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General Description of the Water Management Problems of the Tisza River Basin

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GENERAL DESCRIPTION OF THE WATER MANAGEMENT PROBLEMS OF THE TISZA RIVER BASIN

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Introduction

The Tisza River is the greatest tributary of the Danube River. Its basin lies between $45^{o}09'$ and $49^{o}27'$ northern latitude and between $19^{o}13'$ and $25^{o}45'$ eastern longitude. The watershed runs from the western boundary between the Danube and the Tisza through the regions Baska and Kisknuseg where the height is no more than 174 m. above the Baltic sea level. The Carpathian mountain chain forms the natural boundaries of the Tisza River basin from the north, the east and the south-east. The total area of the basin, 156,000 sq. km., is distributed amongst five countries: Romania - 46 per cent, Hungary - 30 per cent, Czechoslovakia - 10 per cent, the USSR - 8 per cent, and Yugoslavia - 6 per cent (Figure 1). The national economies of these countries are developing rapidly, particularly in irrigation areas. Therefore, the problems of water supply, water quality, and the protection of the water from the harmful effects of floods are becoming more difficult each year.

The relief of the Tisza River basin is very complicated, i.e., 0.7 per cent of the area is situated in the Alpine country, 18.4 per cent in mountainous country, 37.3 per cent in hilly country and the last part in a plain with elevations about 80 to 100 m. Everywhere mountains are the natural boundaries of the basin. It is open only to the west.

In 20 or 30 years, these difficulties will be insurmountable. Today all countries manifest working cooperation in the water management of the basin. The study of the questions which relate to water management measures and design preparation,

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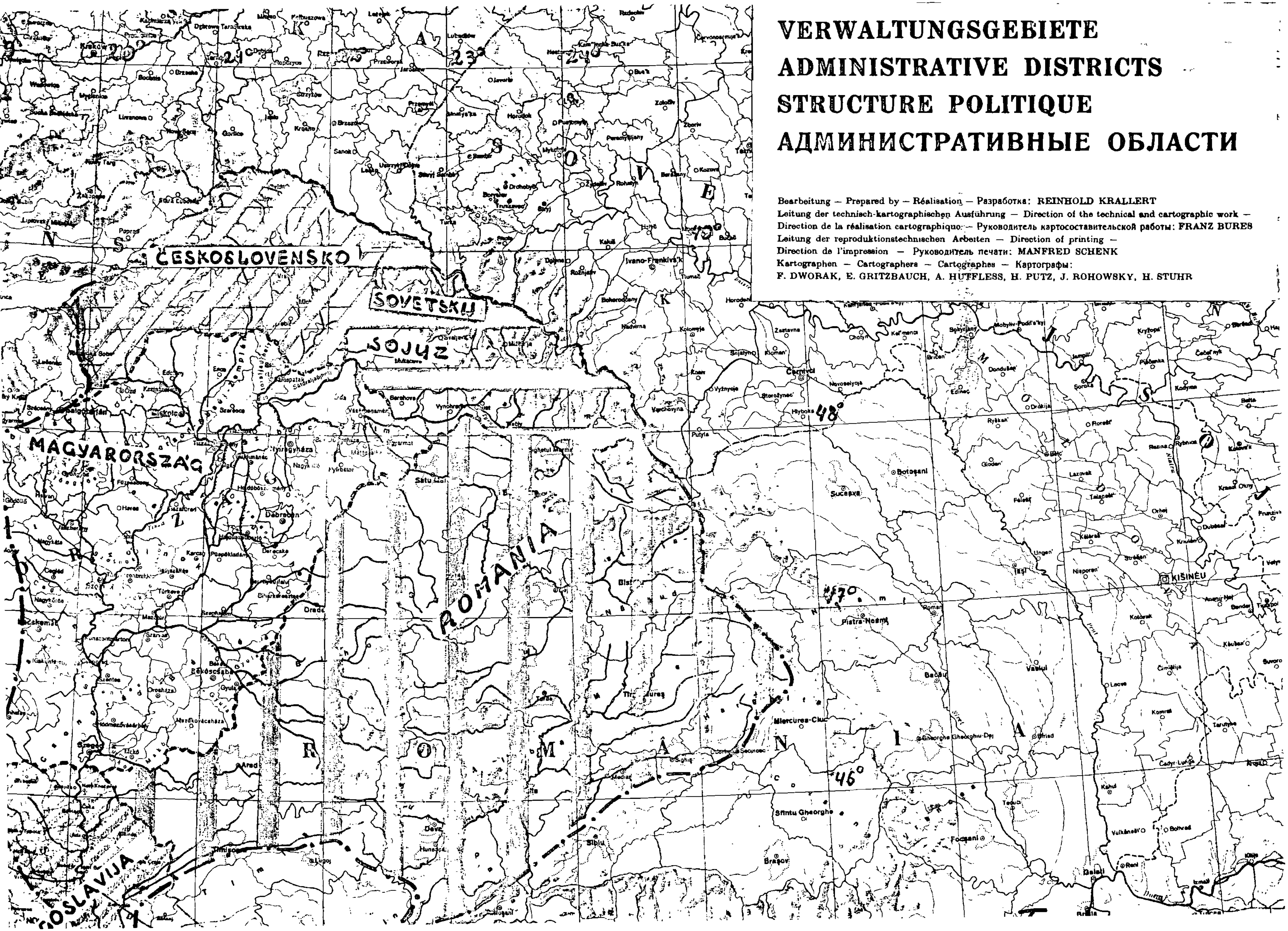


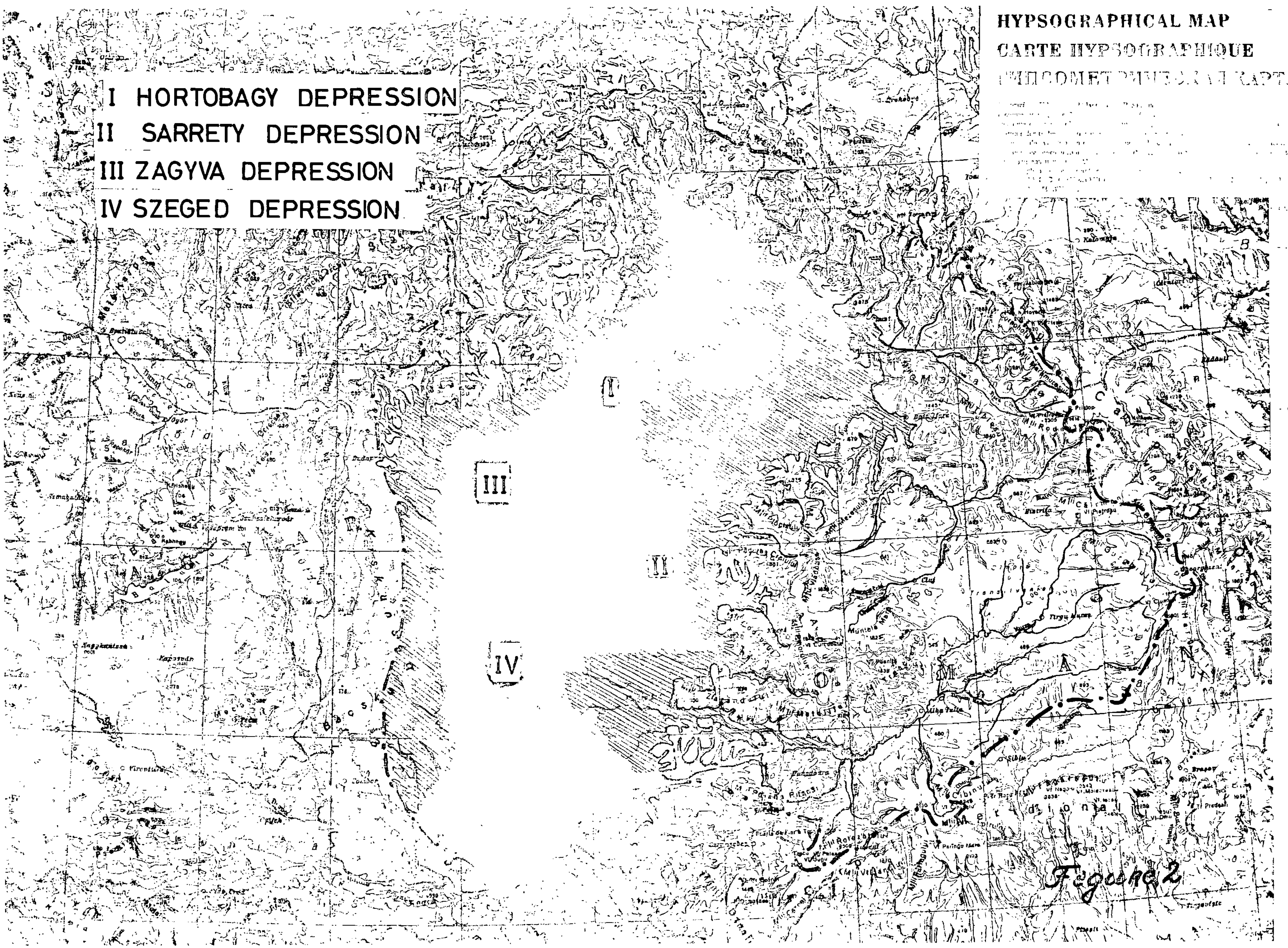
require much time, but immediate measures and studies will have to begin now.

Systems approach to the study of the water economy problems of the Tisza River basin can be of great use, especially with regard to the fact that large investments are necessary for their sucessful implementation.

The ridges of the greatest magnitude of the Carpathians (where the Tisza River watershed lies) are situated in its southern part. The Meridional Carpathians are partitioned here by river valleys (Figure 2). The Eastern and Wooded Carpathians form a continuous mountain system which is of a smaller height but of greater length. Inside the arc lies the Apuseni mountain-mass with heights up to 1850 m., which is separated from the Meridional Carpathians by the Muresh River valley. It separates the Transylvanian Plateau from the valley on the west of the basin. The lowest mountains in the Carpathian chain, the Low Beskudy, separate the Ondava and Taborets tributary basins from the Visla River basin on the north. The vast Alfeld valley situated in the western part of the basin is not homogeneous either. Within the Hungarian lowlands, there are four large distinct depressions (Khortobad, Sharret, Zandva and Seged).

Climate

The climate of the Tisza River basin is temperate continental. Above the basin, atlantic, arctic, mediterranean and continental masses of air meet and interact. Of the air that has been investigated, the maximal temperature is 40°C and the minimal is -36°C; average temperatures range from 3 - 9° in the north to 8 - 11°C in the southern part of the basin.

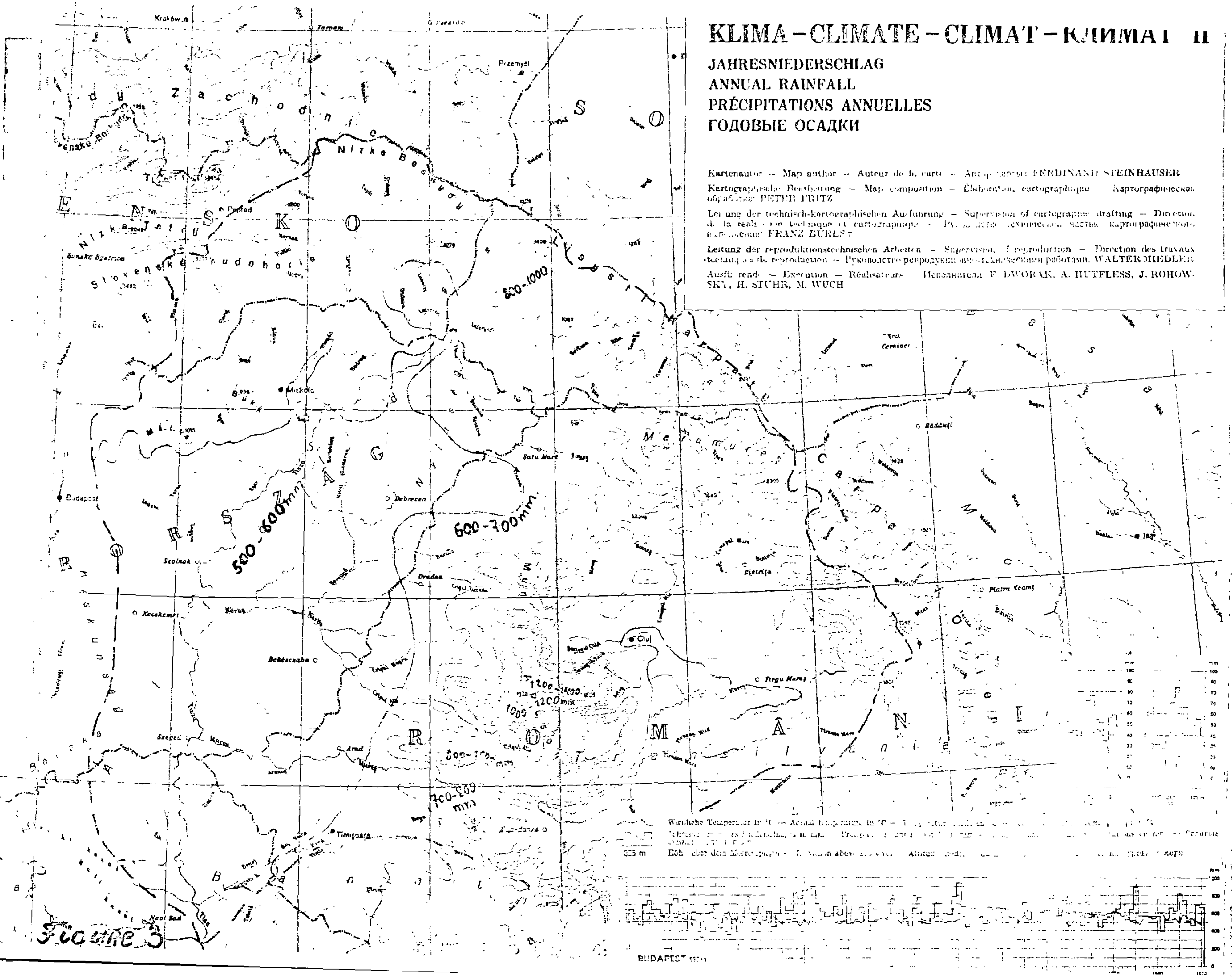

HYPSOGRAPHICAL MAP
CARTE HYPSOGRAPHIQUE
I HORTOBAGY DEPRESSION
II SARRETY DEPRESSION
III ZAGYVA DEPRESSION
IV SZEGED DEPRESSION
I
II
III
IV
Figure 2

The duration of the vegetative period varies from 166 to 236 days. Average yearly precipitation varies from 1200 - 1400mm in the upper part of the river basin to 800 - 1000mm in the foothills and 550 - 580mm on the plain (see Figure 3).

The temperature in summer is highest in the south-east part of the basin in the areas of Hungary and Yugoslavia. The smallest amount of precipitation occurs in July, particularly in the Keresh valley. Hence, recent investigations substantiate the greatest need of water for agriculture.

Hydrological Regime

The hydrological regime of the Tisza and its tributaries is very complicated because the runoff that forms in a distinct part of the basin has a different kind of generation. From its source in the Blake Tisza in the north-west part of the Lisysti Carpathians (Soviet) to the mouth of the Borgava River,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ГОДОВЫЕ ОСАДКИ
Kartenautor – Map author – Auteur de la carte – FERDINAND STEINHAUSER
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Satu Mare
Oradea
Cluj
Tirgu Mureş
Arad
Timişoara
Szeged
Kecskemét
Békéscsaba
Przemyśl
Kraków
Poprad
Piatra Neamţ
Rădăuţi
Szolnok
Novi Sad
BUDAPEST
Figure 3

the Tisza is a typical mountain river. Its runoff is formed under the influence of snow thawing and downpours. Near the Borjava mouth, the Tisza loses its mountainous character and flows onto the plain.

The most complicated part of the Tisza River lies between the Borgava inflow and the Shayo mouth. The riverbed extends from mountains and hills to flat country with the left tributaries: Tur, Somesh and Krasna which originate in Romania. These valleys meet halfway with the left tributaries Bodrog and Shayo which flow from north to south and originate in Czeckoslovakia. Therefore, the north and south provinces of this part of the basin present themselves as independent hydrographical and climatological regions. The volumes of the runoff per year of the Samosh River and Bodrog River are a little less than the volume of the Tisza itself.

It is clear now that forming a regime in this part of the Tisza River is defined by various qualitative influences, the factors action is approximately similar. Naturally, it is here where floods frequently occur. The Tiszalyok barrage is situated in this part of the Tisza River, but its small storage has a seasonal regulation for many purposes: navigational, agricultural and industrial water supply.

The middle part of the Tisza River, from the Shayo inflow to the Marosh mouth, has banks around the riverbed which extend through the plain. Two large tributaries, Keresh and Marosh, whose runoff originates in Romania, join the Tisza here.

The Kishkere dam is also located here and the Cohgrad dam is planned with a channel from the Damube to the Tisza. The purpose of these constructions is to solve the irrigational and navigational problems.

The lower part of the Tisza is a typical plain river surrounded by banks. This part has a very complicated water management system because the Damube Tisza-Danube-channel is situated here.

The total picture of the meteorological and hydrological stations is given in Figure 4. On the basis of all available data, the Tisza River basin can be shown to be one of the most investigated river basins in the world. This data enables us to determine that more than half of the Tisza stream flow is generated in Romania, about 24 per cent in the USSR and close to 20 per cent in Czechoslovakia. Only 4.3 per cent of the total water amount is generated in Hungary and Yugoslavia, (see reference [1]). The Tisza runoff is characterized in the following table (1).

The Water Requirements

The requirements for water are based on the following uses: Municipal and industrial water supply, irrigation of agricultural areas, fisheries, navigation, hydropower and recreational facilities. For determining the water budget, we must take into consideration the water lost through evaporation from surfaces of the existing barrages and the proposed future barrages. The water supply is limited by sanitary discharges which often occur at the borders of the Tisza and its tributaries.

Table 1.

River Gaging Stations	Distances from the mouth of the river, km.	Water Basin area, km^2	Years of record	Average annual Runoff 10^3 M^3 per year	The Characteristics of the runoff of all periods investigated M^3/Sec.		
					Mean	Max.	Min.
Rachov (USSR)	962	1070	1946-1967	0.75	23.9	652	1.1
Vilck (USSR)	808	9140	1954-1967	6.77	215	2750	10.4
Vasharosh-Nameny (Hungary)	696	29057	1941-1966	10.99	349	3561	49
Zachony (Hungary)	636	32782	1951-1972	12.03	382	3360	46.9
Tokai (Hungary)	549	49449	1888-1953	14.96	475	4000	53
Mindsent (Hungary)	216	106202	1950-1972	17.70	562	2945	57.9
Tashkony (Hungary)	402	65674	1955-1972	16.25	516	3560	40.2
Seged (Hungary)	172	138408	1921-1972	25.67	815	4700	95
Seged (Hungary)	172	138418	1941-1966	24.73	785	3702	95
Sekta (Yugoslavia)	137	139715	1941-1966	24.10	765	3400	122

Schemeofmeteorological stations in the Tisa river basin.

Scheme of hydrological stations (▾) in Tisa river basin.

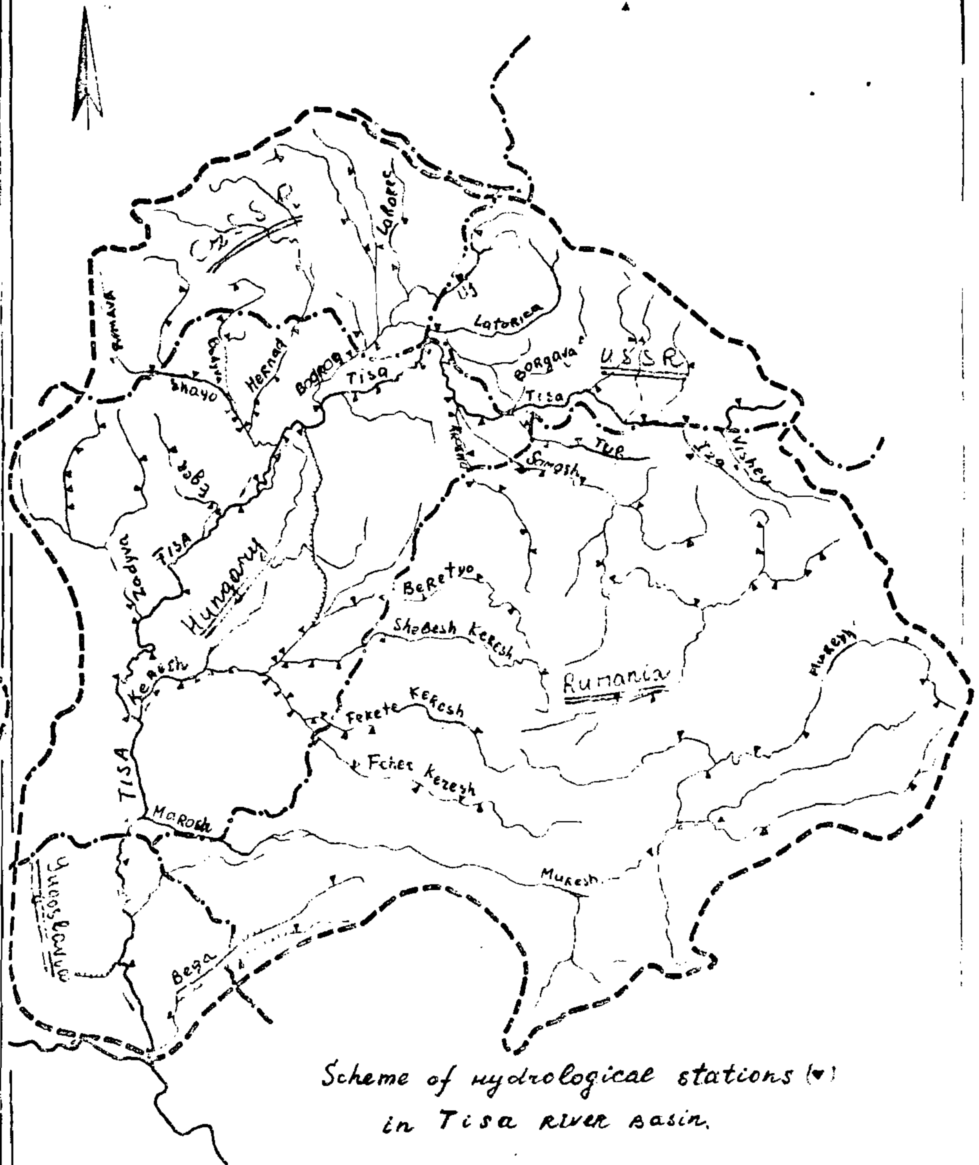

Figure 4.

The preliminary computations show (Figure 5) that the future water consumption may be four times as much as the present. Large water consumption is expected in the Hungarian and Romanian parts of the basin. It is estimated that in Hungary irrevocable water losses in 1980 may be more than the amount of water which is generated in the entire Hungarian portion of the Tisza River basin (about 2.6 km^3 or 10 per cent of the total amount.) The primary users of water at present (and in future) are industry and agriculture (irrigation). The remaining users, share approximately 12-13 per cent of the total amount of water consumption. It is possible that in 1990, these losses will have increased beyond the present rate to: communal - 3.5 time, industrial - 10 times, agricultural - 5 times and fisheries - 3.7 times.

Water Economy Balances

In comparison, the water resources and water consumption available for each region, show that we must expect seasonal deficites arising from the supplying of agricultural demands during August and September of dry years (80 per cent reliability[1]) on all Tisza tributaries except Visheu and Iza.

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[1]Reliability R(x) in this paper is such probability distribution P of random variable ξ that

$$R_\xi(x) = P_\xi\{\xi > x\} \quad \text{and} \quad R_\xi(x) = 1 - F_\xi(x)$$

where F(x) is the well known distribution function with a density of the probability distribution P(x) then

$$P(x) = \begin{cases} 0 & \text{if } x \leq 0 \\ \dfrac{B^d}{\Gamma(x)} x^{x-1} \exp(-Bx) & \text{if } x > 0 \end{cases} .$$

The yearly quantity of water will not be enough in the next 10 to 15 years, if many of the rivers are very dry (80 to 95 per cent reliability). The irrevocable water losses can compose, during dry climatological periods, the following percentages of the total volume of runoff generated by each country are: 10 to 15 per cent in the USSR, 20 to 30 per cent in the CZSSR, and 70 to 95 per cent in Romania. We must pay attention to significant decreases of water resources in the lower part of the Tisza. The stream flow of the river here will diminish 3.5 times in the forseeable future and will contain 4.2 km^3 as opposed to 14.7 km^3 a year at present, with the amount of water approximately 95 per cent reliability.

Water Pollution Problem

The problem of, and struggle against water pollution can be described on the basis of Hungarian data from 1970, although the data is not very good from a hydrological point of view.

The water quality of the Tisza at the Soviet-Hungarian boundary, is relatively good. There are times when large amounts of pollution and phenol reach the Tisza through the tributary Samosh. The influence of the polluted Tisza tributaries between the Samosh and the Bodrog (Lonyae-channel Belfe-channel) during 1970 was less effected as they were strongly diluted. Here we expect very poor quality of water during dry years. The Bodgog water is characterized by an insufficient amount of oxygen. Because of this, the amount of oxygen in the Tisza water decreases sharply after the Bodrog's inflow.

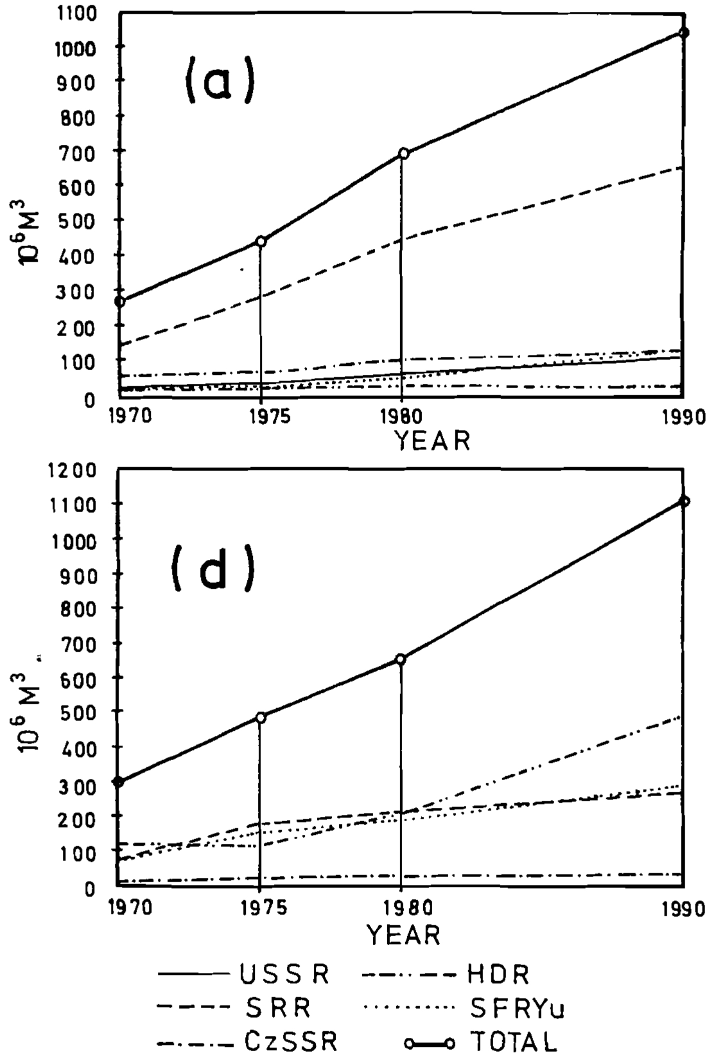
The Shayo River, is the most polluting tributary of the Tisza. The largest amount of organical substances (12,500 tons per year), iron and ammonium come from the Shayo. Due to this reason the amount of pollution in the Tisza below the Shayo mouth, is relatively high. The entire situation of water pollution in Hungary in 1970 is shown in Figure 6.

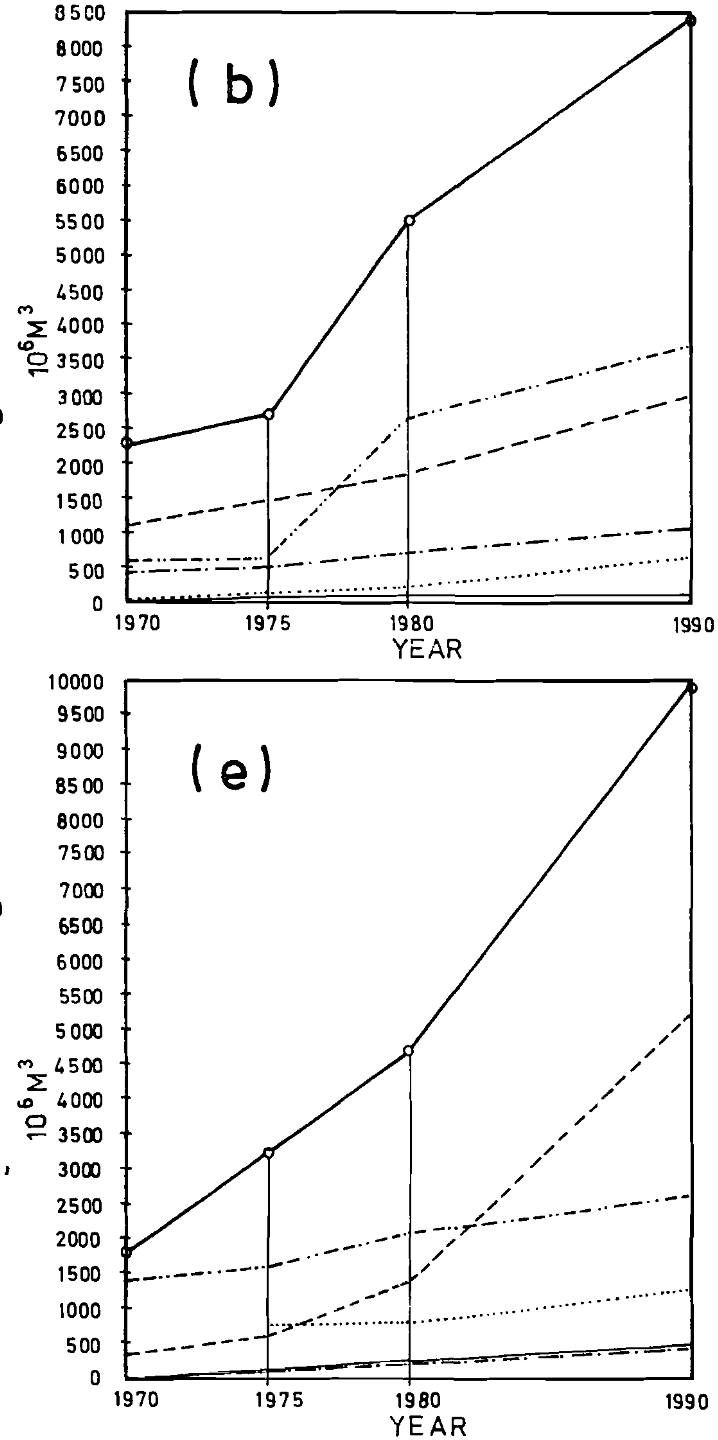
The water quality of the Tisza River basin is explained by waste-flow from industrial plants and municipal buildings. More efficient waste-water treatment must be planned in the future.

The preliminary computations show that in 1985, water pollution will have increased beyond the present rate, to: 1.5 times and in the year 2000, to 3 times. This is related to the drainage problem and to water consumption increases. It is expected the real data may be worse because the runoff during the dry season will be less and influence of control buildings will be more.

Protection from Harmful Influence of Water

Beginning in the last quarter of the 18th century, the people began their fight against floods, which were a destructive influence on their lives. However, the construction works of protective installations in their present understanding were commenced only in 1888 after the calculations of the locations of banks had been done. We can judge about the reliability of those constructions, taking into account the fact that beginning from 1895, constructed banks withstood all the floods and since that time there were no considerable damages of those works.





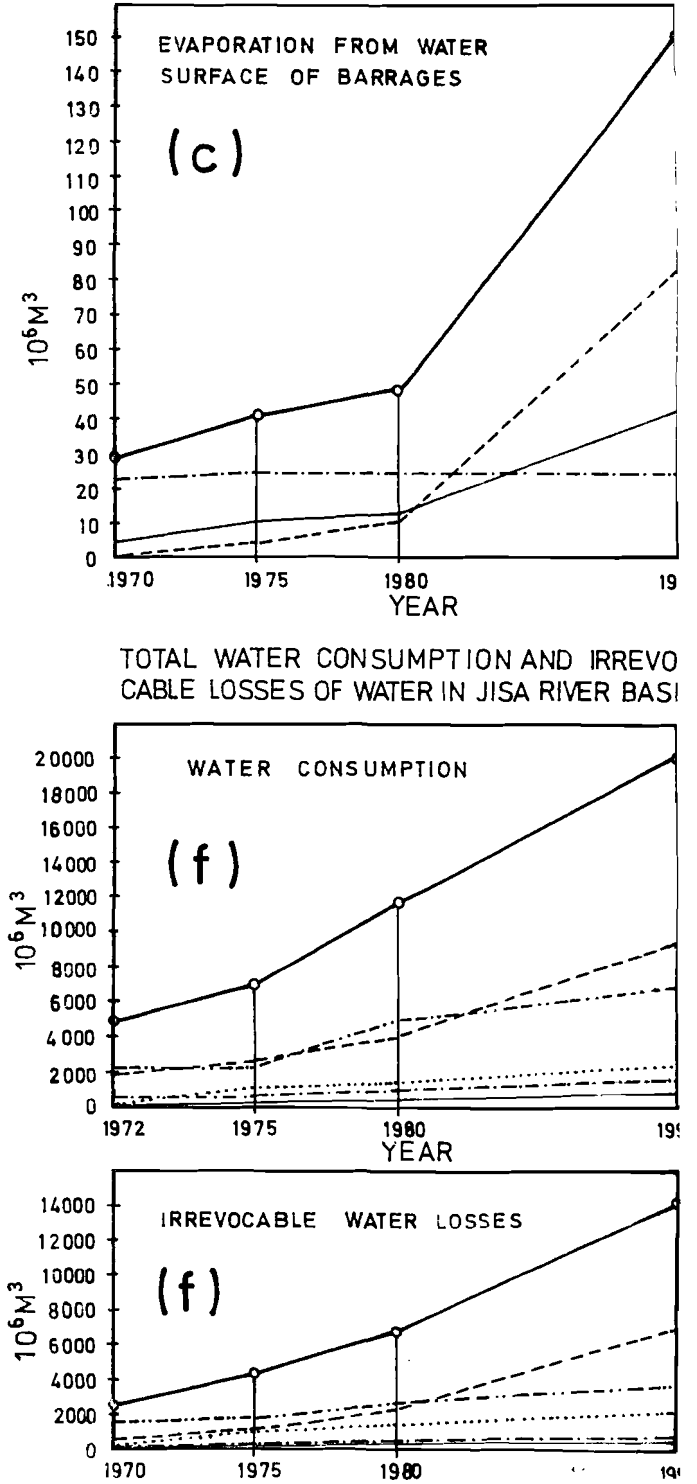


FIGURE 5 WATER CONSUMPTION FOR POPULATION (a), INDUSTRY (b), BARRAGES (c), FISHING (d), AGRICULTURE (e) AND TOTALE (f).

Figure 6

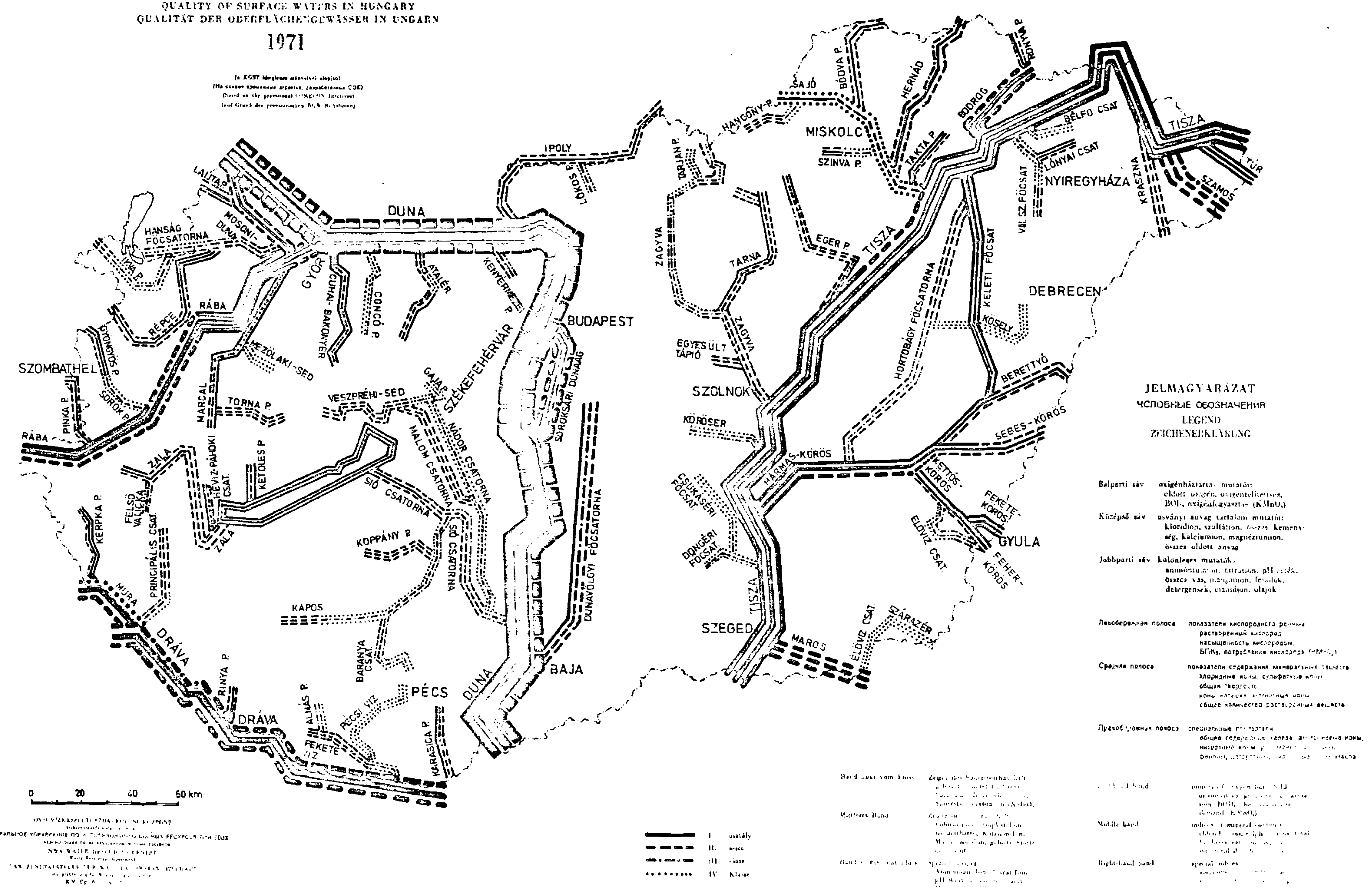
A FELSZÍNI VIZEK MINŐSÉGE MAGYARORSZÁGON

НАЧЕСТВО ПОВЕРХНОСТНЫХ ВОД В ВЕНГРИИ

QUALITY OF SURFACE WATERS IN HUNGARY

QUALITÄT DER OBERFLÄCHENGEWÄSSER IN UNGARN

1971



In 1846 construction work along the Tisza River banks began, and by the end of the century the main works of the present protection system had been finished. But in spite of all the investment and considerable operation expenses, the protective ability of those banks was not enough for abolishing the floods: the protective ability decreased eventually when the geotechnical characteristics of their grounds as well as the foundations of banks, hydrological, hydraulic, and other parameters changed.

The inspection made after 1970 has shown that most of the existing banks according to their heights and other affinities can stand the floods which occur approximately once every 65 years (P = 1.5%). Meanwhile the highest flood levels of 1970 had the following calculated reliability: the Tisza River by Tiszabech was approximately R(x)=0.5%, by Szolnok - R(x)=3.3% and by Szeged - R(x)=1.0%; the Samosh River by Chenger - R(x)=0.2% and at Marosh River by Mako it is R(x)=0.5%.

But the most part of the banks which were made to protect the adjoining areas along the Tisza tributaries, cannot provide the reliability 1.5%.

However, nowadays the existing hydraulic structures in the Tisza River basin cannot fully protect the adjoining areas against floods.

If we take into consideration only the Hungarian People's Republic, the sum of all the material values that are submerged is currently estimated at 274 billion forints.

Table 2.

Some information concerning the most destructive floods is given in the following Table.

River	Station	Date of flood	Maximal annual water discharge m^3/sec.	Harmful flood consequences. billion forint
Tisza	Vasharoshnameny	15 May 1970	3930	798
Tisza	Zahony	17 May 1970	3360	2427
Tisza	Tokay	9 May 1919	3682	8645
		21 May 1970	3659	8610
Tur	Garbolz	14 May 1970	316	601
Samosh	Chenger	14 May 1970	4700	1500
Krasna	Agerdemayor	13 June 1970	295	385
Hernad	Hidashnemety	8 June 1948	552	68
Shayo	Felshejelca	29 March 1940	500	568
Berettyo	Beretyoufalu	15 March 1940	291	1309
Shebesh Keresh	Kereshszakac	12 June 1970	670	1334
Fecete Keresh	Sharkad	13 June 1970	527	292
Feher Keresh	Djula	14 June 1970	364	640
Kettesh Keresh	Becesh	14 June 1970	1091	4586
Hanmosh Keresh	Dyoma	14 June 1970	1547	2845

THE AREA EXPOSED TO INUNDATIONS OF FLOODS AND OVERLAND FLOW IN HUNGARY, WITH THE MAJOR DEFENCE LINES SHOWN

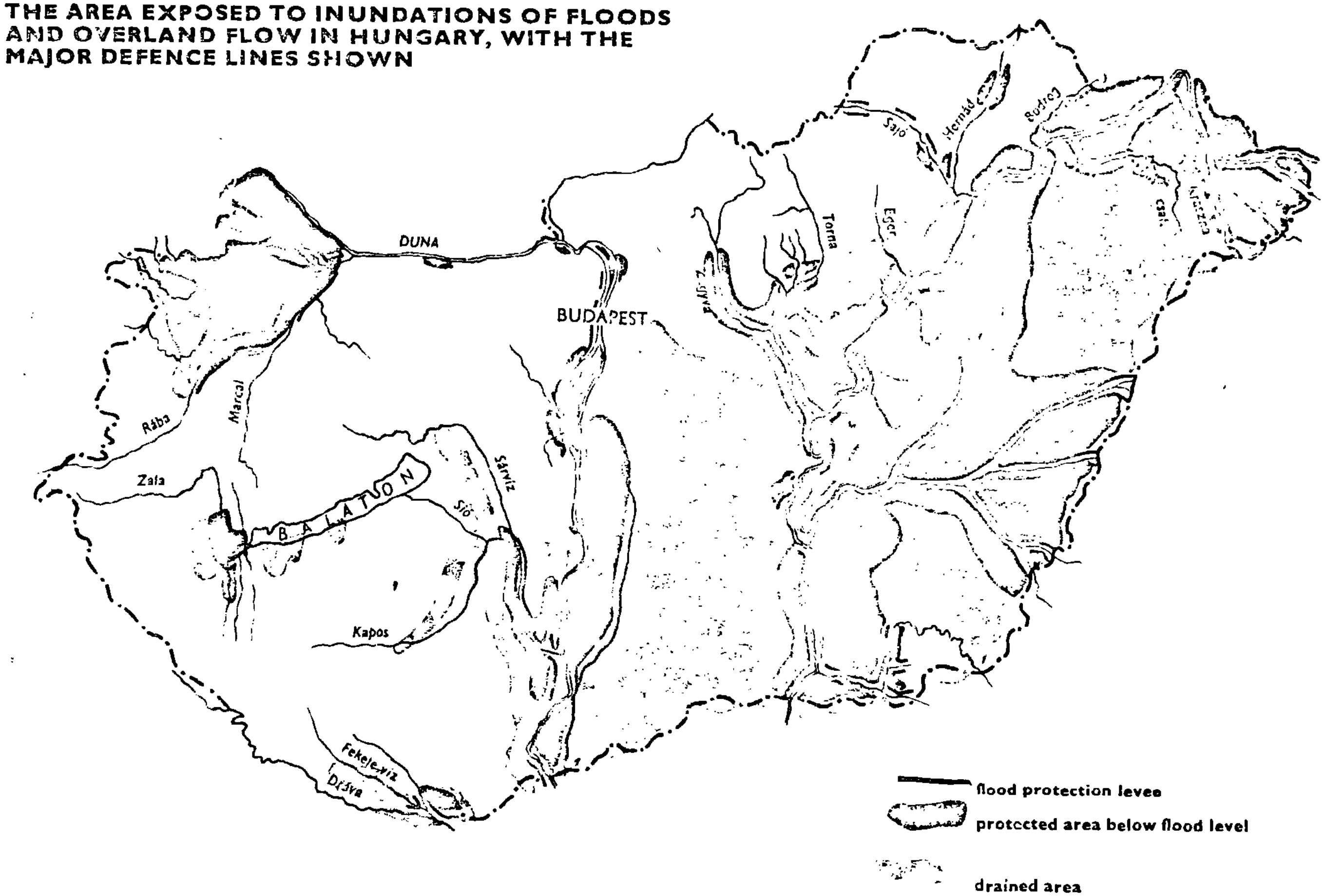


FIGURE 7

It is extremely difficult to plan the economic development of USSR, Socialist Republic of Romania, Czecho-Slovak Soviet Socialist Republic, Hungarian People's Republic and Socialist Federal Republic of Yugoslavia as their territories are constantly under the threat of being flooded. This means that the flood protection in the Tisza River basin has the decisive importance of further economic development in those countries. The necessity of fighting floods, apart from the economic significance is determined by the factors of non-economic character, for example, to provide the safety of the population as well as the cultural values.

The Water Resources Engineering Constructions

For better safety within the Tisza River basin, it is necessary to foresee the following works to be carried out:

- to intensify and to strengthen the existing artificial banks;
- to build up the new banks;
- to carry out the straightening of the river-sheds as well as the river bank works;
- to control the flow of the river by means of constructing the complex and anti-flood reservoirs;
- to develop more intensively the municipal water use and drainage of the population area;
- to extend more intensely the water used by agriculture and irrigation systems;
- to develop the quantity protection of natural waters and to establish the new technology of rectifying the sewage;
- to build up the complex regional systems for water supply of different branches of economy.

As to the USSR territory along the Tisza River and its tributaries, there are about 200 km of man-made banks and 85 bank straightening units. 200 km of protecting banks, 30 km of straightening river cuts, and 32 km of riverbanks are supposed to be built up and straightened. There is a Tereblin reservoir now on the basis of which the Tereblja-Rick hydroelectric power station works.

There were some projects where the possibilities of creating in perspective, 8 reservoirs were considered. The Tisza-Vysheul reservoir with its anti-flood capacity of 450 mln. m^3 could be the main regulator of the flood flow, however, half of this reservoir capacity will be spread over Romanian territory since all the countries located along the river basin are interested in the flood cut. Hence, mutual efforts and investments are needed.

In case the Tisza-Vysheul, Tereblin, or some other reservoirs with total anti-flood capacity of about 600 mln. m^3 will be built on Romanian territory, the opportunity of decreasing the maximal flood level of 1% at the Hungarian border (i.e. approximately just in the place of Samosh and Tisza confluence) to 1,3 - 1,5 m will be given.

However, one should keep in mind that the Samosh floods could cause the floods on the Romanian and Hungarian territories in most cases. But it is quite possible to construct the hydroelectric power stations on the banks of the reservoirs.

The following parts of the Romanian territory have already been banked: the lower parts of the rivers Tur, Somesh, Krasna, Yer, Beretau (Beretje), Krishul Repede (Shebesh Keresh), Krishul Negru (Fekete Keresh), Krishul Alb (Fecher Keresh), Mouresh and Bega. Ten reservoirs with total capacity of about 140 mln, m^3 and useful capacity of 50 mln. m have already been built as well, but they do not essentially influence the natural flow regime. 95 thousand hectares of soil are supposed to be protected by the banks as well as some reservoirs, with a total useful capacity of over 450 mln. m^3 by the beginning of 1975 and about 366 mln. m^3 after 1975 will be constructed.

It is also planned to throw over the flows from one basin to the other, for example, the Temesh River (Donau to the Bega (Tisza) River along the Koshta Kizetsy channel (up to 258 mln. m^3 during the dry season) and within the same basin, that is from Rulka (Eza) River to Firizu (Somesh) River (30 mln. m^3) and from Eary (Mouresh) River to Someshul (Somesh) River (50 mln. m^3) (see Figure 8).

Four reservoirs with total anti-flood capacity of 144 mln. m^3 have been built on the Czecho-Slovak territory. By the beginning of 1975, 3 more reservoirs with total capacity of 90 mln. m^3 are to be built for the purpose of water supply and energy. The existing interbasin throwing over the flow from Gnilitsa River (Hernad) to Slanu River (28 mln. m^3 capacity) will be supplemented with the throwing over flows from Eada River to Hernad (19 mln. m^3/year) for the purpose of water supply.

There is a levee system of almost 450 km long in Yugoslavia, the main water economic object of which is Donau-Tisza-Donau system which solves problems such as irrigation (360 thousand hectares), drainage (760 thousand hect.),

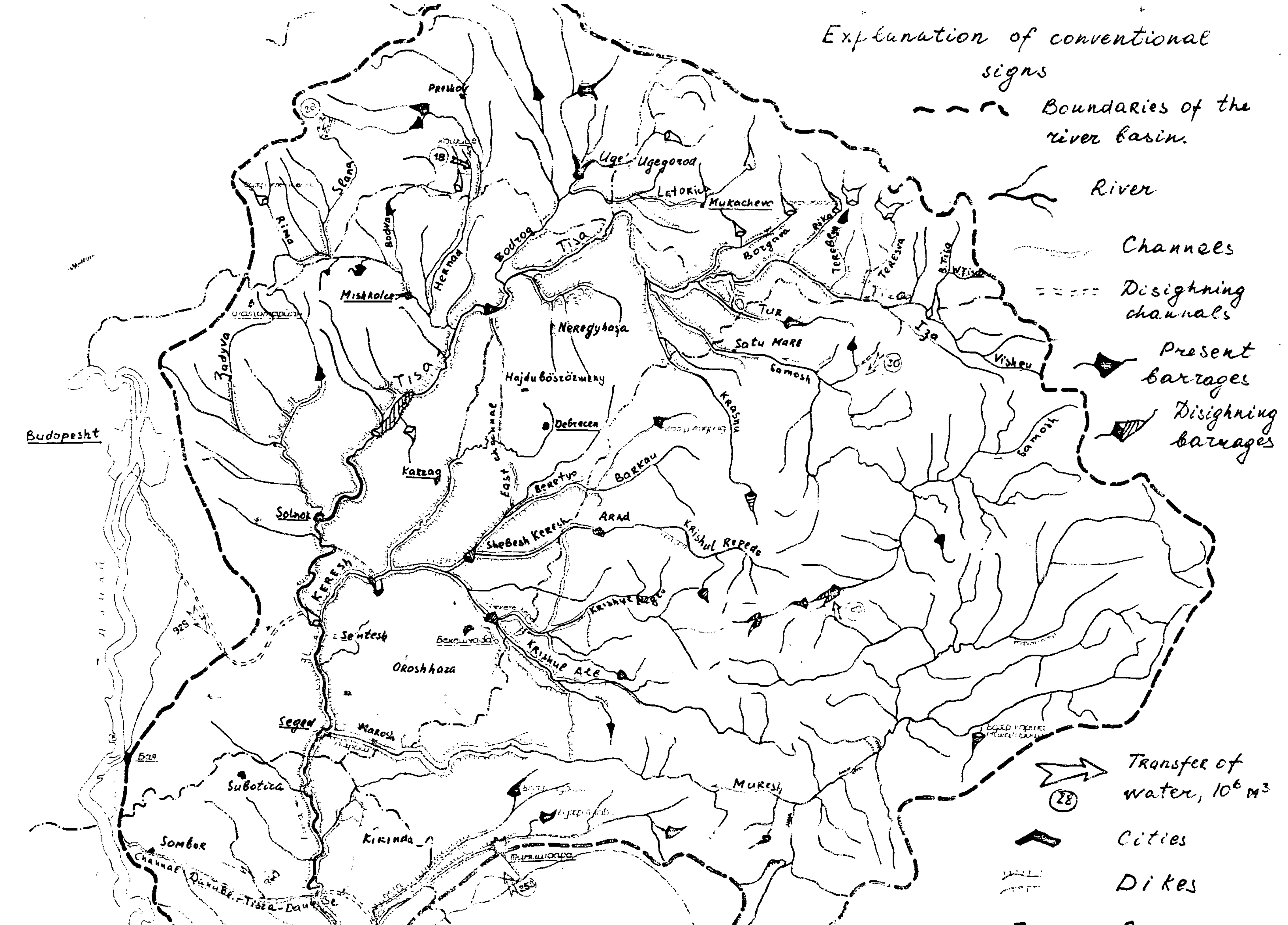

Explanation of conventional signs
Boundaries of the river basin.
River
Channels
Disighning channals
Present barrages
Disighning barrages
Transfer of water, 10^6 m³
Cities
Dikes
Budapesht
Preshov
Slana
Rima
Bodva
Hernad
Bodrog
Tisa
Uge
Ugegorod
Latorica
Mukachevo
Borgava
Rika
Tereblea
Teresva
B.Tisa
Vishev
Tur
Satu Mare
Samosh
Krasna
Misхkolce
Nereдyhaza
Hajdu Böszörmeny
Debrecen
Radyva
Karzag
East channal
Beretyo
Barkau
Arad
Krishul Repede
Solnok
Shebesh Keresh
Keresh
Krishul Negru
Sentesh
Oroshhaza
Krishul Ale
Seged
Marosh
Muresh
Subotica
Kikinda
Sombor
Channal Danube-Tisza-Danube

FIGURE 8

water supply, fishery and navigation. The most important problem is the navigational problem. The total length of the main channel net is 840 km, 663 km of which is navigatable. This channel net was supposed to be finished in 1972. But even if this channel was finished, the problem of navigation along the Donau River on the Yugoslav territory would still not be solved. The Gerdup bank which is constructed on the 943rd km of the Donau River as well as the hydro-unit of Novy Bechey on the Tisza River, serve the same purpose to a considerable extent. The system of constructions that have been built there, may assist in solving the water supply problem in the lower part of the Tisza River, with the help of the Donau water in cases of extreme lack of water.

The Hungarian part of the Tisza River basin is 446 thousand km^2, or 30% of the total area. However, 86% of the land within the Hungarian territory is under the agricultural plants, that is 1/3 of the country's agricultural soil, and more than half of the highways and railways are also located there. The system of banks are more than 2900 km long, the purpose of which is to protect about 2 million hectares of land against the floods, (see reference [3]) is the background of the anti-flood protection on the Hungarian territory (Figure 7). Further developments and strengthening of the banks are planned. The main lines of protection should be calculated to stand the 1%th flood; the most important areas are to be protected against the floods which happen once every 120-150 years, less important territories are to be protected against the floods which happen once every 60-80 years.

The cost of this work is estimated at 12 billion forints; the total earthwork volume will be 100 million cubic meters along the Tisza River and about 150 mln. m^3 within the Keresh River basin.

There are some complex hydro-technical constructions within the Tisza River basin: (see reference [4]) some of them are already in use, some are in the process of construction, while others are still being designed.

The largest hydroassembly called Tisalek, is situated between the place where the Borzhava River discharges, up to the place of its outlet (built in 1954-1959) and consists of a hydroelectric power station, a dam with fish-holes, and a ship's sluice. The hydroelectric power station capacity is 300 m^3/sec, the maximal total generators capacity is 14 MTV, and the output of the electric energy is equal to 55,10^6 kilowatt-hour/year on an average. The dam provides the headwater from 87,00 m up to 94,50 m (A.M.), i.e. from 0 to 7,5 m in normal conditions and up to 95,2 m (8.2 m) in emergency cases. The headwater under NPL spreads against the stream for 80 km; where the useful reservoir capacity is 10 million m^3 and full capacity is 93,32 million m^3. The main purpose of the hydroassembly is to provide the navigation and water supply.

The inner useful length of navigatable sluice is 85 m, and the width is 18 m. Such a sluice is capable of locking either one 1200 ton barge, or two 700 ton barges each. The time taken for the full locking process is 30 minutes.

Above this hydroassembly, the Eastern main channel which serves to supply the Tisalek irrigation system with water (150 thousand hect. of irrigated land, 7 thousand hect. of fish ponds, and navigation) is detached from the Tisza.

In 1973 the Keshkere hydroassembly which consists of a hydroelectric power station, a dam, a ship's sluice with the fish holes and two channels, was set forth. The hydroelectric power station's capacity is 560 m^3/sec, maximal total generators' capacity is 28 MTV, and the output of electric energy is equal to 10^6 kilowatt-hour/year on an average. At present, the dam provides the headwater with up to 86,5-87,5 m (A.M.), and the useful capacity of the reservoir is 22 million m^3. In future, the headwater will be increased to 91,2 m (A.M.), i.e. from 0 to 91,2 m (A.M.), i.e. from 0 to 11,2 m, the full capacity will be 630 million m^3, and the useful capacity will be 452 million m^3.

The main purpose of hydroassembly is to provide the water supply and navigation to the Tisalek hydroassembly. The useful navigatable square of the chambers' ground sluice is 85 x 12 m, the useful depth is now 2,5 m,(in future it will be 3,5 m). At present the tonnage of the known ships and barges is 1350 tons, in future it will be 1800-2000 tons.

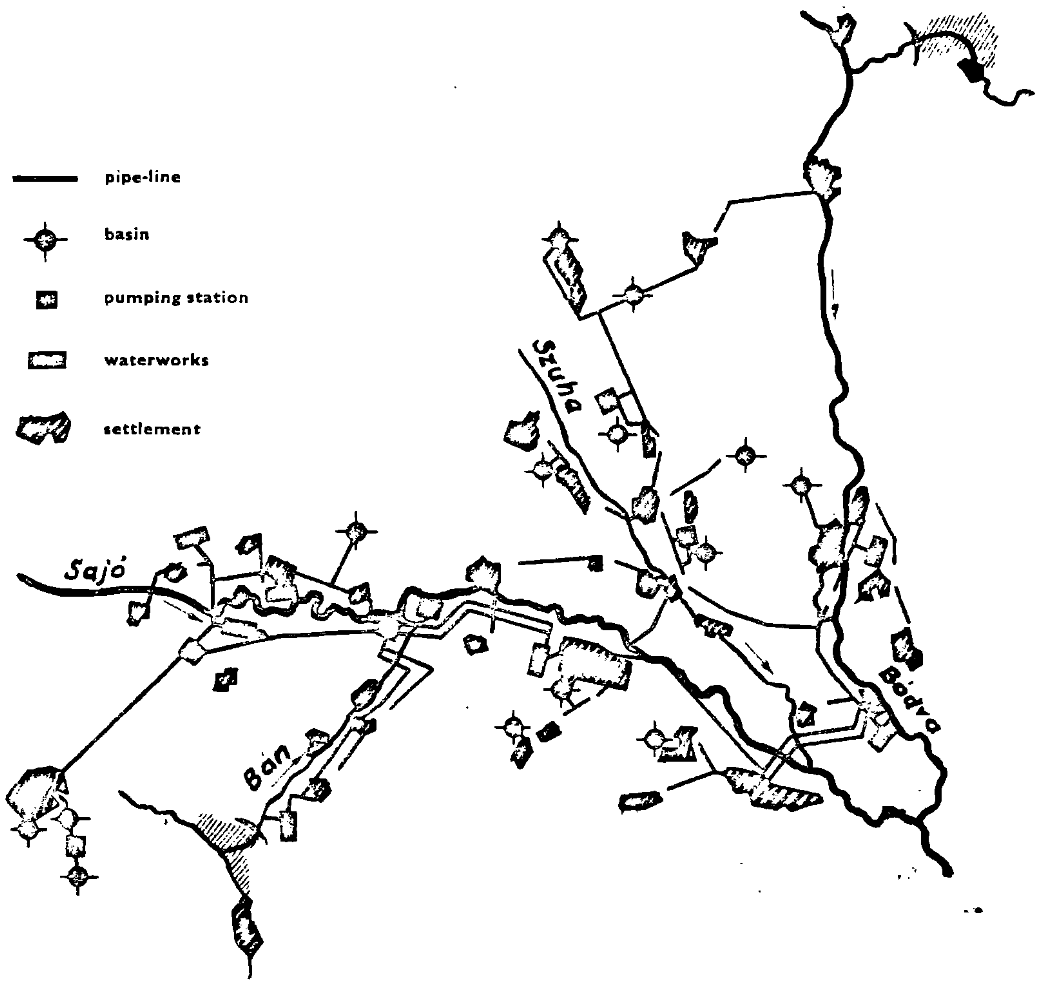
On the left bank of the reservoir, 4 km from the hydroassembly, there is a detached channel the known capacity of which is 80 m^3/sec serves the purpose of irrigating 130 thousand hectares of land, and refilling the water in the Keresh tributary system. On the right bank, one kilometer away, there is a detached channel, the known capacity of which is 48 m^3/sec, which provides irrigation for 70 thousand hectares of land by the gravitation way. The Chongrad hydroassembly which is now being designed, will be located above the Keresh River discharge and will provide navigation from the place of the Tisza River outfall to the USSR border. After the channel system of the Danube-Tisza Rivers will be completed, there will be a united inner-waterway system of the Hungarian People's Republic (Figure 8).

An extremely interesting direction in the Hungarian water economy construction is building a system of regional water economy objects. At present, there is a Borshod regional system within the Tisza River basin which supplies water to 95 thousand inhabitants in 35 settlements (Figure 9), supplying, 35-45 thousand m^3 of drinking water and 45 thousand m^3 of industrial water every 24 hours. It is planned that by 1975 this system will supply 200 thousand inhabitants with 50 thousand m^3 of drinking water and 100 thousand m^3 of industrial water every 24 hours.

It is interesting to note that the construction of the Kishkere hydroassembly system is supposed to be used for creating a new regional system, the scales of which will exceed all previous ones.

1. Water resources of the Tisza River basin are sufficient to meet the needs of the national economy of five countries: Czechoslovakia, USSR, Romania, Hungary and Yugoslavia whose regions form this basin. For many years the average runoff of the Tisza River, near the Seged mountain is about 25 km^3 per year.

Figure 9
LAYOUT OF THE BORSOD REGIONAL WATERWORKS



2. Water resource distribution concerning the Tisza basin territory and the 'time' factor, are extremely uneven. Therefore, it was necessary to use a number of hydraulic structures. These structures considerably affected the hydrological regime of the river and its tributaries in some parts.

3. The most important hydraulic structures in the Tisza basin are artificial banks made for flood protection, and reservoirs which are multi-purpose. The total volume of the existing reservoirs is about 560 mln. m^3.

4. Within the last 20-30 years, all the countries in the Tisza basin have had considerable increases in population and achieved great economic and social developments. As a result, it is estimated that considerable increases of water supplies will be needed, especially during the dry months in some years. To meet this deficiency, huge reservoirs of more than 1 mln. m^3 are being planned and built in this area. On a long-term prospect, more extensive measures are being planned with regard to water economy. It will also be necessary to provide more intensive development for flooded lands and to increase flood-protection reliability.

5. The main problems under these conditions consist in a reasonable utilization investments, the selection of a structure and dimensions of the hydraulic constructions, the determination of the priority of their operation.

6. The water economy problems of the Tisza River basin, as well as other river basins are being studied and solved by traditional methods. Lately, mathematical models and methods are also being used to study and solve some of these problems.

The traditional methods drawbacks are common knowledge but the main one is the lack of possibility to consider a great enough number of alternatives of the development of a complex large-scale water economy system (a large city, a large river basin, economic district).

System analyses can be used for creating models of complex water economy systems and better groundwork for solutions by way of computer processing larger amounts of information.

REFERENCES

1. G. Gangardt, "Water Management Problems of the Tisza River Basin" Hydroproject proceeding. Vol. 29, Moscow 1973 (Russian).

2. "Master Plan of the Complex use of water resources of the Tisza River Basin". NWA of Hungary, Budapest, 1973 (Russian).

3. "Short History of Water Management in Hungary" NWA of Hungary, Budapest, 1970.

4. L. David, "The Central Tisza-Region and the Traus-Tisza area". Hydraulic docummentation and information centre, Budapest, 1972.