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"NETWORK OF DANUBE WATERWAY ADMINISTRATIONS"

South-East European Transnational Cooperation Programme

STATUS QUO REPORT ON HYDROGRAPHICAL ACTIVITIES

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1 Region of interest – general information

1.1. Geographical position

The Slovakia is located in the middle Europe and borders on five states: Czech Republic, Austria, Hungary, Ukraine and Poland. The area country is 49 036 km^2 and the number of inhabitants is approximately 5.38 mil.

1.2. Water river network

Within the Slovak territory, the Danube river basin is covered by watershed contour line divided into two parts:

- River from the western part flow directly into the Danube (Morava, Váh, Nitra, Hron, Ipeľ) – all together 63, 86% from all territory of Slovakia
- Rivers from the eastern part are tributaries of the Tisa river system (Slaná, Bodva, Hornád, Bodrog) – 32.16% territory of Slovakia

In the northeast part of Slovakia territory, the Poprad River, which is tributary of the Dunajec, belongs to the Baltic Sea's drainage area – 3, 98%.

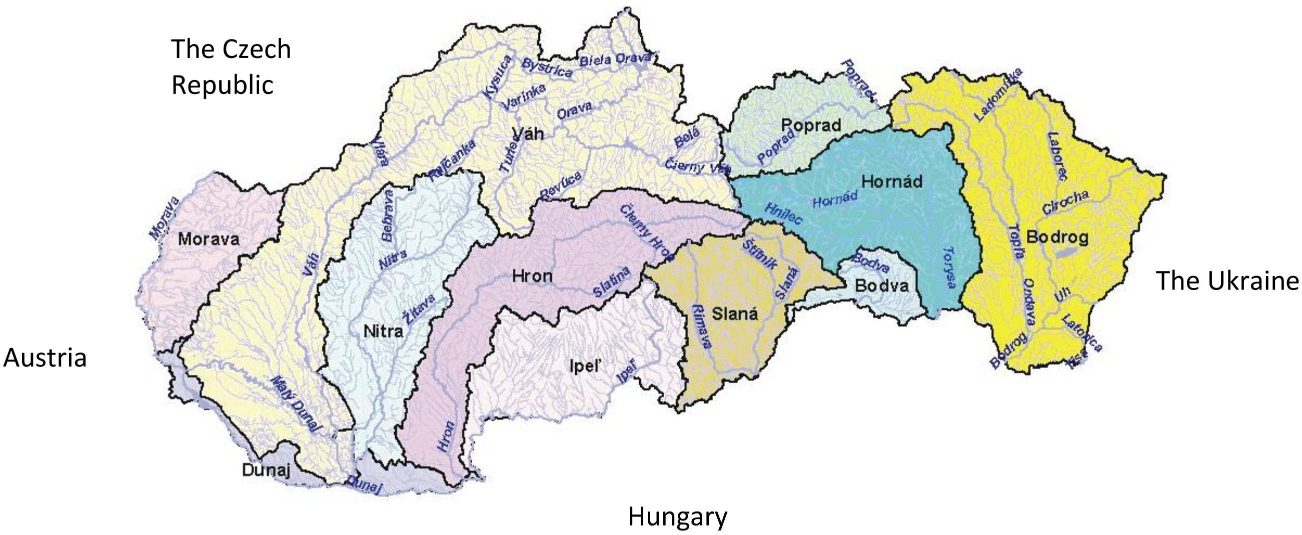


Fig. 1 River basins in the Slovak Republic

In presented contribution the attention will be devoted primarily to the part of country (63, 86%) which drainages water directly to the Danube River. For better understanding and description hydrographical and hydrological activities that region was divided into three main hydrological units:

- The Pannonian Danube (Žitný ostrov – inland delta – the Danube's left bank)
- Morava river
- Rivers – Váh, Hron, Ipeľ

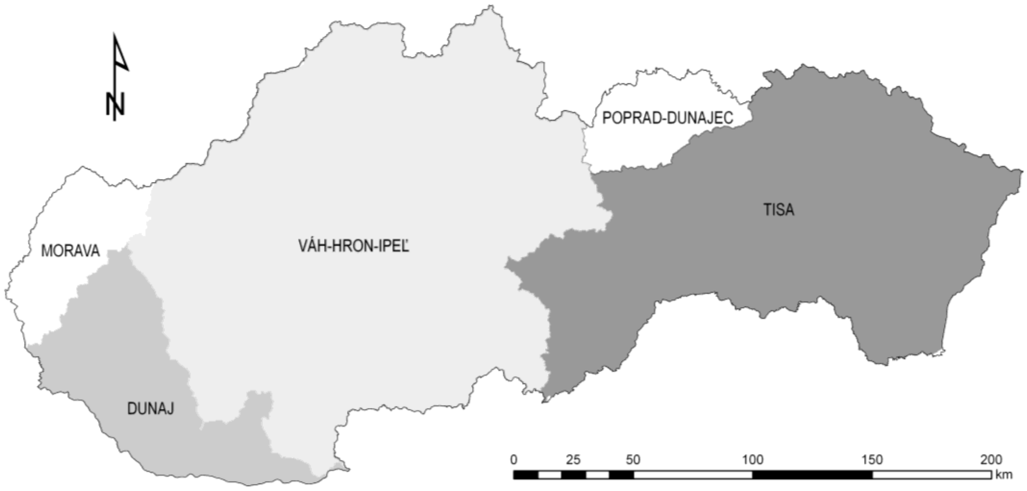


Fig. 2 The river basin of interest region – The Pannonian Danube, Rivers – Váh, Hron, Ipeľ, Morava River

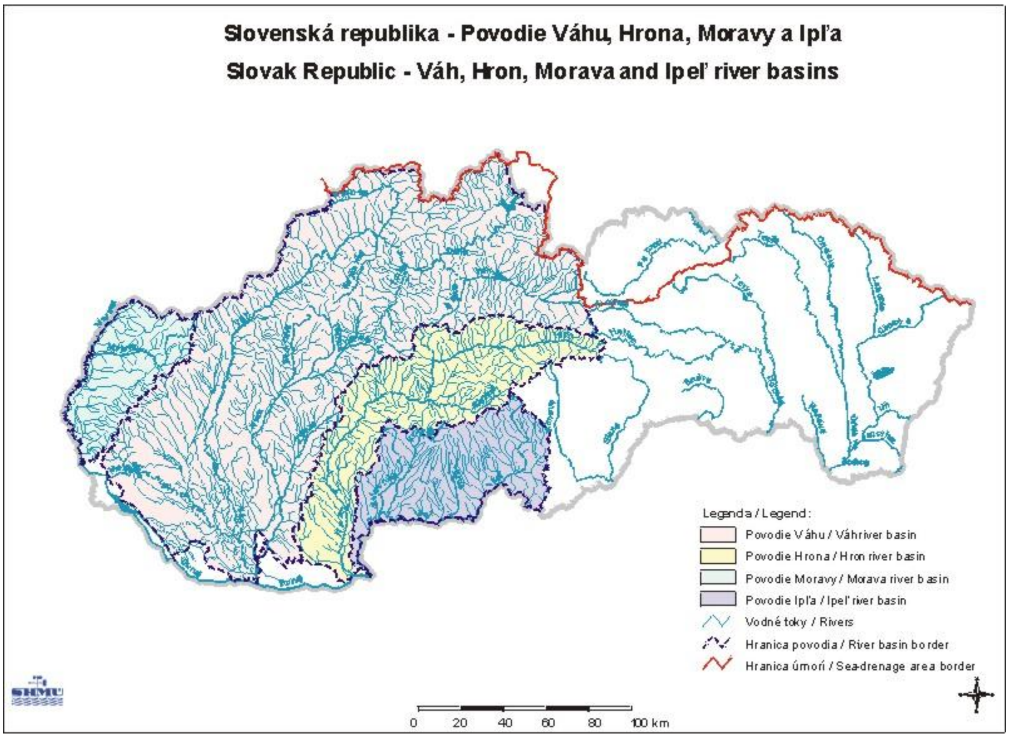


Fig. 3 The River basin of interest region

2 Climatological Condition

Climatic conditions of Morava basin – at the interest basin we have two basic different climatologic areas. Warm area, to which western part of basin belongs, within this area we have warm, moderately dry sub-area with mild winter (west part of Borská nížina (lowland) and warm, moderately wet sub-area with mild winter (remaining part of Borská nížina (lowland) and prevailing part of Chvojnická pahorkatina (upland). Second area, it is moderately warm area, which represents remaining part of basin and within it there is moderately warm, moderately wet sub-area with mild winter (Myjavská pahorkatina (upland) and foothill of Malé Karapaty and Biele Karpaty and moderately warm, wet sub-area (ridge and parts of the slopes of Malé Karpaty and spring area of Myjava river in Biele Karpaty.

The climatic conditions of the river Hron , Ipeľ, Slaná basins are affected by their position in the moderate climatic zone of the Northern Hemisphere with a regular alternation of the seasons of the year. In all three basins – the Váh, Hron and Ipeľ – the upper parts have quite rough weather, due to the complicated orographic conditions. The lower parts belong among the warmest regions of Slovakia.

2.1. Air temperature

The mean annual temperature for the basins is 7.4^{0} *C*, and the whole region varies from –3.0 ^{0}*C* to 10.0 ^{0}*C*. The maximum mean monthly temperature (20.3 ~ 20.5 ^{0}C) prevails during July in the lower southern parts of the basin and the lowest temperature (-3 ~ -10 ^{0}C) during January in the mountain regions. The annual number of days with a temperature above 0^{0} C varies from 71 in the high mountain areas, 96 in the hilly parts to 279 days in the lowlands. A network of climatic observation stations measures the air temperature: 36 in the Váh River basin, 10 in the Hron River basin and 4 in the Ipeľ River basin three times a day.

2.2. Precipitation

Rainfall distribution in Slovak Republic territory is mostly influenced by relief, and altitude is the most important parameter. Exposition of slopes influences the air flow and precipitation. According to long term mean (1931-1980) year precipitation total in Morava basin ranges from 550 mm (along Morava river) up to over 800 mm (in upper lands of this area), as a function of increasing altitude. The lowest monthly totals of precipitation are in January, February, March with mean monthly amounts 30-45 mm, minimum mostly in February and second minimum in September (Indian summer), the highest totals are in June and July (70-90 mm). From extreme monthly amounts of precipitation it is clear that absolute highest amounts of precipitation are mostly in second half of the year and absolute minimums of precipitation amounts are in January, April, September, and October. Significant for the all region are relatively high water accumulation in the snow cover during winter time which determine flow condition of river network and caused floods in early spring time.

The annual precipitation in the three (Hron(Ipeľ, Slaná) basins varies from 525 ~ 580 *mm* in the southern part to 2000 ~ 2100 *mm* in the high mountains. The majority of the basins belong to hilly regions with a total precipitation of more than 700 *mm* (63 % *of the area*). According to the time variability of the precipitation, the maximum annual total occurs in July and August (50 ~ 200 *mm*) and the minimum in September and February (0 ~100 *mm*). Presently, the precipitation stations (6 at the Hron basin, 12 at the Váh basin and 2 at the Ipeľ basin) are equipped with telemetric tipping bucket gauges. There are 247 (*Váh*), 84 (*Hron*) and 48 (*Ipeľ*) stations which conduct measurements at rain gauge stations (once every 24 hours).

2.3. Snow

A network of climatic observation stations on a daily basis measures the basic snow characteristics – the depth of snow cover and the depth of new snow. The values of the snow water equivalent are measured weekly. The number of days with snow cover varies from 30 to 220. The mean duration of snow cover lasts 80 days.

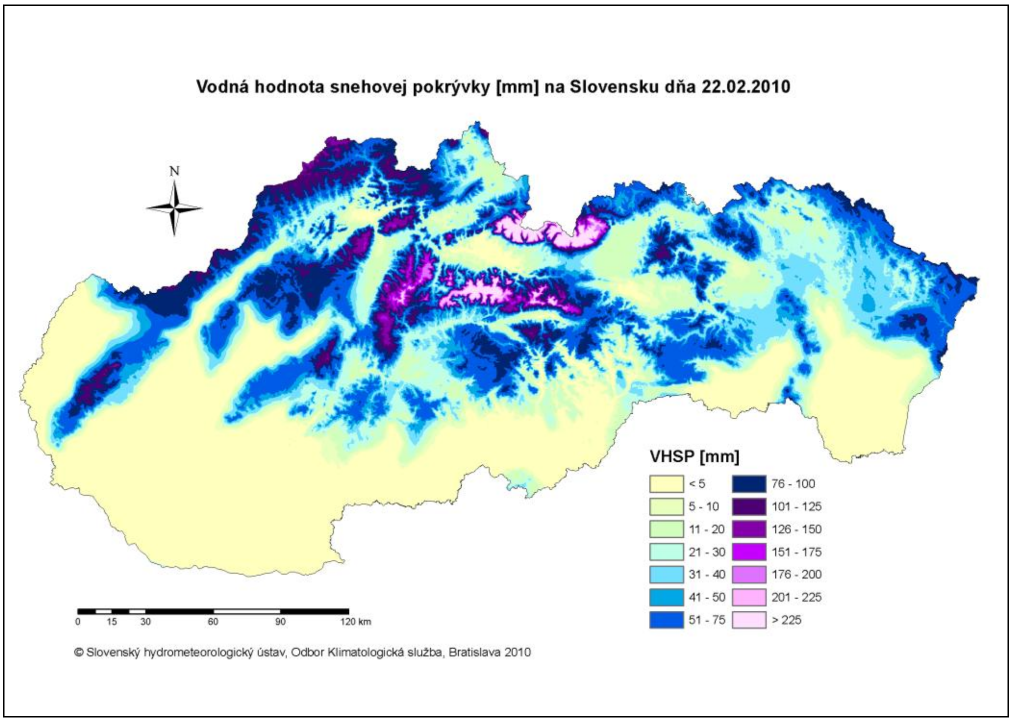


Fig. 4 Water snow equivalent in Slovakia

3 Main Basin Description - Sub-basin of the Pannonian Danube (Žitný ostrov – Inland Delta – The Danube's left Bank)

Area

Žitný ostrov is a part of the Danube lowlands. The borders of the region are composed of the Danube, Malý Dunaj (t*he Little Danube*) and Váh rivers. The total area is around 1469 *km*^{2}. In the past the Malý Dunaj was a stream branch of the Danube. The Malý Dunaj River starts at Bratislava's port (*river kilometer* 1865.43) at present, and the nearby town of Kolárovo flows into the Váh River from the right-hand side (*approximately 25 km from Komarno*). The total length of the Malý Dunaj is 82 *km*.

3.1. Geographical position

The territory belongs to the northern part of the Pannonian basin
The territory of mentioned region has a broken topography; the maximum difference in altitude is about 2450 m. The territory of Žitný ostrov is rather flat; the maximum difference in altitude is no more than 26 *m*.
The Pannonian Central Danube basin at the territory of Slovakia consists from the following main parts (sub-basins):

- Danube river from the mouth of the Morava River to the mouth of the Ipeľ River
- Rivers and creeks the springs of which are located on the south-eastern slopes of the Malé Karpaty mountain range (the Little Carpathian Mountains),

Closing stretches of the Váh River, the Hron River and the Ipeľ River within the influence of the Danube flood water effect

3.2. Geological overview

Historical changes in the Danube system between Bratislava and Komárno (1766 ~ 1865 *river kilometres*) are the consequence of geological developments and frequent climatic variability during the Quaternary period. One has to include changes in the volume and movement of gravel and fine sand in the Danube; the deepening, increasing and meandering of the riverbed; sedimentation and erosion; and frequent floods. The intensive felling of forests, the preparations of new agricultural land, intensive draining measures, and the construction of irrigation systems and river dikes have also affected the environment. At the same time, changes have been caused by urbanisation, industrialisation, population growth, and the development of transportation and communication systems. Žitný ostrov has been a protected water management region since 1978

The Carpathian Mountains create a boundary line between the basins of the Black and Baltic Seas in Slovakia's territory. There are three longitudinal mountain zones:

1. The external flysch zone;
2. The central crystalline zone;
3. The internal volcanic zone.

The external flysch zone lies on the watershed contour line between the Morava, Odra (Baltic Sea catchment) and Váh River basins. The flysch region represents specific hydrological conditions. The weathering of the schist and calcareous clays create fine-grained soils, which are effectively impervious. The water flow on the surface and underground only percolates in waste cones. The precipitation and snowmelt consequently drains away very quickly and forms steep flood waves.

The central crystalline zone consists of granite and crystalline rocks. Variegated mixtures of conglomerates, sandstones, schist's, limestones and dolomites have been there since the Mesozoic period.

The volcanic zone lies southwards of the central crystalline zone. This zone begins in the older Neogenic soil and is composed of andesite, liparite and basalt.

A lower section of the Váh, Hron and Ipeľ River catchments is in the Danubian Lowland. The Danubian Lowland is part of the Little Danubian Fold. The lowland on the left bank of the Danube is composed of the Danubian plain (on the southwest and west) and the Danubian Highlands (on the north and northeast). The territory belongs to the northern part of the Pannonian basin. The Neogene soil is at very variable depths. The Neogene is clay composite and therefore is practically impervious. The Pannonian sea sediments cover thick layers of

Quaternary complexes. The central depression of the Danube Lowland is composed of water-bearing sediment, gravel and sand. The Pleistocene sediments are a substratum of the Danubian Highlands. On the surface are Quaternary eolitic sediments, loess and sand clay.

The West Carpathians´s structure is characterised by zoning. The Mesozoic and the Tertiary formations, which are arrayed in a series of actuated belts, have been tectonically transformed from qualitatively and temporally different sedimentary basins into fold-nappe ranges, which may either be composed of a sedimentary filling alone or may include the original surface.

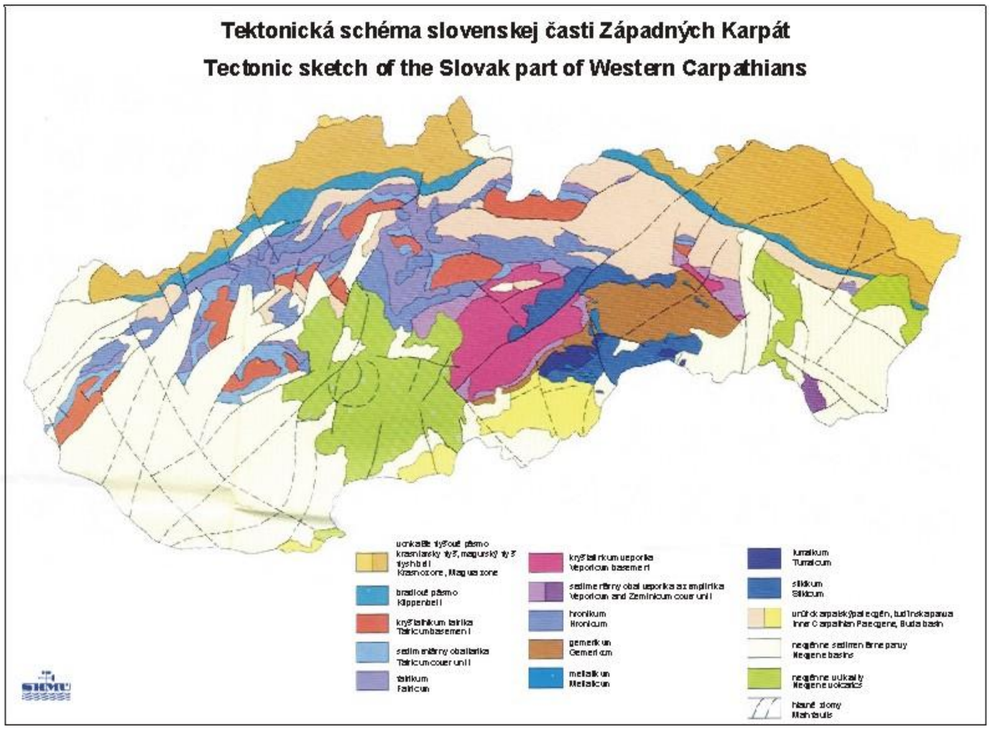


Fig.5 tectonic sketch of the Slovak part of Western Carpathians

The Alpine mountain range of the Western Carpathians stretches across Slovakia's territory. Although the western geographical boundary of the Western Carpathians with the Eastern Alps is located in the Danube River valley, this boundary in geological terms quite clearly coincides with the depression running westward of the Hundsheim hills via the so-called Carnuntum Gate. The eastern boundary of the Eastern Carpathians is conventionally located in the Uh River Valley. Most of the Western Carpathians´s northern boundary is determined by the erosional, morphologically distinct and truncated margins of the Alpine nappes, overlying the foredeep in Moravia and Poland. The inner margin of the Western Carpathian mountain system is dissected by deep extensive basin incursions, which make the southern boundary less distinct. The northern margin of the Great Hungarian plain, which is south of the Buk and Mátra mountains, is a morphologically conspicuous feature indicating the affinity of these mountainous ranges with the Carpathian Mountains.

3.3. Prevailing soil

An outcome of the changes in the water regime and vegetation with the elevation of the height above sea level is the zoned distribution of soils in folds and on mountain slopes. On top of the river basins and hills are thin layers of mountain types of soil. Brown soils prevail in the upper and middle parts of the river basins. Alluvial layers composed of gravel and sand in the river valleys are covered with medium weight soils. The catchment's lower parts are mainly composed of light soils and aluminous medium heavy soils. The driest localities of the lowest folds are covered by heavy black soils.

The Neogene's is at very variable depths. Neogene's is composed from clay and therefore is practically impervious. The sediments of the Pannonian Sea cover thick layers of Quaternary complexes. The central depression of the Danube Lowland is composed of water-bearing sediment, gravel and sand. The physical properties of the soil layers are quite varied. Practically all types of soil occur there. On the western side are mainly light soils with unfavourable amounts of coarse sand. The aluminous medium heavy soils in the middle and eastern part of Žitný ostrov have favourable physical properties.

3.4. Vegetation

The variety of natural conditions results in ecological diversity in the vegetation. The vegetation is stratified on the mountains, especially those on elevations above sea level. The upper boundary of the forests is about 1300 m above sea level in the west and the mountains in northern Slovakia (Vysoké Tatry – High Tatras; Západné Tatry – Western Tatras). In central

Slovakia, the mountains (Nízke Tatry – Low Tatras) are 1400 ~ 1500 m above sea level. The habitat of the dwarf pines and meadows lies even higher. The structure varies from coniferous to leafy forests. Agricultural products are cultivated both in the uplands and in lowlands of the valleys.

3.5. Land use

In the mountainous parts of the catchments, forest management, along with grassland farming and cattle and sheep rearing, predominates. In the valleys by the rivers and in the uplands and lowlands intensive agriculture has developed. The structure of the arable crops varies, depending on the conditions in the individual localities.

Almost all of the land is exploited for agricultural purposes. Forests cover only small parts of the territory.

3.6. Climatological conditions

The long-term mean area precipitation is approximately 555 *mm*; in extreme years, it may be from 300 to 830 *mm*. The rainfall distribution varies too. The vegetation suffers from insufficient precipitation at the end of the vegetal period. The vegetal period lasts an average of 245 days.

The long-term average temperature is 9.7 °*C*; during the vegetal period, it is 15 °*C*. In January, the average temperature is –1.5 °*C*, band in July, it is more than 20 °*C*.

The prevailing wind direction is north-westerly. In an average year, only 70 days are windless.

3.7. Economical position

The Danube River flows in Slovakia through the regions, which have different socio-economic character. The capital city Bratislava is the most important stretch of the Danube River in the Slovakia from the socio-economic point of view. The towns Komárno and Štúrovo are important centre as well. Rapidly developing recreation and trading areas can be found in the surrounding of the hydraulic structure in Čunovo and Gabčíkovo. Agriculture dominates in other zones along the Danube River. The most fertile soils are situated along or close to the river. Population density is lower in agricultural areas, comparing with the close to the river.

Large water courses, as well as numerous smaller water courses are under administration of the Slovak Water Management Enterprise, state enterprise (important water courses). The others ones are administrates by the municipalities, forestry, agriculture, army etc.

4 Hydrographical measurement

4.1. Discharge measurements

Discharge measurements on large rivers are currently provided mostly by ADCP (Acoustic Doppler Current Profiler) from the boat or from the bridge. In certain circumstances and on the smaller streams the measurements are made by propeller type current meters (with rotating element) (A.OTT) from the boat, from the bridge or by wading.

Both techniques belong to the velocity-area method. One of the outputs (in both methods) is also the cross-profile measured.

4.2. Measuring equipment

ADCP measurements

The ADCP measurements on Danube are usually made from a boat. The measurement is repeated at least 4 times in each profile, afterwards the results are checked. If all four measurements fell into the given interval, the measurement can be finished and Agila 6.2 software provide from the inputs the number of outputs including the velocities, discharge, cross profile, etc. If any of the four measurements is out of the interval, it is excluded from a set and one more measurement is made.

Measuring equipment: ADP SONTEK MINI (SONTEK),
ADCP STREAM PRO (RD INSTRUMENTS),
ADCP RIVER RAY (RD INSTRUMENTS)

Software: WINRIVER I, WINRIVER II (RD INSTRUMENS)
RIVER SURVEYOR 4.3 (SONTEK)
AGILA 6.2

The SonTek/YSI ADP (Acoustic Doppler Profiler)

is a high-performance, 3-axis (3D) water current profiler that is accurate, reliable, and easy to use. The ADP uses state-of-the-art transducers and electronics designed to reduce side-lobe interference problems that plague other current profilers. This allows the ADP to make the very near-boundary (surface or bottom) current measurements critical to shallow water applications. The 1.5 and 3.0-MHz profilers are available as Mini-ADPs featuring a compact transducer head designed for applications where small size is critical.

Fig. 4 The SonTek/YSI ADP (Acoustic Doppler Profiler

The profiler combines proved technology of acoustic Dopplers´s effect with software facility dedicated to OS WINDOWS.

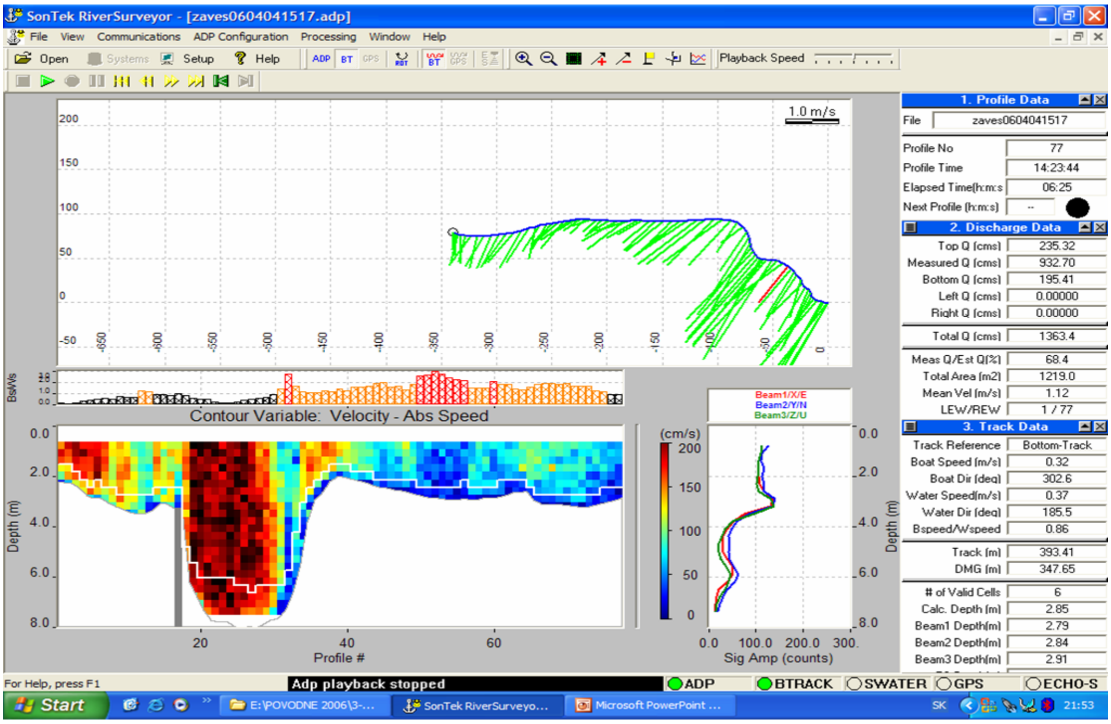


Fig.5 Processing of measurement by ADP

Propeller type current meter measurements

Velocity is observed at one or more points in each vertical by counting revolutions of the rotor during a period of not less than 60 second and as long as three minutes if velocities are pulsating.

Fig.6 Current meter

In larger rivers such as Danube and Morava the measurements by propeller type current meters are made by five-point method, i.e. the point flow velocity measurements are made in five points in each vertical – close to the bottom, in 0,2; 0,4; 0,8 relative depths and close to the water surface. The optimum number of the verticals is 15 to 20; the minimum recommended number is 8. The measurements are usually made from the bridge, using trolley with reeler and propeller with a weight. The weights are used 25 kg, 50 kg or 100 kg according to the actual velocities and depths. This procedure indicates that in comparison with ADCP measurements, the method requires much more physical work and capacity and it is much more time-consuming.

Measuring equipment: propeller tool set (A. OTT)

Software: PDAwin

4.3. Interval of measurements

The recommended frequency of measurements: 6-times/year; in selected international profiles the number of measurements according to bilateral agreements (common measurements).

List of water-gauging stations with discharge measurements on river Danube

Water-gauging station	**river km**	**Interval of measurement**
Bratislava - Devín	1879,80	9* + 2
Bratislava	1868,75	6-8
Dobrohošť	1838,50	5* + 1
Medveďov-most	1806,30	9* + 2
Komárno-most	1767,80	9* + 2

4.4. River bed measurements

For monitoring of the Danube waterway is on OZ Bratislava responsible department of morphological monitoring. Monitoring of the Danube can be divided into monitoring of the riverbed morphology and discharge and current measurement.

4.4.1. Monitoring of the riverbed

To monitor the Danube riverbed we use technology of echo – sounding of the river bottom in combination with the determination of position using GPS instruments. We use "single beam Sounding System, which provides data of sufficient density and accuracy for our needs. Measurements are performed in transverse profile with the necessary density, measured data are reduced to reference level and through 3D models are created water depth izolines.

Measuring equipment and measurement methods

1992 - 2007:

- Vessel: Nordica Nimbus 29 C (2 x Volvo Penta), Quicksilver 380
- Echo sounder: Atlas Deso 22 (210 kHz)
- Position sounding : motorized TS + polar track

2001 - 2006:

- Vessel: Nordica Nimbus 29 C (2 x Volvo Penta), Quicksilver 380
- Echo sounder: Atlas Deso 22 (210 kHz), Atlas Deso 15 200 kHz
- Position sounding: GPS Trimble Pathfinder
- System: Navisound 100 PC

Since 2007:

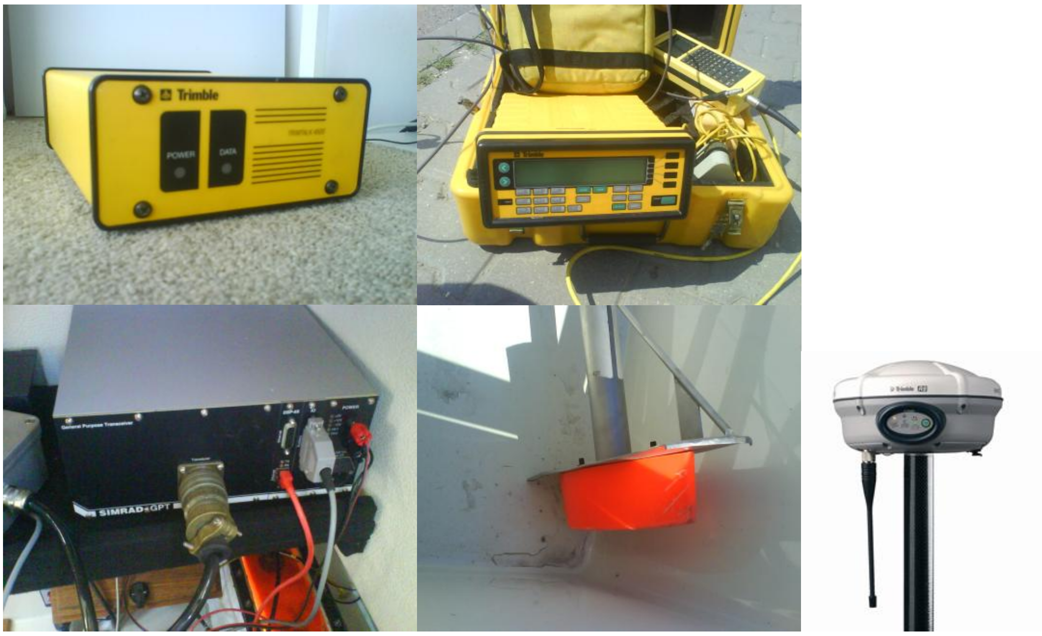
- New vessel - Targa 25.1 (Volvo Penta 6V 330ph)
- Quicksilver 380 HD (Mercury 15)

- Echo sounder: Kongsberg EA 400 200 kHz + 200 kHz
  Kongsberg EA 400 200kHz + 38 kHz
- Transducer: Kongsberg Combi D 38/200kHz
  Kongsberg 200 7F, 200 kHz
- GPS: 3xTrimble 4000 ssi
  Trimble R8 GNSS
  2 xTrimble Trimtalk 450s
  Trible DSM 232
- Software: Kongsberg EA400, Profile 2000, SSM
  Trimble GeomaticOffice
  Microstation V8 XM, InRoads

Fig.2: vessel Targa 25.1

Fig.3: vessel Quicksilver 380 HD

Fig.4: measuring system for sounding (base, echo sounder, transducer, GPS Trimble)



For monitoring of the Danube we are making use the vessel Targa, for meassuring of the shallow waters we use rubber boat. Both vessels are equipped with GPS Trimble R8 GNSS, which operates under the RTK (real time kinematic). If the GPRS service is available, we use a network of reference stations SKPOS provided Geodetic and Cartographic Institute. If not, we use own reference station "Base station" Trimble 4000ssi. We use technology PDGPS.

For meassuring of water depth we use echo-sounder Kongsberg - Simrad EA400 with appropriate software combined with Konsberg Combi D transducer 38/200kHz or Konsberg 200 7F, 200 kHz.

4.4.2. Frequency of monitoring

We are doing monitoring of the Danube in different intervals. Border zones are monitored by engagement of the border commision's working groups. Joint section of the Danube with Hungarian Republic (1708,2 – 1811,0) are monitored every two years. These section is divided into two parts 1708.2 - 1749.00 rkm and 1749.00 – 1811,00 rkm. Monitoring of these sections is exchange every two years. The section of the „original riverbed" of the Danube is monitored by mutual agreement of both countries. Measurements have two countries exchange in WGS-84 coordinate system, format .txt and then evaluate them. Density of measured profiles is 50m. There is a problem with Hungary, we haven't measured identical profiles and then we are not able to compare changes in the riverbed in individual profiles.

Common section with Austria we monitor once a year (rkm 1880.2 - 1872.7), data are evaluated and treated on the department of morphological monitoring, and Austria receives only a paper version. Density of measured profiles is 50m.

Nacional section is monitored once a year, and evaluate process is done on morfological monitoring department, and serves for internal use. Density of measured profiles is 50m.

VD Gabčíkovo (reservoir Hrušov, artificial canal) is monitored every 2 - 3 year (where necessary). Density of measured profiles is 100m.

In addition to periodic monitoring of the Danube riverbed we perform sounding on the purpose of dredging - dredging site is monitored during dredging and after dredging is finished.

We also carry out a more detailed sounding of the Danube riverbed for the purposes of drawing up projects, civil engineering, if the results of periodic soundings are not sufficient for completion of studies and project documentation.

Applied technology and measuring equipment is possible to achieve very accurate results (a few cm) but the movement of ships and the conditions during the measurement accuracy degrades

4.4.3. Data processing

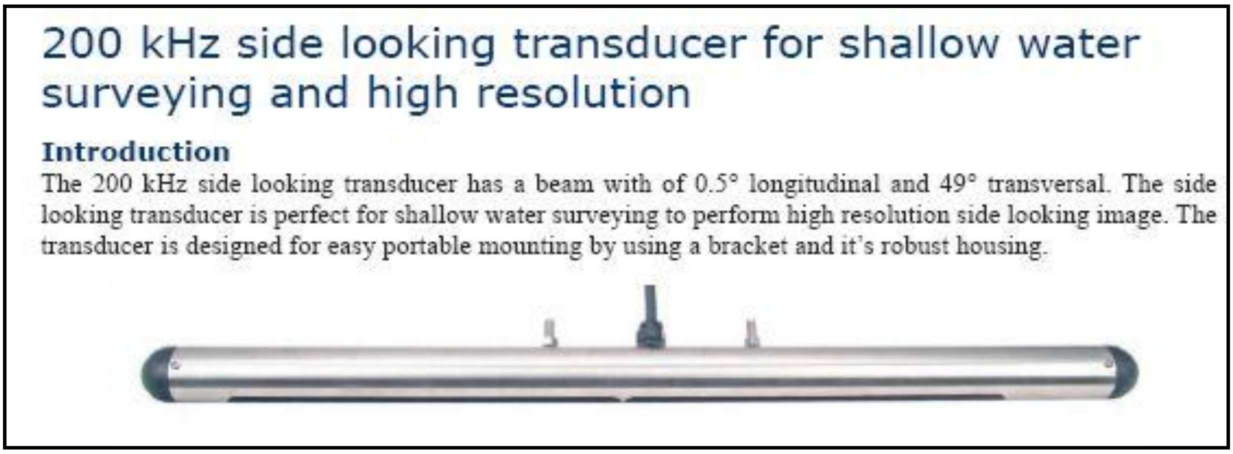
Processing and utilization of meassured data is as follows. Meassured points of the riverbed in WGS84 are transformed into national coordinate system S-JTSK (x, y, z). Data are loaded into MSInroads and then we create DTM of the riverbad and DTM of „regulation low water level". By intersection of these models are generate isolines reduced to HNRV (regulation low water level). The result of the processing and evaluation of data is izoline plan of measured section of the Danube. Plan contains the measured points in each river bed profile reduced to HNRV (regulation low water level) and isolines.

Then the processed results of sounding were subsequently loaded into the ORACLE database through GeoMedia software, and serve as a basis for creating other mapping products needed for the maintenance of fairway or for navigation. Based on this data we are working – out „Project for dredging of the Danube", "Electronic navigation map" and "Project of signalization fairway."

Side scaner as an additional monitoring

In 2009 we purchased the side scanner for purpose of to search wrecks and other obstacles in the fairway. Outputs of the side scanner will serve to further complement the monitoring of critical sections of the waterway. Currently, this device is in the testing phase, we tested it yet on the measurement of port pool in Bratislava and Komarno ship yard. Side scanner is with special bracket attached to the vessel Targa 25.1, during the measuring are data monitored and subsequently processed by software SSM (Software for Sidescan Mosaiking)

Fig.5: Side scaner



200 kHz side looking transducer for shallow water surveying and high resolution

Introduction

The 200 kHz side looking transducer has a beam with of 0.5° longitudinal and 49° transversal. The side looking transducer is perfect for shallow water surveying to perform high resolution side looking image. The transducer is designed for easy portable mounting by using a bracket and it's robust housing.

4.4.4. Discharge and current measurement

Measurement speed and flow rate on the Danube is officially in filled SHMI. The project tasks and studies we are obliged to do on base of data SHMI, but sometime we need measurements in profiles where not data (there are not water gauges) are. In this case we use own measuring system ADCP (Acoustic Doppler Current Profiler).

The ADCP measures water currents with sound, using a principle of sound waves called the Doppler Effect.

ADCP measuring system was purchased in 2009, it is still in test phase, and has been used for specific project tasks (for hydrodynamic model) in the VD Gabcikovo and arm system.

Fig. 6: ADCP measuring system

5 Institutional and Legislative Measures

Slovak Water Management Enterprise

Under the Constitution of the Slovak Republic, all water bodies are owned by the state. The Slovak Water Management Enterprise (in Slovak, Slovenský vodohospodársky podnik) is a state-owned organisation dedicated to the satisfaction of the public needs, public policies concerning water bodies, water, and flood management and protection. The Slovak Water Management Enterprise is managed and controlled by the Ministry of the Environment of the Slovak Republic, and is part of the Water Section.

The Slovak Water Management Enterprise manages all the stream networks in Slovakia, except for little brooks and streams, which are not important from a water management point of view. These are managed by the forest and agricultural authorities and in some areas by municipal authorities. Flood protection is one of the major tasks of the Slovak Water Management Enterprise.

Slovak Hydro-Meteorological Institute

The dominant mission of the Institute, which combines meteorological and hydrological services, is:

- monitoring the quantity and quality parameters characterising the state of the air and waters in the Slovak territory
- collection, validation, assessment, archiving and interpretation of data and information on the state and regime of the air and waters
- providing data and information on the state and its air and water regime
- study and description of the atmosphere’s and hydrosphere’s phenomena.

ACTS supporting basic meteorological, hydrological data and water management

Act No. 201/2009 Coll. of Laws on State hydrological service and state meteorological service

State hydrological service and state meteorological service safeguard state through Slovak Hydro-Meteorological Institute. Institute is corporate entity establish by Ministry of Environment SR to provide monitoring, evaluation and achieving meteorological and hydrological data.

Act No. 7/2010 Coll. of Law on Flood protection

The Act contains the rules for permitted activities in the floodplains. The Flood Protection Act and connected by lows will be amended in order to achieve accordance with Directive 2007/60/EC of the European Parliament and the Council on the assessment and management of flood risk. Regulations for activities in the floodplains are stricter in ongoing proposal of the amended law.

The Water Act and the Flood Protection Act create a legal framework for regulation of activities in the territories that are endangered by floods only. Neither from them has power to order the modification of the land use or change of spatial plans.