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I. INTRODUCTION

At the beginning of November 1998 the river basin of the Upper-Tisza above Zahony experienced the highest flood wave since the river was regulated in the 19th century. At some places the peak water stages exceeded the highest ever measured. The exemplary organization, the good work of the people and organizations taking part in the flood control activities, prevented the catastrophe similar to that in May 1970. This time the teamwork and expertise made up for the existing shortcomings of flood control establishments along the Upper-Tisza, and the weakness of the dikes not having the proper height and width.

Systemizing and summarizing the experiences of the flood control events is an important professional task from the point of view of determining the short term duties but its long term importance can not be denied either. Data collection has been extended to national and international organizations involved in flood prevention. The characteristics of the flood wave and the experience gained during the protection were analyzed by several national expert groups and their conclusions and recommendations have been included into the study.

In the edition of this publication besides the staff of the Upper-Tisza Water Authority several experts and institutions took part: experts of the National Metrological Services, the Academy of Sciences of Hungary, the Institute of Sociology, and the University of Technology of Budapest, Providencia Insurance Company. Further contribution to the contents of this publication by providing data: the Hungarian Army, Civil Protection, Frontier Guards, the County Local Government, the Police and the staff of water authorities taking part in the flood control activities.

II. THE HYDROLOGICAL DESCRIPTION OF THE FLOOD-WAVE

There is an established procedure for flood-hydrological evaluations at the Upper-Tisza Water Authority. During the past decades several detailed analysis have been composed, based on nearly equivalent thematic.[1,2,3,4]

1 Illes, L.: The Upper-Tisza Flood, 1985. Vizugyi Közlemenyek, Vol. LXVII.Booklet No.4. Budapest, 1986.

2 Illes, L - Konecsny, K.: Hydrological Experiences of the Upper-Tisza Flood in 1993 and an Evaluation of Effeciency of the Flood Forecasting System. M.H.T. XIII. National Congress, Baja, 04 - 06 July 1995.

3 Illes, L. - Konecsny, K.: The Hydrology of the Flood Wave on the Upper-Tisza in December 1995. Vizugyi Kozlemenyek Vol. LXXVIII. Booklet 1. Budapest 1996.

4 Illes L. - Konecsny, K.: The Hydrology of the Upper-Tisza Flood in November 1998. M.H.T. XVII. National Congress, Miskolc, 07-08. 1. Volume, p. 28-42.

One of the main characteristics of the flood-wave in the Tisza basin in November 1998 was, that the water stages exceeded the highest water stage ever along the catchment area of the Upper-Tisza above Vasarosnameny, especially in Transcarpathia. In the rest of the Tisza the peak water stages reached, however, remained below the highest water stages that had been measured before.

II.1 DATA-BASE OF THE ANALYZIS

The total territory of the Tisza basin is 157 200 km^2; the territory involved in detailed analysis, the stretch of Bodrog above the estuary, is 35 870 km^2, 22.8% of the totalterritory of the catchment area. 84.8% of the latter is situated over the borders, in Ukraine /Sub-Carpathia/ (23.4%) and in Romania /Transylvania/ (60.5%). The proportion of the catchment area within our country is only 16.1%. Therefore, detailed hydrological evaluations are possible only by using data gained through international corporation. Most of the data and information produced outside the country were available for us. So, we analyzed the rainfall distribution both in space and time based on data provided by 24 Sub-Carpathian, 37 Transylvanian, 53 Hungarian stations and the meteorological radar. We analyzed the trend of the water stages based on the flow data provided by 15 Transcarpathian, 6 Transylvanian and 8 Hungarian stations. Moreover, we used the data of the 8 hydrological remote sensing stations of the Upper-Tisza Water Authority, provided in every 5 minutes. With the help of the national hydrological cooperation, altogether 74 discharge measurements were done at high water, so we gained valuable hydrological data, which we had never possessed before.

II.2 THE HYDROMETEOROLOGICAL AND HYDROLOGICAL CHARACTERISTICS OF THE TIME PERIOD PREVIOUS TO THE FLOOD WAVE

During the first 10 months of 1998 the rainfall in the catchment area of the Upper-Tisza outside Hungary neared or exceeded the average. In the mountainous areas during the three month before the flood wave the increase of the rainfall was remarkable. The rainfall was 609 mm in Plaj, 606 mm in Okormezo, 508 mm in Raho. This exceeds the mean annual average of the same time of the year by 60-85%.The high rainfall filled up the rivers and was gradually raising the level of groundwater.

In October the rainfall in the eastern half of Transcarpathia, in the catchment areas of the Nagyag, the Tarac, the Talabor, the Black – and the White Tisza, exceeded the annual average by 20-50%. Similarly high rainfall was measured at some stations in Romania too. As a result in the first half of the month several flood waves of various size formed on the Tisza and on its tributaries.

From 27th October to 02nd November the rainfall on the Upper-Tisza was 30-150 mm. A part of the late-October precipitation occurred in the form of snow on higher altitudes, e.g. above 1000 m (for example there was 220 mm snow on Jezer at the height of 1785m).The melting of this snow at the beginning of November slightly increased the surface runoff.

So, just before the formation of the big flood in November a remarkable flood wave was in progress on the Upper-Tisza. The water stages along the stretch between Tiszabecs and Vasarosnameny exceeded the 3rd grade alert level and remained only 0.8 -1.5 m below the maximum ever measured.

II.3 HYDROMETEOROLICAL FACTORS TRIGGERING THE FLOOD WAVE

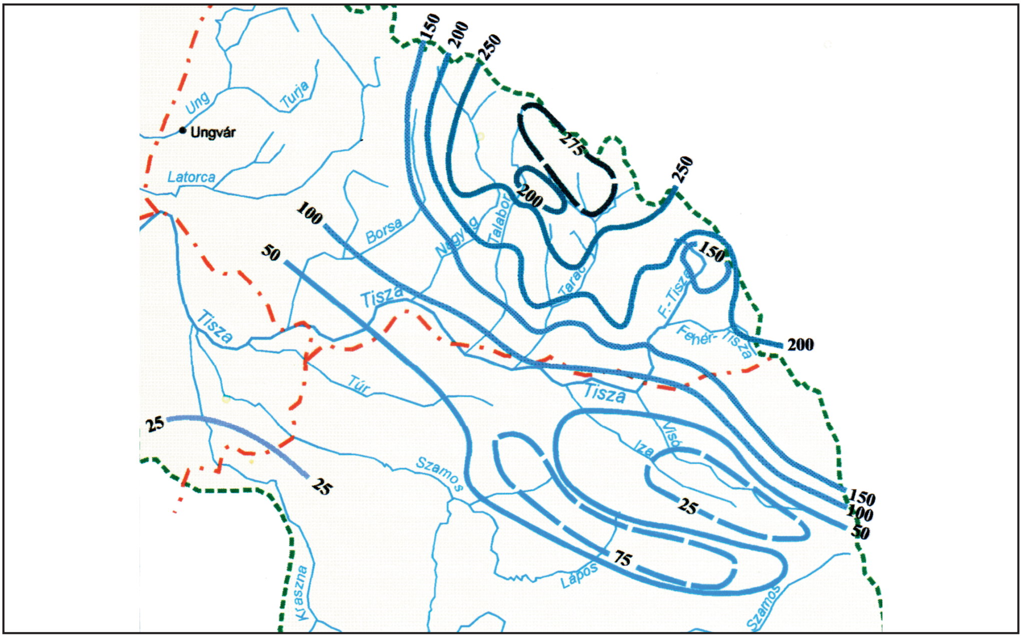
The meteorological events that triggered the big flood wave on 3rd and 4th of November can be linked with the cyclone first swirling above the British Isles, and then shifting to the Baltic States. The centre of the precipitation activities was located in the catchment area of the Transcarpathian tributaries on the right side of the Upper-Tisza above Tivadar. The three-day total rainfall area average in the catchment area of the Tarmac, Talabor, Nagyag and Borsa exceeded, while along the White -and Black-Tisza reached 200mm. The area where the three-day total rainfall was above 200mm can be estimated 2500-3500 km^2. The probability of the 24-hour total rainfall neared or reached 1% at some stations on two consecutive days. In Oroszmokra the rainfall was 171 mm on 4th November, which, considering the database available so far, is likely to occur in every 200-300 years.

II.4 MAIN HYDROLOGICAL CHARACTERISTICS OF THE FLOOD WAVE

II.4.1 Water stages, progress of floods

The Upper-Tisza flood wave from 2nd to 5th November was triggered by heavy rainfall in the mountains. Its hydrological features were influenced by the meteorological events during the previous spell and the surface and floodplain conditions in the catchment area. From these the effect of the saturated soil and the bare forest can be emphasized. At some places the effects of breaches of dikes as well as local backwater and depression effects were sensible. The peak formed on the main branch of the Upper-Tisza was influenced by the flood waves arriving from side branches at the same time.

The water level started rising in all the right side branches of the *Upper-Tisza in the mountains* at the same time, at dawn on 4th November, as a result of heavy rains early afternoon on 3rd November. The average intensity of the rise was 80 -150 mm/h and the maximum was 150 – 300 mm/h. On the bigger side branches the peaks appeared on the water gauges nearly at the same time, between midnight and 4 a.m. on 5th November and almost everywhere exceeded the highest level before.
After a short break, the rains continued on the upper part of the Black-Tisza cathment area until 4 a.m. on 5th November. This caused two maximums in the Tisza-Raho segment, so the water stage was above 4900 mm for 12 hours (90 mm below the highest). The data base had not contained such prolonged flood waves before. The flood waves of the right side branches and the flood wave approaching from Raho on the main branch arrived at the Maramarossziget-



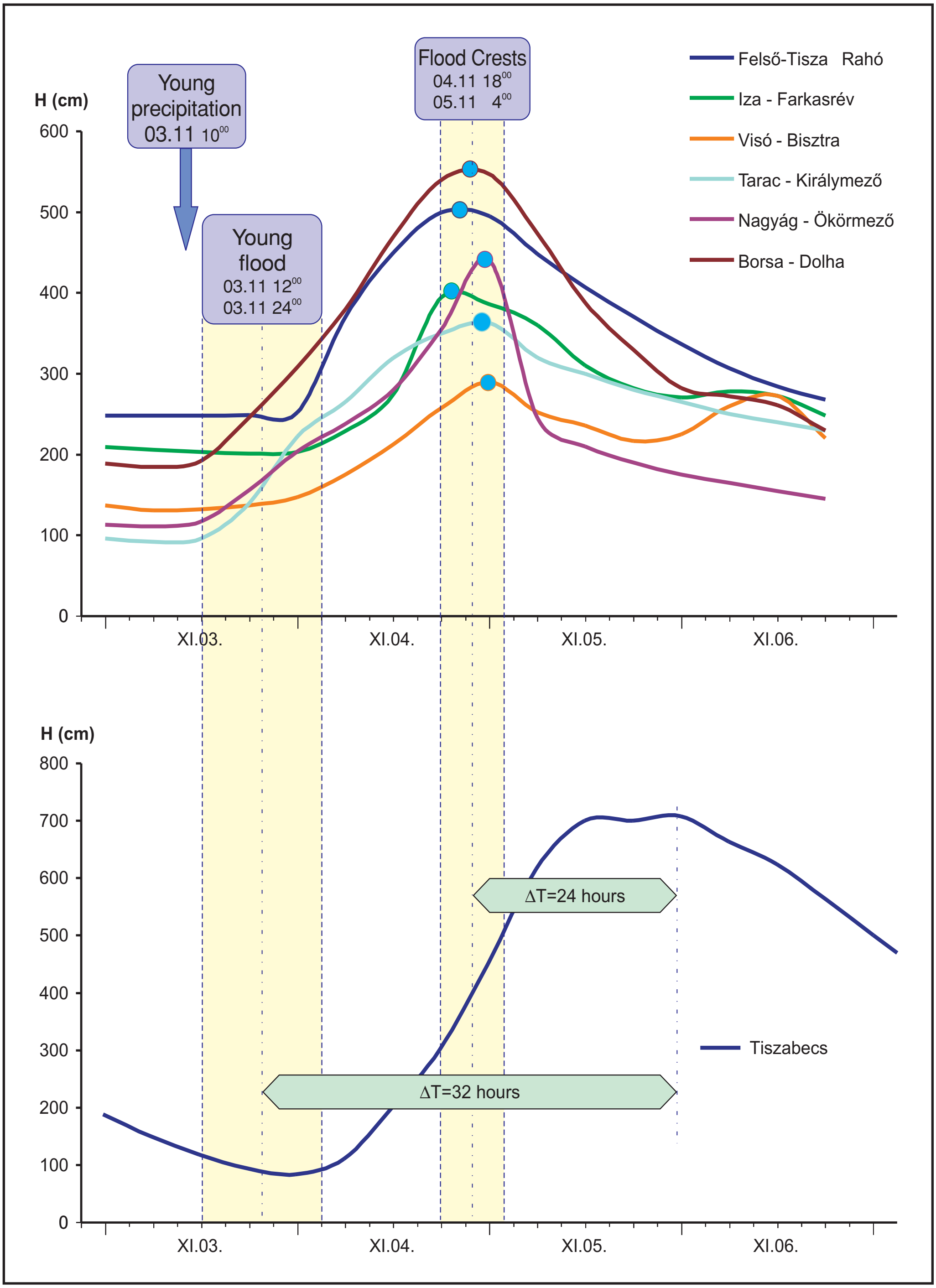
Rainfall in the catchment area of the Upper-Tisza between 2-5 November

Tivadar segment nearly at the same time. This situation could occur because the flood waves on the main left side tributaries in Romania (Viso, Iza, Tur) were not high.

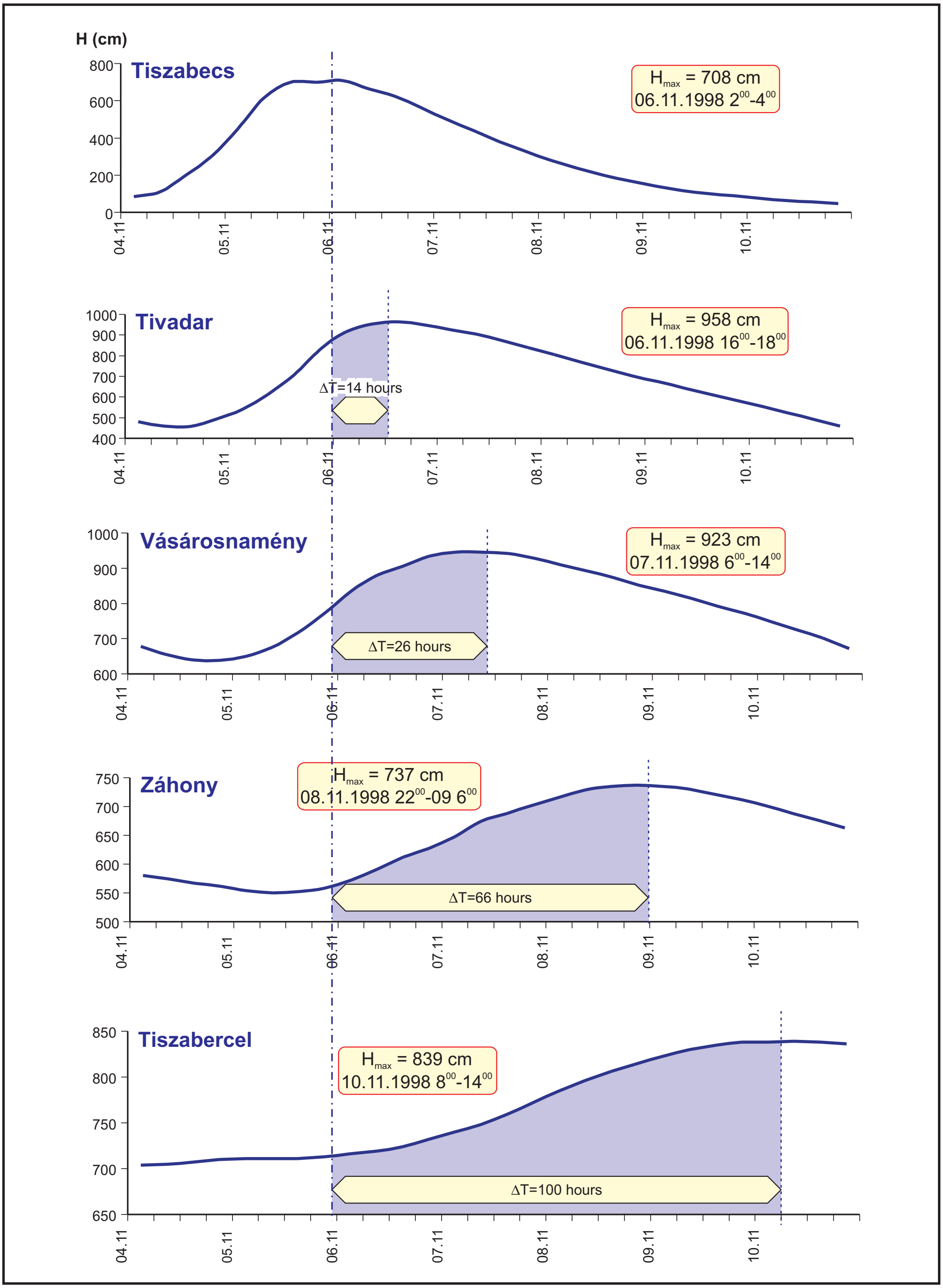
At Tecso, the coincidence of the flood wave on the Tarac and the Upper-Tisza caused the peak exceeding the previous highest level by 460 mm. At Huszt the exceedence was only 20 mm, because on the tributary "Nagyág" the flood wave was not as high as the previous record.

On the Hungarian reach of the Upper-Tisza, at Tiszabecs, in the morning on 4th November the subsiding of the previous flood wave was observable. The rise of the water level began at 10 o'clock. Its average intensity was 150mm/h; the maximum intensity (between 4 and 6 o'clock on 5th November) was 340 mm/h. A sudden rise, like this is not exceptional, similar ones had occurred more than once. The peak water stages between Tiszabecs and Lonya every

The water gauge at Tiszabecs in the afternoon on 5th November 1998. The measured water stage was 6800 mm



Flood hydrographs and time characteristics of progress of floods on the Transcarpathian area of the Upper-Tisza



Flood hydrographs and time characteristics of progress of floods on the Hungarian territory of the Upper-Tisza where exceeded the highest stage ever measured. The checked and corrected peak water stages: Tiszabecs 7080 mm, Tivadar 9580 mm, Vasarosnameny 9230 mm.

Along the stretch in Hungary the previous highest stage was most significantly exceeded by the flood wave at Tivadar. The most outstanding water stage was caused by the coincidence of very high peaks on the Upper-Tisza and the Borsa.

It was investigated if the new maximum values changed the design flood level determined in 1990 and decreed in 1997and if determination of new design flood levels was justified. These hydrological evaluations covered the segments of Tiszabecs, Tivadar, and Vasarosnameny. The completion of the data series was followed by homogeneity tests to secure uniformity[5, 6]. Using two types of probability distributions, based on data series including those of November, the 1% probability level was determined. The existing and the newly calculated 1% levels including the maximums in 1998 did not vary considerably. This statement is especially true if we consider that the 70% confidence level means 250-300 mm in this range. Concluded from the above the modification of the present design flood level is not justified, so the Upper-Tisza Development Concept 5 actualized in 1999 does not count on it.

Local events influencing water stages

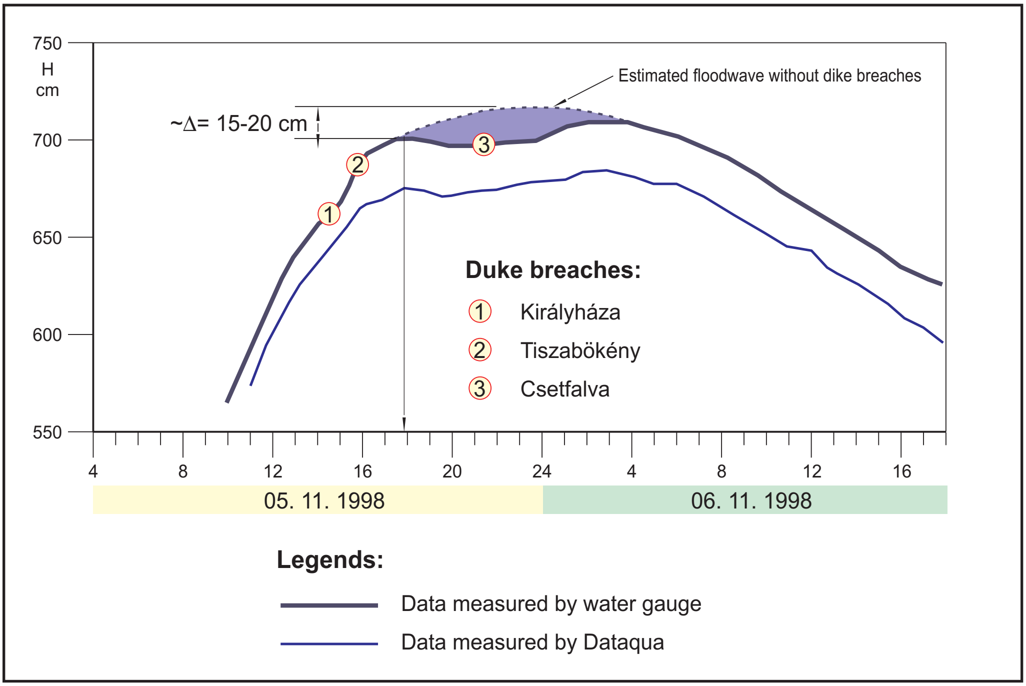
During the November flood wave there were several breaches of dikes in Transcarpathia. Most of these did not influence the shape of the flood wave remarkably, for most of them occurred on the mountainous sections in narrow valleys, where flooding of large areas is not possible. More important inundations took place in the Tecso and Huszt basins that have no continuous dike system. The area in Transcarpathia flooded by the water flowing through the breached dikes is around 950 km^2 [7]. Three dike breaches effected the water levels along the Hungarian border sections. These are in chronological order: Kiralyhaza, Tiszabokeny and Csetfalva. The effect of the dike breaches could be clearly measured only on the water gauge at Tiszabecs. According to our estimations the peak at Tiszabecs, without the dike breach, would have occurred at dawn on 6th November with the maximum of 7200 – 7500 mm.[8]

5 FETIVIZIG-VIZITERV: Hydrological Bases for the Development of Flood Prevention in the Upper-Tisza Region. Nyiregyhaza-Budapest, 1996. 1999

6 Illes, L. - Konecsny, K.: The Hydrology of the Upper-Tisza Flood in November 1998. M.H.T. XVII. National Congress, Miskolc, 07-08. 1. Volume, p. 28-42.

7 Ivanyickij, O.: Prevention of Demaged Caused by Flood and Flood Forecasting. Presentation at the Hungarian-Ukrainen forestry and water conservancy meeting. Nyiregyhaza, 08. 06. 1999

8 Konecsny, K.: The Hydrology of the Flood and Inland Water in Summer 1998. Felso-Tisza Hirado, No4-5. FETIVIZIG Nyiregyhaza, 1998



Effects of dike breaches on the Ukrainian side on the flood hydrographs at Tisza-Tiszabecs

Discharges

During the flood wave in November 1998 the flow was not measured in Transcarpathia and along the Ukrainian-Romanian border sections. Thus, the Hydrometeorological Services of Ukraine estimated the rates of flood, based on previous data. Along the section in Hungary, in Tivadar, Vasarosnameny, Zahony and Tiszakanyar, based on 44 measurements, it was possible to correctly calculate the highest range of the interrelation between the water stage and discharge.On the flooding and receding branches of the hydrograph the difference between discharges belonging to the same water stage reached 10-30%. The highest flows measured: Tivadar (6th November) 3550m^3/s, Vasarosnameny (7th November) 3488 m^3/s, Zahony (8th November) 3890 m^3/s, Tiszakanyar (9th

Flow measurement on the Tisza at Vasarosnameny 7th November 1998 at 9230 mm water stage

November) 3220 m^3/s. Based upon these measurements, it can be stated to all probability, that the May 1970 4160 m^3/s of Tiszabecs published in 1971,[9] was about 30-35% overestimated.The measurements provided useful results for calculations of the discharge capacity of both the main river course and the floodplain. The low proportion of flow of the floodplain compared to the main river is obvious (Tivadar 15-20%, Vasarosnameny 2-16%).

River	*Station*	*Catchment km^2*	*Max. discharge m^3/s*	*Date*	*Max. specific runoff l/skm^2*
Tisza	Raho	1070	700*	XI.05	654
Tisza	Nagybocsko	3330	1460*	XI.05	438
Tisza	Tecso	6470	3180*	XI.05	491
Tisza	Huszt	7690	3110*	XI.05	404
Tisza	Tiszabecs	9707	3160*	XI.06	326
Tisza	Tivadar	12540	3590	XI.06	285
Tisza	V.nameny	29057	3620	XI.07	124
Tisza	Zahony	32782	3900	XI.08	119

*Note: * estimated figures*

Maximum discharges in the main branch of the Upper-Tisza

Specific runoff and the mass of water

The largest specific runoff formed in the catchment area of the Tarac and Nagyag (770-1100 l/s km^2), however, high figures were also characteristic of the two smaller side branches, the Ruszkova (645 l/s km^2) and Mara (647 l/s km^2) streams. The specific runoff correlated with the segments in Hungary gradually decreased to 9 its third from Tiszabecs (316 l/s km^2) to Zahony (119 l/s km^2), due to the enlargement of the catchment area and the decrease of the areal average rainfall that triggered the flood wave. Between 29th October and 15th November 1998 at Tiszabecs on the Tisza 1.71 billion m^3, at Tivadar 2.09 billion m^3, at Vasarosnameny 2.53 billion m^3, at Zahony 3.3 billion m^3 mass of water passed by. The River Szamos fed the River Tisza by 0.55 billion m^3 water during this spell. According to calculations done by hydrologists in Romania during the flood in the Ruszkova Valley the runoff coefficient was between 0.65 – 0.70.[10] It can be assumed that the runoff coefficient was similar in the catchment areas of the rivers Tarac, Talabor, Nagyag and Borsa.

9 Csoma, J.: Development of Flow on the Tisza and its Tributaries. From "The Technical Conclusions of the 1970 Flood in the Tisza Basin. VIZDOC. Budapest, 1972.

10 Farcas, R. - Fetea, P. - Cocut, M. - Stefanik, M.: Viitura din perioada 3-11 noiembrie 1998 si impactul ei asupra asezarilor umane existente in bazinul hidrografic al raului Ruskova. (The flood wave and its impact on the settlements located in Oroszi Valley, 3-11 November 1998. Sesiunea de Comunicari stiinntifice, INMH Bucuresti, 1999.

II.5. THE EFFECTS OF DEVELOPMENT ON THE FLOOD RUNOFF

Following the large November flood wave both the experts and the interested public started to look for the cause of the "extraordinary flood" event. Firstly the harmful consequences of the reduced forest areas were mentioned, however, water storage and the negative effects of narrowing mountain valleys came up as well.

The role of forests effecting flood

Cathment area of Maramaros, covered by forest

In the region of the Upper-Tisza (Transcarpathia and the Maramaros Basin in Romania), the original, natural denseness of forests could be about 90-95%.[11] Economic activities done by humans gradually and remarkably changed this state during the past centuries. According to data produced at the end of the last century the territory of forests along the Upper-Tisza was 48%.[12] The total forest territory of Transcarpathia was 694.000 ha., from which 647.000 ha. was actually covered by forest. The total forest coverage is 51%. This is much larger in the mountains than on the flatlands.[12] The proportion and components of forest coverage has not considerably changed during the past decades. However, the upper timberline has changed for the worse, by lowering about 100-400 m. The large proportion of young forest in the catchment area is a factor that increases flow, which is a result of the intensive cutting done in the 1950s. The factors and features of forestry played an important but not determining and measurable role in the formation and progress of the November flood wave, especially if the fact is considered that the role of forests in retaining water is only effective to a certain extend.[13] According to the data collected from experimental areas in Sub-Carpathia, in mature forests above 1750 mm, in young forests above 1000 mm rainfall in 24 hours, the retaining role of forests becomes unimportant.

11 Sztojkó, Sz.M.: Causes of catastrophic floods in Sub-Carpathia, tasks of prevention and forecast. Presentations at the Ukrainen - Hungarian forestry and hydrological Conference. Nyírerdő Corporation, 08-09 June 1989.

12 Kicsura, V.: Increasing the hydrological role of forests in the catchment area of the Tisza. Presentation at the Ukrainen-Hungarian forestry and hydrological assembly. 08 June 1999

13 ***: Connection of forest and water management in the catchment area of the Upper-Tisza. (Evaluation of flood wave genetics, Phase 1). FETIVIZIG Nyíregyháza, 2000.
Possible effects of climate changes

No.	*Water course*	*Name of reservoir*	*Effective volume. million m³*	*Function of reservoir*
1	Kraszna	Varsolc	41	Water supply, flood management
2	Kraszna	Majtény	30	Flood management
3	Túr	Kányaháza	23	Flood management, hydropower utilization
4	Meleg-Szamos	Béles	250	Hydropower utilization, flood management
5	Meleg-Szamos	Tarnóc	78	Hydropower utilization, flood management
6	Meleg-Szamos	Meleg-Szamos	10	Hydropower utilization, sedment retention
7	Kis-Szamos	Gyalu	4	Water supply, hydropower utilization
8	Beszterce	Kolibica	78	Water supply, flood management, hydropower utilization
9	Fernezely	Fernezely	18	Water supply
10	Talabor	Olsoni	20	Hydropower utilization
Total effective volume including small reservoirs			576	

Major water reservoirs and their catchment area of the tributaries of the Upper-Tisza

Effects of water storage on the progress of floodwave

In the catchment area there are 9 large water reservoirs operating, with the total storage capacity of 578 million m^3 The largest reservoirs are situated in the catchment area of Szamos, but the degree of mean annual flow-control is the highest (24%) on the River Kraszna (Agerdomajor) and the lowest (11%) on the River Szamos (Csenger).[13]

The proportion of the cathment area belonging to water reservoirs, compared to the whole border section is 40% and 80% on the Tur and Kraszna respectively. Along the Vasarosnameny and Zahony segment of the Tisza, this is only 7% and 11%; and the degree of flow-control is hardly more than 4%. There is no remarkable change above Tiszabecs, only one energy producing reservoir, with a storage capacity of 20 million m^3, is in operation on the River Talab. The reservoirs did not have a considerable effect on the November flood wave, since there was no remarkable water stage increase on the Rivers Tur, Kraszna and Szamos.

Effects of narrowing and diking valleys

Dikes are constructed along the Upper-Tisza and its tributaries in Transcarpathia on the length of about 230 km. The smaller side branches also have about 220 km flood preventive dams and embankment. The flood wave in November 1998 was affected by the dike system mainly because of the breaches. Along the mountainous stretches the dikes, functioning also as bank protecting objects, breached at several locations, their flood plain narrowing effects appeared even slighter than before.

Possible effects of elimate changes

In the framework of strategic research at The Academy of Sciences of Hungary detailed analysis was conducted on the subject of the effects of climate changes[14, 15, 16]. The results of cause-effect studies are as follows: A 5% increase in the annual precipitation, which might be 15% during the winter months. This is mostly able to compensate the higher evaporation caused

14 Bálint, G. - Gauzer B. : The impact of climate changes on the runoff in the catchment area of the Upper-Tisza. Strategical questions of national water management. MTA. Strategical research program (manuscript). Budapest 1999.

15 Mika, J.: Meteorological scenarios influencing the strategy of the Hungarian water management. Strategic questions of national water management. MTA Strategical research program (Manuscript). Budapest 1999.,

16 Nováki, B.: Hydrological scenario of climate change and hydrological strategies (surface waters). Strategic questions of national water management. MTA Strategical research program (Manuscript). Budapest, 1999.

by a temperature rise of 2.5 degrees Celsius, and only a slight decrease of 3-5% can be expected in the runoff. A larger decrease is possible in catchment areas with dryer climate. Remarkable changes can be expected in the development of runoff within the year. The winter temperature and the rise of precipitation results a 10-20% increase of the runoff. Due to earlier snow melting the first flood waves caused by the melting occur earlier and their peak flow can rise by as much as over 50%. The increase of winter precipitation can lead to the rise of inland water in late-winter and in spring. The rise of the temperature together with the potential increase of evaporation in the summer months goes together with a 5-10% decrease of runoff. The 80% August flow, considered as design flow from a water resources management point of view will decrease as well, by 5-15%.

II.6 POSSIBLE FUTURE FLOODS ON THE UPPER-TISZA

In the framework of strategic research the Academy of Sciences of Hungary conducted Upper-Tisza flood simulation tests in 1999. In these tests the situations forming along certain watercourse sections were modeled for various combinations of factors that triggering the floods in 1970 and in 1998.[18] The results of these tests draw attention to the fact that even slight unfavourable changes in the meteorological events causing floods, can be followed by extraordinary consequences on the Upper-Tisza. The floods in November 1998 and in March 1999 proved again, that the Upper-Tisza has not produced all the possible variations that are inherent within the results of statistical calculations based on high-water data series. There is a chance, that during the formation of flood waves the tributaries will play roles not experienced before.

III. FLOOD FORECASTING

During the flood in November 1998 realizing the height and intensity of the water, the hydrological analysis of the situation very quickly, mainly in the early part of formation of the flood wave, played an essential part in successful flood control. The good cooperation between the Upper-Tisza Water Authority and the National Meteorological Services largely helped setting the alarm in time. The success was based upon the of several experts effort during decades.

18 Bartha P. - Gauzer B.: Simulation flood tests on the Upper-Tisza. MTA Strategical research - Water management in Hungary after the millennium. Research study. Manuscript. Budapest, 1999.

III.1 SYNOPTIC CONDITIONS OF DEVELOPMENT OF FLOODWAVES ON THE UPPER-TISZA

The physical and statical rules of the formation and progress of floods in the Carpathian Basin are rather complicated. Most of the flood waves, about 94%, are caused by macro- or mezoscaled cyclonal systems (perhaps coinciding with snow melting), while only 6% is caused by rapid snow melting, triggered by zonal, warm advection. The Carpathian Mountains and the Alps induce remarkable orographic effects.

Along the Upper-Tisza systems containing high precipitation can be most often formed by Mediterranean cyclones passing by, or in case of central type weather patterns. Every tenth mezoscaled system carrying high precipitation develops under zonal, macroscopical conditions. In this case the development of high precipitation is mainly due to the ororgraphic convection, which, in this region is helped by the fact, that the mountain ridges are nearly perpendicular to the west, south-west current.

According to Bodolaine's [19] weather types, in the cases of the catchment areas of the River Bodrog and Upper-Tisza the biggest chance for the highest precipitation is in a macroscopic state connected to the passing by of a Mediterranean cyclone (35% of high precipitation cases). At the same time in the catchments area of the River Szamos intensive rainfalls develop in cyclone-centered situations. In the development of high precipitation West border turbulence situations play a considerable role; however, its proportion does not exceed 25%.

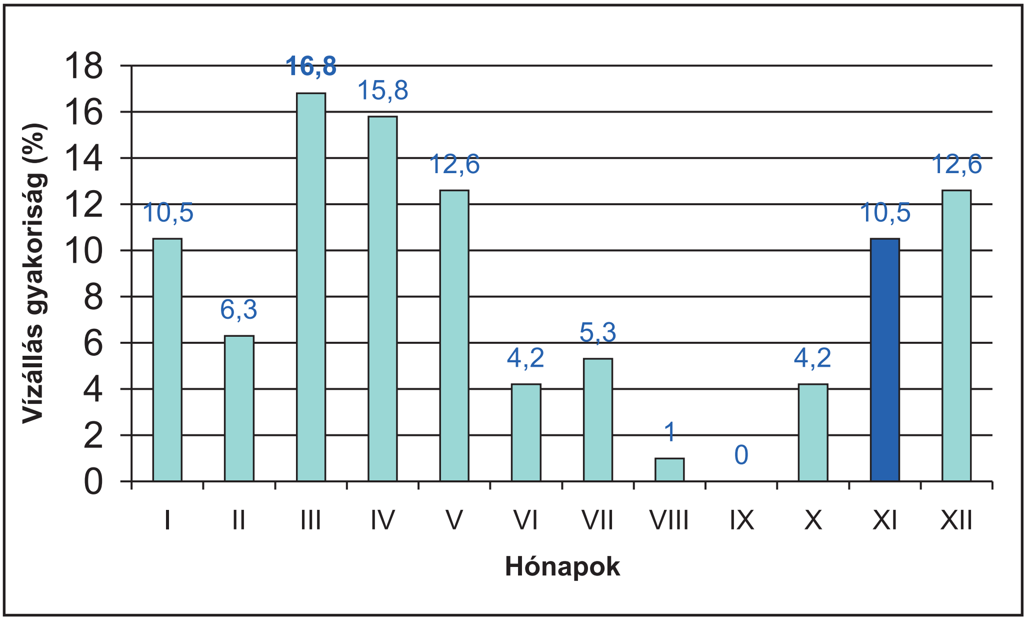
II.2 THE DEVELOPMENT OF FLOOD FORECASTING ON THE UPPER-TISZA AND THE PRESENT STRUCTURE OF THE SYSTEM

To the success of the November 1998 flood forecasting largely contributed the fact, that the Hungarian forecasting services, which has gone through a continuous development, operating as a unified organization during the past century, has huge professional experience. In the years following 1970, research and development for flood forecasting were not done in the VITUKI only, but also in the regional water authorities. A few experts of the Upper-Tisza Water Authority also played an important role in this work.

MAIN PRINCIPLES OF THE DEVELOPMENT OF FLOOD FORECASTING ON THE UPPER-TISZA

The sections of Upper-Tisza located close to the mountain ranges of the Carpathian Mountains have intensive changes in water level. In the 12-36 hours following precipitation an 8-10

19 Bodolainé Jakus Emma: Synoptic condition of flood waves in the catchment area of the Rivers Danube and Tisza. OMSZ Official publications, Volume LVI. 1983.



Monthly frequency of annual peak water stages on the Upper-Tisza

m water rise may occur and this can be expected in any part of year. Starting from these features, during the past two decades the development of the Upper-Tisza flood forecasts was done in order to reach two equally important targets: to increase the lead time of alerts and forecasts, to increase the correctness of maximum water stages. Special attention was paid to the development of the equipment and methodology of flood alert.
On the Upper-Tisza, under optimal circumstances, the existing forecasting system is able to produce the first alert 60-70 hours before the peak along the border section at Tiszabecs.

An important principle of strategy development is that the updating must be extended to every element of the system:

- national measuring-observing and data collection system,
- constant development of informatics backup,
- introducing remote sensing solutions (meteorological satellites, radars),
- methods of water stage forecasting,
- data basis, that serve as basis for forecasting models,
- international exchange of data and information,
- development of organization.

Detailed conceptual plans were made at the water authority for the development of certain elements of the information and forecasting system.

ELEMENTS OF THE UPPER-TISZA FORECASTING SYSTEM

Non-automatic observing and data collecting network

Parts of the non-automatic flood observation system:

- The hydrological observation stations within and outside the country, with sensors;
- Equipment for data collection and progress;
- Organizational units operating the system;

The national hydrological basic network in the water authority consists of 158 stations. 374 flood stations are connected to these, which are in operations not only in times of flood and inland water. As a summary, the following can be stated about the Upper-Tisza flood observation and data collection system:

- The density of the measuring network and the frequency of observations was built up and determined with consideration of several decades' practical experience and it meets the requirements.[20] The existing information data collecting network at some places, mainly along border sections, is duplicated, thus loosing of data happens under extraordinary circumstances only. In the data collection network centre at the water authority, a computer program (OPERA), worked out in 1986-88 is operating. Now it is justified to update and develop it, and it is possible to substitute by a VIR OHM module.
- In Ukraine the density of stations is less than the required, and the operation of the data collecting information network is not stable either. From a Hungarian point of view it is fortunate that most of the processed data is forwarded every time, during flood control time and apart from it too. There is a possibility for direct information exchange between water authorities during floods as well, which accelerates the access to data.
- The density of the station network in Romania is satisfactory and the information network is quite reliable. The Hungarian counterpart has access to a limited selection of data, since the orders of cooperation for data and information exchange regulate it so. During the past few years there is a possibility of initiating data exchange among water authorities, and gaining access to a larger access of data. In times out of flood control, the main tool of international data exchange and data forwarding is the GTS, so the data circulation is slow and complicated.

The hydrological remote senseing network

Along the Upper-Tisza, automatization of hydrological measuring has a 30-year history. During this period, besides utilizing the technical, informatical and data forwarding facilities at the time, three generations of equipment have been in use.[21] Before the commence of the

20 * * *: Results of the inspection of Hydrological sensing network in the district of the Upper-Tisza Water Authority. FETIVIZIG Nyíregyháza, 1992.

21 Illés, L.: Modernization of the remote sensing network at the Upper-Tisza Water Authority. FETIVIZIG Nyíregyháza, 1995.

newest development, the following aims had been set. [22]

- – The security of operation and the correctness of data should reach a level, that enables the spacing and gradual ending of non-automatic sensing;
- – The system should be built up from universal components, so that their replacement, repair is possible;
- – Hardware and software parts should be commercially easily available;
- – Extension and involving further versions in the operation should not depend on any particular expert; further extension of the system should be easily feasible.

The hydrological remote sensing station in Vasarosnameny, on 8th November 1998

The hydrological remote sensing network consists of 10 units:
Nyiregyhaza centre; URH transmitter in Jarmi; 8 hydrological stations: Tisza –Tiszabecs, Tisza – Zahony, Szamos – Csenger, Szamos – Tunyogmatolcs, Tur – Gabolc, Kraszna – Agerdomajor, Retkoz Lake – Szabolcsveresmart.

Applications of remote sensing

The catchments of the Upper-Tisza is divided by country borders, thus flood forecasting without international data is not possible. Several times there is not enough ground data available for forecasting. Data provided by meteorological radar and satellite supplement this shortcoming. Besides these, they provide information that is not possible to gain by ground measurements.

Meteorogical radar system[23]

The presently operating system includes the MLS-5 radar control and the computer, producing digital radar-data; the communication computer connected by a local network; the computer, capable of representing digital radar images. This system secures that following the

22 Illés, L. – Konecsny, K. – Lucza Z.: Operation of the modernized remote sensing system in November 1998. MHT XIII. Congress, Miskolc, 1999.

23 Nagy, J.: Operation of the meteorological radar and evaluation of its data during the Upper-Tisza flood in November 1998.

measurements; the high-resolution digital radar images can reach the users. Radar images, gained from continuous measuring can be transferred to the FETIVIZIG though public telephone lines using modem and computer, directly from Napkor, or indirectly though the meteorological observatory of Pestlorinc.

In the 90s, follow-up evaluations of data produced by the meteorological radar took place several times.[24, 25, 26] Besides correcting the algorithm the main aim of these evaluations was to discover further possibilities and the limits of flood-hydrological usages. The main results of the evaluations done:

- With the help of the meteorological radar the shifting direction, speed and size of precipitation zones and the present intensity of spatial distribution of precipitation can be closely followed. It can be estimated, in which part of the catchments can a remarkable water stage rise be expected;
- Calibrations, conducted by ground stations can improve the correctness of precipitation total. Because of the present density of stations, however, the meteorological accumulated precipitation fields are not suitable for using in precipitation-runoff models. For automaticinstruments do not operate in catchments parts outside our country, the possibilities of real-time calibrations are restricted;
- Because of the increase of the mountainous features and the distance in certain part-catchments, remarkable incorrectness can occur. With sufficient experience and with knowing the place this can be largely reduced;
- In the Upper-Tisza catchments divided by frontiers, the meteorological radar is a crucial tool for increasing the lead-time of flood alarm. During the November 1998 Upper-Tisza flood waves, the radar performed this function excellently. Up-to-date flood information and forecasting system on the Upper-Tisza is not feasible without the meteorological radar.

The METEOSAT satellite receiver

The METEOSAT satellite produces images belonging to 3 wave-lengths: in the visible, infrared and moisture content ranges. Based on the satellite images taken every half an hour, cloud-coverage, the movement of clouds and the cloud-top height can be followed. Through the computer network at the water authority every user, involved in flood control, has continuous access; the central receiver unit is operated by the Hydrological Group of the Water Manage-

24 Illés, L.: (theme leader): Theme report on the research-development project of 'The development of hydrological aimed radarmeteorogical data processing.' FETIVIZIG Nyíregyháza, 1993.

25 Illés, L.: (theme leader):Theme report on the research-development project No. 2007-043-28-7 OMFB – KHVM of 'Flood protection development with the help of meteorological radar data'. FETIVIZIG Nyíregyháza, 1995.

26 *** Experiences of using digital radar measurements. OMSZ, LMFO RMO. February 1995.

ment Department. Animation and enlargement are among the services of the representing software. The METEOSAT images in the flood information and forecasting system as a supplementary information source supplements the short and ultra-short term precipitation forecasts, the data of the meteorological radar.

Short and ultra-short term precipitation forecast

In the framework of a service-contract, quantitative precipitation forecasts are taken directly from the National Meteorological Services by the Upper-Tisza Water Authority. The work relationship between the two institutions has been direct and stable for many years. This largely contributed to the on-time and successful hydrological forecasting activities of the November 1998 flood.

Regular, 24-hour precipitation-quantity forecasts have been made for the 20 sub-catchment areas, including the catchments of the River Danube and Tisza outside the country. The forecast regions number 14, 15, 16 cover the Upper-Tisza area. During the past years precipitation forecasts, produced by computers abroad, the results of the newest research, as well as information provided by radars and satellite, have been playing an increasingly important role in the process of producing 24-hour precipitation quantity forecasts. Since 1994 The National Meteorological Services take over the forecasts provided by the global forecasting model (ECMFW) made in Reading, Great-Britain, and by the ALADIN model ran in Toulouse, France, which has improved the quality of our forecasts.

FORECASTING FLOOD WATER STAGES

In 1979 – 1981 a forecasting model based on numerical regression calculation “EJEL” [27] was worked out at the water authority, which forecasted flood water stages and their expected time. This computer program was last updated in 1988. Its database has continuously been extended, at present it contains more than 100 flood waves. 6-hour water stage data of above average flood waves that progressed since 1950 have been processed. During the progress of the data base an examination and homogenization of the data series was done.
Experiences collected during the more than a decade application of the forecast model:

- The most reliable results can be expected when the number of independent variables reaches 5-6 and these are located on the major branches;
- Sometimes it is practical to slightly correct the figures of forecasts calculated by the model, depending on local experience and hydrological circumstances.
- In case of large, individual flood waves, the model is particularly reliable, its reliability decreases in case of overlapping flood waves.

27 Bálint, Z. – Simon, B.: Computerized flood forecasting on the Upper-Tisza using multivariate regression techniques. User manual. FETIVIZIG, Nyiregyhaza, October 1981.

III.3 THE OPERATION OF THE INFORMATION AND FORECASTING SYSTEM IN NOVEMBER 1998

Based on the document of 1997, regulating the order of National Hydrological Services, official alarm and water stage forecasts are prepared and issued by the water authority, concerning the main hydrological stations within the territory belonging to the Upper-Tisza Water Authority. The forecast of the November flood was done according to the above regulation.

Every element of the flood information and forecast system had been operating since late October, 24-hour practically without break, and the security of operation did not lessen during the flood either. The duration of any disturbance in the operation sometimes occurring at an element of the system did not exceed 1-2 hours.

The frequency and content of data information exchange with the water authorities of Ukraine and Romania was far beyond that of the restricted in the cross-border agreement. We also played a transmitting role in the international data exchange by continuously transmitting Romanian and Ukrainian data to Uzhgorod and Cluj.

The Upper-Tisza Water Authority issued a total of 40 hydro meteorological reports and forecasts based on the data base, between 29th October and 20th November to provide information for the management of local and national protection.

About the forecasts of the European Middle-term Forecasting Centre (ECMWF) in late October the following can be stated: their products deserved attention, they also had sufficient lead-time and properly supported the possibility of high precipitation. The 24-hour precipitation quantity forecasts, produced by the National Meteorological Services between 28th October and 5th November, showed overestimation. Remarkable underestimation (10-15 mm) occurred only in the Sub-Carpathian region in connection with the high precipitation of 29th October. The forecasted location of the maximum was correct, there was larger difference only in the figures.

The progress of precipitation on 3rd and 4th November can be considered as well controlled and well forecasted, in the highlight of the 24-hour precipitation forecasts and the alarms issued for the Upper-Tisza Water Authority. In case of Transcarpathia the 24-hour forecast issued for 4th November was 22mm, based on these and other national data.

According to the alarm issued at 13.00 on 4th November: *"The flood wave forming at Tiszabecs will approach or exceed the height of those a few days ago. At the foreign stations the water stage is still on the rise, at some places they can exceed the highest levels so far." For the request of FETIVIZIG, another forecast was prepared at 16.10 by OMSZ: "during the next 20 hours the catchments area of the Upper-Tisza will receive as high further precipitation as 30-35 mm."*

Alarms were prepared continuously, then the first numerical water stage forecasts for Tiszabecs and Vasarosnameny with the following content:

"16.45: Based on the amount of precipitation fallen and the increasing foreign flood water stages at Tiszabecs an a water level above grade 3 alert level is likely. Taking the precipitation forecast for the next 24 hours into consideration, even a higher water stage can develop."

"21.00: Tomorrow night a water stage of 6500 mm, far exceeding the grade 3 alert level is probable at Tiszabecs."

"23.45: Expected peak at Tiszabecs: 7000 – 7400 mm, at Vasarosnameny: 9000 – 9500 mm."

Based on the above alarms and forecasts, the leader of the flood control ordered grade 1 alert at 15.00 for the Tiszabecs -Vasarosnameny section at the time of a mere water stage of 1460 mm, below the I. grade flood alert by 1540 mm. At 19.00 he initiated to assemble the county flood control committee and at 24.00, during the first committee meeting it was possible to decide about the most urgent actions to take. Heightening the dikes began, it was time to initiate state of emergency towards the government, the protection squads of partner water authorities could start to come.

Four hydrological evaluations of the state and correctness of forecasts were conducted on 5th November. These confirmed the correctness of the alarm and forecasts issued on 4th November and determined the expected height of peaks on major sections of the Tisza.

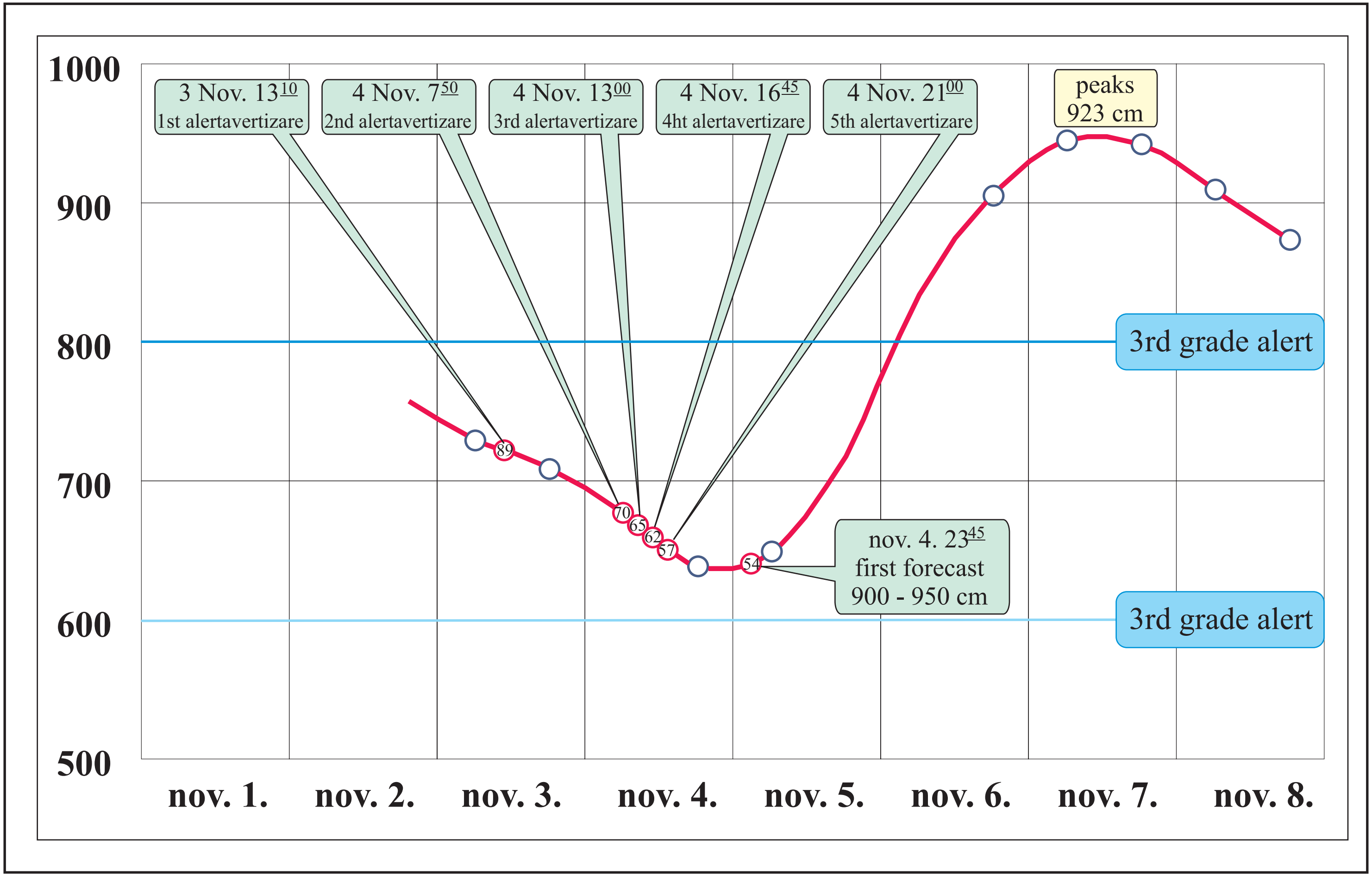
Evaluation of the reliability of hydrological forecasts

According to the usual practice set at the water authority, the forecasts of the flood peaks are described by the expected lowest and highest figures. The width of the range forecasted varies between 300 – 500 mm. The forecast can be considered good from flood control point of view if the real peak is within this range. It is adequate if it does not differ more than 100 mm from the lower or upper limit, acceptable if it does not exceed 200 mm difference.

In case of the Tiszabecs section on the River Tisza the maximum lead time is 60-70 hours. Thus, the alarm can be considered excellent if the lead-time nears this figure. The alarm is adequate if it reaches at least 24-36 hours, because in this period the flood wave has its peak on the mountainous sections and the flood starts in the border section.

The first major alarm took place at 13.00 on 3rd November by issuing the precipitation forecasts made by National Meteorological Services and the water authority forwarded them to the partners abroad. The lead-time of this was 68 hours. The lead-time of the alarm warning of the potential formation of a big flood wave was 41 hours, which we repeatedly confirmed 38 and 33 hours before the peaks. The lead-time of the forecast for the peak water stage at Tiszabecs was 26 – 30 hours.

It can be stated, that the lead-time of alarms and forecasts issued approached the possible maximum, that is, the information and forecast system achieved maximum of its limits.



The lead-time of hydrological forecasts for Vasarosnameny issued 4th – 7th November

III.4 DEVELOPMENT TASKS

Based on the experiences gained in November 1998, with consideration of development completed and being under completion, the following mid-term development is justified:

- Working out a complex development plan for the flood information and forecasting system on the whole catchments area of the Upper-Tisza including the areas across the frontier too. In this mid-term development such recommendations have to be worked out, which can serve as bases for common and individual tenders submitted to various regional development funds and which build upon the results of the informatical and communicational revolution. Only such a plan can secure the reasonable and coordinated use of national and international resources.
- The development and updating of the non-automatic observing land stations has to be continued.
- Following the completion of a successful updating of the hydrological remote sensing network in 1998, the number of stations has to be increased on the short run by further 5 – 8 stations, on the middle run by 10-15 stations.
- The Soviet made MRL-5 meteorological radar of Nyiregyhaza-Napkor has to be replaced by a new one. Attached to the development of remote-sensing in Hungary and abroad, such calibrated precipitation areas must be produced with the help of the radar, which make the application of rainfall-runoff models possible.
- We have to be cooperative and financially support the development of systems serving international data and information exchange.
- The financial support must be spent on increasing the density of stations that improve the efficiency of flood alarms; on updating the data transferring -system; and the autoimmunization of hydrological measuring.
- The methodology and the computerized backup of flood alarm and forecast must be developed.
- The entire infrastructure of the flood prevention information system at the water authority has to be reformed.

IV. FLOOD CONTROL

38% of the territory of Szabolcs-Szatmar-Bereg County is jeopardized by river floods. Nearly 200 thousand people, in 118 habitations. This territory of 2000 km^2 is protected by 544 km long flood prevention dikes, of which 283 km, 52,3% of the total flood control line is built up to the regulated height. The lead-time for preparations for flood control is very short, so it is crucial, that in our region flood control structures are built 1.0 above the design flood level.

IV.1 THE NATIONAL AND LOCAL LEGAL BACKGROUND OF FLOOD CONTROL IN NOVEMBER 1998

Activities connected to flood control, institutions carrying out flood control, the tasks of these and the obligations of residents are all regulated in the law. The tasks and legal status of those directing flood control, the obligation of doing organizational and technical work are regulated too.

The Water Act, No. LVII/1995 contains the basic regulations for flood control. Based on the Water Act a Government Decree No. 232/1996 and an Executive Decree of the Minister for Transport and Water, No.10/1997 regulate technical-engineering works during floods, give detailed regulations on responsibilities and actions and the list of basic water gauges serving as the reference for alert levels. Stand by material and appliance is regulated in Instruction No. 8005/1997 of the Ministry of Transport and Water. National level management of flood control activities is regulated by Executive Decree No. 1/1991 issued by the Minister of Transport and Water and the duties of the water authorities are determined in the Flood Control Regulations of the water authorities. Professional leadership of the Regional Flood Control Committee is executed by the Minister of Transport and Water based on the LX Act §15 (1993.).

Professional and administrative tasks of the various ministries related to flood control activities are executed by permanent representatives of the Ministry of Interior, Ministry of Agriculture, Ministry of Social Affairs and Ministry of Finance besides the National Technical Management Committee. (232/1996. 3§14.). Co-operation with neighbouring countries, that is with Ukraine and Romania related to flood control and inland water drainage is regulated in bilateral cross-border agreements and by-laws.

Local governments and water management associations obliged to participate in flood control, as well as other interested partners do their activities under the professional leadership of the water authorities. The water authority worked out local protection regulation documents for all the 17 flood control sections and the 12 inland water drainage sub-regions containing data, conditions and operation instructions for all control structures. The local civil defense institutions worked out the evacuation, rescue and resettlement plans. Local governments and water management associations must have control plans for the structures they operate.

The Upper-Tisza Water Authority has Co-operation Agreements with FETIVIZ Ltd., Volan Ltd., water management associations, the army, Civil Defense, Fire Brigades, the Mid-Danube Water Authority and the Public Roads Maintenance Company in order to have enough capacity both in man-power and machinery. Transport and other machinery are secured by contracts with private entrepreneurs.

IV.2. GENERAL STATE OF THE UPPER-TISZA FLOOD PREVENTION SYSTEM BEFORE THE NOVEMBER 1998 FLOOD

The state of technical establishments of the flood control system

Out of the flood control line of 554 km in the operational territory of the Upper-Tisza Water Authority, 541 km is earth dike, 111 km is flood control wall and 3, 0 km is high bank. Out of the flood control dikes 306 km was not built up to the regulated height (maximum flood level) in November 1998.
The largest segment and lack of length was located on the left side dike of the Tisza in the regions of Panyola – Kisar, Szatmarcseke – Nagyar, Tiszacsecse – Milota and Tiszabecs. The lack of height on the right bank is nearly the same everywhere; it is between 600 – 800 mm. There is a remarkable lack on the left bank of the River Tur and on the right bank Kishodos – Frontier and on the outlet section, on the left bank of River Palad.

The grass on the dikes, after the early September-October cuttings in 1998 and as a result of favorable weather, grew stronger, which had a great importance in times of overtopping.
The building material at the time of dike construction was mostly and directly gained from the riverside of the dikes, so about 6-10 m far from the foot of the dike there are deep, steep ditches, grown over with trees, shrubs and bushes, nearly all along the dike. Free zones on the protected side are usually clear without trees and bush, however, instead of the regulated and desired 10 m clear zone it is only 5-6 m at most places. Fields and orchards close to the dikes are cultivated right next to the foot of the dikes. Along several sections within inhabited areas the borders of properties (fences) are located immediately at the foot of the dike. Outside the inhabited areas most of the free zones are heavily stamped due to traffic.

There are 220 objects located along the Upper-Tisza flood control line, from which 128 are managed by the water authority. The average age of the objects is 60 – 110 years; the newest object is 20 years old. Right before the flood the condition of the objects was satisfactory, due to a coordinated reconstruction carried out in 1992-93. In November 1998 the water level was so high that through the siphons at Tarpa and Gulacs and the water abstraction pressure pipe at Tiszabecs water was flowing across.

At most places the dikes could be approached on agricultural dust roads only, and transport was possible on the crest or in the free zone on the protected side. Flood forecasts predicted water stages above the previous maximums and on the upper sections above the design flood levels, so overtopping was possible at several places, or at least it could be expected that the water would level with the top of the crest. Under these circumstances traffic could not be allowed on the crest, so for lengthwise traffic and transport only the free zones could be used. Roads approaching the dike, except for hard surface roads, were not in usable condition, due to the previous rains and heavy traffic because of autumn harvesting.

Some of the dike keepers' houses are 50-60 years old, others were built after the 1970 flood, and a few were constructed recently. The older dike keeper's houses are not suitable to accommodate extra flood control stuff; there is no room for this. We managed to keep up the comfort and acceptable condition of dike keepers' houses and protection centers in spite of the tight maintenance budget, but the protection tool-houses are run down, many roofs leak, are damp and mouldy, etc.

The quantity of flood control material according to ABSZ (Regulations for flood control operation) regulations was usually sufficient. The regulated protection stock necessary to start the protection proved to be enough. Most of the sandbags were previously used, still proper quality jute sacks. The wood ware (posts, planks, beams) needed selection. Sand, needed to fill up the sandbags was available at very few places. There was no machine for filling sandbags. Spare deposits are available in the protection dikes only; good quality material is usually to be found within 10-30 km. The Upper-Tisza Water Authority practically has no transportation vehicles or earth moving machinery, thus the missing equipment had to be hired from outside contractors. 4WD jeeps, necessary for the management of the flood control or needed to approach possible incidents, were not available for the water authority even by contracts.

Flood control information system

The setting up of main components began 50 years ago. Civil engineering objects (dike keepers' houses, pump-plants, E.T.C.), were placed close to telephone lines running along protection dikes. In the territory of the Water Authority more than 400 km aerial wire, 11 km aerial cable and 80 km earth cable telephone network was constructed.

The USW radio network is a good supplement to the wired network, so a duplicated connection can be secured, which increased the security of communication. Frequencies were given to the hydrological services in the frequency band of 160 MHz. Mainly the flood control sub-centers and the dike keepers' houses were equipped with radio stations besides a few vehicles and ships, which had mobile devices. Besides the out-dated networks of the water authority, there was a possibility to supply the most important stations (flood control sub-centers, dike keepers' houses, pump-plants) with MATAV telephone lines in the second half of the 90s. In November 1998, it was possible to use the facilities given by the radio telephone service for 20 colleagues, while the new URH network was still in trial operation.

The development of flood control system

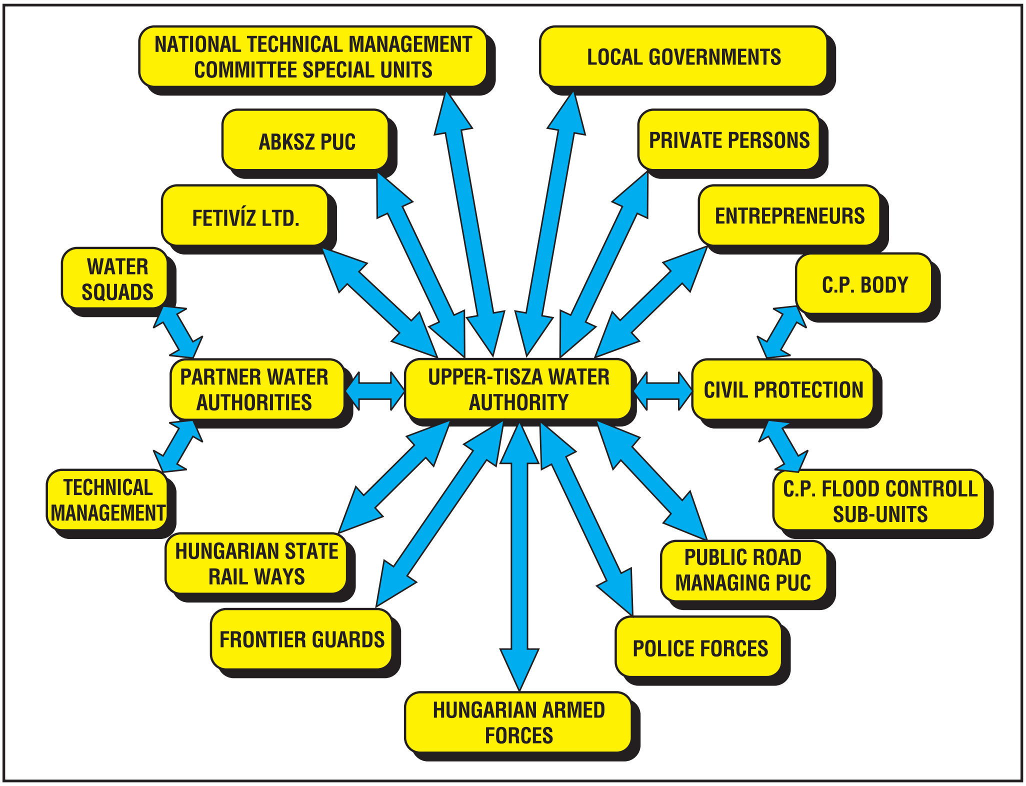
Important constructions began after the big 1970 flood in the river basin of the Upper-Tisza. After a rapid progress in the beginning, by the end of the 80s there was a slow down and the construction budget completely ceased. Following the Upper-Tisza floods at Christmas in 1993 and 1995, in its No. 2182/1995 resolution the Government made a commitment to accelerate the Upper-Tisza flood prevention development projects. They secured HUF14.3 billion (1998 value) for the quick accomplishment of the most urgent tasks.

A feasibility study for the development of the flood control system on the Upper-Tisza region was completed, which analyzed the development requirements and directions of the section above 622 river-kilometer (rkm) that is upstream of Zahony, along the Tisza. According to the study, among others the following tasks are urgent: the development of dikes having not sufficient height of cross-sectional area; riverbed sections near dikes; protection points; and the forecasting and information systems. Based on this study the program for the first phase of construction was prepared in 1996, which included the most urgent dike sections on the Tisza. In the framework of this engineering works worth a total of HUF 900 million were accomplished in 1997 and 1998. In 1998 dike constructions commenced along a 1350 m long section in the region of Milota and on the right bank of the River Szamos at Olcsvaapati. On the left bank, the dike section between the frontier and Szamosker, a dike section of 3000 m length in the area of Szamosszeg and a 1615 m long dike section in Olcsva was completed. From the implementation works of 1998 strengthening of the Kisar and Milota sections could not be completed, due to the long lasting summer flood wave and the flood in October and November. From the protective dike the earth had been pushed away and on slope steps had been formed, which resulted in a considerable decrease in the dike's resisting capability. Grassing had not taken place along the finished sections.

State of the flood control organisation and composition of the staff

The Director of the Water Authority, as flood control leader, directs the flood control through the assistant protection leaders and Flood control Core Team. The Core is helped by specialist groups. Protection activities requiring special skills are done by the protection squad.
The operation of the protective organization in the Water Authority is regulated in the Regulations for Water Damage Prevention. In these regulations the decision making levels and the superior and inferior positions are clearly described. Planning of water damage prevention has been done according to the ISO9002 quality control system since 1998. By 1998 the number of staff working at the water authority has considerably declined to 448 employees. Thus, the water authority is not able to carry out the flood control activities with its own staff only. So, based on general contract with various organizations and individuals, technical operational, assistant physical staff was involved in the protection activities. To carry out flood control tasks requiring special training and equipment, the Special Technical Services Unit (STSU) was set up. The protection squad, when not in action, operates within STSU. In action it is directly inferior to the sectional flood control leader, however it works independently. Alerting the squad happens according to an alert plan, prepared in advance and continuously updated. The number of staff in the protection squad was 94 in 1998, of which 60% was water authority employee, and 40% was the employee of FETIVÍZ Ltd.

The County Flood Control Committee carries out protection management tasks with the assistance of the local protection committees. In 1998 there were 10 local Flood Control Committees in operation with centers in: Csenger, Fehergyarmat, Kisvarda, Mateszalka, Nyiregyhaza, Tiszavasvari, Vasarosnameny, Zahony, Nagykallo and Nyirbator. The local Flood Control



Local participant directing the flood control

Committee coordinates the administrative tasks of the flood control taking place in the region concerned, with the assistance of mayors, town-clerks and mayors' offices.

The forces and equipment of the *Hungarian Army (HA)* took a significant part in the flood control in 1998. At the moment the army is able to immediately mobilize 3000 people. The special work teams – protection, rescue – are mobilized depending on the necessary restoration requirements, it does not matter which region they belong to. Their professional management is done by the protection management through delegated teams' leaders.

Civil Protection (CP). Besides 2 local offices in Nyiregyhaza and 2 local offices in Mateszalka, divisions were organized in 6 settlements in our county. Altogether 18151 persons belong in the organization of CP. The 10 Complex Flood Teams, which can be mobilized all over the county, carry out direct flood control activities with its staff of 500. For the actions of evacuation and accommodation the Civil Protection used a continuously updated evacuation and accommodation plan, furthermore an annually analyzed and updated public forces action plan, which includes the necessary number of workers and technical equipment to carry out protection tasks.

Ministry of the Interior (MOFI) – Frontier Guards. Disposition over the necessary number of staff and equipment is the authority of the national commander of the frontier guards. The Nyirbator Frontier Guards Office is on the possession of 112 staff, 5 trucks and transport capacity, able to transport nearly 600 people at the same time.

Police – the number of staff, appointed for flood control is 430. Their tasks are: maintaining public order, property protection, securing road blocks, securing traffic for organized flood control forces.

Local Governments provide most of the protective forces, the entire number of assistant staff of the water authority. Each settlement has a flood and inland water protection plan, relevant to the area. The local protection tasks are coordinated by the mayors. In times of protection there is a protection duty operating in the mayor's office, which is a civil protection duty at the same time.

International cooperation

The Upper-Tisza region has borders with three countries (Slovakia, Ukraine, Romania). Co-operation with Romania and Ukraine are more important from flood a prevention point of view because flood form in these two countries, the dikes protect both countries across the borders, and the water flowing through the breaches of dikes can flood the territory of the other country too. Valid agreements regulate the tasks and methods of cooperation with the three countries.

IV.3 EVENTS AND EXPERIENCE OF THE NOVEMBER 1998 FLOOD CONTROL

On 30th October a flood wave formed on the Upper-Tisza, which reached 3rd level flood alert between Tiszabecs and Zahony, 1st level alert between Zahony and Dombrad, 2nd alert level between Dombrad and Tokaj. Among the tributaries there was 3rd level alert on the Tur and 1st level on the Kraszna. The Flood control Core Team, together with special teams of hydrology, information and technical committee swung into action. Mr. Laszlo Fazekas, the flood control leader (director of water authority) ordered 1st level alert for the river section between Tiszabecs and Szatmarcseke, later on the other sections. The sub-regional protection leaders, the assistant leaders and the technical staff went out to the flood control sub-centers and took the necessary measures.

On the Tiszabecs-Vasarosnameny section of the Tisza the alert was terminated at 10 a.m. on 1st November and at Nagyar at 8 a.m. on 4th November, so following this termination the sub-regional leaders went home.

In the morning hours of on 4th November it seemed probable, that a new flood wave, which would exceed 3rd level flood alert and also exceed the previous flood wave was in progress on the Tisza. *Based on the above, the director of the water authority ordered 1st level alert for the three flood control sections between Tiszabecs and Vasarosnameny, at a time when the river was still subsiding, at the water stage of 1460 mm at Tiszabecs on 4th November at 3 p.m.* The sub-regional protection leaders and staff immediately went back to the protection line and commenced preparations for the prevention of another major flood wave. At 4 p.m. it was already certain that a flood wave, nearing or exceeding the highest ever measured was approaching Tiszabecs. Seeing this the protection leader took the following measures:

- Strengthened the Flood control Core Team, which directed and coordinated the protection by joining technical staff to it, and activated all the special teams;
- From 8 a.m. on 4th November he activated the protection squad of the water authority;
- Informed the relevant departments of KHVM and the director-general of the OVF;
- Asked the National Technical Management Committee for technical help. As a response three protection squads were ordered to start out;
- At 9 p.m. the sub-regional protection leaders were informed about the expected extraordinary flood and were ordered to determine the necessary protection measures to be taken in the shortest time possible, expecting a flood water stage that would exceed the height of the crest at several places;
- He ordered the building contractors then working on dike construction to build protective structures on the unfinished sections immediately;
- At 7 p.m. he initiated to assemble the Regional Flood Control Committee.

The National Technical Management Committee started operation in Budapest.

In accordance with the flood situation from 10 p.m. on 4th November, the commanding officer of Civil Protection in Szabolcs-Szatmar-Bereg County ordered to form an Operative Team and ordered 24 hour duty for the respective sub-centers.

The Regional Committee assembled at 24 midnight on 4th November and ordered the necessary measurements to be taken and during the flood assembled once or twice a day as necessary. They asked the army to direct as many soldiers and as much technical equipment to the region as possible. Parallel with the progress of the flood wave the Zahony, Kisvarda, Nyiregyhaza and Tiszavasvari local Flood Control Committees were ordered to operate emergency preparedness and duty services.

From 7.45 a.m. on 5th November the leader of the flood control activities ordered 3rd level flood alert on the full length of the protection line along the Tisza then informed the president of Regional Flood Control Committee about his initiating state of emergency at 8.45 a.m.

Moved by the Minister of Transport and Water the government declared state of emergency based on the Civil Defense Law No. XXXVII §2, and ordered emergency flood preparedness along the Upper-Tisza and its tributaries' endangered sections at 11.45 a.m. on 5th November.

This involved a length of 450 km protection line. The Government immediately decided to secure HUF 500 million for expenses of the protection. During the emergency flood preparedness, due to the absence of the Minister of Traffic, Transport and Water, firstly dr. Sandor Gyurkovics, under-secretary of state, later Kalman Katona, Minister of Traffic, Transport and Water, through the National Technical Management Committee directed and coordinated the flood control activities on government level as government commissioner.

Dr. Sandor Gyurkovics under-secretary of state and dr. Bela Hajos assistant under-secretary of state conducted a local inspection in early afternoon on 5th November along the most dangerous sections of the Upper-Tisza. Dr. Bela Hajos spent a few days in the region of the water authority, gathered information and made arrangements. It is due to his arrangements, among others, that when at night on 6th November considering the situation hopeless, the public force left the protection line, by mobilizing the army and making the people return, they managed to build emergency dams and avoid dike breaches. The flood control activities done by the local governments, Civil Protection, the Army and the water authority were successfully coordinated on the spot by Jozsef Zilahi, President of Regional Flood Control Committee. During the protection local inspections were done by Arpad Goncz, President of the Republic; Viktor Orban, Prime Minister; Kalman Katona Minister of Traffic, Transport, Communication and Water; Jeno Manninger Political Under-secretary of State; Ferenc Vegh, Commander of Hungarian Army.

Milota, 5th November

The emergency preparedness was denounced in two steps, parallel with the progress of the flood wave. First from 8 a.m. on 15th November between Tiszabecs and Zahony on the River Tisza, than along the section below Zahony from 16.00 on 17th November. The full protection was lifted along the right bank of the Tisza from 18.00 on 9th November, after completing the repairing works on the dike in the areas of Tivadar and Tarpa.

A COMPREHENSIVE DESCRIPTION OF FLOOD CONTROL

In the late hours of the evening and at night on *5th November* a crisis situation developed on the left bank of the Tisza in the area of Tiszabecs, Tiszacsecse and Milota. The peak water stage occurred at Tiszabecs at 2-4 a.m. on 6th November, with 708 cm, this exceeded the 1970 maximum by 28 cm. During the flood the water stage was rapidly rising. Following the decisions made by the mayors, a total of 850 people – women, children, sick people – had to be evacuated from Tiszacsecse, Milota, Tiszakorod, between 20.00 on 5th November and 1.30 on 6th November. The men, able of work, stayed behind on the dikes to help protection works. The resettling began at 18.15 on 6th November.

Along the section of Tiszakorod-Tiszabecs it was necessary to build emergency dams to avoid overtopping. The emergency dams held 10 to 50 cm, at some places 70 cm, water above the crest along a more than 4 km-long section. Along a further 1.5 km section the water approached the crest by 0 to 50 cm. For a few months prior to the flood there were dike strengthening constructions done in the fields of Milota, which could not be completed before the arrival of the flood waves, so the open dike had to be fixed and heightened.

Hightened dike at Tiszacsecse on 6th November, 1998.

The number of people taking part in the protection reached 2500 by then. Despite the extremely difficult conditions the transport of material necessary for the protection was undisturbed. Due to a joint effort made by the forces of the water authority, the Civil Protection, the army, the frontier guards and the inhabitants, the catastrophe of dike breach could be avoided.

In the evening and at night of *6th November*, while the flood wave was progressing, protection already had to commence along the Tiszakorod-Olcsvaapati and Tarpa-Vasarosnameny sections. The peak water stage of 958 cm was at Tivadar between 16.00 – 18.00 on 6th November, which exceeded the maximum so far by 93 cm. On these sections the peak water stage was above the crest along a length of 5,0 km and approach the crest by 0 to 50 cm along a further length of 34 km. Besides the construction of emergency dams in order to secure the stability of dikes and slopes, it was necessary to use excess weight stone bands and stop underground leakage. The saturation of free zones and dust roads made the work more difficult. The most critical situation occurred between Tarpa and Badalo on the right bank of the Tisza at the location of 62+500 – 62+600 km, along the dike section running parallel with the frontier of Ukraine, where the slope on the protected side had a slough of 20 m length. There was an immediate danger of dike breach, however the dike could be stabilized by sandbag support by 7th November morning. On the right side dike of the Tisza, at the location of the 1947 dike breach, an underground leakage formed, which could be localized by constructing a contra-pressure pool.

On *7th November* the flood wave had its peak of 923 cm at Vasarosnameny between 6 a.m. and 2 p.m. A critical situation developed on the right bank of the Tisza between Gulacs and

Increasing the height of the dike at overtopping water

Tivadar along the 48+900 km section, where besides the water leveling the crest there were major underground leakage problems on the pressure terrace and slopes and there were also signs of sloughs. Despite the bad road conditions they managed to transport the necessary material to the spot and construct the excess weight stone band. On the left bank of the Tisza, between Szatmarcseke and Olcsva-apati, most problems were caused by the lack of height but owing to the works that had began before the flood a successful heightening of the dike was carried out along an 8 km stretch. At the two locations of the dike strengthening works, the original protective capacity could be restored in time, by involving contractors. It was necessary to construct excess weight stone bands at some places and drain the leaking water. Underground leakages had to be stopped at three locations. The number of people involved in the protection was at its maximum of 11,991 people.

On 8th November the centre of the flood control shifted to the Vasarosnameny – Zahony section. Water stage exceeding the highest ever measured developed above Lonya. This approached the crest level by 10-20 cm at some places. In order to increase stability, protection against saturation, soil softening, underground leakage and wave erosion was necessary. Along the reach between Zahony-Tiszabercel and below the quality of the dike was better, however, because of the long time pressure there were leakages and at Dombrád an underground leakage had to be stopped.

At the end of the flood control big effort was needed along the Lonyai Channel to: construct emergency dams along the stretches having not sufficient height and cross-sectional area ; secure stability of the dikes by building excess weight stone bands.

IV.4 EVENTS OF THE FLOOD AND THE MEASURES TAKEN

Protection against overtopping

In case of flood preventive dikes with less than design height and cross-sectional area prevention against overtopping was the hardest task. Protection was necessary against overtopping water along a stretch of altogether 19 km. At some places the constructed emergency dams held the pressure of 10 – 50 cm occasionally 70 cm of water. The time for constructing the unusually long stretch of emergency dams, for transporting the material needed for the construction, for organizing the workforce and transportation vehicles and for constructing temporary protective structures, was as short as 30 hours beginning with the alert at 3 p.m. on 4th November. The emergency dams were built up from sandbags. The sandbags were filled up at previously prepared storage places and transported to the locations in need.

The protection of protective dikes could be successful because:

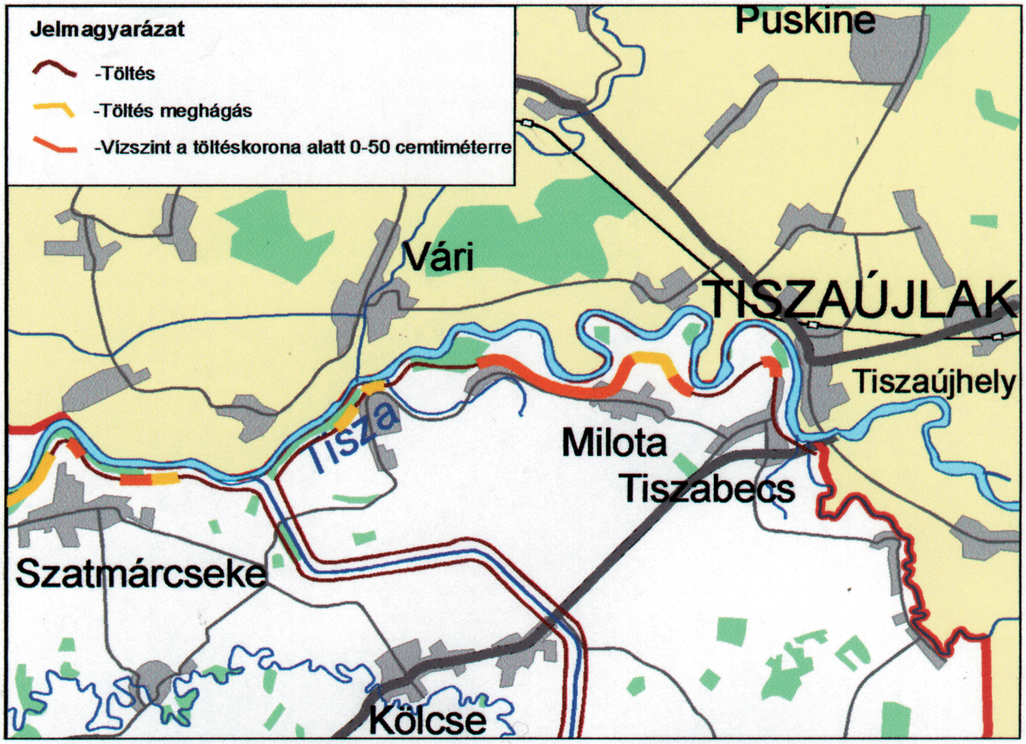
- The order for flood alert and preparations for protection took place prior to the 1st level flood alert at Tiszabecs, thus preparations could begin already in the afternoon 9 hours earlier while the 1st level alert water stage occurred only at midnight. As a result of the efficiency of local and national flood control management, the functioning of protection organizations, and good teamwork everything took place in time: rearranging material and workforce, and forces of the army and those of the Ministry of Interior, furthermore the joining of Civil Protection and inhabitants took place in time.
- It was possible to produce correct forecasts because there was enough data available about the foreign catchment areas from our partners over the borders.
- As a result of the rainy but not frosty autumn weather the grass on the dikes grew stronger, strong enough to prevent erosion caused by long lasting overtopping.
- Because of dike breaches in Ukraine the peak water stage was 10 -20 cm lower than the expected at Tiszabecs. This resulted in a slow down in the intensity of flooding, which gave 4-6 hours for the completion of construction works on the provisional protective structures.
- Building emergency dams took place in a windless spell.

Protection against underground leakage and seepage- through

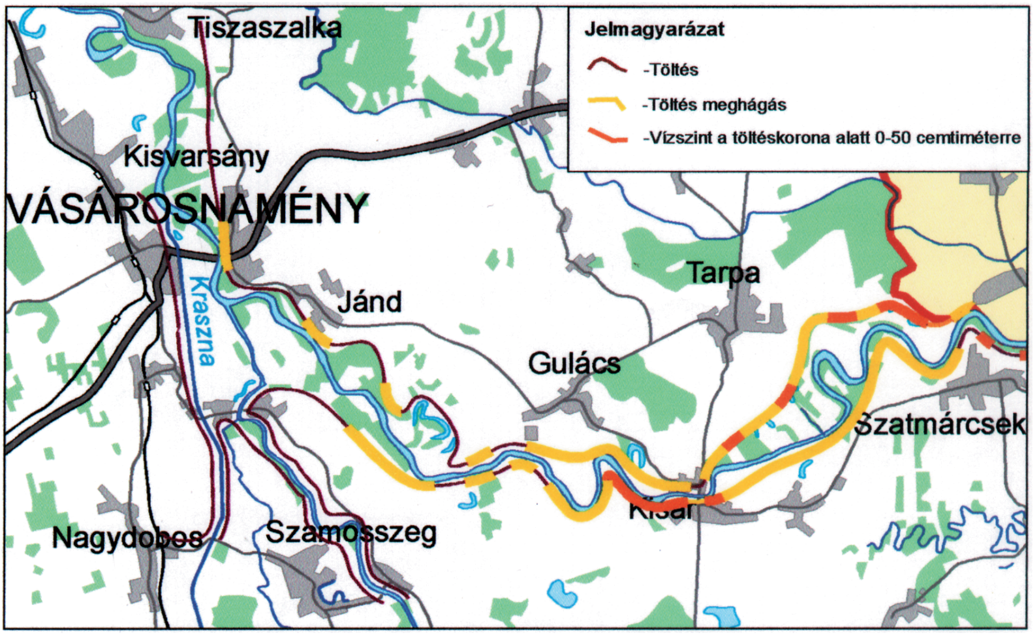
During the times of water leveling or exceeding the dike crest there were damaging flood events nearly along the full length of protection line system due to the following circumstances: water pressure; narrow cross-sectioned dikes; faulty dike basement; not homogeneous, not water resistant, improperly compacted building material; unfavorable layers of subsoil; inner holes in the body of the dike. Along stretches, where saturation endangered stability, excess weight sandbag bands were used and when necessary, continuous drainage network was constructed between the bands. Where there was a danger of washing out soil grains TERFIL material was placed under the weight bands.

Protection against underground leakage

From a flood control point of view, underground leakages that formed on the right bank along the section at 52+500 km of the Tisza (Tivadar) and on the left bank at 33+300 km



Dike sections overtopped between Tiszabecs and Szatmarcseke



Dike sections overtopped between Szatmarcseke and Vasarosnameny.

(Dombrad) caused the biggest danger. A leakage formed along the right bank section at Tivadar 52+500 km, in the section of the dike breach in 1847, in the line of the leakage at the time of the flood in 1970, in the free zone of the protected side, in the garden of a weekend house. They managed to stop the leakage by constructing a 4 m diameter, 1 m high sandbag pool. Based on the exploration it was concluded that the problem area was the same that breached in 1947 with a length of 60 m and a depression pool of 10-12 m depth. Under the underground leakage area, at the edge of the depression pool a lens of granular material was detected with a depth of 3-14m. The material carried away by the leakage can be categorized as quicksand. The dike at this place was built of weak, probably frozen soil.

At Dombrad 15-20 m from the foot of the dike on the protected side, in a low lying area, underground leakage occurred. Stopping was done with a sandbag circle in a height of 0.7-0.8 m. In the middle of the pool several small leakages were identified under a water cover of 0.5 m. At the same section similar problems occurred in 1970. Soil mechanical exploration proved that the ground here follows a regular layer pattern, the grain size grows together with the permeability coefficient in the exploration hole. The soil on the surface is clay and heavy clay. The leakage washed away well defined grains of the underground section without showing the pattern of the layers.

Protection against slough

The Hungarian-Ukrainian frontier is located 5-10 m from the foot of the dike on the protected side in the fields of Tarpa. Previous rains heavily saturated the soil so the narrow lane suitable for transportation became impassable, therefore the traffic of transporting vehicles had to be diverted to the foot of the dike. At places stairs of the 60 -70 cm formed, weakening the support from the protected side. The lower part of the slope without sufficient support slid on 6th November afternoon. The residents of Badalo, a village on the other side of the frontier, in fear of the immediate risk of being flooded, seeing the water leaking through the dike and experiencing the slide on the protected side, built up a sandbag coverage from the foot of the dike up to three quarters of the slope. This could not be prevented by the low number of local managers.

At 23.00 on 6th November at a water level nearing the height of the crest, the stability of the soaked and saturated, loose dike body became critical due to the following factors: dike sections with small size and high seepage coefficient, damaged slope on the protected side, ditches that formed along the protective zone of the protected side, thin covering layer, backwater effect because of the distributed load. On the slope tension cracks formed and a 15 -17 m long stretch, between the sections 62+533 – 62+551 km slid. A soil mechanics disclosure stated that the damage is the result of a slough or an underground breach.

The local flood control management immediately began to dismantle the sandbag coverage and transform them into excess weight bands. By constructing the most important weight band the section was stabilized before 2.30 on 7th November, however, until the dismantling of the sandbag coverage, the construction of the excess weight bands, the construction of the drainage net between the bands the condition of the dike was not reliable, the risk of having a breach existed. 34 sandbag bands were built along the 83 m long section. As a result of the quick reaction the problem was localized in an early phase of the phenomena, the breach was prevented.

Construction of an excess weight band at the slough at Tarpa along the frontier at night on 7th November 1998.

A critical situation similar to the Badalo problem occurred on 7th November on the right bank of the Tisza around the 48-900 dike km between Gulacs and Tivadar. There along a 300 m section at a water stage leveling with the crest of the dike signs of slough were observed. The phenomenon was localized by constructing excess weight sandbag bands.

V. ECONOMIC AND FINANCIAL ANALYSIS OF THE FLOOD CONTROL

Flood risk areas and property

The extreme flood wave risked and damaged the drainage basins along the River Tisza. The comparatively low damage is the result of successful protection. We are mostly talking about a peripheral region of the county with a comparatively low population density, property, and economic intensity. The proportional numbers, characteristically about 25-30%, indicate a high level insecurity.

68.2% of the nearly HUF 400 billion worth market value property is in residential possession, mainly in the form of village residential houses. The Szatmar-Bereg National Park, which is fully located within the flood risk area has a major, not numerical value too. Human lives, the psychological and physical shock of devastation, and new beginning are not possible to express in numerical value.

The expenses of flood control

A very big quantity of material, much more than the deposited or regulated quantity had to be used and built in during an extremely short period. It required permanent 24-hour work and involving outside forces. One part of the expenses was connected with the personal cost of workers taking part in the flood control activities, the other part was connected with the construction of sandbag support and emergency dams.

The expenses of the protection, which directly occurred at the water authorities, the civil protection, the local governments, the army, the frontier guards and other organizations carrying out government tasks, were basically covered by the state budget. In several cases enterprises and individuals contributed to the protection on a voluntary basis without any payment, thus, the financial value of their work was not added to the total of the expenses. The location of the protection expenses: Upper-Tisza Water Authority HUF 492 million; partner water authorities HUF 92 million; local governments HUF 197 million. The total cost of the flood prevention was HUF 1.3 billion plus. The overwhelming part of personal expenses (62.0 %) was the fee for workers. Out of the 448 civil servants 305 people directly took part in the protection, a further 100 people indirectly assisted the work. Because of the extraordinary nature of the task it was necessary to do 24-hour duty, however it was possible only three times subsequently.

1573 assistant dike keepers, 30 pump machine-operators, 20 telephone operators, 228 unskilled laborers from communal workers, and 5 outside experts to assist technical coordination were employed on a short term contract basis.

Elements of material expenditure: technical material 51,000 thousand HUF; outsider services 214,853 thousand HUF; inner services 3,280 thousand HUF; usage of private vehicles 761 thousand HUF; other material 614 thousand HUF. The largest amount within the material expenses were the cost of 656 thousand bags for sand(28.2 million HUF), 62 thousand torches (7.1 million HUF), 32 thousand m^3 sand, 18 thousand m^2 terfil isolating material, 2.25 thousand tons of stone. Only a fraction was available in store, so purchasing and transporting the rest had to be organized to secure immediate (in 1-2 days) availability. The National Technical Management Committee organized redistribution of 174 thousand bags from partner water authorities while 780 thousand bags had to be purchased directly from the manufacturer.

Machinery services, transportation, loading, were ordered from 80 partners. We had had a conceptual agreement for involvement in flood control events with most of them. There was a need for import services too: it was necessary to employ machinery and labor from the Ukrainen side to construct support structure for a geologically specially located dike section near Tarpa on the Tisza. The expenses, USD 23 thousand, were transferred.

Damage caused by the flood

Concerning the nature and extend of the damage the fact, that the water did not breach the dike and the flood remained within the embankments all the time, is crucial. At locations effected by dike overtopping, the amount of water was not considerable. Consequently, material damage was done only in the body of the dike and in the flood plain. Dike sections, structures and bank protection structures in the river basin got damaged. Cultivated areas, roads and parts of settlements located within the flood plain were damaged by flooding. Protection lines and structures were damaged on the one hand by water pressure, on the other hand by activities during protection. The total damage caused to water related establishments was HUF 1,110 million. The total material damage was HUF 4,182 million.

Damages prevented by flood control

The estimated damage and reconstruction expenses in the effected area with a 50% probability is HUF 57 billion, which has a reconstructed value of HUF 145 billion. The economic efficiency of the protection can be clearly justified, with 1.3 billion protection expenses against 57 billion damage and 145 billion reconstructed value further more the non-material, however, extensive damage (lives of people, loss of livelihood, ecological damage, infections, etc.)

Economic efficiency of the use of development and protection funds

According to a study on the development of the flood prevention system on the Upper-Tisza of 1996, to create necessary and sufficient security a total of HUF 23.3 billion is required (1998 value). By sufficient security to be achieved by the development we understand construction of dikes capable of protecting floods occurring in every 100 years, based on statistical data. This means a dike height of the design flood level + 1 meter, together with proper size cross section. The most critical 15-20 km section can only reliably resist flood only with a dike designed for floods in every 10 years. Along the full length of the reach an average of 30 years can be calculated.

66.8% of the material wealth in the region are residential houses. Damage or destruction done to them is not only a financial question of reconstruction. Some of the 65 thousand inhabitants consider migration as well, which involves the multiple of the above calculated expenses, not to mention the psychological damage. Analyzing the efficiency of development we have to calculate with the expenses of reconstruction for the devastated property and this can not be considered as marketing of products.

At the present built up level the probability of damage is 3.3%, which means an annual average of HUF 4,361 million damage. After the development the average annual damage can be estimated as HUF 1,322 million. The outcome of the investment is the difference between the two figures, actually an annual saving of HUF 3,039 million on the reconstruction expenses. Concerning the protection activities, out of the HUF 1.3 billion total expenses a minimum of 1.1 billion could have been saved if there had been dikes with proper dimensions. Calculating with the financial outcome of the development (HUF 3,072 million) the rate of return is 6.9 years. This means sufficient efficiency in itself, however, the non-material positive outcomes have to be considered as well, the implementation of the development project is a definitely profitable investment.

Flood and insurance

Some of the insurance companies arbitrarily pick out natural phenomena from the insurance policy and group them into other policies, moreover exemptions are not uniform either. In national insurance policies inland water is a risk included, torrential rains belong in the category of storms, and blockage can belong to the insurance category of water conduit damage.

There is no stipulated government standard in Hungary, flood damage insurance is directed by the rules of market only. In the field of mass insurances like citizens, small enterprises, insurance companies group the risk of flood damage into the storm package together with earth-quakes, as elementary damage, natural disasters or catastrophe (flood, earth-quake) and they sell them together (up to the insurance value limit of HUF 40 – 250 million).

The presumed value of the insured property is: HUF 111 billion in the area in question. In the areas that were considered flooded, the average estimated damage for the various water sensitive groups of property, the total amount of damage would have reached HUF 75 billion. Taken into consideration that some of the insurance companies set a maximum limit of compensation payable for one insurance claim, the actual total amount of compensation payable can be estimated HUF 40 billion.

VI. FLOOD CONTROL IN THE CATCHMENT AREA OF THE UPPER-TISZA OUTSIDE HUNGARY

VI.1 FLOOD CONTROL IN UKRAINE

The rivers of Sub-Carpathia take their sources in highlands of the Carpathian Mountains. This area has a dense water ways network (1.7 km/km^2). Within the borders of the county the River Tisza has a length of 201 km, and a 12,760 km^2 area of cathment. Main factors causing flood waves are: hydro meteorological features, mountainous nature of the catchment area and human activities within the catchment area. For the protection of settlements and other various areas, a flood control system of several elements was created. Experience gained from floods during previous years prove, that the flood control system needs development.

In the first ten days of November 1998 there were heavy, intensive rains (200 mm in two days). A rather high flood wave developed, causing extensive damage, with the highest water stage ever measured on most of the water gauges. As for the damages caused, this flood exceeded all the previous ones except for the flood in 1946 so it can be definitely considered catastrophic.

The flood was formed by two flood waves: the first was in the days between 28th October and 3rd November and the second from 4th November to 9th November. During the first flood wave the rise of the water level reached as much as 4 m, however, there was not much damage caused. The second flood wave formed and ran on the first one when the water level of the river was 1-5 m higher than the low water levels. So during the second flood wave in early November the water level rises reached 5.5 – 7.5 m, exceeding the highest ever measured at several places.

Flood damages

The November flood wave cause extensive damage both to the citizens and to the whole of the economy. The total damage is worth 350 million Hrivna in the county. The floods destroyed 2695 houses and damaged 2877 buildings. Extensive damage was caused in roads, power systems and other infrastructural establishments. Along the River Tisza and its tributaries 40.4 km long flood control dike, 8.9 km bank protective structure, 17 km channel and men made river bed got damaged. In the period after the flood wave geological events, which caused damage to the infrastructural network, were experienced at 178 locations. There were 162 landslides and 16 mudflows out of the 178 events.

During the time of the flood wave there were direct flood control activities carried out by the water authorities, by various catastrophe preventive organizations, by units of the army and by local residents. Due to the sudden water level rises having human victims and flooding of large areas could not be prevented. Especially extensive damage was done along the river sections in mountainous areas, where the previously constructed flood control and river regulation structures did not work properly.

Tasks of restoration and development

To assist restoration, the State Hydrological Committee of Ukraine provided a significant capacity of building units and technical equipment. At the end of November there were about 200 machines and other appliances in operation in the county. Besides the water-machinery unit road constructing and maintaining firms took part in the works. By the end of the year, in less than two months time, reconstruction and restoration work was completed at 25 locations. In November and December 1998 and in January 1999 6.7 million Hrivna worth restoration work was done by the water construction firms. For the restoration a total of 17,600 m^3 stone was used up and 443,600 m3 earthwork was done. A 6.5 km long flood protective dike section and 24.4 km riverbed were renovated and restored. A 3.4 km long river section was cleansed and 42 acres of island together with the floated timber.

The dike breach below Királyháza (Ukraine). It happened between 14.00 and 16.00 on 5th November 1998

During the time of the restoration works a complex flood prevention development program for Sub-Carpathia for 1999-2000 was worked out as an assignment given by The Prime Minister's Office of Ukraine, by the State Hydrological Committee of Ukraine and the Sub-Carpathian County Administration. The program described the quantity and nature of the work to be done and marks the locations of flood development.

In accordance with the minutes of the multi-party meeting in Uzhgorod, on 16-17 February 1999, attended by the delegations of the Hungarian Republic, Ukraine, Romania and the Slovak Republic, feasible tasks along the Ukrainian – Hungarian section to be done by Ukraine are:

- Along an 18.2 km section on the right bank of the Tisza between Szaloka and Salamon dike heightening has to be carried out,
- Dike heightening has to be done between Tiszaújlak and Badalo along an 18 km long section,
- Reconstruction of a 34 km long stretch of dike between Kiralyhaza and the frontier on the left bank has to be completed.

The present Upper-Tisza flood alert system can not forecast the various parameters of flood waves in progress in time, those, that would be necessary for protection of economic establishments and objects and for the efficient operation of flood control systems. The efficiency of the Upper-Tisza hydrological alert and forecasting systems in the first place can be improved by installing automatic measuring systems. The installation of this system was begun by the Water Authority of Sub-Carpathia and the implementation of Phase 1. is still in progress. The basic aim of the system to be created is to make flood forecasts possible with the help of mathematical models, using data base and programs. In 1999 the first part of the measuring and observing system will be put to operation. A direct information contact is being established between Uzhgorod and Nyiregyhaza in the first phase of the installation of the automatic measuring and observation system. We plan to carry out the implementation of the development project in the framework of multi-party cooperation together with the other countries involved.

VI.2 FLOOD CONTROL IN ROMANIA

The Upper-Tisza forms a natural frontier between Romania and Ukraine, in the north-east of Romania along a 62 km stretch, beginning at Viso Valley (Valea Viseului) up to Palosremete (Piatra-Remeti). In the area belonging to Maramaros county the Tisza receives water from Romanian territory from the following tributaries: Viso (Viseu), Iza (Iza), Szaplonca (Sapanta) and Suhatag (Sugatag). Along these water courses intensive, large flood waves tend to form in a short time. From 1993 till the end of 1998 fifteen flood waves progressed, three of which were above alert level (1st level) and three were above flood level (2nd level) [28.]

Hydrological features of the flood wave in Romania [29]

In the cathment area of the Upper-Tisza in Romania a real big flood occurred only along the Tisza and along the River Oroszi (Ruskova), the right side tributary of the River Viso. High water stages formed on the Viso, Iza, Mara (Mara) and Tur, however, they did not cause considerable flooding or water damage.

From the 3rd November there were heavy rains and the daily maximum was as high as 71 mm. The areal average precipitation between 3rd and 5th November was 30 mm on the Viso, 49 mm on the Iza, 45 mm on the Tur. Considerable flood waves formed and at some places the highest water stages ever were measured. The peak water stage reached the Romanian section of the Tisza in the early morning hours on 5th November.

At 4 a.m. the water gauge of the hydrological station of Maramarossziget measured 436 cm water stage, which was 24 cm higher than the highest ever measured in 1970. The two flood waves lasted 360 hours on the Romanian section of the Tisza. For the Tisza is a border river, the staff of the water authority in Romania did not do any discharge measurement, so we have no data about the discharge during the flood wave. The peak discharges on the Viso, Iza and Tur were lower than the highest ever measured. On the Iza the 334 m^3/s peak flow was 55 %, on the Viso 446 m^3/s 42 %, on the Tur 126 m^3/s, 24 % of the maximum ever measured. The mass of water that progressed was: 201 million m^3 on the Viso at Petrovabisztra; 121 million m^3 on the Iza at Farkasrev; 94 million m^3 on the Tur at Turterebes. The areal runoff for segments of the catchment area varied between 50-175 mm. The highest figure occurred on

28 Székely I.: Bazinul hidrografic Tisa aferent județului Maramureş. Presentation at the international conference on flood control development on the Upper-Tisza in Nagybanya on 10th December 1998.

29 Fărcaş R.-Fetea P.-Cocuț H.-Stefanik M. : Viitura din perioada 3-11. noiembrie 1998 si impactul ei asupra asezărilor umane existente în bazinul hidrografic al râului Ruscova. CNAR SA. Direcția Apelor Someş-Tisa, Cluj. 1999.

the tributaries of Iza, on the Mara at Kracsfalva (Mara) with 175 mm; on the stream tributary of the Tur, Rossz-völgy (Valea Rea), at Lajos-völgy (Huta Certeze) 129 mm, at Visooroszi with 123 mm.

The flood wave on the River Oroszi caused extensive damage on the Luhej-Havasmezo (Poienile de Sub Munte) river section. The equipment of the hydrological station (water gauge, measuring bridge) were totally destroyed. At Luhej station the measurement was interrupted. The maximum flood flow was 250 m^3/s, which equals a 1337 l/s km^2 specific runoff. During this period similarly high figures were characteristic along the upper courses of the Tarac and Nagyág, two right side tributaries of the Upper-Tisza in Ukraine.

Structure and operation of the hydrometeorological information system

The information and alert system covering the rivers of Maramaros is part of the system operating in the Tisza-Szamos catchment area[32]. In the catchment area of Oroszi the circulation of data worked well at the beginning of the flood, alerts could be issued in time, according to the regulations. After the hydrological station and the house of the observer at Luhej got flooded, observation and data forwarding was cut from the evening 4th November. The radio-telephone connection was cut because the electricity supply failed and the telephone was out of order because of broken cables. There were no disruptions at the data collecting centers.

FLOOD CONTROL IN ROMANIA

In Romania flood control is regulated by the "Regulations for protection against floods, dangerous metrological phenomena and damage caused to hydrological structures", reinforced by the 615/92 Government Decree, and the No. 72/1994 Government Resolution on Emergency Situations.[33, 34]

On the water courses of Maramaros, river regulation, bank-protection, dike construction was carried out along an 84 km long bank line after the flood in 1970. Out of this 48 km length was on the Romanian side. The total length of the flood prevention dikes is 23.6 km, out of which only 6 km is located on the Romanian side of the Tisza. According to the Romanian – Soviet hydrological agreements flood prevention structures can be built only up to the height of the river bank [35].

32 Barna, E. Melinda – Pándi, G.: Hydrological information system in Romania. MHT. Water and water environmental conservation in the Carpathian Basin. Volume 1, 1-10, 15-18 October 1996, Eger.

33 ***: Hotărâre de guvern nr 615/30,09,1992 privind aprobarea "Regulamentului de apărare împotriva inundațiilor, fenomenelor meteorologice periculoase şi accidentelor la construcțiile hidrotechnice". Ministerul Mediului.

34 ***: Ordonanță de guvem nr 47/12,08,1994, privind apărarea împotriva dezastrelor. Monitorul oficial al României, Partea I. Nr.242.

35 Sofronie C.-Székely I.: Gospodărirea apelor în bazinul hidrografic Tisa, pe teritoriul României-condiția unei dezvoltări durabile (Manuscript). Cluj-Baia-Mare, 1996"

The flood control activities were carried out in accordance with the actual flood control plans, with the coordination of the Regional Catastrophe prevention Committee, which declared preparedness in the county following the forecasts of expected water stage exceeding flood alert level. On 4th November, in the afternoon following the continuous flooding on the River Oroszi, arrangements for evacuation from the houses in danger in the villages of Havasmezo, Oroszko and Visooroszi. Road transportation and traffic facilities of Oroszko and Havasmezo with the rest of the county were disrupted. Following the arrangements of local and county catastrophe prevention bodies, provisional and bypassing roads were constructed[36, 37, 38]. Flood prevention structures along the rivers, hydrological stations, agricultural areas, houses, the railway, roads and bridges, forests, the flora and fauna got damaged.

According to the opinion of the Szamos-Tisza Water Authority, it is necessary to continue the development that began in the valleys of the Viso, Iza and Mara. The lead time of flood forecasts have to be increased. Establishing a monitoring system, based on data exchange between Romania, Ukraine, Hungary and Slovakia is crucial. There are plans to construct a remote measuring and alerting system of 25 automatic stations on the Rivers Viso, Iza, Tur and Kraszna. In order to forecast meteorological phenomena and to secure efficient alert it is necessary to install a Doppler meteorological radar (on Rozsaly Peak, near Nagybanya). The radar has to be able to show precipitation fields forming above the cathment area in Ukraine. In order to reach this aim, a tender titled 'Flood forecasting on the Upper-Tisza' was worked out and submitted by the Romanian Waters National Company, Szamos-Tisza Water Authority of

After-flood situation in the basin of the River Oroszi

36 Székely, I.: Bazinul hidrografic Tisa aferent judetului Maramures. Presentation at the international conference on the development of the Upper-Tisza flood protection in Nagynánya, on 10th December 1998.

37 Fărcaş R.-Fetea P.-Cocuţ H.-Stefanik M. : Viitura din perioada 3-11. noiembrie 1998 si impactul ei asupra asezărilor umane existente în bazinul hidrografic al râului Ruscova. CNAR SA. Direcţia Apelor Someş-Tisa, Cluj. 1999.

38 Marina V.: Evaluarea lucrărilor de infrastructură-drumuri afectate de camalităţile produse de râurile Repedea si Ruscova afluenţi ai Tisei superioare. Presentation at the international conference on flood control development on the Upper-Tisza in Nagybanya on 10th December 1998.

Cluj and it was recommended for PHARE CBC financial support [39]. A statement of support was issued by the Upper-Tisza Water Authority in order to assist the implementation of these plans.

VII. FLOOD CONTROL AND PUBLIC RELATIONS

Due to the rapidly progressing emergency situation and risk of a catastrophe the national water management and within this the water authority got into the focus of attention thought the country. The management of the flood control tried to issue correct information, drew public attention to the emergency situation in time but avoided panic.

The County Flood Control Committee assembled at midnight on 4th November then a press conference took place where the media was present too. Dealing with the press, issuing reports, statements and giving background information, producing information material, organizing press conferences, is the task of the public relations team. Each person asking for information or advice was equal and important because preventing the catastrophe was a common goal. Daily information about the most important hydrological, hydro meteorological and technical issues was sent to the partner water authorities by Lotus Notes. On note boards continuous information was provided to the staff of the water authority.
During the thirteen-day flood control period the FETIVIZIG issued 1475 pieces of information to the press and further 900 to other places. Continuous information was given to journalists and reporters inquiring on the phone or in person. Instead of spreading alarming rumors, several reporters confirmed the correctness of the news before publishing. Following the meetings of the Flood Control Committee, press conferences, helicopter field-trips were organized. During the days of flood control several live interviews were made by various radio and TV channels beginning with the Hungarian Radio to 'Slager Radio', Hungarian TV and the commercial TV channels. Some of them gave fresh information in every hour.

The members of the flood control committee, the cooperating and partner organizations received daily written reports. The local governments got up-to-date information through the local flood control management. During the most critical period most of the government officials visited the water authority. The visits and the publicity attached to them were helpful for the flood control activities.

Despite of the few but loud negative reactions, the publicity of the flood control period can be considered successful. During the most critical period 117 reporters of 91 press organs (59 newspapers, 15 radio channels, 17 TV channels) contacted the water authority, most of them giving correct information. Handling alarming rumors, that usually occurred at night took

39 ***: Prevenirea inundațiilor in bazinul Tisei superioare. (Fişa proiect pentru Phare CBC). MAPPM CN Apele Române. 1999.

big effort and despite all the effort taken, unfortunately some of the rumors were published in national daily papers.
A collection was edited from the publications photos and broadcasts, which is available on CD as well.

The activities and role of media in the flood control

The basis of the analysis is the Flood Control Press Review (31st October 1998 – 10th April 1999) edited from the articles published in national daily papers, complemented with materials of situation reports and press conferences made by the water authority during the flood.

The interest of the press in the flood had various periods. The first period was in the early stage of the flood 'Flood wave on the Upper-Tisza' [40]. In this period the interest of the press was comparatively low. The second period was the state of emergency: "Continuous Struggle with the Flood' [41], when the interest of the press had its peak. Finally, the last period was the period of subsiding when evaluating and analyzing articles were published. Professional publications in papers printed every second month concentrated on technical issues and the accuracy of the reports. The articles analyzed almost every aspect of the flood; summarized the experiences; drew the conclusions and made suggestions concerning the future.
Based on the press review it can be concluded that during the periods in question the press of the flood published in Hungary gave mostly realistic information, based on facts and not rumors, not sensation-hunting, misinforming news.

Sociological response on public opinion and citizen's views on flood risk

Several settlements in the region of the Upper-Tisza from Tiszabecs to Tokaj were affected by the flood in autumn 1998. Among these settlements' citizens a survey was done with the involvement of variously risked villages such as Gulacs, Kisar, Kisvarsány, Olcsvaapati, Szatmarcseke, Tarpa, Tiszabecs, Tiszakorod, Tiszaszalka, Tivadar. From each settlement 20-30 persons were questioned the total number was 249. The subjects of the survey were relevant people to answer the questions.

Most of the people questioned had been directly affected and risked by the flood. The residents played a very important role in the flood control and also expected the relevant organizations to efficiently participate in the coordination of the flood control. The following bodies were counted on to meet the realistic expectations of the residents: local governments, county government, government bodies, water authorities, army, civil protection, etc.

40 Népszabadság, 31 October
41 Békés Megyei Hirlap, 12 November

The role of the water authorities was satisfactory, according to opinions, however, the judgment about them reflected contradiction. According to the judgment of those taking part in the survey, the water authorities' public relations and their public role in the system was less obvious than their professional activities. This can define important tasks for the department in the future. In general the result of the survey shows that there was a feeling of some delay at the beginning of the flood, which resulted in loss or lessening of confidence. However, about the management of the flood control, the efficiency of flood control activities the general opinion was positive. In this aspect the people questioned were not able to have a clear view and distinguish between the importance of the groups of residents involved, NGOs and various institutions.