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"NETWORK OF DANUBE WATERWAY ADMINISTRATIONS"

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STATUS QUO REPORT ON HYDROLOGICAL ACTIVITIES

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1 Introduction

This document desribes the main hydrological activities of Danube basin and subasin in Slovakia. This report contents outline of monitoring network system (hydrological an meteorological), forecasting method, flood disaster and extreme flow and transboundary cooperation Institutional and legislative measures.

2 Hydrological Network

2.1. Hydrological monitoring the network

Hydrological monitoring the network for the main river basins (Danube, Morava, Váh, Nitra, Hron, Ipeľ) is illustrated in Fig.1

The network consists of 45 hydrological forecasting stations from 282 regime stations. The forecasting stations were created and arranged for the best representation of the hydrological situation and its progress in all the Danube River's sub-basins in Slovakia.

Fig. 1 Distribution of water gauge stations in 6 main river basins (Danube watershed) in Slovakia

Basin	Number of stations	among them – number of telemetric
Morava	29	20
Danube	20	18
Váh	120	67
Nitra	29	21
Hron	55	28
Ipeľ	29	20
Total	**282**	**174**

Information from the state monitoring network's surface water gauge stations represents:

- Measurements of water stages of 282 stations
- Discharge measurements of 258 stations
- Measurements of water temperatures of 250 stations
- Turbidity measurements of 9 stations

Daily hydrological information from hydro forecasting stations (MARS 5i automatic stations,) contains the following parameters: water stages, discharges and water temperature. The appearances of ice-related effects are observed by voluntary observers. Moreover the hydrological information deals with the relation of current water stages/discharges to their long-term observed means.

- Water stage – is measured at hourly intervals (MARS5 automatic instruments), continuously (water level recorder). Controlling measurements are provided by voluntary observers from water stage gauges.
- Discharge - is derived from a discharge rating curve, which is constructed and analysed from the measurement of discharges at different water stages
- Water temperature is measured by a thermometer once a day or automatically at one-hour intervals
- Appearance of ice – is observed visually by voluntary observers once a day during the winter season

- Turbidity (concentration of a suspended load) – water banks are sampled daily, 2 times a year from the entire profile. Valuations of the samples are made in a laboratory using the filtration method.

In addition to the state monitoring network, measurements and observations are conducted at 14 extra line purpose-built water gauge stations and 7 stations in countries neighbouring Slovakia.

2.2. Gauge equipments

Dicharge at a given time can be measuremed by several different methods, and the choice of methods and equipments depends on the conditions encountered at a particular site

Fig. 2 Water gauge station

Datalogger MARS5i

is based on removing of hydrostatic pressure of water columm**.** Data logger MARS5i with data & voice transmission is designed for the early flood warning and forecasting systems located in:

- rivers
- dams and reservoirs
- lakes
- wells and boreholes
- another locations for scientific studies and flood analysis

The transmission of data & voice is provided via the Public Services Telephone Network (PSTN) or via the radio-telephone GSM-GPRS Network and is based on internal analog (PSTN) modem or GSM modem.

Data logger MARS5i can automatically measure, record to the memory and transmit data for the following:

- water level
- discharge (rating curve)
- water temperature
- air temperature
- precipitation (quantity and intensity)

Data logger **MARS5i** is battery powered and does not require mains power supply ~ 220 V. Battery life is 2 years by average PSTN operation.

Basic Functions:

- recording of data into internal memory at programmable time intervals
- on the trigger event (3-stages of high water) data logger MARS5i sends ALARM to the selected phone number with the all necessary information (ID number, water level, etc.).
- automatic and manual readout of data at programmable time intervals via telephone line from main PC.
- Transmission of voice

- immediate values (water level and tendency, discharge, etc.)
- values at 6:00 AM
- average and extreme values from previous day

Basic Technical Data

Power supply	12 V DC
Memory	15 000 readings
Recording period	1 to 60 minute with step 1 minute
Water level sensor	Precision, temperature compensated stainless steel pressure sensor, range 0–1 *m*, 0–5 *m*, 0–10 *m*, 0– 0 *m*, 0–40 *m*, 0–80*m*
Accuracy ± 0.15% of Full Scale	
Water temperature sensor	–5°C…+50°*C*, accuracy ±0.1°*C*
Air temperature sensor	–50°C…+60°*C*, accuracy ±0.2°C, Pt1000 shielded
Precipitation sensor	Tipping bucket, 0.1 *mm* or 0.25 *mm*
Baud rate	19200 bps (PSTN), 9600 bps (GSM), GPRS
Operating temperature	–30°*C* – +55°*C*
Dimension **MARS5i**	90 x 158 x 258 *mm*
Protection	IP65, watertight robust cast aluminium housing
Weight	2.9 *kg*

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Fig.3 Datalogger Mars 5i

3 Inventory of Methods and Practices of Hydrological Forecasting and Warnings. Hydrological products, modelling tools, forecasting organisations

Centre of Forecasting and Warning and both Department Hydrological and Meteorological Forecasting and Warning perform the following services (as well as other services):

- operation, maintenance and development of the meteorological forecasting system, numerical weather models
- preparation of weather forecasts and warnings about dangerous meteorological phenomena for the public and special users
- operation and development of a monitoring network
- forecasts and warnings for surface water courses – a hydrological forecasting service

3.1. Hydrological Forecasting and Products

The Department of Hydrological Forecasting and Warning provides sets of various types of forecasts as follows:

Numerical forecasts are provided for***:***

- 5 hydrological forecasting stations on the Danube river (water stages, discharges)
- 1 hydrological forecasting station on the Morava river (water stages, discharges)
- daily forecasts for 13 reservoirs

Forecasting trends in water stages – increases, decreases, stability:

- are provided for other rivers. The time of arrivals and value of culminations are issued during flood situations.

During the winter season processed and issued once a week***:***

- information about snow conditions for the whole territory (depth of snow) and
- water equivalent of the snow – developments from 140 climatic stations
- accumulation of water in the snow cover for 10 water reservoirs and 8 measurement gauge profiles

The Department also produces bulletins and statements concerning flood situations and droughts as well, as expert opinions and references.

3.2. Forecasting Methods

For the Danube – the basis of the forecasting methods is a simple method of corresponding water stages/discharges, which can be seen as more traditional but also very reliable. Also, the rainfall - runoff relation to the API (antecedent precipitation index) with numerical and graphic expressions is used. The following methods are also used: At the present time several approaches for rainfall – runoff models ("HRON" model, adaptations of the HBV model etc.), are being developed within the framework of the project "Flood Warning and Forecasting System in the Slovak Republic" (POVAPSYS).

3.3. Dissemination of hydrological information

Water gauge stations are divided on prime (operative on- line) stations and secondary one (on-line). The prime stations are determining for enouncement of alert activity on significant sections of water courses in daily hydrological elaboration they are to disposal to institutions responsible for flood protection. From the total number 174 water gauge telemetric stations, in daily mode of hydro-forecasting service they are working 79 stations. Transportation of all information from system is performed by data and voice transmission. Frequency of data transmission is determined by demands of clients and by technical equipment of relevant water gauge station. The data are transmitted via mobile network and via telephone. An advantage of mobile network is possibility of data transmission every 15 minutes.

Number of stations and their connection

Connection of station	Interval of data transmission	Number of stations
GSM -GPRS	15 minutes	128
GSM	According to demands	136
JTS- fixed network	o 6, 12, 17-primary stations according to demands – secondary stations	38

The innovated stations network is equipped with alarm system which has been activated after exceeding limit (critical) values defined for - water stage, intensity of rain and gradient increasing. After exceeding define limit the station sends message – alert – to the centre of hydro- forecasting service and to operator in emergency service via SMS.

All parameters – water stages, discharges, water and air temperature – measured in hydrological stations are possible to be controlled in visual way and analyzed both in table mode and graphic one. Equipment of stations allows display of data in 15 minutes time interval, too.

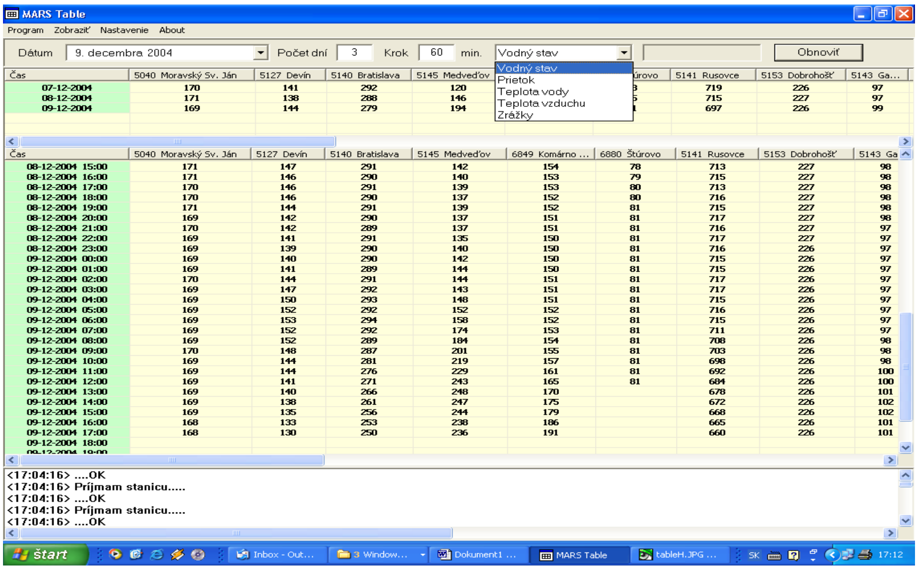


Fig. 4 Sample of output elaborated data in table mode

Graphical form of elaboration provides courses of - water gauge scan, discharge scan, temperature of air and water scan, precipitation scan (as a total in certain number of hours or cumulative for identify time interval). From the technical parameters of station – voltage of battery - simultaneously in 15 minutes time interval as late as 10 stations. At the same time it is possible to change temporal scan – year, day and so on.

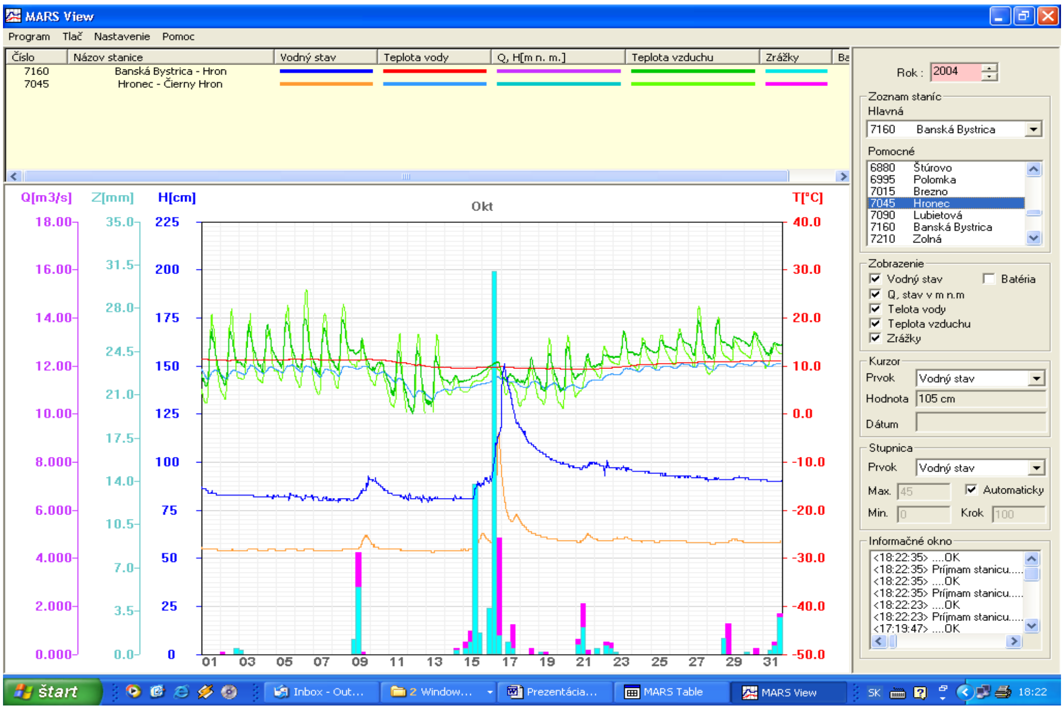


Fig. 5 Samples of output elaborated data in graphical mode

In framework of provision of the obligations in respect of navigation and flood protection as well as in result of bilateral and multilateral agreements on co-operation on traunsboundary waters, hydro-forecast service has been regularly receiving also hydrological information from abroad (Austria, The Czech Republic, Hungary, Ukraine, Poland). The exchange of operational information takes place according to agreed form and time periods. The hydrological information is distributed by NTC (National telecommunicating Centre), by phone and by internet.

After the checking and analysing the state of the hydrological and meteorological data have been processed in tabular form and according to distribution prescription send to institutions as is given by Law No. 7/2010 Coll. Among the main users there are civil service, municipalities, regional and district environmental offices – authorities responsible for flood protection and water management institutions. Operational information are provided on demand to general public and firms.

The output of elaborated data regularly presents daily information on:

A – Water stages, discharges, temperature of water and air, ice phenomena, precipitation and relation of current water stages/discharges to their long-term means – in table format

B – Water stages in 1 hour time interval elaborated in table form graphical form and as maps

C – Numerical forecasts for 5 hydrological on the Danube River, 1 forecasting station on The Morava River

D – Daily forecast for 13 reservoirs

And as addition - seasonal information:

E – water temperature in reservoirs

F – snow bulletins – depth and water equivalent of snow cover, accumulation of water in the snow cover

G – information for water tourism and fishing – water stages and discharges

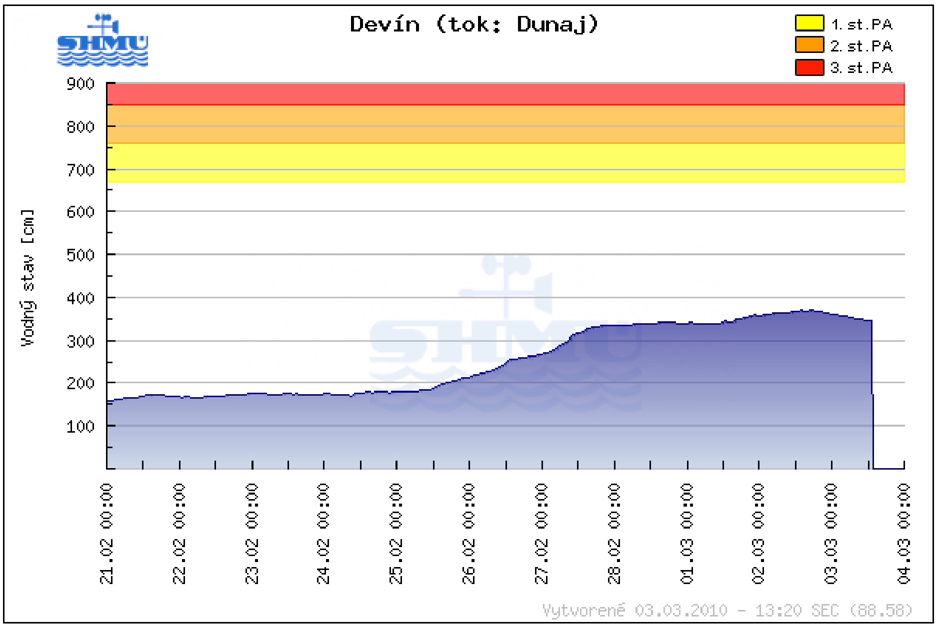


Fig. 6 Hourly data in graphical form (1.st PA – state of alert, 2.st PA state of danger, 3.st. PA - state of emergency).

Tabular elaboration of data

Údaje majú operatívny charakter, neprešli korekciou. Čas je udávaný v LSEČ

Čas merania	Vodný stav [cm]	Teplota vody [°C]
19.05 2010 16:00	559	9.1
19.05 2010 15:00	558	9.1
19.05 2010 14:00	555	9.1
19.05 2010 13:00	553	9.1
19.05 2010 12:00	552	9.1
19.05 2010 11:00	549	9.1
19.05 2010 10:00	546	9.1
19.05 2010 09:00	544	9.0
19.05 2010 08:00	541	9.0
19.05 2010 07:00	538	9.0
19.05 2010 06:00	535	9.1
19.05 2010 05:00	531	9.1
19.05 2010 04:00	527	9.2
19.05 2010 03:00	523	9.3
19.05 2010 02:00	520	9.3
19.05 2010 01:00	516	9.4
19.05 2010 00:00	511	9.4
18.05 2010 23:00	507	9.5
18.05 2010 22:00	502	9.5
18.05 2010 21:00	496	9.6
18.05 2010 20:00	490	9.7
18.05 2010 19:00	484	9.7
18.05 2010 18:00	479	9.7
18.05 2010 17:00	474	9.8
18.05 2010 16:00	468	9.8

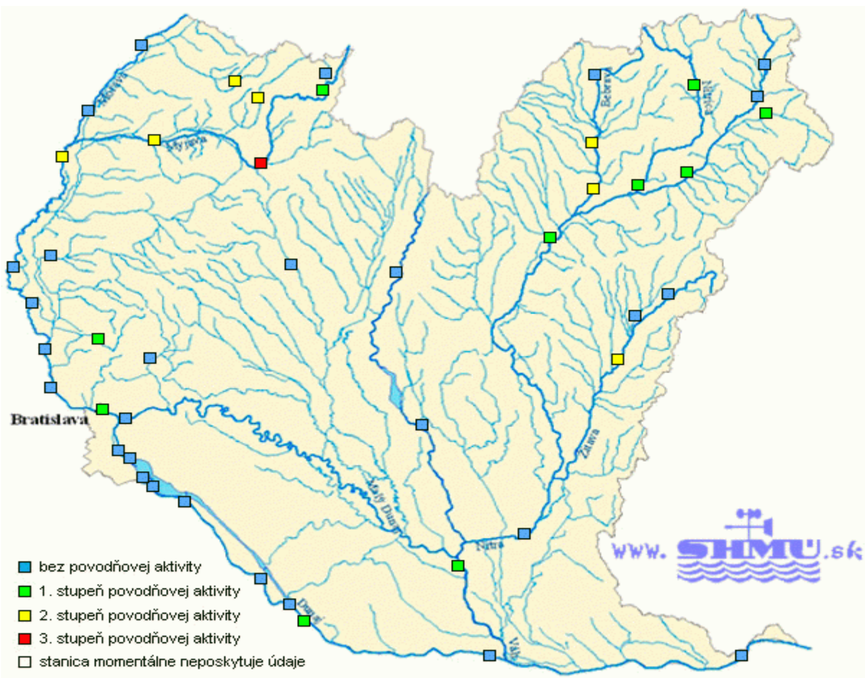
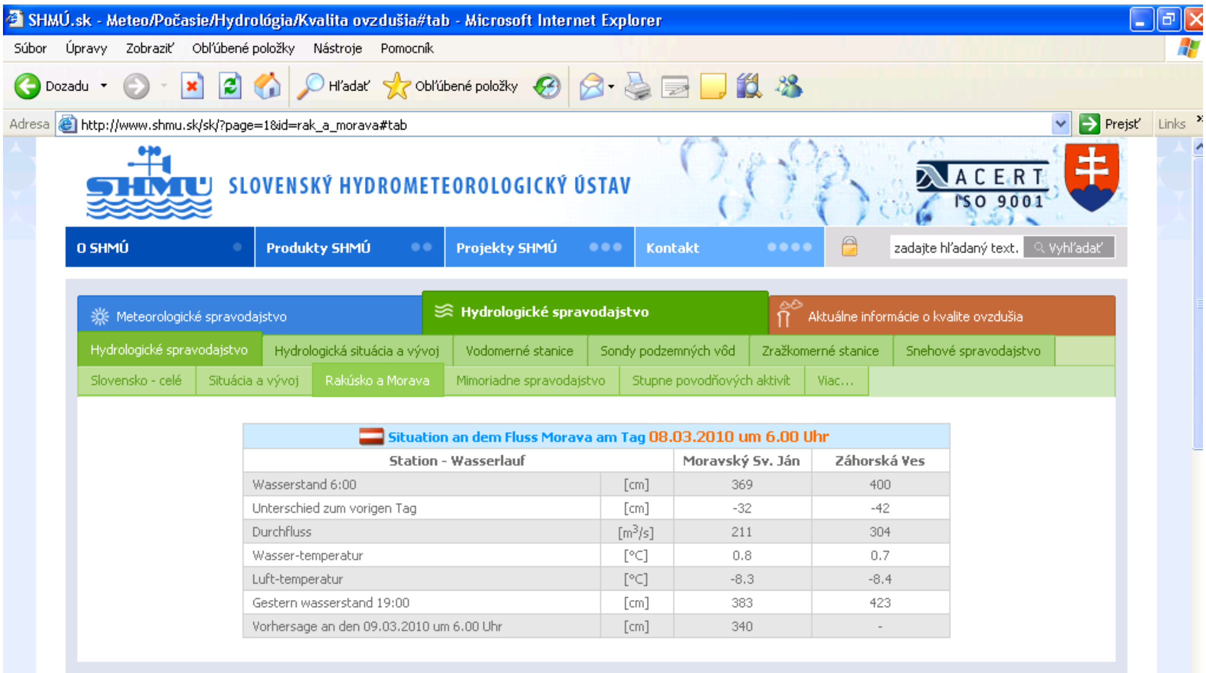


Fig. 7 Graphical illustration of basin according to region



Station - Wasserlauf		Moravský Sv. Ján	Záhorská Ves
Wasserstand 6:00	[cm]	369	400
Unterschied zum vorigen Tag	[cm]	-32	-42
Durchfluss	[m^3/s]	211	304
Wasser-temperatur	[°C]	0.8	0.7
Luft-temperatur	[°C]	-8.3	-8.4
Gestern wasserstand 19:00	[cm]	383	423
Vorhersage an den 09.03.2010 um 6.00 Uhr	[cm]	340	-

Fig.8 Presentation of data on hydrological situation on the Morava River - output in German for Austrian Hydrological Service

All presented information are distributing by NTC, Internet -www.shmu.sk, Teletext, Telephone.

3.4. The flood service

The Slovak Water Management Enterprise's internal organizational structure is divided into divisions, which correspond to the following river basins (see Figure 1):

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. Each of its branches has the following responsibilities for the river basins within its jurisdiction:

- Maintenance of the river channels and adequate channel flow capacity;

- Maintenance, improvement of the existing flood protection systems and realisation of new systems where existing ones are insufficient;
- Continuous operation of hydro structures all year;
- Management and supervision of flood protection works such as flood planning in entire catchments, flood inspections, flood prevention measures, execution of patrol services, salvage operations, etc.;
- Case studies, development and design of new flood protection systems, and realisation of all necessary preventive measures.

These activities require a monitoring and information system, which is closely linked to the meteorological and hydrological forecasting and warning system of the Slovak Hydrometeorological Institute. Operation of hydraulic structures requires the flow of this basic information in real time:

1. Inflow and outflow from a reservoir;
2. Water level in a reservoir (filled volume and room for retention of flood waves);
3. Outflow situation in the upper part of a river basin;
4. Water levels and discharges downstream from a water structure.
5. Meteorological and hydrological forecasting.

The Hydrological Service of the Slovak Hydrometeorological Institute provides data on current situations in river basins and forecasts for the following:

- Information on stages and hydrological forecasts is provided during prevailing outflow situations for a 24-hour period everyday in the morning; this data is confirmed or specified twice a day in the afternoon and evening.
- The time step of a hydrological forecast is shorter during the run of a flood; at that time the time step is three or six hours (depending on the type of flood wave). The information on the hydrological situation in a river basin is provided at the same time as the forecast.

The operating staff at a water structure, almost continuously monitors the situation at least every hour and during flood events. This set of data is added to the flood database every hour as well as at the moment of the culmination of a water stage or peak discharge (but only when they can be explicitly recognized):

- The water levels in a reservoir and also water downstream;
- The set of inflow into a reservoir;
- The set of outflow data from a reservoir, which is divided into specific structures (a hydropower plant, spillways, outlets, navigation locks, number of turbines in operation, position of gates, etc.);
- Specific meteorological data, for example, a rainfall and the water and air temperatures.

Each staff transmits a set of collected data from the hydro structure every hour to the competent water management dispatcher, which is in the Branch's domicile (in Bratislava, Piešťany, Banská Bystrica). The Slovak Water Management Enterprise uses e-mail, fax, telephone, and transmitter-receivers for information transmission, because the communication must be fail safe under every condition. The set of data is stored at the water management dispatcher's. In this way the flood database is also created.

Every water management system and every hydro structure have developed rules for operating in any situation, including stages of emergency.

The operational rules result from hydrological analyses, hydro technical research and operational practice. The state water authority body approves each operational rule. The water management dispatcher analyses the current situation and hydrological forecast in a river basin and issues instructions for future operations, which follow from the operational rules. Each operation executed by a hydro structure solicits feedback; the results of any operation are checked in real time at least every hour.

The actual course of a flood and operations by a water structure are analysed after every flood event according to the operational rules to determine their adequacy.

4 Transboundary Cooperation

4.1. Inventory of data transmission networks and communication systems of flood information services among Slovakia's neighbouring countries

All the rivers in Slovakia, which belong to the Danube river basin, flow into Hungary. The exchange of all sorts of information related to flood protection and actual flood routing is realised by the treaty between the Government of the Czechoslovak Socialist Republic and the Government of the Hungarian People's Republic on the regulation of water management issues related to border waters, which has been valid since 1976. The technical team of the joint Slovak-Hungarian Commission for Border Waters has negotiated forms concerning the frequency and transmission of the necessary datasets, which are suitable for both sides.

The exchange of separate modes of information has been arranged for the Danube River, including the Gabčíkovo hydro structure. Slovakia passes this set of information to the Hungarian water authority .

The Slovak Water Management Enterprise has a special agreement with the Morava River Basin Authority in the Czech Republic. The water management dispatcher of the Bratislava Branch has access to the information system of the Morava River Basin Authority on the internet and obtains basic hydrological information from this source, including information on water stages and discharges at the following state discharge gauging stations:
The Morava River: Kroměříř, Spitihněv, Strážovice and Lanžhot;
The Dyje River: Nové Mlýny and Ladná the hydro structure.

If necessary, it is possible to obtain additional information by e–mail or phone at any time. This information exchange concept is suitable for the organising needs of the flood protection work in Slovakia.

Exchange of data among the countries is under way of bilateral and multilateral agreements among the neighbouring countries. The Slovak Republic has signed bilateral agreements about co-operation on transboundary waters.

***The bilateral agreements*: CO-OPERATION ON TRANSBOUNDARY WATERS**

River basin; rivers	Riparian countries	Treaties	Year of establishment
The Danube river basin; Danube and Morava	Slovakia – Austria	Treaty between the Czechoslovak Socialist Republic and the Austrian Republic on regulation of water management issues related to border waters	1967
The Danube river basin; Danube, Ipeľ, Tisa	Slovakia – Hungary	Treaty between the Government of the Czechoslovak Socialist Republic and the Government of the Hungarian People's Republic on regulation of water management issues related to border waters	1976
The Danube river basin; Morava	Slovakia – Czech Republic	Treaty between the Government of the Slovak Republic and the Government of the Czech Republic about co-operation on transboundary watercourses	1999

Under the authority of the above mentioned agreements, joint measurements are provided 5 to 9 times a year and from those and the following stipulated numerical profiles – a total of 56 stations. In the Table 4 lists the amount of water gauge stations in which join international measurements are planned for 2005.

The numbers of water gauge stations in which join international measurements are planned yearly**.**

Country	Hungary	The Czech Republic	Austri a
Number of measurement profiles	19	2	3
Number of measurement	150	13	27
Station providing data	32	3	10

4.2. Cooperation with the Institute for the Environment and Sustainability (JRC) Ispra

The Memorandum of Understanding between the Institute for the Environment and Sustainability (JRC) Ispra and the Slovak Hydrometeorological Institute on The Development of a European Flood Forecasting System (EFAS) was signed by the General Directors of both Institutes on May 24, 2005. The new system provide the national authorities of countries in the Danube River Basin with up to 10 days to prepare for large floods

4.3. Cooperation in framework Danube Commission – Navigation issues

The Danube countries cooperate on navigation under several agreements dating back 1856. The Danube, particularly the middle and lower reaches, has been an important natural waterway for centuries. There are close cooperation between selected countries and Danube Commission (in Budapest).

The list of main water gauge stations from which data are transmission regularly for navigation needs

WATER GAUGE STATION	DISTANCE FROM THE SOLUNA /KM/	GAUGE "O" POINT ABOVE SEE LEVEL /M/
Devín	1879,80	132,87 B
Bratislava	1868,75	128.43 B
Sap	1809,97	108,10 B
Medveďov	1806,40	107,42 B
Zlatná na Oostrove	1779,10	103,92 B
Komárno	1766,20	103,69 B

5 Assigned Regions of Interest

5.1. Sub-basin of the Pannonian Danube (Žitný ostrov – Inland Delta – The Danube's left Bank)

5.1.1. Water river network - main basins and subasins

The Danube River channel is trained in the whole section from the mouth of the Morava River (the state border with the Austria) to the mouth of the Ipeľ River (the state border with the Hungary). The flood protection dykes are built on the river bank/banks. Other types of flood protection structures are applied on the short stretches in Bratislava city centre and in the town Komárno. The dykes are stretched between the villages Marcelová and Radvaň. The total length of the dykes on the left bank of the Danube River channel in Slovakia is 160.341 km. and on the right bank 22.707 km.

The rivers and creeks, the springs of which are located on the south-eastern slope of the Malé Karpaty Mountains range (the Little Carpathian Mountains), have the natural character in the mountains parts only. They are trained in the inhabited areas and either downstream to their mouths. Some stretches of the creeks are closed from top in the villages, which creates potential for hazardous situation during floods, because of insufficient flow capacity.

Number and length of the watercourses in the Pannonian Central Danube River basin – Slovak territory

River Sub-basin	Total number of water courses	Number of important water courses	Total length of water courses (km)	Length of important water courses (km)
Danube	502	319	1 107.33	874

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Basic characteristics of the Pannonian Central Danube basin at the Slovak territory

River Sub-basin	Watershed area	Share	Long-term Mean Discharge	Average Annual Precipitation	Annual Precipitation	
					Runoff	Evaporation
	Km^2	%	$m^3.s^{-1}$	mm	%	%
Danube	1 138	2.32	2 348	550	6	94

5.1.2. Stream flow network

Creeks flow from the left bank of the territory into the Malý Dunaj River. They flow from the mountain ranges of the first stretch of the West Carpathian's bend and the artificial canals from the area of Žitný ostrov. The drainage basin area at the point of confluence with the Váh River is 3642 km^2.

There are only a few natural creeks on the territory of Žitný ostrov, which are not significant. More important is the large system of drainage and irrigation canals, which are controlled by pumping stations at the periphery of the area.

5.1.3. Sensitivity of basins to creation the flood extreme

From the viewpoint of evaluation based at K index it can be stated, that region of Pannonian Central Danube basin at the Slovak territory is less sensitive to creation of flood extremes, comparing with other sub-basin. Small spots with higher sensitivity can be founding the Little Carpathian Mountains. On the other hand, such evaluation is not representative for the Danube River itself. The main sources of large Danube floods are snowmelt in combination with regional rainfalls, which can be affect large territories in the sub-basins of Upper Danube and Austrian Danube and their tributaries, or intensive rainfalls in the summer or autumn (rarely), again affecting large territories. Floods caused with ice jams were also very dangerous, spatially in the past.

5.1.4. Extreme flows and flood disasters

The long-term mean annual runoff of the Danube in Bratislava is 63,845 mil. m^3, with a mean annual discharge of 2025 $m^3 \cdot s^{-1}$ and a mean annual specific yield of 15.42 $l \cdot s^{-1} \cdot km^{-2}$. The annual runoff distribution of the central Danube reflects the high mountain conditions at the headwaters. The seasonal percentage of the runoff is as follows: 24.2 % in the spring, 33.8 % in the summer, 18.8 % in the autumn and 23.2 % in the winter. The driest month is November with a 5.9 % percentage of the annual runoff. The wettest months are June, May and July with 11.3 %, 11.2 % and 11.2 % percentages, respectively. The maximum mean monthly discharge of 7324 $m^3 \cdot s^{-1}$ was monitored in June 1965, and the absolute minimum monthly discharge of 633 $m^3 \cdot s^{-1}$ was observed in October 1947.

It is possible to illustrate the flooding periods by the date of occurrence of the maximum annual discharges. From 1876 – 2003, they were:

Month	Number of occurrences	%	Month	Number of occurrences	%
January	8	6.3	July	24	18.8
February	6	4.7	August	21	16.4
March	10	7.8	September	11	8.6
April	5	3.9	October	4	3.1
May	13	10.2	November	2	1.6
June	21	16.4	December	3	2.3

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The greatest floods of the Danube in Bratislava during that period were:

№:	Date	Q_{max} $m^3 \cdot s^{-1}$
1	19. 09. 1899	10870
2	15. 07. 1954	10401
3	16. 08. 2002	10390
4	04. 08. 1897	10040
5	06. 08. 1991	9430
6	16. 06. 1965	9225
7	06. 01. 1883	8790
8	05. 07. 1975	8715
9	07. 02. 1923	8695
10	12. 09. 1920	8616

One of the most important parameters of the flood is the duration of a flood wave. The duration (*in days*) of flows over the selected threshold value during some of the most important floods can be seen in the following table:

Flood	4000	5000	6000	7000	8000	9000	10 000
	$m^3 \cdot s^{-1}$						
1899	13	10	8	7	6	4	1
1924	47	14	2	-	-	-	-
1926	64	41	25	3	-	-	-
1954	22	14	10	9	7	4	2
1965	81	62	40	20	9	4	-
1975	15	8	6	5	2	-	-
1991	13	6	5	3	2	1	-
2002	1	1	4	-	2	1	2

The first water level gauging stations on the Slovak part of the Danube were established in the first half of the 19th century: the Bratislava station in 1823 and the Komárno station in 1830. Records from these stations have been available since 1876. The greatest flood during the observation period was in 1899. The flood of August 1501 can be regarded as the highest flood in the upper Danube reach and also in Bratislava. According to the reliable records of the Austrian hydrological service, the peak discharge was estimated as up to 14,000 $m^3 \cdot s^{-1}$.

The first flood records in the Slovak part of the Danube have existed in Bratislava's municipal documents since 1526. That 1526 flood occurred without warning during the night and resulted in 53 human fatalities. Other high floods damaged Bratislava in 1721 and 1809. During the flood of 1809, ice destroyed several houses.

The following flood events had greater effects on the Žitný ostrov area:

Flood	Devastation (flooding)
Ice flood 1876, February	50,000 ha
Summer flood 1897, July	9,775 ha
Summer flood 1899, September	36,000 ha
Summer flood 1965, June	55,000 ha

5.1.5. Drought and minimal flow – Pannonien Danube River

There were processed and elaboration data series from period 1. 11. 1901 – 31. 10. 2005.

Marginal condition of elaboration:

- Minimum rate of discharge below reference value 1056 m3/s – which means 90% security from series average daily Q elaborated period

- the shortest duration low flow 5 days

On the table are significant season's minimal flow and real time of duration with Q behind 1056 m3/sec:

Time of duration	Number of day
4. 10. 1953 – 17. 1. 1954	106
1.10. 1908 – 16. 1. 1909	98
13. 10. 1948 – 18. 1. 1949	98
16. 8. 1947 – 12. 11. 1947	89
5. 10. 1959 – 26. 12. 1959	83

5.2. Sub-basin The Rivers Váh, Hron , Ipeľ and Morava

Sub-basin of the Váh, Nitra, Hron, Ipeľ Rivers consist from the following parts:

- The Váh river basin, with the sub-basins of the Nitra River, the Orava River, the Kysuca River and some smaller creek and brooks. The negligible parts of the Váh River basin are situated at the territories of the Poland and the Czech Republic
- The Hron river basin, situated completely at the territory of Slovakia.
- The northern and north-western part of the international Ipeľ River basin. It's the south - eastern and southern parts are situated in the Hungary.

All tributaries are on the left-hand tributary of the Danube.

Basic hydrological characteristic of the river basins of interest can be found in the next Table

River sub-basin	Watershed Area [km^2]	Share [%]	Long-term mean discharge [$m^3.s^{-1}$]	Average Annual precipitation [mm]	Annual Runoff [%]	Precipitation Evaporation [%]
Váh	18 756	38.25	198.80	879	33	67
Hron	5 465	11.15	55.20	869	37	63
Ipeľ	3 649	7.44	21.70	686	19	81

5.2.1. Sub basin the Váh river basin

The longest river in Slovakia, the Váh, is a left-hand tributary of the Danube. It enters the Danube at river kilometer 1766, in the town of Komárno. The Váh river basin lies on the western and northern parts of Slovakia. It includes two basic hydrological catchments: the Váh River basin and the Nitra River basin. The whole catchment area (*except for the Malý Dunaj river basin*) is 15,755 km^2. It constitutes 32 % of Slovakia's total area.

5.2.2. Sub basin the Hron River basin

The Hron river catchment has a total of 5,286 *km* of natural rivers and creeks, and they form a network density of 0.96 $km \cdot km^{-2}$.

5.2.3. Sub basin the Ipeľ River basin

The Ipeľ River flows into the Danube from the left–hand side at river kilometer 1708. It is a border river; of its total length of 248 *km*, 151 *km* of the river is the Slovakia – Hungarian border. The Ipeľ river basin's area totals 5,151 km^2; of this area, 3,649 km^2 are in Slovak

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territory, and 1502 km^2 are situated in Hungary. The river catchment has a rectangular shape with a maximum length of 110 *km* and a width of about 70 *km*.

5.2.4. Sub-basin of the Morava River

The international Morava River basin at the territory of Slovakia consists from the following main parts (sub-basins):

- The area on the left side bank of the Morava River from the state border with Czech Republic (near the town Skalica in the western Slovakia) to the mouth of the river into the Danube River in the village Devín (suburb of the capital Bratislava),
- River basins of the Chvojnica, the Myjava, the Rudava and the Malina rivers.

Basic characteristics of the Morava River basin in the territory of Slovakia

River Sub-Basin	Watershed Area	Share of country area	Long-term Mean Discharge	Average Annual Precipitation	Annual Precipitation	
					Runoff	Evaporation
	[km^2]	[%]	[m^3·s^{-1}]	[mm]	[%]	[%]
Morava	2 282	4.65	118.70	634	22	78

Water river network – main basin and sub-basin

The main residential settlements are situated along the Morava River and the Chvojnica River channels, the north-eastern foot of the Malé Karpaty mountain range (the Little Carpathian Mountains) and in the highlands Myjavská a Chvojnická pahorkatina. The land use map of the Morava river basin at the territory of Slovakia (according to Corine landcover 2000) is given in the Appendix 2.

The channel of the Morava River was systematically trained in the stretch from mouth to the Danube River upstream to the confluence with the Dyje River earlier and from the Dyje River to the town Hodonín (the Czech Republic) later. The freeboard of flood protection dykes is determined according to the water level of Q_{100} flood. The more important left side tributaries of the Morava River –on the Slovak part of the Morava river basin are the rivers Chvojnica (125 km^2), Myjava (745 km^2), Rudava (418 km^2) and Malina (517 km^2).

Chvojnica, Myjava, Rudava and Malina rivers – were trained in the lower stretches and also there are the dykes on the safety levels of the discharge Q_{100}. The middle stretches of these rivers were trained either, but without the construction of the flood protection dykes. The upper stretches of the Morava River tributaries are not systematically trained, but shorter stretches of the river channel regulations and the local flood protection measures according to various concepts can be found here.

In the upper regions of the Slovakian part of the Morava River basin are situated several water management reservoirs, the most important of which are the Kunov, Lozorno and Buková reservoirs (see Table 2.3 for details). The main purposes of these reservoirs are irrigation of agricultural land and increase of discharges during the dry seasons. Their importance in the flood protection system is particular only, because of lacking significant retention volume.

The important water reservoirs in the Slovakian part of the Morava River basin

Name	River	Catchment area	Volume	
			Total	Retention
		[km^2]	[$10^6 \cdot m^3$]	[$10^6 \cdot m^3$]
Brestovec	Myjava	17.7	0.454	0.127
Buková	Hrudky	10.8	1.420	0.185
Kunov	Teplica	93.6	3.050	0.760
Lozorno	Suchý potok	18.9	2.051	0.140
Stará Myjava	Myjava	6.1	0.069	0.013

Several polders are already constructed or planned in the highly vulnerable river basins of Chvojnica (existing polder in Oreske) and Myjava (existing polder in Myjava).

The detailed survey of watercourses in towns and villages from the viewpoint of the flood protection has been carried out by the Slovak Water Management Enterprise, s. e., in the period from 1999, April to 2002, March. The results of the survey are updated according to the floods occurrence in the individual river sub-basins annually. The results of evaluation are summarized in the next Tables:

List of hydrological and prognosis stations in the sub-basin Morava

Distribution of water gauging stations in the Slovak part of the Morava River basin

Sub-basin	Number of stations	among them: number of telemetric stations
Morava	25	13

List of the hydrological prognosis stations in the Slovak part of the Morava river basin

№	Name	River	№	Name	River
5040	Moravský Svätý Ján	Morava	5085	Záhorská Ves	Morava

Sensitivity of basin to creation the flood extreme (K)

It can be seen from both Annex , that the spots of areas, which are very sensitive to the creation of flood extremes can be found in the Slovak part of the Morava river basin– especially upper parts of the Myjava, Chvojnica river basin as well as of small water courses in the Little Carpathian Mountains.

The flash floods are the main sources of flood risk in the basins of the Morava River tributaries, especially in the areas located on the slopes and by foot of the mountains which range from the town Myjava to the village Borinka near the north-western boundary of the capital Bratislava. The lowland areas along the Morava River itself can be endangered in the case of flood protection structures failure. Dangerous are large –scale floods (whole basin-wide) of large volume and long duration, like the floods from 1997 and 2006.

Due this reason LWS has been constructed in the Myjava river basin (close to Vrbové village) in order to provide the local authorities with sufficient lead-time warning on originating of floods and to eliminate their destructive consequences.

Extreme flows and flood disaster

Summary of significant floods in the Morava River basin (period 1997-2008)

period	affected territory	flood characteristics and consequences
July 1997	Morava river and floodplains	flood caused with regional heavy rainfall which affected large territory, evacuation plans prepared but not carried out
July 1997	Myjava river basin	flash flood which affected Myjava town and numerous smaller settlements
June 1999	Myjava river basin	flash flood caused with local intensive rainfall which affected Myjava town and numerous smaller settlements
January 2001	Morava river and adjacent territory	sudden increase of water level because of snowmelt and rainfall, extraordinary high groundwater levels, pumping stations activated in January, March and April
January 2002	Morava river	winter flood caused with ice jams
March 2005	Myjava and Chvojnica river basins	floods caused with snowmelt
May 2005	Myjava river basin	flash floods cause with local rainfall
February	Malina river basin	flood caused with combination of

2006		snowmelt and rainfall
March/April 2006	Morava river and floodplains	significant flood caused with combination of snowmelt and regional rainfall, historical maximum water levels exceeded, breaches of Austrian flood protection dykes, flooding of large territory
March/April 2007	Morava river and adjacent territory	sudden increase of water level because of rainfalls, high groundwater levels

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