term unemployment is endemic, but a large gray economy is present.

GDP per person is more than doubled since 2001, but it is still quite low in comparison with EU standards (€4,650 against EU-27 average €23,500).

The population in Serbia is in constant decline, especially working-age, largely due to the emigration and a low birth rate. That leads to the conclusion that Serbia has the aging population.

The internal disparities within Serbia exist due to the fact that the impact of growth has been concentrated in the major cities in the northern and western part of the country. It is a problem which must be dealt with in the future. As a first step, a new Law on Regions is prepared, focusing on preventing further disparities between the regions.

It is expected that Serbia will have negative growth rate in 2009, and that 2010 will be a year of stagnation or small growth. However, it is expected that the strong positive growth will be achieved in 2011 and the following years. GDP per capita, labor productivity and employment rate will have the similar positive dynamics.
2.3. Area and water river network

Area of the Republic of Serbia is 88,361km$^2$ and of that area 81,660km$^2$ is within the Danube River Basin, (more then 92%).

As a Pan-European "Corridor VII", the Danube River is an important transport route. Navigation on the Serbian sector of the Danube River is divided into two sections: from Hungarian-Serbian-Croatian border to Belgrade and from Belgrade to Serbian-Romanian-Bulgarian border. In the first sector navigation for the convoys according to the AGN class VIc is possible, and at the downstream section navigation for the convoys according to the AGN class VII is possible, which allows for the sea going vessels to arrive to Belgrade from the Black Sea.

The stretch of the Danube River in Serbia (from Bezdan to Timok River) is 588 km long, of which 137.5 km is a borderline with Croatia, and 229km is a borderline with Romania. By performing large river training works, on what once used to be a natural flow of the river, navigation was secured in line with the recommendations of the Danube Commission.

From the territory of Serbia waters flow in three directions: predominantly to the Black Sea (Danube River Basin), Adriatic Sea (Drim and Plavska River), and Aegean Sea (Pčinj, Dragovištica, and Lepenac Rivers), Figure 4.
As mentioned above the largest and most important river in Serbia is the Danube River. With its length of 588km it connects Serbia both with West and East. Coming from Hungary largest tributaries to Danube River are: Drava, Tisza, Sava, and Velika (Great) Morava Rivers (Figure 4).
Largest left tributary to the Danube River is the Tisza River with the drainage area of 157,200km². It comes to the Serbian territory from Hungary, at village Djale, and has its

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confluence with the Danube River near city of Slankamen. Largest tributary to the Tisza River in Serbia is the Begej River.

Right tributary to the Danube River is the Sava River, the largest tributary of the Danube on Serbian territory. The drainage area of the Sava River Basin is 96,400km². The total length of the Sava River on Serbian territory is 211km (from Jamena to the confluence in Belgrade). Along its course, the Sava River has several tributaries: Drina, Kolubara, and Bosut Rivers.

Second largest right tributary of the Danube River in Serbia is the Velika (Great) Morava (drainage area of 37,400km²), established from two rivers: Juzna (South) Morava (15,400km²) and Zapadna (West) Morava (15,680km²).

Other tributaries of the Danube River at Serbian territory are: left tributaries Tamis, Karas, and Nera Rivers, and right tributaries Mlava, Pek, Porecka, and Timok Rivers.

In order to present the sizes of some of the abovementioned rivers the drainage areas and average annual discharge for selected gauging stations are presented in Table 1, (Water Master Plan of Serbia, 2001), Error! Reference source not found..

Table 1 Drainages areas and mean annual discharges for selected gauging stations

<table>
<thead>
<tr>
<th>River</th>
<th>Gauging Station</th>
<th>Drainage area (km²)</th>
<th>Mean annual discharge (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danube</td>
<td>Bezdan</td>
<td>210,250</td>
<td>2,263</td>
</tr>
<tr>
<td></td>
<td>Veliko Gradiste</td>
<td>570,375</td>
<td>5,466</td>
</tr>
<tr>
<td>Tisza</td>
<td>Novi Becej</td>
<td>145,415</td>
<td>766</td>
</tr>
<tr>
<td>Sava</td>
<td>S. Mitrovica</td>
<td>87,996</td>
<td>1,532</td>
</tr>
<tr>
<td>Drina</td>
<td>Radalj</td>
<td>17,493</td>
<td>371</td>
</tr>
<tr>
<td>Velika Morava</td>
<td>Ljubicevski most</td>
<td>37,320</td>
<td>230</td>
</tr>
</tbody>
</table>

3 CLIMATOLOGICAL CONDITIONS

In general, climate of one area is in the close connection with its geographical location and land relief. The territory of Serbia is located between 41°53’ and 46°11’ northern latitude and 18°49’ and 23°00’ eastern longitude, (Statistical yearbook, 2008). The area of the Republic of Serbia, of
approximately 88,361 km² covers various types of relief, from wide plains on the north, to hilly terrain and valleys going further to the south, and mountain ranges in eastern, western, and southern parts of the country (Water master plan, 2001).

With the change of latitude, the duration of insulation and solar radiation changes on both daily and annual basis. The reception of heat energy is in close correlation with the relief.

The climate of Serbia can be described as the moderate-continental with more or less pronounced local characteristics. The spatial distribution of the climate parameters is caused by the geographic location, relief and local influence, as a result of combination of relief, distribution of air pressure on the major scale, terrain exposition, presence of river networks, vegetation, urbanization etc. Among the geographic characteristics significant for the weather and climate of Serbia the following outdoor and indoor influences should be mentioned: the Alps, Mediterranean Sea and Genoa Bay, Panonian Plain, Morava River valley, the Carpathian and Rodopi mountains as well as hilly-mountainous parts with ravines and highland plains. The prevailing meridional location of the river ravines and plains in the northern area of the country make the deep southward intrusion of polar air masses possible².

Republic Hydrometeorological Service of Serbia (RHMZ) is the governmental institution in charge for collection and distribution of meteorological data on the territory of the Republic of Serbia.

The Meteorological Observation System of Serbia (MOSS), the part of the RHMZ, which operates with the rules and regulations of the World Meteorological Organization (WMO), as a part of the Global Observation System (GOS), monitors and records data on the status of the atmosphere in Serbia. MOSS data are continually exchanged within national and international frameworks, following the rules and methodologies of the Global Telecommunications System (GTS).

The network of meteorological stations is comprised of 31 synoptic stations (classified into ground stations, inland stations, and elevated stations) and 710 precipitation stations (main stations, special-purpose stations and ordinary stations). The locations of synoptic stations in

² http://www.hidmet.gov.rs/
Serbia are shown in Figure 6. These are main climatological stations with a synoptic monitoring program, so that, in addition to precipitation, they record the following: wind direction, speed and intensity; air temperature; air humidity; atmospheric pressure; and sunshine. They are staffed by professionals and referred to as Main Meteorological Stations (MMS). Observation and reporting is undertaken every hour, and precipitation measurement and reporting every 6 hours. Also, special measurement and reporting is performed based on predefined criteria. Each MMS has its own network or ordinary climatological and precipitation stations, and collects their reports on a monthly basis. (ICPDR, 2006).

The network of precipitation stations has the highest density within the MOSS and it generally meets climatological requirements: 24-hourly precipitation quantities are measured and phenomena are monitored on 600 stations (at 6AM UTC). These stations submit monthly reports. Measurement is performed by conventional rain gauges and graduated cylinders. Monitoring is undertaken by the trained amateurs. There are also ordinary climatological stations at 70 locations. In addition, these stations measure and record air temperature and wind data at three times per day (6AM, 1PM and 8PM UTC). Measurements are performed by the conventional instruments. Reports are submitted once a month. Monitoring is provided by the trained amateurs. However, 12 stations are within hail suppression centers and allow for daily reporting (ICPDR, 2006).

3.1. Air Temperature

Air temperature is one of the main climatological elements. It is in direct correlation with longitude, latitude, distance from the sea, elevation. Analysis of air temperature is performed at predefined times, three times a day (7AM, 2PM, and 9PM) two meters above the ground. Data analysis for 55 climatological stations, for period 1946-2006. showed that highest average monthly temperatures are in July, and lowest in January.

At the northern part of Serbia the average annual temperatures are between 10.8 and 11.5C, and at the lowland parts of the Central and Southern Serbia temperatures are between 10.0 and 12.1C. In the mountain regions temperatures are even lower. For territory of Serbia, at elevation of 300m, average annual temperature is 10.7C (for period 1946-2006), at elevation of
1000 m is 7.4°C, and at 1700 m is 3.3°C. Mean vertical gradient of average annual temperatures is −0.6°C/100 m.

Lowest temperature was recorded at the station Sjenica −38°C, and highest recorded was at station Jagodina 43°C.
3.2. Precipitation

Precipitation is, by its character, most variable meteorological element. As consequence, the atmospheric processes and relief, the precipitation is unevenly distributed in the time and space. The southwestern parts of Metohija belong to the maritime precipitation regime (more than 50% of annual precipitation falls during the cold part of the year), and the rest of Serbia has continental regime (more than 50% of precipitation falls during the warm part of the year). In Central and Eastern part of Kosovo is the boundary zone, where influence of both regimes can be seen.

Average precipitation on the territory of Serbia is 699.7mm/year. Regime of precipitation is very diverse, since the annual precipitation in different parts goes to extreme (from 1500mm at the Beli Drim River drainage area, to 900mm at the upper parts of the Ibar River, Plavska River, or Lepenica River). In the Central Serbia the height of annual precipitation is between 600m and 1000mm in the mountainous regions, while in plains those values are in decline. Lowest annual precipitation are registered in the drainage areas of Juzna (South) and Velike (Great) Morava Rivers and in Vojvodina (Pannonian Plain). Precipitation of 800mm is characteristic to all lower parts of Serbia and lower part of the Drina River, (Figure 7).

In general, most rain falls in period May-July, and least in period January-March. It is safe to say that month with most precipitation is June, and month with least is February, or March.

The absolute daily maximum for precipitation of 220mm was measured at station Rakov Do, while maximum annual precipitation was measured at the station Krnjaca - 1884.7mm.

Mean annual precipitation rise in average with the altitude. In the lower regions annual precipitation range in the interval from 540 to 820 mm. Areas with the altitude over 1000 m have in average 700 to 1000 mm of precipitation, and some mountainous summits in southwestern part of Serbia have heavier precipitation up to 1500 mm. Major part of Serbia has continental precipitation regime with higher quantities in warmer part of the year, except for south-western parts where highest precipitation is measured in autumn. June is the rainiest with the average of 12 to 13 % of total annual precipitation sum. February and October have the least of precipitation. Snow cover occurrence is characteristic for colder part of the year,
from November to March, and majority of days with snow cover is in January. The mean annual precipitation within Serbia is presented in Figure 7.

Figure 7: Mean annual precipitation (1946-1991), (Water master plan, 2001)
3.3. Wind

Wind is an important climatological element and as such very often defines the climate where it blows. If it comes from the sea it brings elements of maritime climate (heavy precipitation), and if it blows deep within the continent it brings continental climate (dry and cold weather). It mostly influences the temperature and humidity, and has influence on cloudiness and precipitation.

Two types of winds are predominant in Serbia: kosava (SE) and etezija (NW). Kosava is south-eastern wind most common during the winter time. It has highest influence in most of Vojvodina, eastern Serbia, Pomoravlje and Sumadija regions. This wind has a significant impact on navigation, since it, during the winter times, can stop the navigation on the Danube River.

During the summer prevailing wind is etezija. It blows over the whole Serbia, with most influence on the area around Danube and Morava Rivers. It is relatively mild wind, developed as a result of the difference between the high atmospheric pressure in Central Europe and low in East Mediterranean. Northwestern direction has most impact on Vojvodina.

4 MAIN BASINS DESCRIPTION

As it was mentioned before, area of the Republic of Serbia is 88,361km$^2$, and the Danube River Basin covers about 81,660m$^2$ of that territory, or about 92.5%.

Serbia is predominantly hilly and mountainous country (65% of territory), and about 60,000km$^2$ is suitable for agricultural production. About 30% of the area of the Danube River Basin in Serbia is forested (ICPDR, 2006).

Territory of the Serbia can be divided in to two distinctive regions – Pannonian Plain on the north and hilly and mountainous region located on the south from the Danube River (Figure 8). Pannonian Plain is intersected by numerous watercourses - Danube, Sava, Tisza, Tamis, Begej Rivers and canals of the DTD System (Danube-Tisza-Danube). Along these rivers system of
levees were erected. Similar systems are developed in the valleys of other major rivers (Morava, Kolubara, etc) in Central Serbia, where all major cities and significant industrial facilities are located in flood-prone areas.

*Figure 8: Topography of the Republic of Serbia*
4.1. Topography, Geology, Prevailing soils

Topography, geology, prevailing soils and vegetation of river sub-basins within the Danube River Basin were studied within the CORINE (Coordination of information on the environment) Program of the European Commission. For that purpose Danube River Basin in Serbia was divided into the following sub-basins: the Danube River (Danube Corridor) sub-basin, the Tisa River sub-basin, the Sava River sub-basin, and the Velika Morava River sub-basin. The Danube Corridor is considered herein without river basins of its three major tributaries, Tisa, Sava, and Velika Morava, which are treated as separate sub-basins.

4.1.1. The Danube River (Danube Corridor) Sub-basin

The Danube River (Danube Corridor) sub-basin has an area of 11,610 km², which represents 12.5% of the whole Danube River Basin in Serbia. It comprises lowlands (northern province of Vojvodina), hilly and mountainous terrain (watersheds of rivers Timok, Pek, and Mlava), as well as Djerdap gorge (Iron Gate).

After regulation of river streams within this sub-basin, main streams were cut off from the former branches, stagnant tributaries, swampy and marshy areas and ponds, all of which had an adverse effect on the natural wildlife habitats. A part of these habitats has been converted into pasture and agricultural land. However, earth for the construction of embankments was excavated from the floodplain, so that the new floodable wetlands were formed (so-called “kubici” in Serbian). Presently, floodable wetlands cover $1.3 \times 10^6$ ha.

An important characteristic of the Danube River sub-basin is very large channel network of multipurpose Hydro System Danube-Tisa-Danube (HS DTD) in Vojvodina. The total length of waterways along the channel network is 695 km, which exceeds the total length of the Danube River within Serbia (588 km).

4.1.2. The Tisa River sub-basin

Only a small part, 6% or 8,994 km², of the total Tisa River Basin (148,973 km²) lies in Serbia—in its northern province of Vojvodina. The Tisa River divides the province of Vojvodina in two
regions: the Bačka on the west and the Banat region on the east. This area (Banat and Bačka) is predominantly lowland. Here, Tisa drains the Pannonian Basin, which is the largest of sediment-filled post-orogenic basins of the Alpine region. The Miocene sediments are primarily marine limestone, whereas later Tertiary sediments consist of brackish to freshwater clays and sands. Fluvial and fluvio-glacial deposits of Pleistocene age also exist. Thick loess deposits are abundant especially along Tisa watercourse. Regulation of river streams within this sub-basin also resulted in cutting off the main streams from former river branches, flooded meadows, and other wetlands, with significant decrease of such areas. The other important characteristic of the Tisa River sub-basin is its connection with Hydro System DTD. Via canals of HS DTD, Tisa is linked with both Danube River and Timisoara in Romania.

4.1.3. The Sava River Sub-basin

The Sava River sub-basin in Serbia an area of 31,046 km², which represents about one third of the total Sava River Basin area (95,132 km² with the part in Montenegro). In Serbia it covers a part of Vojvodina, and the western part of central Serbia. In this section Sava River is a typical lowland river, which flows through large alluvial valley and forms large meanders. The valley occupies the southern edge of Pannonian Plain. Sediments are primarily Miocene sediments marine limestone, whereas later Tertiary sediments consist of freshwater clays, sands, and gravel. Thick loess deposits also overlay Tertiary sediments. The Sava River sub-basin comprises lowlands of Srem and Macva (along Sava river waterway), as well as hilly and mountainous terrains of Drina River watershed, which is included in this sub-basin. River Drina watershed is known for high biodiversity and protected eco-systems. Number of relict and endemic species are concentrated within national parks “Durmitor” (with glacial Crno Jezero lake, river Tara watershed, and river Tara Canyon in Montenegro), “Biogradska gora” (with glacial Biogradsko lake, in Montenegro), and “Tara” (with river Drina Canyon, in Serbia).
4.1.4. The Velika Morava River Sub-basin

The Velika (Great) Morava sub-basin is the largest sub-basin in Serbia. Its area of 37,269 km$^2$ within Serbia represents almost entire Velika Morava River Basin (total area of 38,345 km$^2$). The sub-basin spreads over mid, southern, and southeast parts of central Serbia. Diverse terrain in this sub-basin comprises of hilly and mountainous area (with altitude increasing towards southern and south-eastern borders of Serbia), as well as wide river valleys.

Numerous reservoirs for water supply and hydropower generation, important groundwater resources along Velika Morava River, and a number of thermal springs also characterize this sub-basin. Erosion is pronounced in upstream parts of the sub-basin. Mountainous and hilly parts of the sub-basement feature forests and orchards, while river valleys host agricultural lands.

Land types in Serbia are divided depending on the hydrogeological structure of the soil. In general, three types of soil are predominant: authomorphic soil, hydromorphic soil, and halomorphic soil (Water Master Plan, 2001).

Hydromorphic soils are prevailing in the lowlands, especially in the Danube, Tisza, Sava, Morava River valleys and their tributaries. High ground levels are characteristic for spring time.

According to its geological structure and geographical layout the Danube River Basin can be conveniently divided into three regions: upper, middle and lower Danube (Figure 10).

The territory of Serbia belongs to the middle part of the Danube River. The Middle Danube Basin creates magnificent and unique geographical unit. It extends from the Devin Gate, connecting the last promontories of the Alps (Leitha Mt.) with the Little Carpathians downstream of the confluence of the Morava and Danube River, to the mighty fault section between the Southern Carpathians and Balkan mountains near the Iron Gate Gorge. The Middle Danube section is the largest of the three regions. It is confined by the Carpathians in the north and east, and the Karnische Alps and Karawnaken, Julischen Alps, and Dinaric range of the mountains in the west and south. This closed circle of mountains embraces the South-Slovakian and East-Slovakian Lowland, the Hungarian Lowland, and the Transylvanian Uplands.
Figure 9: CORINE Land-cover of the Republic of Serbia
4.2. Typical Land Use in the Mountainous Parts of the Catchment and on the Floodplain

In general, the mountainous parts of all sub-basins in Serbia host smaller settlements, while larger cities, industry, and infrastructure (network of roads, railways, etc.) are located in the river valleys and floodplains.

According to the 1991 census, the Danube River (Danube Corridor) sub-basin has 2,833,954 inhabitants (population density of 244 inh./km$^2$), with urban population (67.4%) dominating over rural. The capitol Belgrade and the province of Vojvodina center Novi Sad are located in this area, together with several other larger cities, related industry, and infrastructure. The Tisa River sub-basin has 809,755 inhabitants (population density of 90 inh./km$^2$), with urban population (57.6%) dominating over rural. In the Sava River sub-basin live 1,354,592 inhabitants (population density of 111 inh./km$^2$), with urban population (50.2%) dominating over rural.
inhabitants, with rural population (64.9%) dominating over urban. Population density in this sub-basin is low – only 64.6 inh./km$^2$ - due to very scarcely inhabited regions in upper parts of Drina watershed. In the Velika Morava River sub-basin live 4,081,046 inhabitants, with rural population (56.1%) dominating over urban. Population density in this sub-basin (107.8 inh./km$^2$) is close to the average population density for the whole Danube River Basin in Serbia.

Danube River Basin in Serbia represents 92% of arable land and even higher percentage of total national agricultural production. The land under cultivation makes 63,190 km$^2$ (61.4%) of the complete territory of Serbia and Montenegro, with 10% of population engaged in agriculture as the only activity. As shown in Figure 11, farming, fruit- and vine-growing, and cattle breeding are differently territorially represented in highland and plain areas.

Figure 11: Land Use in Serbia (1993)

4.3. Sensitivity of Basins to Creation of the Flood Extreme

In general, southeastern, eastern, and southern parts of Serbia have higher water potential than northern and central parts. Since mountainous regions in these parts have higher both precipitation and specific runoff coefficients, specific runoff from these areas is over 15 l/s per km$^2$. In lowland and hilly areas of northern and central parts of Serbia specific runoff is generally lower than 6 l/s per km$^2$. Smallest water potential (from 2 to 5 l/s per km$^2$) is detected in lowlands of Vojvodina and in the area of left tributaries of Velika Morava and Kolubara Rivers.

5 HYDROGRAPHICAL MEASUREMENTS

5.1. River bed measurements

Hydrographic (bathymetric) survey is the process of gathering information about navigable waterways for various purposes such as: safe navigation, dredging, planning of the engineering works, etc.

The hydrographic survey of international navigable waterways in Serbia is the task that is performed by Directorate for Inland Waterways “Plovput”. Survey on the Danube, Sava, and Tisza rivers are being performed annually.

5.2. Types of used equipment

For the hydrographic survey Plovput uses three vessels:

1. MB “EHO” – engine power 2x103kW, with auxiliary engine 20.5kW, (Figure 12);
2. MB “EHO II” – engine power 2x62kW, with auxiliary engine 8kW, (Figure 13);
3. Speedboat– 5 m long, with engine power 37kW, (Figure 14).

MB “EHO” is equipped with 200kHz transducer, with echo-sounder Marimatech E-SEA SOUND 103.
MB “EHO II” is equipped with 200kHz transducer, with echo-sounder Navi Sound RESON 200. Speedboat has two 200kHz transducers, with echo-sounder Marimatech E-SEA SOUND 103, and portable equipment for single beam measurements. Precision of the echo-sounder is 1cm +/- 0.1% of measured depth.

Two global positioning systems (GPS) are being used, depending on the vessel where they are installed:

- Marimatech GPS-RTK with precision of +/- 20cm,
- Trimble DGPS-RTK 5700 with precision of +/- 2cm.
The reference coordinate system used for all geographical data in Serbia is the State Geographical Coordinate System (Gauss–Krüger Zone 7).

Since April 2001, Plovput is equipped with Atlas’s Fansweep 20 multibeam survey system. It has been used for the detailed survey of critical river sections. It is mounted on the MB “EHO II” vessel.

![Multibeam survey of Apatin sector](image)

**Figure 15: Multibeam survey of Apatin sector**

### 5.3. Data processing

Before the beginning of survey, coordinates of boundary points of cross-sections should be entered into the specialized software. Survey tracks follow those predefined profiles.

Depth (z) and location data (x, y) are transferred to the specialized software for hydrographic survey – “Masterchart”. The software synchronizes data constantly, so that the boat location is known in real time.

Information on the speed of sound in water is determined using the information provided by the SVP (sound velocity profiler) device. Differential GPS station is mounted on the solid ground, at the reference point with known geographic coordinates. The base station is connected with the boat by radio signal, sending information on differential correction, providing the required accuracy for the performed survey.
Depth information is obtained using the time necessary for ultrasound waves to travel from the echo-sounder to the river bottom and back. Two sounders are mounted on the boat. One is set to send the signal, and another to receive it. Such system provides depth measurements of 30cm below the eco-sounder, and 50 cm below the water surface. This setup is of importance for surveys in shallow waters.

Data on depth and location are synchronized in real-time, and information stored in ASCII format in the form of x, y (position) and z (depth) coordinates.

Water stages are measured and updated every couple of hours, in relation to the reference point. After completion of the surveys, the quality control is being performed, spikes removed, and data stored into the database with cleaned x, y, z coordinates for each of the cross sections.

5.4. Long-time data elaboration

Establishment of the cross-sectional database is of a great importance for analysis of navigable waterways in Serbia. This database, developed completely by Plovput’s engineers, is in use for almost 10 years, (Figure 16).

![Figure 16: Cross-sectional database interface](image)
This database provides necessary information for the analysis of the condition of the waterway (Figure 17), comparison of cross-sectional data surveyed in different years (Figure 18), etc.
6 LEGISLATIVE MEASURES

Activities performed by the RHMZ are defined by the number of laws. Most important among them are:

- Law on Ministries, Official Gazette of the Republic of Serbia 65/08

Other documents important for the field of flood protection are:

- General Flood Defense Plan,
- Flood Defense Action Plan, and

International (sub-basin) co-operation is based on Serbia’s membership in the Danube Commission, and on bilateral agreements with neighboring countries within the Danube River Basin. The former Yugoslavia signed several bilateral and multilateral agreements and conventions governing the use of the international waterways that form or cross national borders.

Some of these agreements are still in force (Table 2). Bilateral agreements governing sustainable management of transboundary water resources are still not signed with Bosnia & Herzegovina and Macedonia. The agreement on navigation on navigable waterways with Republic of Croatia is in the ratification phase. The responsible Ministry of Agriculture, Forestry and Water Management - Directorate for Water of Serbia has initiated extensive preparations for the formulation of agreements and the commencement of a negotiation process with neighboring countries, incorporating contemporary solutions and the best of international practices. Such agreements are not only a precondition for the bilateral, but also for multilateral cooperation.
Table 2: Bilateral agreements and co-operation on transboundary waters

<table>
<thead>
<tr>
<th>Rivers</th>
<th>Riparian countries</th>
<th>Treaties</th>
<th>Year of establishment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Danube, Tisza</td>
<td>Serbia, Hungary</td>
<td>Agreement between the governments of the FPR of Yugoslavia and the PR of Hungary regarding water management issues</td>
<td>1955</td>
</tr>
<tr>
<td>Danube, Begej, Tamis, and other rivers in Banat region</td>
<td>Serbia, Romania</td>
<td>Agreement between the governments of FPR of Yugoslavia and the PR of Romania concerning water engineering issues related to boundary and transboundary systems and watercourses</td>
<td>1955</td>
</tr>
<tr>
<td>Nisava, Timok</td>
<td>Serbia, Bulgaria</td>
<td>Agreement between the governments of the FPR of Yugoslavia and the PR of Bulgaria concerning water management issues</td>
<td>1958</td>
</tr>
<tr>
<td>Danube</td>
<td>Serbia, Croatia</td>
<td>Agreement between the governments of Republic of Serbia and Republic of Croatia concerning the navigation on navigable waterways, their marking and maintenance</td>
<td>In the process of ratification</td>
</tr>
</tbody>
</table>
7 LITERATURE

1. AGN, 1996, European Agreement on Main Inland Waterways of International Importance - AGN, ECE/TRANS/120/Rev.2, United Nations, Geneva
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