Mihály Erdélyi

Hydrogeology of the Hungarian upper Danube section

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Contents

Preface

This book is the summary of my studies on the Hungarian Danube Zone upstream of Budapest published between 1978 and 1990.

I completed it with many new data acquired during the accelerated large-scale hydraulic constructions on the Czecho-Slovakian territory.

This feverish contruction activity proved most of the predicted catastrophic changes of the environment. The rate of the detrimental changes of the environment is still rapidly increasing with the passing of time.

I am fully aware of some degree of disparity of this book.

1. The lack of similar summaries, written in English, on hydraulic engineering, microbiology-toxicology, water chemistry, aquatic life, botany, etc. on the Danube area discussed here. For this reason I was compelled to refer to data and citation of published articles in connection with my subject in order to complete my statements.

2. A substantial part of the information was inaccessible for me up to 1989 being "secret material".

The situation has not improved even with the partial change of the political system in 1989/90. Many so-called "useless" documentations were discarded and destroyed or lost when the state-owned planning bureaus or its parts were dissolved or subdivided and became private property. Most of the preserved useful documentation continued to be inaccessible for they are in private ownership of members of the former elite.

I am indebted to Sándor Maller, PhD and to Tibor Fuisz for revising the English text, to Mrs Ilona Honfi for drawing a part of outstanding illustrations and to László Peregovits for the technical editing. I especially would like to thank Mr Gyula Marót, civ. eng., for his valuable advice, constructive criticism, unremitting interest in my work and for making available his valuable and numerous unpublished expert opinions on hydrology and hydraulic engineering concerning the Danube Zone from 1983 up to now.

Budapest, 29th December, 1992

Mihály Erdélyi PhD
hydrogeologist

1

Introduction

The Danube catchment area is the largest fresh-water aquatic ecosystem in Europe being at the same time the biggest fresh-water reservoir thereof. The central part of it contains the biggest high-quality groundwater reservoir stored in the coarse-grained quaternary Danubian deposits of the Little Plain. This 13–14 km^3 groundwater of drinking water quality (Erdélyi 1983) is being rapidly recharged when the Danube's flow rate is over 1900–2100 m^3/s.

The original concept of the Gabčikovo–Nagymaros barrage system is over 40 years old. The story of the Danube barrages project in the Little Plain began in 1947 when a six-column article appeared in the Süddeutsche Zeitung "*Wasser mit immenser Sprengkraft*" (16th October 1992, p. 3). The start of the monumental project in chapter "*Monumentale Ineffizienz*" was described as follows:

"*Die Geschichte begann mit diesem Traumsommer 1947, der einen Teil der Sowjetmacht aufs Trockene setzte. Der Donaupegel war auf Tiefstand gesackt und hatte auf den rund 120 kilometern, in denen der Fluss Slowakei und Ungarn trennt, die Schiffahrt zum Erliegen gebracht. Mittendrin, in Komárno, die sowjetische Binnenkriegsflotte – die sich nun im gerade aufdämmernden Ost-West-Konflikt als bewegungsunfähig und wertlos erwies. Der Kreml forderte von Ungarn und der Tschechoslowakei, den unbotmässigen Strom unverzüglich für alle Jahreszeiten schiffbar zu machen. Hier liegt der politische Grundstein für das noch vor dem Rhein-Main-Donau-Kanal umstrittenste, ökologisch gefährlichste und politisch explosivste Wasserbauprojekt des Kontinents, für das Donau-Doppel-Kraftwerk Gabčikovo-Nagymaros.*"

The changes of the environment in the last four decades require a new order of priorities. In my opinion the first one is the joint interest in groundwater protection of municipal, agricultural and industrial water supply, than come the environment and forestry, navigation and hydroelectric power is in the last place.

The author has already reviewed the changes of the past decades (Erdélyi 1983). The heavy industries of the cold-war period proved to be disasterous economically. Contrary to this one-sided economical structure the predominance of the agriculture became gradually obvious in the case of Hungary, as the main foreign currency-earner of the country. The loss of about 500,000 hectares of agricultural land after the Second World War by the early 1980s was irremediable. All the postwar plants of the heavy industries were unfortunately constructed on the most productive arable lands of excellent soil-mechanical properties, and in most cases underlain by coarse-grained deposits filled with high quality and copious groundwater, susceptible to pollution by toxic industrial wastes.

The Little Plain has many economic advantages: it is situated close to the hard-currency markets, its infrastructure is among the best in Hungary, its predominantly rich soils, copious and high quality river and groundwater combined with top quality agrarian products. The Little Plain traditionally supplied the Vienna area with foodstuffs for centuries but especially so from the mid-fifties of the 19th century till the end of the Second World War.

The water quality of the Danube and its tributaries has been deteriorated by industrial development of the area in and around the Little Plain. There is no hope to improve the quality of the surface water in the next decades. The pollution of the groundwater will also continue. The improvement of water quality cannot be expected because of the present slump and lacking funds for protecting the environment.

The strive for improving life standards, the rapid expansion of the piped water systems, the improper use of chemicals in agriculture continuously deteriorate the quality of the groundwater.

This situation is worsened by some geographical factors: population, industry and agriculture are concentrated on about half of the Little Plain, i.e. on the elevated part of the flood plain, being generally above the flood levels.

The fertile soils of the upper flood plain level comprise porous loams with gradually increasing grain-size down to the gravel. The structure of soils ensure excellent drainage.

All the groundwater contamination hazards are not listed above. The situation is also aggravated by the fact that over 90% of consumers are supplied with piped water and only about 30% of the waste water is being disposed of or treated.

Even human factors deteriorate the quality of the groundwater. Lack of professionally constructed septic tanks, the removal, treatment and expert disposal of sewage are mostly neglected owing to costs, insufficient supervision and unpopularity of the matter. So domestic sewage and often industrial waste waters are put away into abandoned dug and tube wells acting as "recharge wells". The generally accepted argument is that the groundwater is already polluted everywhere. Although this view is not true, unfortunately it is widespread even among civil servants.

2

The geology of the Little Plain

Since the late Pliocene a thick and coarse-grained sequence has been deposited by the Danube river and its tributaries over the subsiding central part of the Little Plain (Fig. 1). The 21.8 km^3 gravel and sand aquifer formation in the southern half of the lowland contains 5.4 km^3 high quality groundwater carefully calculating with 25% formation porosity (Erdélyi 1983).

The coarse-grained basin fill is a two-storey structure. The upper gravel unit is undoubtedly of Quaternary age and its known maximum thickness is around 400 m (Fig. 2). The underlying sequence is composed of alternating fine- and coarse-grained deposits supposedly of Upper Pliocene age.

The Quaternary unit is characterized by hydrostatic pressure distribution (Erdélyi 1978) as well as the underlying Upper Pliocene unit according up to now incompletely documented views concerning groundwater recharge.

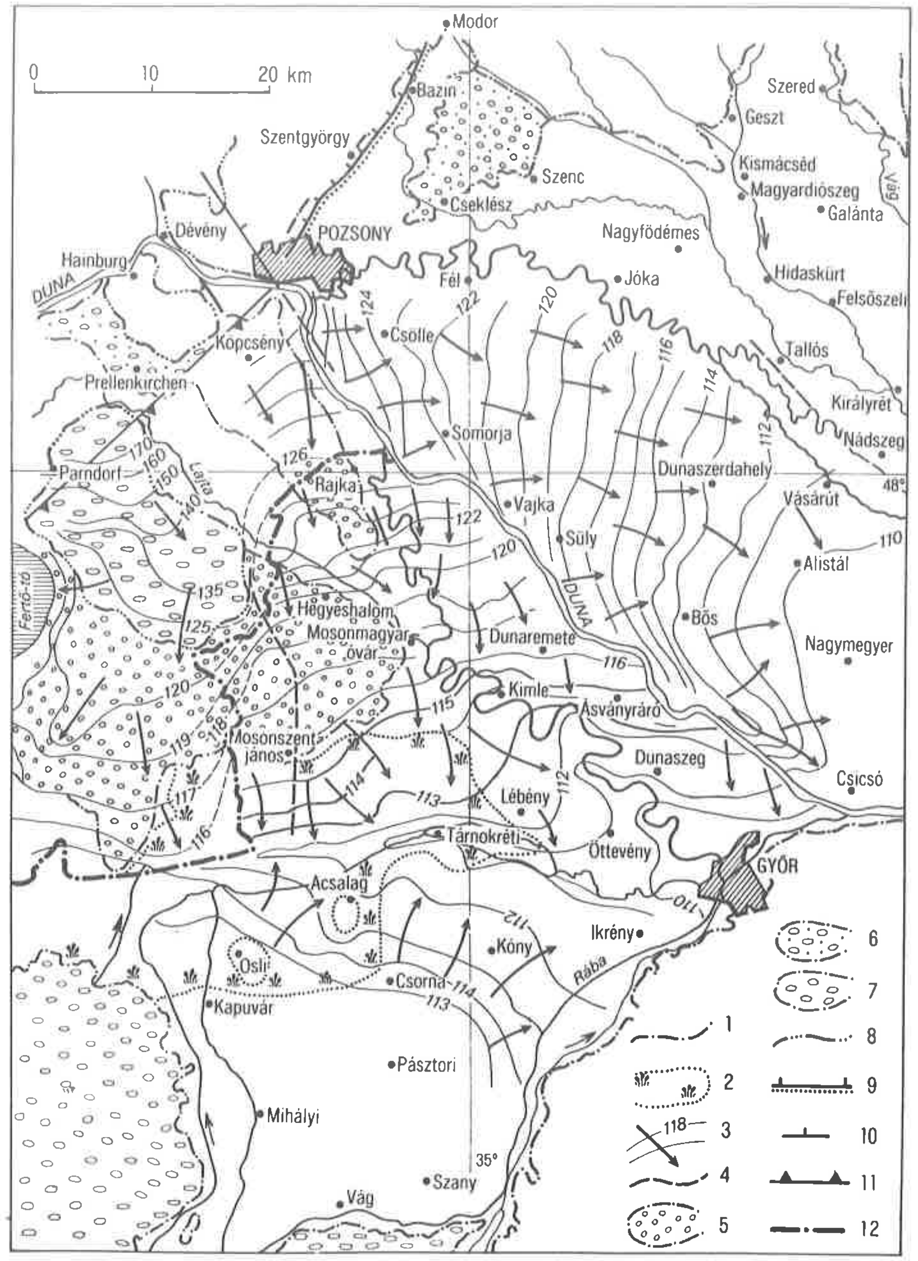


Fig. 1. Hydrogeological map of the Little Plain (Erdélyi 1990). *Explanation*: 1 = boundary of the alluvial plain; 2 = area of the Hanság swamp in 1769; 3 = groundwater contour a.s.l. and direction of flow; 4 = outer boundary of the Danube river recharge of the groundwater (at high river stage); 5 = area of groundwater susceptible for surface contamination (thin gravely soils); 6 = higher alluvial terrace; 7 = high level of old gravel sheet; 8 = border of pre-Quaternary rocks; 9 = upthrust (Cepek 1938); 10 = fault-zone (Cepek 1938); 11 = fault-zone (Geological Map of Austria, 1961); 12 = western frontier of Hungary

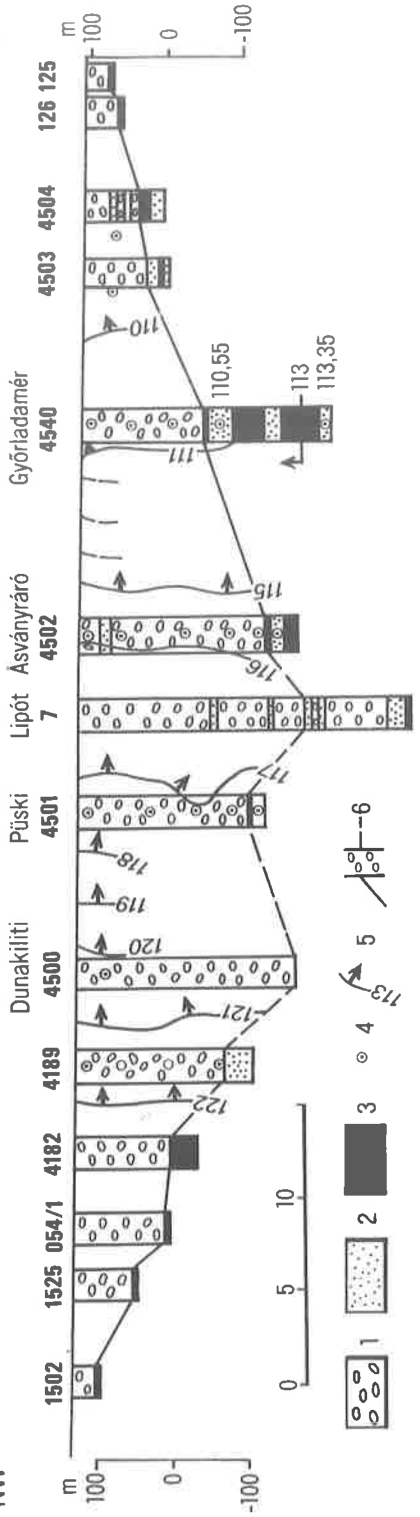


Fig. 2. Hydrodynamic cross-section along the Danube (redrawn after Erdélyi 1983). *Explanation*: 1 = gravel; 2 = sand; 3 = impermeable, poorly permeable; 4 = depth of piezometric measurement; 5 = equipotential contour a.s.l. and direction of groundwater flow; 6 = Quaternary–Pliocene interface

3

The connection between flow rates and groundwater recharge

The braided Danube flows on the crest of its alluvial fan (Fig. 3). The hanging channel position has increased the flood hazards. In the past frequent floods inundated large areas in the middle of lowland. The number of catastrophic floods has been diminished in the past 150 years by constructing flood protection levees and improving bed regulations. In the past decades infrequent floods by the passing of time increasingly caused more damage to the "protected" land (Janácek 1971).

The water regime of the Danube began to undergo fundamental changes since 1957 when the construction of the first Austrian barrage was started and later followed by others.

Prior to the completion of the Austrian barrages 600–650,000 m^3/yr bedload crossed the river at the Bratislava river gauge (Study... 1985). The erosion deepened the river bed there by 0.8–0.9 m up to 1984. The cessation of river bed sinking diminishes flood hazards, but adversely affects the groundwater recharge.

3.1. The recharge of the groundwater

Groundwater stored in the coarse-grained basin deposits is recharged directly by the Danube water (Fig. 1).

The permeability of the basin sediments is very high and reaches an average of approximately from 3.8 m^3/s to 10.3 m^3/s (Lehocky 1990, in Sibl, Ch. 6.5).

The amount of recharge is dependent on the flow rate of the river and the hydrogeological properties of the rock material of the river bed and its bank as well as the elevation difference between the groundwater table and the river water level.

The chemical properties of pollutants in the river water as well as those of toxic wastes stored at or near the riverside should be known because of possible clogging of the rock material. The colmatation of the pore space may considerably diminish the recharge rate or may even stop it (Szabó 1990).

Groundwater recharge by precipitation is negligible compared to the immense mass of the Danube water (Honti 1954).

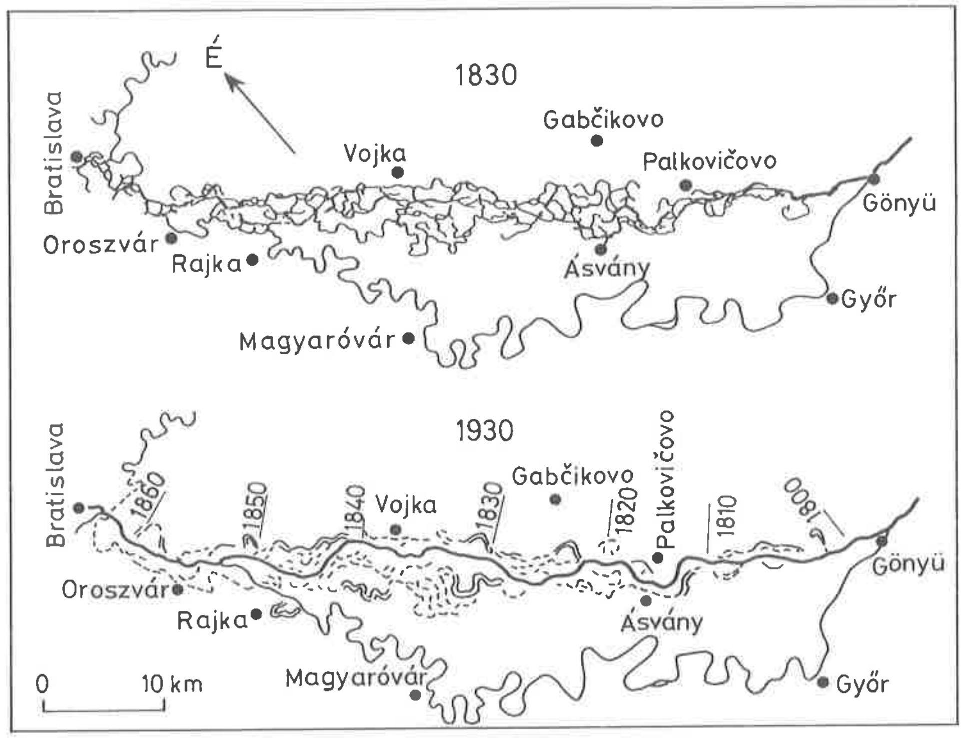


Fig. 3. The Danube prior to and after the early river regulation (after Károlyi 1975, in *Regional Geography of Hungary*, Budapest, No 3, p. 88)

3.2. Area, quantity and flow directions of the groundwater recharge

The infiltration of the Danube water into the sand and gravel sediments consists of some vertical infiltration through the bottom of the river bed, but mostly of horizontal infiltration through the river bank being most intense in the Bratislava region (Fig. 1).

Recharge along the left bank between Bratislava and Komárno: at a low river stage is 20 m^3/s, at high river stage 70 m^3/s, and at an extremely high stage 200 m^3/s (Lehoczky 1979).

The existing Danube river bed is placed on the gravel sand sediments and the river water infiltrates easily into the underground.

Groundwater potential and flow direction is shown by gradually widening distances along the slope of the alluvial fan (Fig. 1).

A considerable part of the groundwater recharge enters from Austria and Czecho-Slovakia. Downstream the diminishing groundwater recharge is shown by the amount of the horizontally moving water, which is the highest 130–300 l/s/km in SW between the Danube and Lajta rivers, and the lowest 3.4–3.5 l/s/km in the SE corner of the Szigetköz Island (near Vének). Honti (p. 131) shows the diminishing influence of the river moving away from the river bed over a hydrological year (Fig. 4, after Honti in Göcsei 1979).

Hydrodynamic cross-sections show the direction of the groundwater movement in the basin deposits. Figure 2 depicts the hydrodynamic character of the groundwater flow parallel to the river (called underflow). Figures 5 and 6 show the groundwater flow perpendicular to the river.

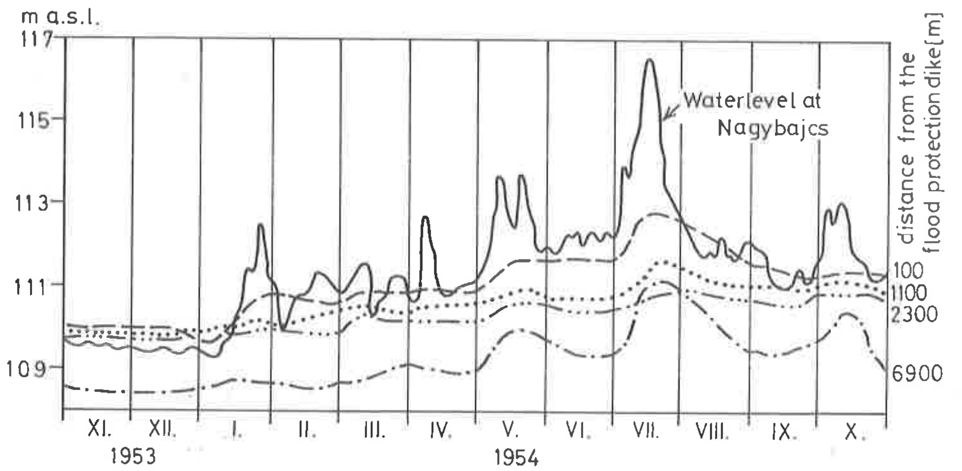
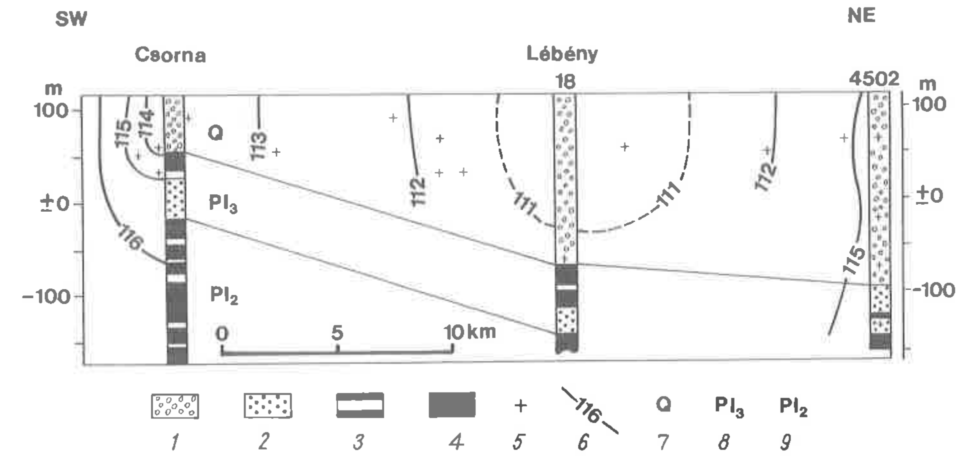


Fig. 4. Change of groundwater level in monitor wells in dependence of the distance from the flood protection dike (m) (after Honti 1954, in Göcsei p. 47)

Fig. 5. Hydrodynamic cross-section between Csorna and the Danube (Erdélyi 1983). *Explanation*: 1 = gravel; 2 = sand; 3 = poorly permeable; 4 = impermeable; 5 = depth of piezometric measurement; 6 = equipotential contour a.s.l.; 7 = Quaternary; 8 = Upper Pliocene; 9 = Upper Pannonian (Pliocene)



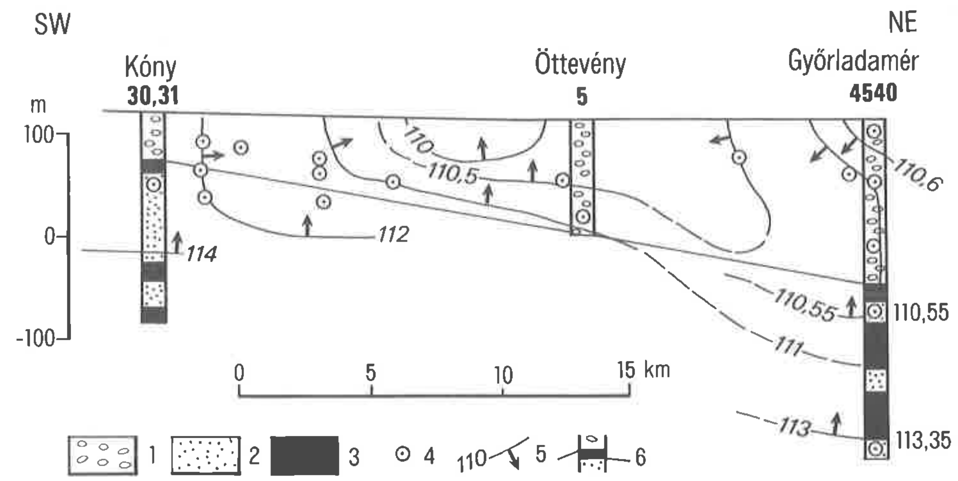


Fig. 6. Hydrodynamic cross-section between Kóny and the Danube (Erdélyi 1983). *Explanation*: 1 = gravel; 2 = sand; 3 = impermeable, poorly permeable; 4 = depth of piezometric measurement; 5 = equipotential contour a.s.l. and the direction of groundwater flow; 6 = Quaternary–Pliocene interface

Figure 7 shows decreasing groundwater recharge both downstream and along the slope of the alluvial fan based on differences in the specific yields of the wells. (Specific yield is the quantity of water pumped by one metre drawdown

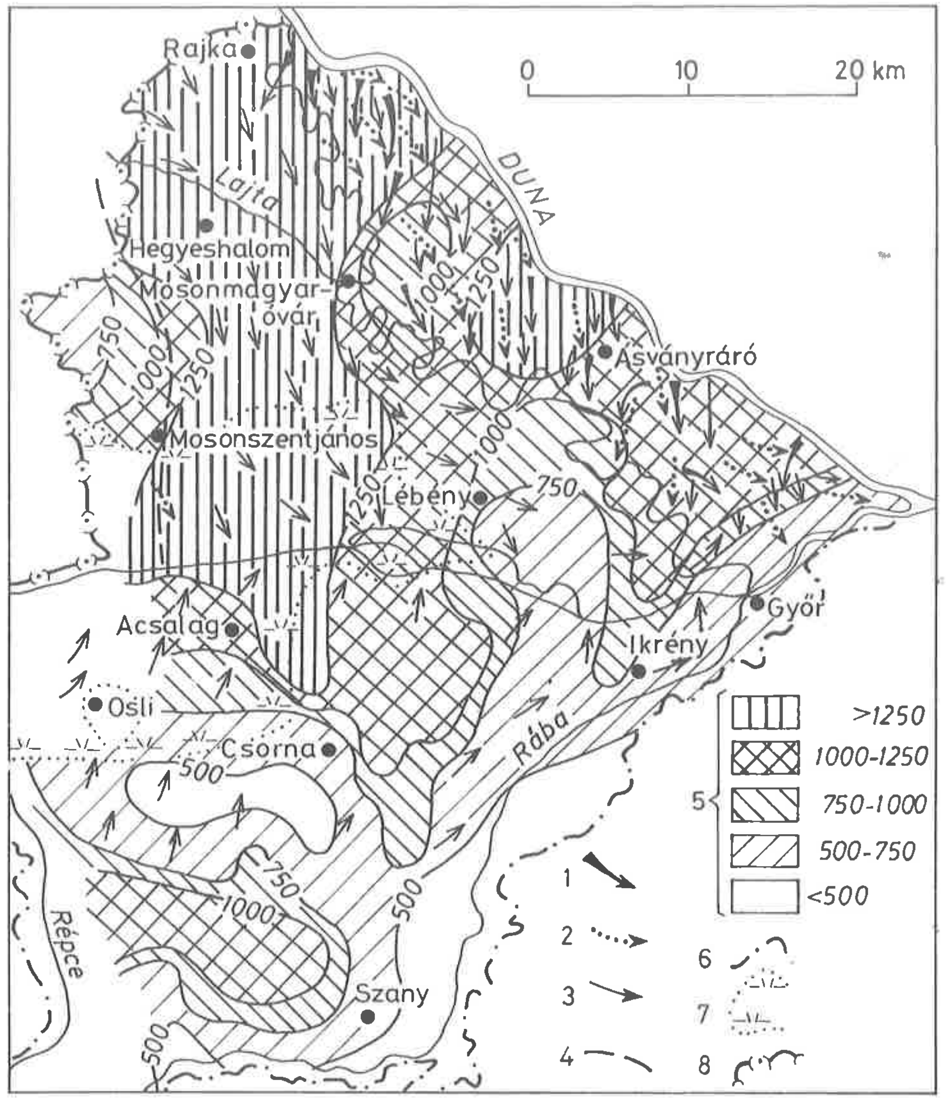


Fig. 7. Specific yields of tube wells (diameter of filter tube 159 and 165 mm, depth 10-30 m, drilled between 1960 and 1972). *Explanation*: Direction of groundwater flow: 1 = at very high river stage (26.06.1965); 2 = at very low river stage (29.03.1972); 3 = at average river stage; 4 = western border of the average groundwater recharge from the Danube; 5 = specific yields of the tube wells (l/minute of the well discharge at one m drawdown); 6 = border of the Győr basin; 7 = border of the Hanság swamp in 1769; 8 = western frontier of Hungary

(l/min/m), in this case the calculation was based on the specific yields of hundreds of tube wells of 10–30 m depth and 159 and 165 mm diameter of filter tubes drilled between 1960 and 1972.) The area of the Danube discharge depends mainly on the river stage. The groundwater area influenced by the highest and lowest river stage is only 1.1% of the total area (Fig. 7).

There is difference concerning the areas recharged by the Danube between the official 755 km^2 (Study... 1985) and the about 910 km^2 unanimously accepted by competent experts (Rónai, Major, Erdélyi etc.) out of which 375 km^2 is the

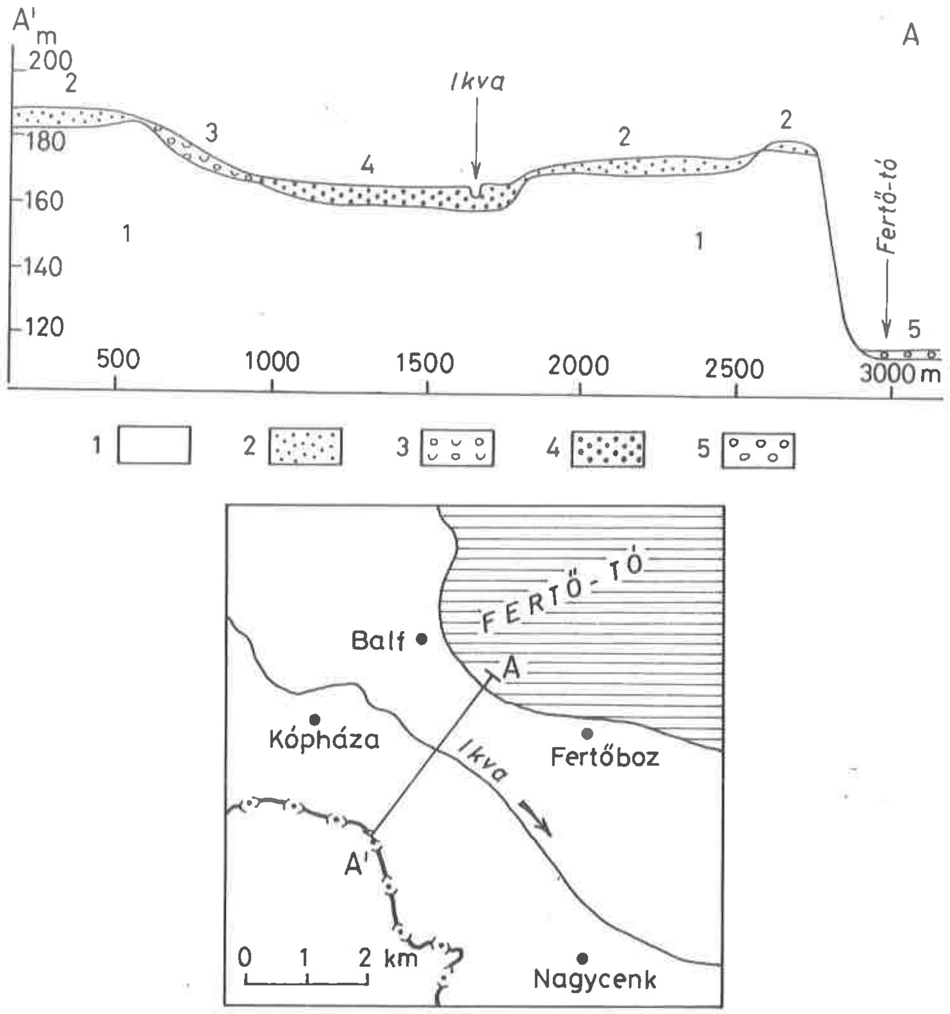


Fig. 8. Cross-section between the Ikva valley and the Lake Fertő (Erdélyi 1978). *Explanation*: 1 = sand, clay and marl (Upper Pannonian); 2 = gravel (Lower and Middle Pleistocene); 3 = rock debris on slope; 4 = gravel (Upper Pleistocene); 5 = coarse-grained sand (Upper Pleistocene)

Szigetköz area (Göcsei 1979). The difference between the two areas is 155 km^2 (17% of the 910 km^2 area).

Measurements regarding the natural isotope content of the groundwater show southward decreasing values along a line perpendicular to the Danube compared with that of the Danube water. According to these measurements the Danubian recharge locally crosses the Hanság-Rábca depression, which is the approximate boundary of the Danube recharge (Deák 1978).

3.3. The original hydrography of the alluvial fans

The southern part of the Little Plain has been filled up by deposits of the Danube and its tributaries flowing from the south. The natural drainage area of the

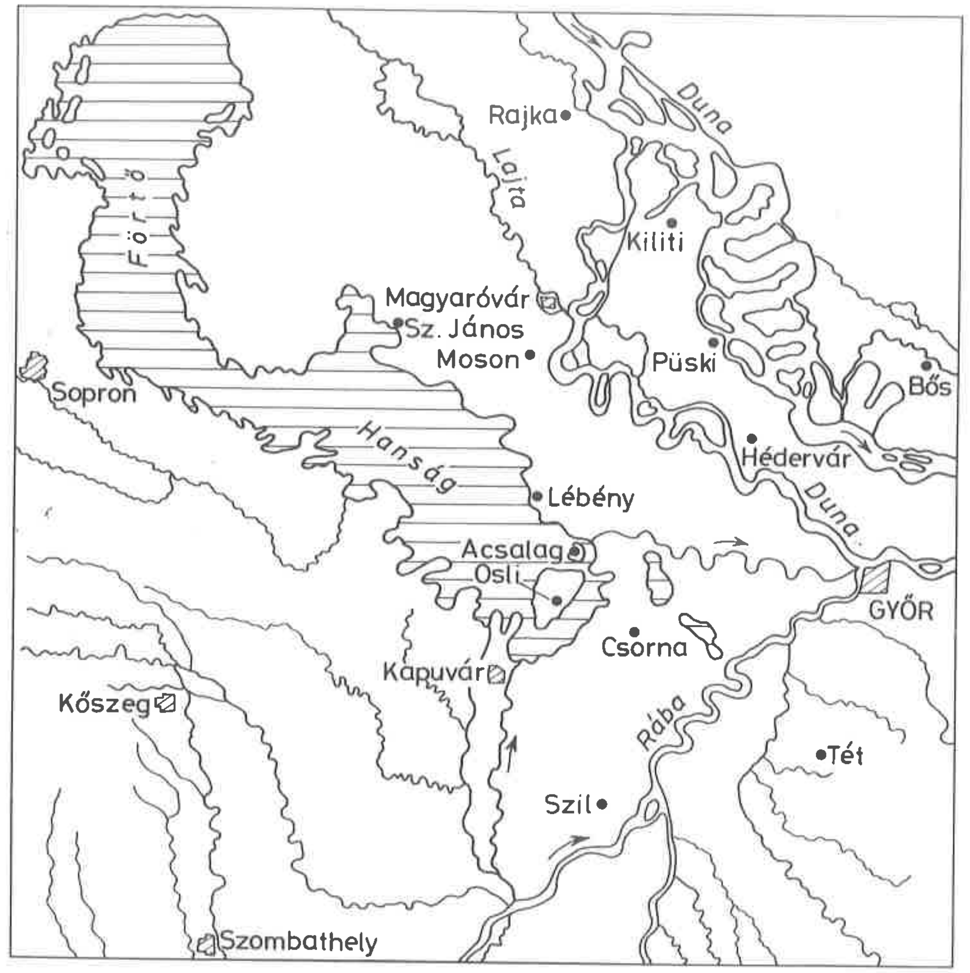
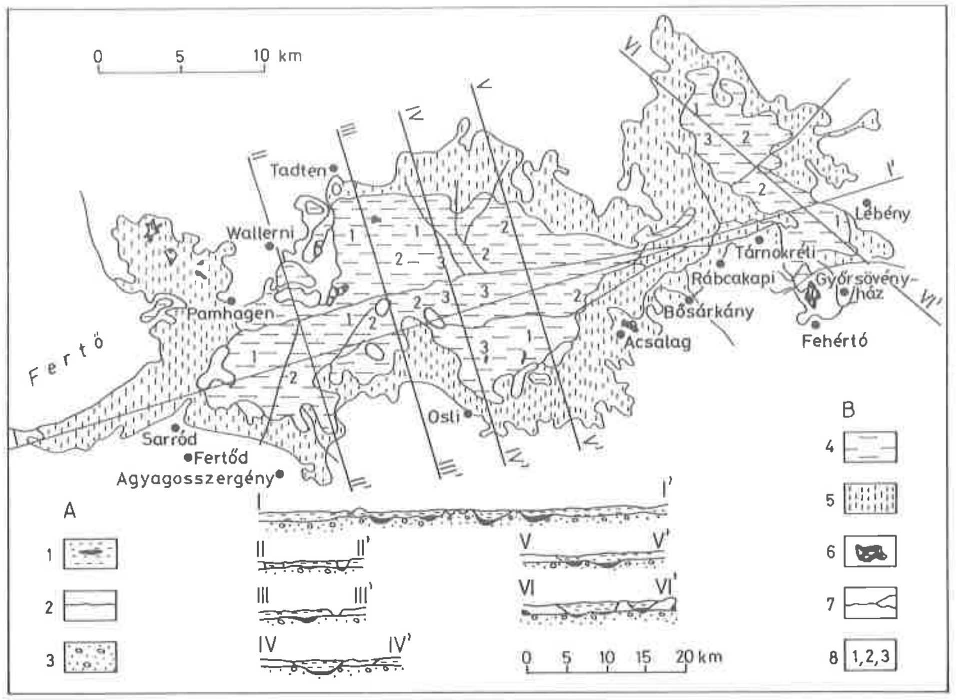


Fig. 9. Map of the Hanság swamp (after Ignaz Müller 1769)

Fig. 10. Map of the Hanság swamp (after László 1975, in *Regional Geography of Hungary*, Budapest, No 3, p. 79). *Explanation*: 1 = peat; 2 = peaty soil; 3 = pebbly sand; 4 = peaty soil; 5 = marshy soil; 6 = excess water; 7 = canal, ditch; 8 = thickness of peat (m)



southward sloping alluvial fan of the Danube and those of the tributary rivers flowing to the north is a geologically young depression of the Hanság swamp and the Lake Fertő (Fig. 8). The undisturbed hydrography of the southern half of the Little Plain is shown by the map of Ignaz Müller drawn in 1769 (Fig. 9).

The river regulations of the 19th century reduced the area of Hanság to that of the early 20th century (Fig. 10).

Prior to the middle 20th century the Hanság basin had three groundwater levels. The first was the independent groundwater of the peat, recharged by precipitation and surface water and was separated by an impermeable lime silt from the second groundwater layer in the gravel, which was under pressure (Fig. 11). The third is the deep artesian groundwater of Pliocene aquifers characterized by positive hydrodynamic gradients.

3.4. The destruction of a unique wetland habitat

Repeated efforts of reclaiming the swamp reached their climax in a large-scale canalization carried out in 1950–1960. This project resulted in a natural disaster, by today a total burning out of valuable peat resources, e.g. the fibrous peat much in demand by the pharmaceutical industry, has taken place and desiccation combined with wind erosion affected the valuable light topsoil.

The lime silt layer cut through by drainage ditches resulted in the mixing of the upper two groundwater layers followed by disastrous consequences. The restoration of the wetland area became practically impossible because of the loss of the upper groundwater as well as the contamination of high quality groundwater stored in the gravel.

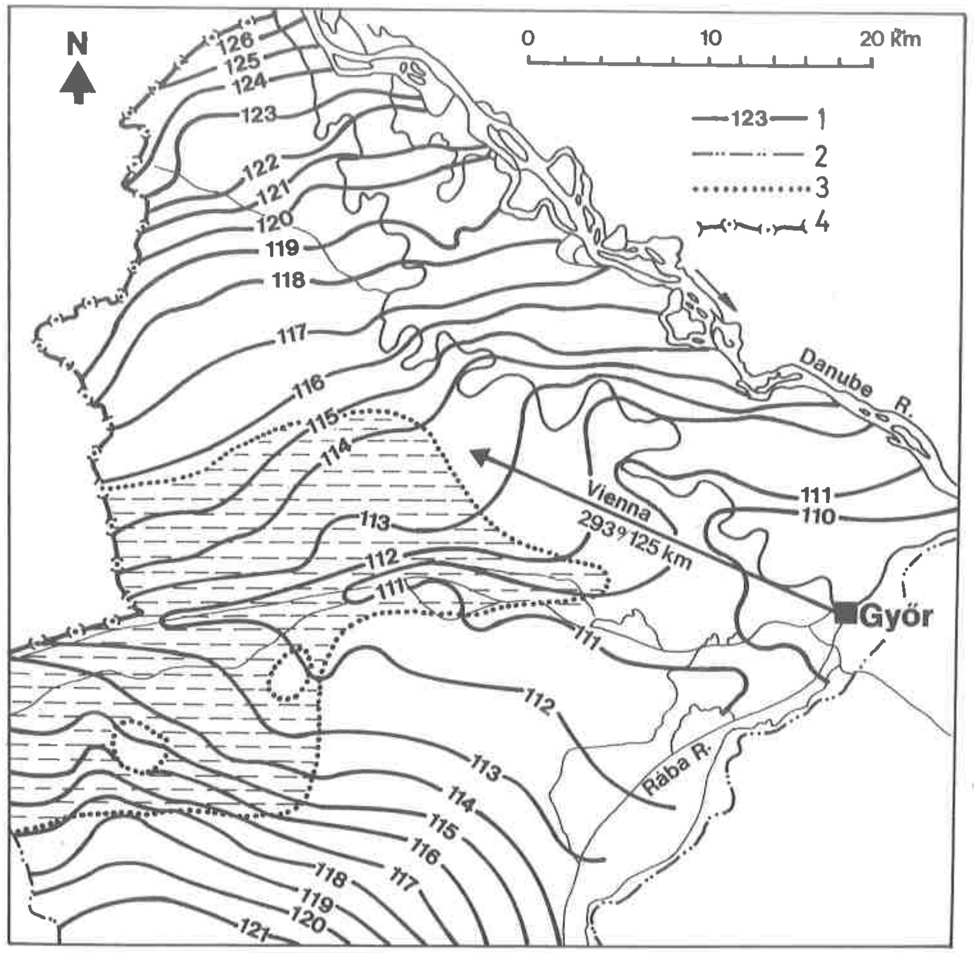


Fig. 11. Groundwater level (after Major, in Erdélyi 1978, p. 112). *Explanation*: 1 = groundwater contour a.s.l. (m); 2 = boundary of the deep central depression; 3 = area of the Hanság swamp (after Ignaz Müller 1769)

This grandiose project has been executed against unanimous protests of scientists, agriculturists, foresters and environmentalists. Irrecoverable large wetland, a well-known sanctuary of wild-fowl, had forever disappeared.

Political interest prevailed. Thousands of students worked there in the summer months, "reclaiming worthless swamps" for agricultural purposes.

4

The hydrodynamics and water quality

4.1. The chemistry of the Danube water

The groundwater of the Little Plain is an undivided hydrogeological unit. The change of groundwater level follows the river stage with a delay.

The river has influence on the groundwater of the narrow strip close to the river bank. Moving away from the river, its effects are gradually lessened. Similarly under undisturbed conditions the changes of the groundwater quality along the seepage route depend on the flow rate (Lehoczky 1979).

At low river stage, predominantly in winter, the total salinity is the highest, and lower in summer when the snow thaws in the high Alps. In spring (from February to April) at low river stages, at 10–30 m depth, the total salinity is high both in the river water and groundwater, whereas at greater depths it is less. During the high river stages of summer the salt content is increasing as the water seeps deeper and deeper until the total system reaches equilibrium.

The influence of the river water is felt far from the river bed and the quantity of groundwater recharge is proportionate to the hydraulic conditions and to the length of the rising water levels. The high hydraulic pressure increases the seepage velocity and thus the mixing groundwater reaches greater depths.

Slight differences in the specific weight of the groundwater at different depths produce weak conventional circulation so the whole groundwater may also be gradually polluted (Erdélyi 1990). The deep groundwater of the coarse-grained basin fill is characterized by low total salt content and its quality is practically the same as that of the water entering into the narrow riverside strip (Lehoczky 1979).

4.2. The contamination of the groundwater

The groundwater is contaminated by surface water and human activity. The main contaminants are the Danube, the Mosoni-Duna, and Lajta rivers as well as the irrigation and drainage canals and their double purpose combinations, the small puddles and similar undrained depressions where contaminated waters, effluents (from manure dumps, depots of agricultural chemicals, workshops etc.) accumulate. A generally accepted practice is to put away the unpleasant and poisonous substances into the underground. This is probably the main source of groundwater contamination. Most common is the disposal of municipal, agricultural and often industrial liquid wastes into abandoned dug and tube wells.

The most susceptible areas to groundwater pollutions are: (1) sandy soils of the upper flood level where the majority of settlements, industrial plants and the intensive agricultural areas are located, (2) gravel regions without protective poorly permeable soils, and (3) permeable gravelly soils (Fig. 1).

The diversion of the Danube into Czecho-Slovakia is now an accomplished fact. The well-known grave consequences are: (1) loss of 1,000,000 m^3/day bank-filtered water reservoir, (2) practically total cessation of the groundwater recharge from the Danube with deleterious consequences: sinking of the groundwater table (Figs 12 and 13), (3) cessation of the continuous dilution by the recharging river water maintaining the one way water movement towards the Hanság depression, and (4) cessation of removing the contaminants with the discharging groundwater.

4.3. The contaminants of the Danube water

On the Rajka–Szob reach the Danube receives 8–10 times greater pollution load from Czecho-Slovakia than from Hungary (Sibl, Ch. 6.3).

Silt and mud of the river bottom contain toxic metals occasionally well above the concentration of the supposed unpolluted water (Szabó 1990). The water of the Danube entering from Austria is first class quality, but shortly thereafter it is heavily polluted by the Morava river upstream Bratislava. The Morava river (fourth class) carries the most toxic water of the whole Danube catchment. The heavy industries of the former Austro-Hungarian Monarchy were concentrated in the Morava basin. Czecho-Slovakian diversification multiplied the production capacity of the area and thus increased both the mass and toxicity of the pollutants.

From the mouth of the Váh river (at Komárno) the load of pollutants is considerably increased owing to the fact that the sewage (treated and untreated) and the toxic industrial fluids of the Bratislava capital area is being discharged into the Maly Dunaj, the northern branch of the Danube, flowing in the deep depression situated between the northern part of the alluvial fan of the Danube and of the rivers coming from the north. This river bed is an actual sewer owing to the

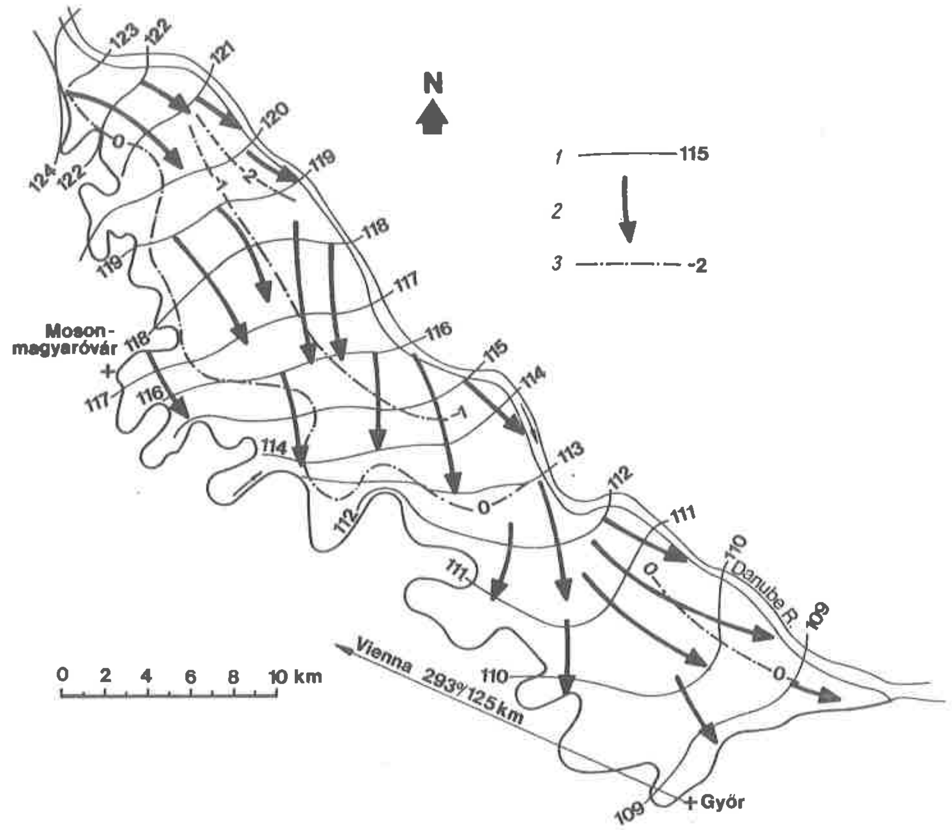
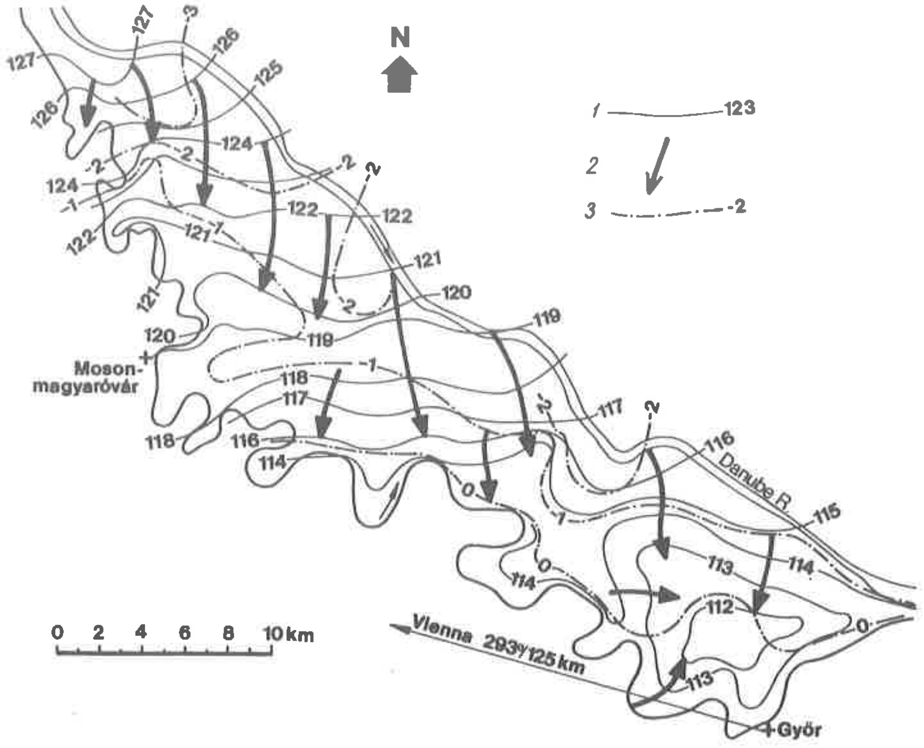


Fig. 12. Calculated change of groundwater level – at low river stage (after Csoma 1975). *Explanation*: 1 = groundwater contour a.s.l., on 29.03.1972; 2 = direction of groundwater flow; 3 = difference between calculated and measured groundwater level [m]

Fig. 13. Calculated change of groundwater level – at high river stage (after Csoma 1975). *Explanation*: 1 = groundwater contour a.s.l. [m] on 26.06.1965; 2 = direction of groundwater flow; 3 = difference between calculated and measured groundwater level [m]



unfavourable ratio between its small discharge and the mass of sewage of the capital area. Prior to the 1989 partial change of the political regime the Czecho-Slovakian frontier police repeatedly prevented by force the Hungarian officials from taking water samples out of the downstream current from Komárno.

A few recent data are sufficient to state that there is no hope of improving Danube water quality. In the raw Danube water e.g. number of algae increased from 9.7 millions/l (1975) to 22.4 (1986), and the nitrate content increased from 1–2 mg/l (1958) to 12–15 (1983) (Bozzay 1985). The amounts of the usual pollutants also increased proportionally.

Microbes and toxic substances will increasingly penetrate from the river into the bottom and bank deposits and will contaminate for a long time, probably for decades, the drinking water supply of millions of people along hundreds of kilometres, including the area downstream of Budapest (Szabó 1990 and 1991).

5

Bank-filtered water supply reserves along the Danube river

5.1. Central Part of the Little Plain

The right side Hungarian Danube bank is 53 km long and bordered by a few kilometre wide strip of the forested lower floodplain, a favourable area for pumping bank-filtered river water. There are many advantages of this riverside, (1) excellent hydraulic properties of both the Danube and riverside deposits, the gravel of the river bed is washed owing to relatively high flow velocity, (2) at present the water quality of both of river and groundwater is acceptable, (3) high flow velocity facilitates filtration through clean gravel and hence improves quality.

This riverside belt is at present the best area of Hungary for bank-filtered water extraction, because of its excellent hydraulic properties, acceptable water quality, high specific yield of pumping, sparsely inhabited wooded area without agriculture. All these ensure protection of water quality.

The author estimated 1,000,000 m^3/day bank-filtered water reservoir along the 53 km long riversection (Erdélyi 1984). The average specific yields of the pumped units are the best and surpasses those of the waterworks at the Szentendre Island north of Budapest. The Second National Master Plan for Water Management (OVH 1984) estimated 750,000 m^3/day bank-filtered water production capacity along a 32 km long riversection, which is situated within the optimal stretch of the above mentioned 53 km long riversection.

5.1.1. Extracts from official statements prior to 1989 concerning water resources of the Little Plain

The practical loss of the total river recharged groundwater is alleviated by stating that the water of dug wells became everywhere unsuitable for drinking, and wells of operating waterworks tap aquifers deeper than 100 m (Study... 1985).

These statements are refuted by official data collections from 1980 on (Urbancsek 1965, Vols XI–XIV). With the exception of two wells drilled in 1979–80 for drinking water supply, all wells are no deeper than 70 m. Examples: municipal waterworks of Győr, wells of recreational areas and youth centres, and even wells of the workshops and settlements of the barrage constructing company at Dunakiliti.

Both official statements and their 1988 televised versions are misleading because all wells drilled there up to 1985 supplied potable groundwater.

The official view up to 1980 was that "the protection of groundwater is negligible" and "water yielding capacity of aquifers recharged by the Danube water will not be influenced by the barrage system", and "the existing wells may be used for water supply" also in the future (Gabčikovo–Nagymaros barrage system).

These passages are misleading because a number of professional investigations carried out prior to 1980 proved the opposite (Karkus 1953, Honti 1954, Rónai 1960, Dávid and Nagy 1972, Csoma 1975, Major 1976, VITUKI 1977, Erdélyi 1983 and 1984).

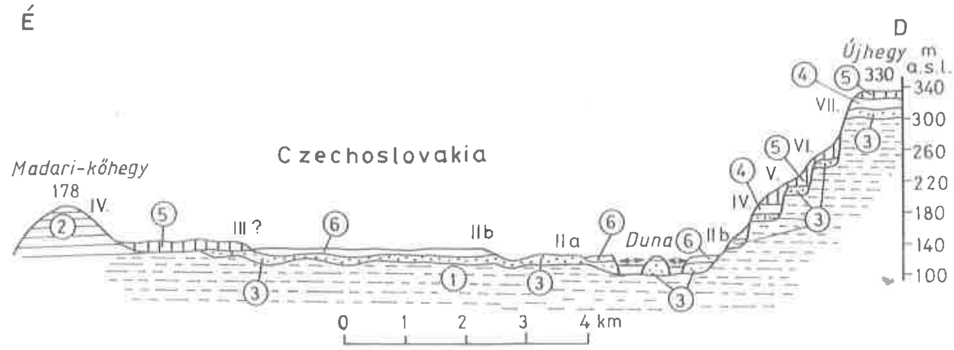
5.2. Danube riverside from the mouth of the Rába river to Dunaalmás

The riverside from the mouth of the Rába to Dunaalmás is mostly unsuitable for bank-filtered water supply because along a lot of kilometres the Danube gravel is thin, the underlying Pliocene strata are either aquiclude or the bottom of the gravel lies above the river water level. The wide, low Danube gravel terrace is covered predominantly by sandy soil. The groundwater stored in the gravel is highly vulnerable to contamination, because of the heavy use of chemicals in agriculture, and a number of industrial plants threaten it as well.

5.3. The Danube valley in the Middle Hungarian Mountains

The Danube valley in the Middle Hungarian Mountains is the counterpart of the Little Plain. The Danube was able to fill up the subsidence area of the present

Fig. 14. Danube terraces between Madar and Dunaszentmiklós (after Pécsi 1975, in *Regional Geography of Hungary*, Budapest, No. 3, p. 151). *Explanation*: 1 = clay (Oligocene), 2 = sand and clay (Pliocene); 3 = sand and gravel on terrace; 4 = travertine (freshwater limestone); 5 = loess; 6 = silt



Little Plain and at the same time continued to flow across the then emerging present Middle Mountains and their Upper Pliocene and Quaternary terraces (Fig. 14). There are only few wider parts of the valley underlain by Upper Quaternary Danube deposits. These are filled with polluted groundwater with the exceptions of few waterworks at the densely populated industrial areas. The polluted groundwater of the terrace gravels would have threatened the big karst aquifers prior to stopping the construction of the Nagymaros barrage. The headwater level of the barrage and that of the groundwater of the low terrace would have risen well above the pumping head of the regional karst aquifer (Figs 15, 16 and 17) with the probable disastrous consequence of polluting the huge karst aquifer and the high-discharge thermal and sub-thermal springs of Budapest (Erdélyi 1984, Sárváry 1990).

The planned site of the Nagymaros barrage is a narrow gorge cut into Neogene volcanics of the Middle Ranges (Fig. 18).

5.4. Water reserves of the Szentendre Island

The Danube branches bordering the Szentendre Island north of Budapest are the main supply area of the Budapest Waterworks, with an average water production capacity of 750,000 m^3/day.

Consequences of illogical and unsystematical dredging are

a) remarkable thinning of the gravel (thickness in the early 1960s was 4–7 m, at present 1–4 m; b) 1.6 m erosional deepening of river beds; c) loss and reduction of the filtering, purifying capacity of the gravel; d) uneven surface of the river bed (Confidential research project, Budapest Waterworks 1985); e) furrows and deep cavities will be filled by toxic sand which may occasionally be carried downriver by floods (Szabó 1990).

The eastern Danube bed is bordered from the east by a broad area of gravel terraces. The lower terrace is a continuous line of settlements and factories. The total terraced area contains polluted groundwater. The effluent industrial waters are moving downslope to the Danube riverside. The surface water processing plant of the Budapest Waterworks is situated here.

The decline of pumped yields and deterioration of water quality started in the early 1980s. The accelerating quality deterioration of the upstream Danube water downstream from the Austrian border is the main cause of the miseries here, and

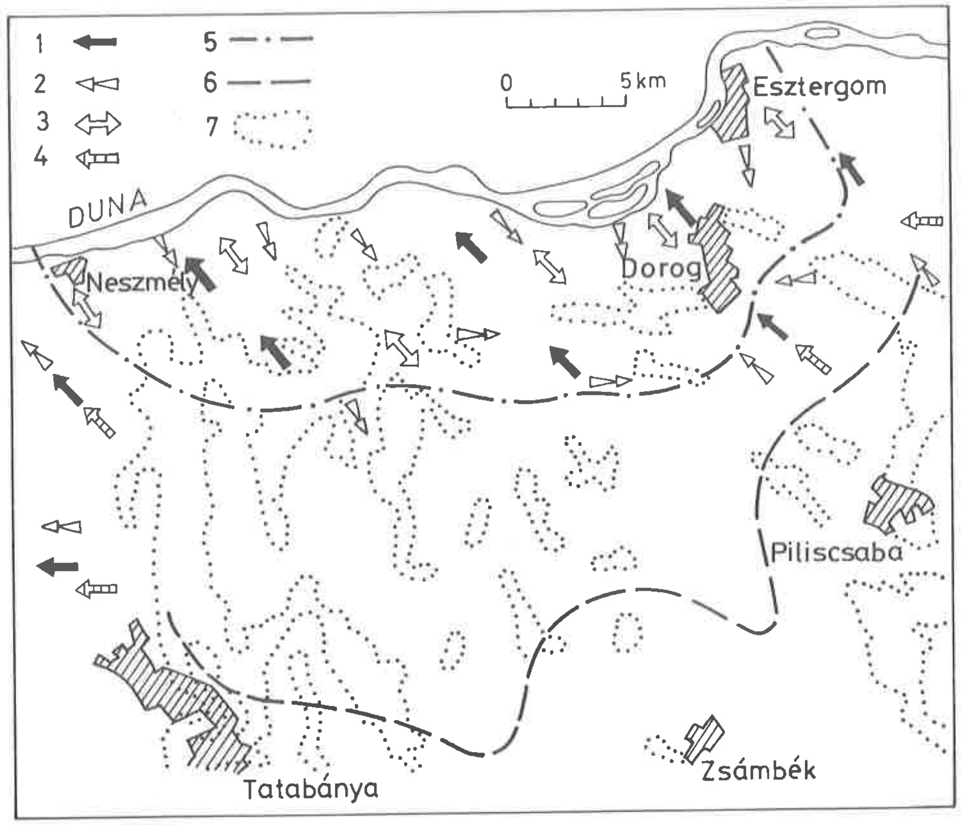


Fig. 15. Interaction between the Danube-recharged groundwater and karst water, in the Danube Bend region (after Böcker, in Erdélyi 1984). *Explanation*: 1 = direction of groundwater movement (end of the 1950s); 2 = the same in 1967; 3 = after 1975 (dependent on the Danube river stage); 4 = after 1975 on areas not affected by the pumping of coal mining; 5 = calculated boundary of the shallow groundwater intrusion into the karst aquifer; 6 = probable boundary of the shallow groundwater intrusion after the start of the large-scale drawn-drown of karst water; 7 = karst rock near to, or on the surface

is being further aggravated by (1) the dredging of river bed, and (2) the large-scale practically total excavation of alluvial gravel beds from the wide stretches of the valley crossing the Middle Mountain Ranges (Fig. 16). These large area gravel pits are collectors of wastes and contaminated groundwater, which are occasionally washed up and carried down by floods. The exploitation of large gravel masses was justified by the mass production of prefab concrete slabs to fulfil the ambitious program of building numerous blocks of houses, even whole districts, in and around Budapest. Twenty-five million m^3 gravel and sand was dredged from the Danube beds, mostly in the Szentendre Island area.

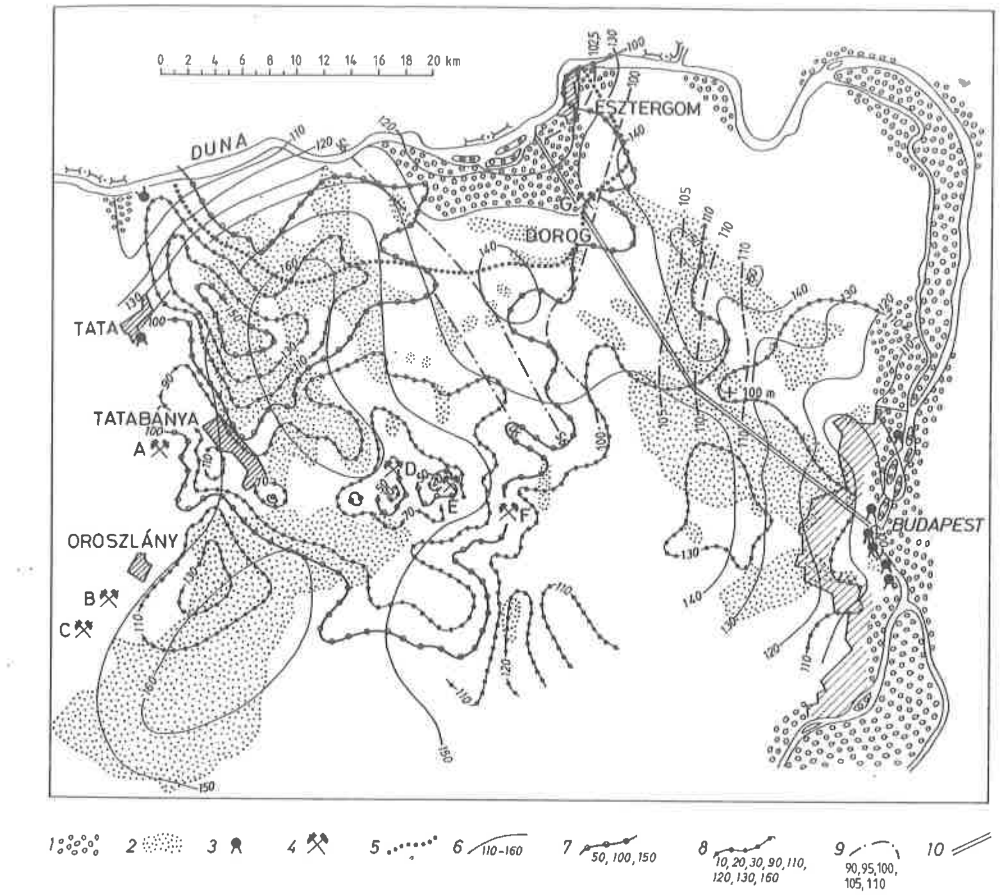


Fig. 16. Hydrogeological map of the Danube Bend region (Erdélyi 1989). *Explanation*: 1 = gravel of the Danube valley floor; 2 = area of karst rocks; 3 = high-discharge thermal and subthermal karst springs; 4 = deep coal mine (in operation, abandoned and planned); 5 = boundary between shallow groundwater and karst water (1979); 6-9 – karst water levels: 6 = original level (around 1910), 7-8 = actual level (1986), 9 = pumping level (01.01.1988); 10 = trace of cross-section

5.5. The Budapest capital area

The old historical districts with the exception of the Buda Castle Hill are underlain by gravel deposits (Fig. 19). A number of rows of wells are operated from 1870, when the first units of the waterworks were built. In the older districts practically every house had its own well prior to the piped water system. Most of these shallow wells were not abandoned later and in the two months long siege of 1944–45 winter saved the population from epidemics. The groundwater quality is not uniform and depends on the recharge rate of the Danube. Thousands of old wells made possible drawing a detailed hydrogeological map. This map delineate both the quality of groundwater and potential of the gravel aquifers and help to locate both high quality and contaminated groundwater in dependence on the rate of Danube water recharge.

The eastern area of Budapest is composed of a series eastward rising gravel terraces, some of them is a locally important aquifer. The groundwater of the higher terraces moves towards the Danube alluvium (Fig. 19). Planning of longer subsurface structures (underpass, subway, tunnel etc.) requires careful planning in order not to block groundwater movement and by this way hinder water accumulation in cellars, causing damage to fundaments of buildings.

There are two instructive examples in recent past, when the one-sided technical conception did not consider the natural environment: (1) the Danube barrage scheme, and (2) the 7 km long subway tunnel parallel to the Danube connecting the downtown and the northern suburb Újpest.

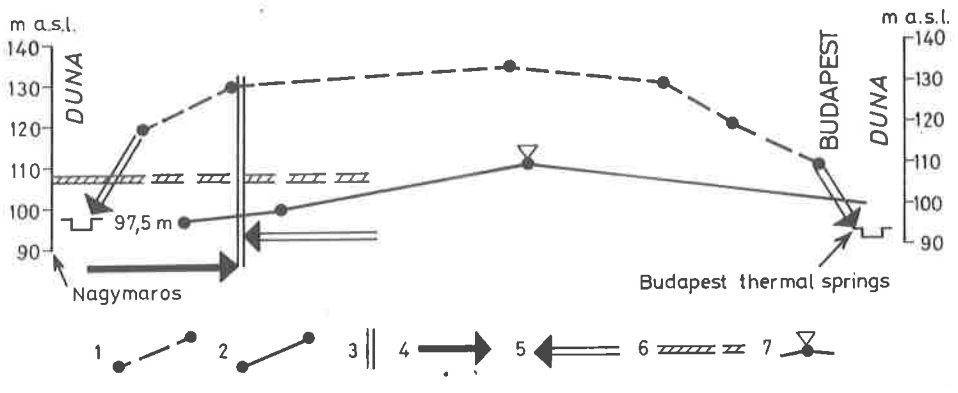


Fig. 17. Schematic cross-section between Nagymaros and Budapest (Erdélyi 1989). *Explanation*: 1 = original (undisturbed karst water level); 2 = the same at the end of 1986; 3 = boundary between contaminated shallow groundwater and karst water in 1979; 4 = direction of movement of the contaminated groundwater; 5 = direction of the karst water movement; 6 = retention level of the planned Nagymaros barrage; 7 = karst water divide (end of 1986)

Fig. 18*a*. A structural geology of the Danube Bend region (after Balla and Czakó, in Erdélyi 1989*a*). *Explanation*: 1 = base of the volcanic rocks; 2-3 – stratovolcanic rocks: 2 = andesitic, 3 = dacitic; 4 = andesitic intrusion; 5 = sedimentary cover (Middle Miocene); 6 = structural line

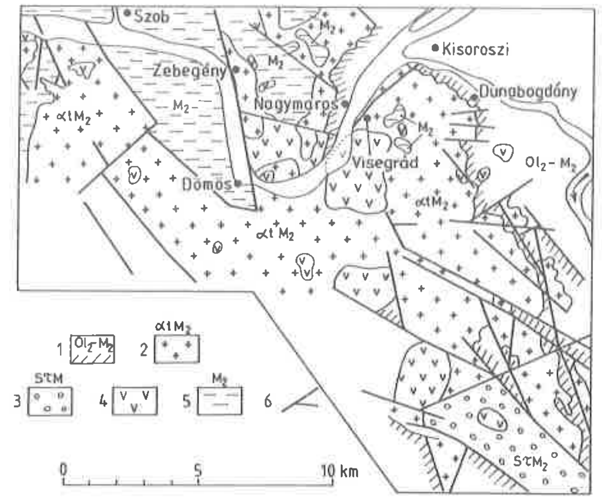
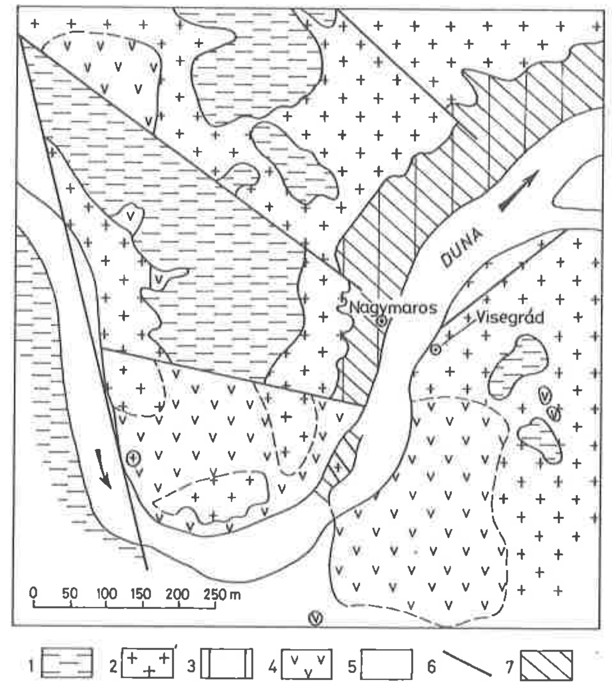


Fig. 18*b*. Geological map of the Nagymaros area (Balla and Czakó). *Explanation*: 1 = sedimentary cover (Middle Miocene); 2 = stratovolcanic andesit (middle Miocene); 3 = sedimentary base of the volcanic rocks (Oligocene and Middle Miocene); 4 = andesitic intrusion



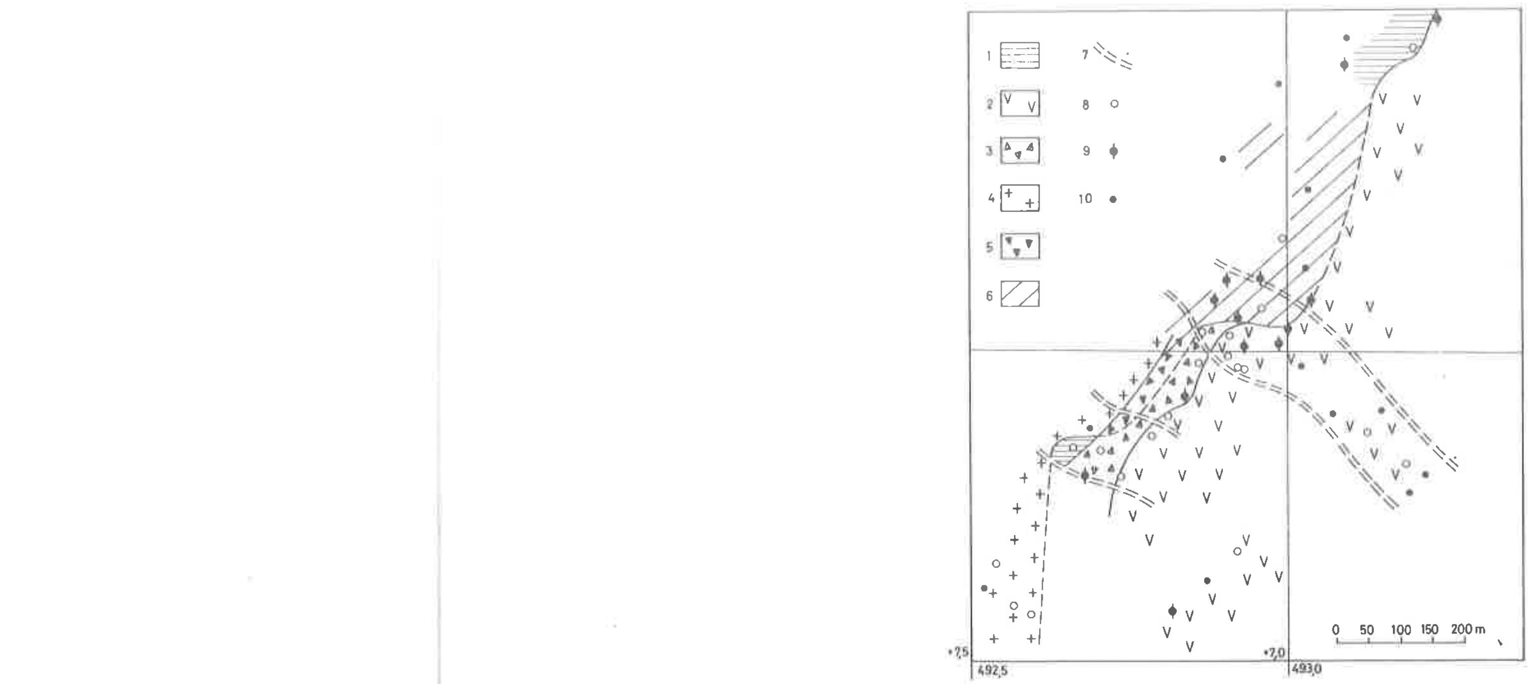


Fig. 18*c*. Geological map of the planned Nagymaros Barrage site (Archives of Hung. Geol. Survey, L-34-2-17 map sheet. *Explanation*: sedimentary base of the volcanic rocks; 2 = andesite, 3 = andesite over sedimentary base deposits; 4 = porfiric andesite; 5 = porfiric andesite over sedimentary base deposit; 6 = stratovolcanic andesite; 7 = boundary of fractured zone; 8 = test hole in the Danube bed; 9 = test hole hit brecciated andesite; 10 = test hole of the preceeding survey

5.6. Water supply installations of the area downstream of Budapest

The future of the Budapest Waterworks will be aggravated by:

1. The inevitable loss of 38 km long bank-filtered production capacity between river stations 1810 km and 1848 km. 2. The diversion of the Danube at the 1842 km river station. 3. Predictable severe water quality deterioration in the reservoirs. 4. Besides the already existing contamination sources the rapid increase of contamination of the groundwater was caused by the loss of recharge from the Danube.

The predictable rapidly rising costs of the future water supply of the Budapest capitol area, combined with the decreasing quantity and quality of the water of the already totally developed upstream areas, forced the Budapest Waterworks to move to downstream areas.

Several deleterious effects were recognised: Seriously polluted groundwater aquifers in the southern suburbs: the eastern riverside of the main branch (in the Csepel Island) are densely built-up residential districts, with poor sewage treatment capacity.

Wide area of more than hundred years of heavy industries, produced great diversity of large quantities of toxic water. There are large areas of workshops, military barracks, magazines, and the airport of the Soviet troops also stationed here for 40 years: immense quantity of highly toxic waters and thousands of m^3 of gravel aquifers were polluted, among others by aircraft kerosene.

The eastern Danube branch (Soroksári-Duna) is a heavily polluted dead water, in fact a depot of industrial wastes and community sewage.

The unsuitable environment forced the construction of water supply installation moving to a better location along the river. These new downstream bank filtered areas are far from ideal, if compared them with those of upstream Szentendre Island.

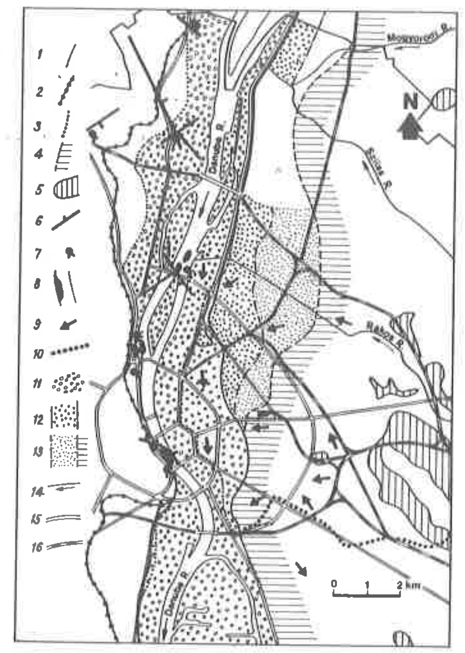


Fig. 19. Groundwater in Budapest (Erdélyi and Gálfi 1984, p. 302). *Explanation*: 1 = border of the flood-plain; 2 = western border of the Danube valley; 3 = boundary of the influence on the groundwater of the multi-annual highest water level of the Danube (June-July, 1965); 4 = western border of the discontinuous Quarternary gravel deposits; 5 = outcrop areas of the base of terrase gravels; 6 = fault-line; 7 = high discharge carstic thermal spring; 8 = area of springs discharging into the riverbed; 9 = direction of groundwater flow; 10 = groundwater divide; 11 = thick gravel with very copious groundwater; 12 = thick gravel with less copious groundwater; 13 = mostly thin gravel with groundwater; 14 = small water course; 15 = main streets; 17 = main railway line

The Budapest capitol area (two million inhabitants and divers industry) is producing large quantities of incompletely treated waste water. A part of the untreated municipal sewage and industrial waste water of the southern suburbs are disposed into the Danube. Numerous consequences are as follows: (1) the low quality of raw water, (2) lower specific yield of wells and fast decrease of pumping rates, (3) clogging of the aquifer pore-space, as a consequence of drawing in dirty water by pumping.

5.7. Summary of opinions of competent experts

It is worthwhile to refer to statements of competent experts who recognized the immense economic values of the whole Middle Danube region. I remember well the discussion in Vienna in 1964 with Dr Heinrich Küpper, director of the Austrian Geological Institute at that time and engaged in the geological investigations of future source areas for the areal extension of the Vienna Waterworks. He emphasized that the groundwater and bank-filtered capacity of the total Little Plain on both sides of the Danube were probably the largest unspoiled and high quality water supply of Europe (Fig. 1). He repeatedly stressed the responsibility of experts of both countries (Czecho-Slovakia and Hungary) to save these unique renewable resources, a part of which would be exportable drinking water of immense quantity prior to the end of the 20th century. The renewable Danube recharged groundwater of the Little Plain amounts to 5.4 km^3 in Hungary and 13 km^3 in Czecho-Slovakia, an estimated total of 18.4 km^3 groundwater reserves.

A regional water management study of great importance was published in 1972, discussing the perspectives of supplying regional waterworks of areas in need of water with the Danube raw and bank-filtered water in the future. The study stressed the importance of the Little Plain groundwater of the Danube, which at that time, was unspoiled (Dávid and Nagy 1972).

Dr F. Boroviczeny, Deputy Director of the Austrian Geological Institute, prepared an expert opinion in 1989 on behalf of the WWF, concerning the Gabcikovo–Nagymaros barrage system, which represented also the official view of that institution. Dr Boroviczeny compared the detrimental effects to be expected in this region with those caused by some European barrage systems in operation. His views and other Austrians' (Fischherz and Bolzer 1984 etc.) are very close to those of Hungarian experts. Boroviczeny's study was accessible only for a limited number of Hungarian professionals interested in the planning and construction of the barrage system.

Until the 1989 change of regime it was a secret material and therefore inaccessible for outsiders. The high degree of similarity of Dr Boroviczeny's views with those experts not interested in the barrage construction was probably the motive of not to make it accessible to the critics of the scheme.

6

Agriculture and water management

6.1. Hydrological investigations

A number of geological mappings (e.g. Rónai 1960, Franyó 1965) and hydrogeological investigations (Honti 1954, Rónai 1956, 1960, Ubell 1959 and 1965, Csoma 1975, Major 1976, Deák 1978) proved that an area of 910–920 km^2 is being recharged by the Danube (Fig. 1) and the role of precipitation is negligible (Honti 1954). According to the "official" view only an area of 755 km^2 is influenced by the Danube (Study... 1985).

The multiannual average depth of the groundwater table (Fig. 20) is in sharp contrast with the official view (Study... 1985), which shows one of the lowest depth in 1984 caused by a series of dry years.

Rónai's map shows the depth to the mean groundwater level in an area of 910–920 km^2.

Different depths of the average groundwater table (after Rónai's map; Fig. 20): 0–2 m – 4.9%; 2–3 m – 85.3%; 3–5 m – 9.8% (total 100%).

(Study...1985) official data (for 1984): 0–2 m – 16%; 2–3 m: 31%; 3–5 m – 47%; 5–6 m – 6% (total 100%).

Plants compensate the lack of moisture in summer from the soil water and groundwater, accumulated in winter (Kovács 1972).

Different investigations proved here that "domesticated plants" can utilize about 1 m thickness of water under the surface soil (Study... 1985). There are other views about the thickness of the soil water which may be about 2 m, when the upper soil cover is in contact with the top of totally saturated gravel subsoil.

6.2. Irrigation at present and in the future

The best agricultural crops (cereals, fodder-crops and industrial plants) of the Little Plain occupy those areas, where the depth of the groundwater table is no more than 2 m, and irrigation is necessary only locally and of complementary character (Rónai 1956). Authors of the official study (Study... 1985) were interested in stressing the inevitable necessity of large-scale irrigation to compensate the loss of groundwater after the construction of the barrages (Figs 5, 12 and 13). Therefore they used the data of very dry years, among others the 1984 depth of the groundwater table. This and other official views are misleading because they corroborate the false statement that the groundwater has no determining role in the agriculture (Study... 1985), contrary to all competent documentations (see Figs 1 and 20). "*Considerable part of the surface layer has an independent water regime, which is influenced first of all by the precipitation*" (Study... 1985). I wish it would be so!

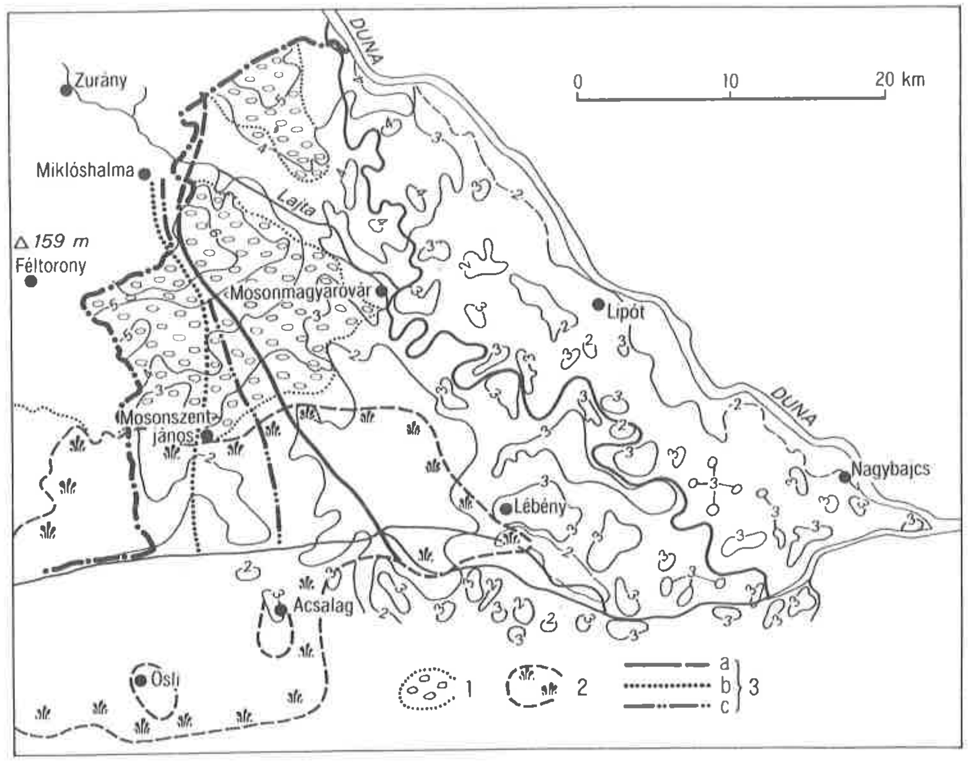


Fig. 20. Depth of the mean groundwater level (m) (Bóczán, in: Rónai 1966). *Explanation:* 1 = gravel and gravely soil; 2 = area of the Hanság swamp (1769); 3 = boundary of the Danube river recharge of the groundwater: a – low, b – high, c – average river stage (by Erdélyi 1984)

These and other statements diminish the role of the groundwater in the agriculture and suggest that loss of the groundwater recharge from the Danube is not regrettable, because "*the precipitation is usually not sufficient to reach optimal yield*". "*4000–5000 hectares were also irrigated in the past year.*" (Study... 1985). This is only about 13% of the total 375 km^2 area of the Szigetköz Island. The years from 1980–81 on were dry years culminating in 1983 and 1984. In spite of the drought, the irrigations were only of complementary character.

"*That reach of the Danube bed, which will be shut off by the diversion of the river from the present water circulation, will loose its function of regulating the groundwater regime, because the river branches will take over this function*" (Study... 1985). The length of the abandoned Danube bed is 38 km long now (November 1992).

6.3. Critique of the proposed groundwater regulating system

Will the proposed groundwater regulating system, which will consist of interconnected reaches of side-branches, be able to replace the groundwater recharge capacity of the "living" Danube?

This is doubtful: because (1) the total length of the planned system is more than the shut off bed of the Danube, therefore its gradient will be lower, (2) it will not be in contact with the gravel of the basin fill, (3) because of the lower flow velocity, clogging and silting up will take place, and (4) the removal of silt will not be sufficient. The system will be more or less parallel to the old main river bed, the pressure difference along the short distance between the old bed and the regulating system will force most of its flow into the old bed, and only a small part of it will regulate the groundwater of the Szigetköz Island. What will happen if the regulating system will dry out, because all the water will be needed for navigation and generation of electricity at the Gabčikovo barrage?

The groundwater will practically loose its total recharge. It is possible that the planned regulating system will stabilize the groundwater table on a lower elevation, but cannot maintain the high velocity and the amount of groundwater recharge rate of today (about 2000 m^3/s), which is indispensable for diluting and freshening the locally polluted groundwater and carrying it to the natural drainage zone (Fig. 10). In the lack of the present recharge rate and the high velocity of groundwater movement the contamination of the 5.4 km^3 groundwater stored in the southern part of the Little Plain will speed up (Fig. 11).

7

Predictable changes of the groundwater regime

Between the main branch and the Mosoni-Duna the groundwater level will be stationary. The extreme low groundwater regime will be stabilized at the depth of the present average level and the area of excess water will be substantially less (Study... 1985).

The present deepest groundwater discharge belt (Hanság and Rábca) will be shifted to the north (Fig. 1).

The Mosoni-Duna will pass water towards the abandoned main river bed.

The Budapest area after completion of the barrage system, in contrast to Bratislava, is exposed to natural disasters. All of the following constructions are situated on the area upstream of Budapest:

(1) the Dunakiliti reservoir (completed but unused), (2) the nearly completed Gabcikovo barrage, (3) barrages of the Váh river (one constructed, two planned), (4) the planned Nagymaros barrage.

The first constructed Váh barrage was shown to have numerous disastrous effects soon after its construction:

1) the groundwater level rose near or to the land surface, 2) this caused salt accumulation in the topsoil over large areas, and 3) damaged fundaments of hundreds of village houses, and 4) contaminated drinking water.

Prior to the construction of the Váh barrage, the dug wells yielded excellent quality groundwater at 3–5 m below the land surface. Earlier the saline (alkali) soils were very rare.

Number and duration of low river stages at Budapest will increase and cause irreparable damage to the Budapest riverside stone protection wall built of big stone slabs in the second half of the nineteenth century. The massive structure is supported by a continuous row of oak poles driven into the river bed at the foot of the protective wall. The oak poles will protect the stone structure from collapsing as long as their top is always under water.

The large-scale dredging of the Danube bed for construction material (gravel) downstream of Bratislava was really not limited, as the thickness of gravel under the Danube bed is great (Fig. 2). In the Szentendre Island area upstream of Budapest, where the gravel deposit is thin, long kilometres of river bed had been dredged.

Czecho-Slovakia protested against the construction of the planned Hainburg barrage in Austria, stating that the Danube bed will dangerously be deepened in the Bratislava area. But the real motive of the protest was the fear of an accidental unexpected natural disaster, which might be in connection with the Hainburg area situated within the "Mur-Mürz Linie" zone, discussed in the 10th chapter. In Bratislava there is practically no danger of catastrophic flood disaster of seismic or meteorological origin.

Protests of Hungary against the Czecho-Slovakian construction was flatly rejected.

7.1. Changes of old Danube beds

The Danube area has been fundamentally changed by the regulations (Fig. 3). The flood protection and safe navigation compelled the localisation of the main bed. The branches were shut off partly or totally and got also regulated.

The regulations changed the natural environment of the area downstream from Bratislava. The fishing suffered irreparable losses, the ratio of valuable fish species dramatically decreased. Some species of fish has already disappeared. The spawning areas of valuable "noble" fish species require high, naturally fluctuating river stages (Tóth 1984, Woynarovich 1992).

The role of the branches diminished in the groundwater recharge. All the river branches' bottom were underlain by gravel.

The consequence of the construction of the Austrian barrages was that the Danube bedload considerably decreased, therefore the silting up of the Danube bed in the Little Plain practically ceased, and the Danube bed eroded in the area downstream of Bratislava. Consequence of the bed erosion and the excessive dredging resulted in an unforeseen erosional deepening of the Danube bed, therefore the finished big Bratislava river port cannot be operated at low river stage, because the bottom of its canal is above the bottom of the Danube bed. For safe operation of this port the downstream barrage (e.g. of Dunakiliti) is an unavoidable requirement.

Construction of the barrages in Germany and Austria has caused irreversible damages. Continuous sinking of the river bottom caused a decrease of groundwater recharge. The contamination of the river continued to increase by the passing of time.

A possible advantage of the upstream barrages is the diminishing flood hazard as a consequence of the substantial decrease of the bedload material.

The silting up of the Danube bed was suddenly stopped by the diversion of the river and construction of the reservoirs. The old bed of the Danube will be a depository of local and transported contaminated water.

The construction of two Austrian barrages will be necessary. The first one will be placed downstream from Vienna for regulating the water supply along the Danube beds within the city.

The Hainburg barrage will be indispensable for the protection of the Danube riverside environment, both the biological assets and the surface and subsurface water reserves.

The Hainburg barrage will accelerate the downstream deepening of the river bottom also in the Bratislava zone.

The 38 km long old main Danube bed will receive water whimsically. Longer dry bed periods may occur, and it will be the partial depository of pollutants coming from the whole upstream area, as well as all of the local contaminants. I am not competent to discuss the possible loss of the now protected natural heritage, and the loss of fishing, sports, local navigation and of the highly productive forestry (Tóth 1984, Woynarovich 1992). The expected changes were gratuitously optimistic, reflecting the view of people and companies economically interested in the barrage scheme (Study... 1985).

The most unsuitable 8 km long riverside for bank-filtered water extraction of the main Danube was left for Hungary, downstream of Palkovičovo (Fig. 7). This riverside will receive all the polluted water (1) from upstream the river diversion, (2) and the additional pollutants originating in the reservoirs, the canals upstream and downstream Gabčikovo, as well as those originating in the barrage (Szabó 1990, 1991).

Czecho-Slovakia planned a big groundwater extraction of 600,000 m^3/day and hundreds of kilometres of pipe network for a number of regional waterworks based on this water reserve. Water quality hazards will be the same here as on the Hungarian riverside discussed above.

7.2. Is there a possibility of substituting the lost water reserves?

The Danubian recharge of groundwater of the Little Plain will practically be stopped. The planned network for recharging the groundwater reserves will not be sufficient.

The best area for riverside pumping is practically lost (Fig. 7). The subsoil under the reservoir dikes were compacted on the left side, applying mechanical and chemical treatments (Fig. 21). The foundations of the following dikes were compacted: (1) the shutting of the Danube bed for the newly (1992) constructed Čunovo reservoir (2 km), (2) the southern dike of the same reservoir (10 km).

The old Danube bed between the 1852 km and 1810 km river stations upstream from Palkovičovo is totally lost the bank-filtered water supply.

7.3. Critique of the planned groundwater recharging systems

A part of the planned water distribution network is based partly on the Dunakiliti reservoir. The seepage water of the reservoir will be collected in a seepage canal, which will allegedly supply good quality water. It is possible that at the beginning the water seeping through the reservoir bottom will be potable as long as the settled silt will not influence the water quality. In proportion with the thickening silt accumulation the water quality will be deteriorating, and the seepage will be decreasing and eventually be stopped.

Further problems were discussed in Ch. 6.3. [Critique of the proposed groundwater regulating system.]

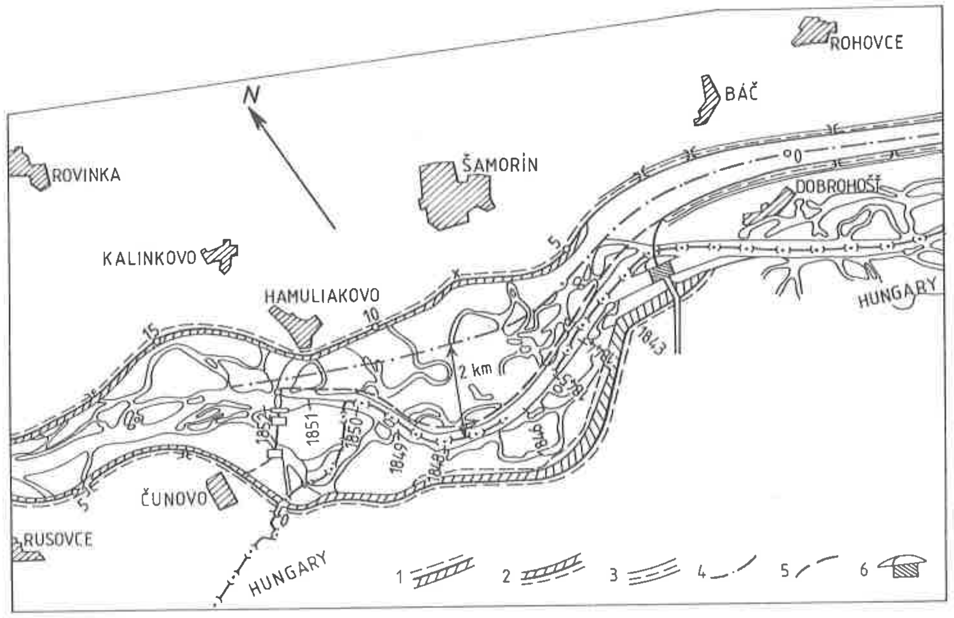


Fig. 21. Plan of the Danube reservoirs. *Explanation*: 1 = left-side dike, 2 = right side dike (Dunakiliti and Čunovo reservoirs); 3 = dike of the navigation canal; 4 = new navigation line; 5 = dike of the Čunovo reservoir (built in 1992); Dunakiliti dam

7.4. Deposits of the reservoirs and canals

The study and analysis of dredging, deposition and eventual treatment and agricultural use of huge quantities of fine-grained silt is one of the future tasks of scientists. There are already excellent examples of analyses (Tóth 1984, Hem 1985, Szabó 1990, 1991, Woynarovich 1992 etc.). Seepage of polluted water through the bottom of reservoirs and canals into the groundwater is a hydrological issue, as well as groundwater contamination by seepage from depots of toxic substances.

The reservoirs and the navigation canal considerably facilitate algal growth. The shallow water, the very slow water movement, its warming up and transparence are the main factors of the rapidly deteriorating water quality.

The Dunakiliti reservoir (Fig. 21) is a considerable future source of water contamination owing to its area of 45 km^2, and 180 million m^3 storage capacity at 131.0 m retention above sea-level. The accumulation of silt may be 2–3 million m^3/yr, strongly depending on the mass of the algal growth. The total filling up of the reservoir may be estimated 20–25 years after the start of the operation of the barrage system.

The Čunovo reservoir area is 12 km^2, its depth is 3–4 m. For this reason a new navigation line has been set out.

7.5. Selected passages from "Damming the Danube"

The fate of "*Zitny Island will be determined by processes undergoing in the reservoirs situated downstream from Bratislava, where water infiltration into the groundwater of Zitny Island occurs. The amount of infiltrated water is 2 to 8 m^3/s... an average of 4.4 m^3/s*" (Zekeova 1990, in Sibl, Ch. 6.5).

"*When forecasting water quality in the reservoir, especially the left-bank infiltration zone, the amount and composition of waste water discharged directly into the reservoir from the two big industrial complexes of Istrochem (river km 1863.4 and 1863.45) play a very negative role. Even from the viewpoint of a currently good hydrological regime of the Danube, this state is not satisfactory due to the composition of these waste waters. The quality of the infiltrated water will decline due to the changes in water flow velocity in the reservoir, changes of dispersion conditions sedimentation, and possible interactions between the liquid and solid phases*" (Zekeova 1990, in Sibl, Ch. 6.5).

"*The municipal sewerage system from the Bratislava suburb of Petrzalka is ousted into the right bank of the Hrusov reservoir. Waste waters from 120,000 inhabitants of this part of the city and from city industry are currently not treated*" (Zekeova 1990, in Sibl, Ch. 6.5).

"Changes... in the quality regime of groundwater will show themselves in the following way:

1. The intensity of water infiltration into the groundwater basin will increase in the first stage of the Hrusov reservoir filling, due to increase in the water level (from 122 m a.s.l. to 131.1 m a.s.l.).

2. Due to decrease in the water flow velocity in the Hrusov reservoir great amount of deposits (about 2.6 million m^3 of suspended material per year, that is a layer about 5 cm thick over the whole area of the reservoir) with a 10–12% content of organic matter in the dry residue will remain deposited in the reservoir. The decomposition of this organic matter will demand a certain amount of oxygen, so the present oxygen balance of the Danube will be unsettled (anaerobic processes will occur in some places in the reservoir."

3. "The amount of oxygen in the reservoir will decrease about 40.50% that is to a concentration of 5.6–6.0 mg/l O_2.

4. Complicated phenomena in the structure of groundwater flow are expected to occur in the infiltration zone. This fact may result in the spreading of contaminated material via the so-called "privileged routes" (at high water levels oil substances and other contaminated matter can be found in deep horizons (50–80 m) and at a distance of over 100 m from the river bed)."

"The above-mentioned facts, in relationship to the evolution of groundwater quality in the riverine zone of the Danube after filling the Hrusov reservoir, lead to the following assumptions:

a) A considerable and fast decrease in groundwater quality will occur in the Danube riverine zone. Fast transport of various hydrocarbon substances and others of a mainly organic character can be expected (oil hydrocarbones, Cl-insecticides, phenols, products of organic decomposition, decades of sludge deposits in the Danube river-zone and the area of the Danube floodplain).

b) These water pollutants will penetrate and spread relatively quickly even to regions distant from the reservoir edge (to a distance of hundred of metres, or even some kilometres by groundwater flow and diffusion flow).

c) These processes and their negative influences will speed up in areas of usable water sources (Kalinkovo, Hamuliakovo, Samorín and other sources) by increased pumping of groundwater, which could prevent utilisation for drinking purposes for weeks or even months. It is necessary to stress that these pollutants are dangerous or have mutageneous and teratogeneous effects" (Lehoczky 1990, in Sibl, Ch. 6.5).

7.6. Overdraft of karst aquifers

The catastrophic losses of the karst water regimes is a consequence of the excessive withdrawal of the mining industry.

Table 1. Quantity of pumped karst water (1000 m^3/day), Middle Hungarian Ranges (see Fig. 16)

Year	A	B	C	D	E	F	G	Total	%
1979	159.8	6.9	–	5.3	14.5	–	12.4	198.9	100
1986	83.4	–	5.3	129.2	60.0	47.7	23.3	350.9	176
1988	12.9	B+C	4.0	170.0	24.8	56.8	14.4	282.9	142

Projected withdrawal of water from coal, bauxite, fire-clay and uranium (content in coal seams) mines [("Eocene Programme") D, E and F total 19.8, 1979; 236.9, 1986 and 251.6, 1988 (1000 m^3/day)].

For comparison:

a) Multiannual average total discharge of karst springs (natural recharge) is 412 thousand m^3/day.

b) Total production of the Budapest Waterworks is 1.1–1.2 million m^3/day.

c) Pumped karst water of bauxite mining in 1988: 458,000 m^3/day.

8

Diversion of the Danube and its consequences for the Lake Fertő (Neusiedler See)

The Lake Fertő and part of the Hanság depression is a very young (late Pleistocene early Holocene) subsidence area (Figs 8 and 9).

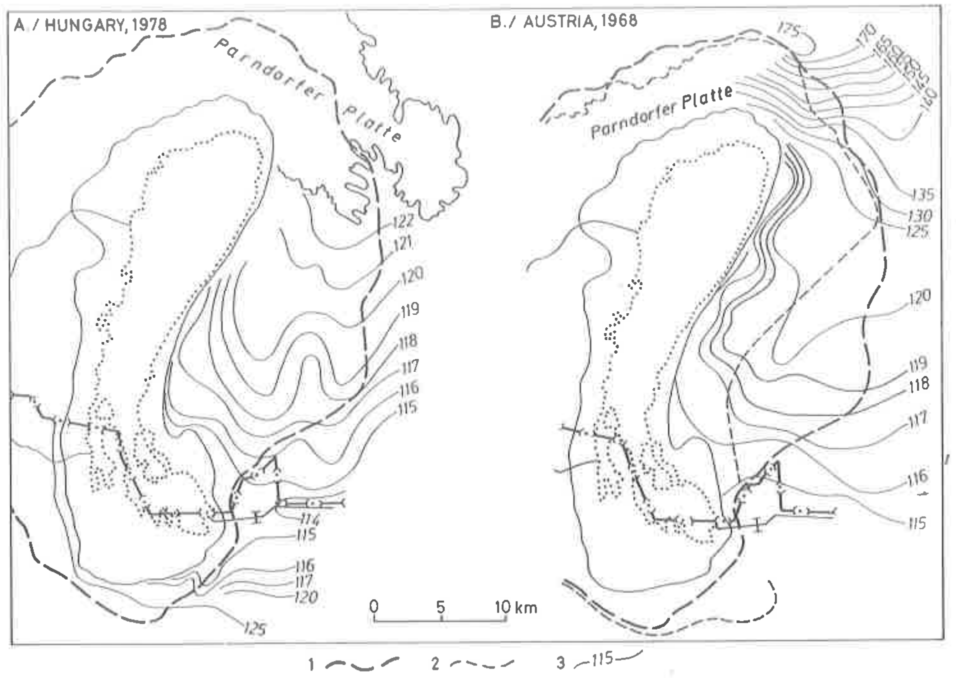
The Lake Fertő (Neusiedler See) hydraulic regime is closely connected to the Danube groundwater recharging capacity (Figs 11 and 22).

The water of the Lake Fertő is predominantly precipitation water and naturally drained groundwater. The lake basin's catchment area is very limited, and there are only few ephemeral water courses of very low discharge rates. Springs are few and artesian discharge is questionable.

The area of Lake Fertő and the Hanság swamp was a single hydrogeological unit (Figs 9, 10, 11 and 12). Later it became possible regulating water levels in the whole Hanság–Fertő Basin by digging the main Hanság canal and constructing its lock. By training the Rábca river the lake-swamp area became an independent water management unit, capable of regulating the water regime in the deepest area of the Little Plain (Fig. 10).

The diversion of the Danube will have disastrous consequences for the water supply of the Fertő–Hanság depression discussed above. It will be very difficult to maintain the actual water regime when the Danubian recharge of the groundwater will greatly be decreased and the potential distribution will substantially be distorted (Fig. 1). The present belt of the natural groundwater drain (Hanság) will be shifted to the north owing to the greatly reduced groundwater recharge of the Danube alluvial fan. How will be possible to regulate the water regime and sup-

Fig. 22. Groundwater contours of the Lake Fertő (Neusiedler See) area. a) Hungary, 1978; b) Austria, 1968 (after Baranyi and Urbán 1978). *Explanation*: 1 = surface watershed; 2 = hydrogeological watershed; 3 = groundwater level (a.s.l.)



ply the lacking water of the basin? What about to fill the Hanság depression with stream water from the east through the Rábca river?

Another vague possibility of recharge is from the north. In the past, prior to the Danube river training, rare Danube overflows from the Rajka–Dunakiliti zone entered directly into the Hanság–Fertő depression.

9

Hydrodynamics and deep groundwater of the Little Plain

The official view does not differentiate the groundwater stored in the gravel characterized by hydrostatic pressure and the deep (artesian) groundwater characterized by both negative and positive hydrodynamic gradients (Fig. 23) (Gabcikovo 1980, p. 21). The official opinion is irresponsible and unprofessional because the artesian water in the water supply cannot substitute the groundwater stored in the gravel aquifer formation. This groundwater will progressively be polluted after the diversion of the Danube and especially if an up-to-date regional water treatment system will not be realized soon. The economical values of the two sorts of groundwater types are incomparable. The average specific yield of 38 artesian wells is 54 l/min/m, and only a few is more than 100 l/min/m. Large diameter shallow wells with gravel packing may have 5000–6000 l/min/m specific yield. The specific yield of the wells tapping the gravel aquifer in 95% of the cases is more than 1000 l/min/m (Urbancsek 1966–86, Vols III–XI).

The artesian water is an independent hydrogeological unit and its pressure is different from that of the groundwater. An artesian aquifer may get into connection with the contaminated groundwater when the artesian pressure is lowered by excessive pumping. Improper cementing (or grouting of casing) or corroded steel pipes may also cause contamination if the artesian pressure is lowered below the groundwater level. In the last three decades the artesian pressure heads decreased. Because of the insufficient number of artesian monitor wells we have not got enough information on the scale and the areal distribution of the decreasing artesian pressures. Catastrophic decline of the artesian pressure is a nationwide phenomenon, which was further aggravated after the realization of the piped water supplies from the late 1950s to the middle of the 1970s years.

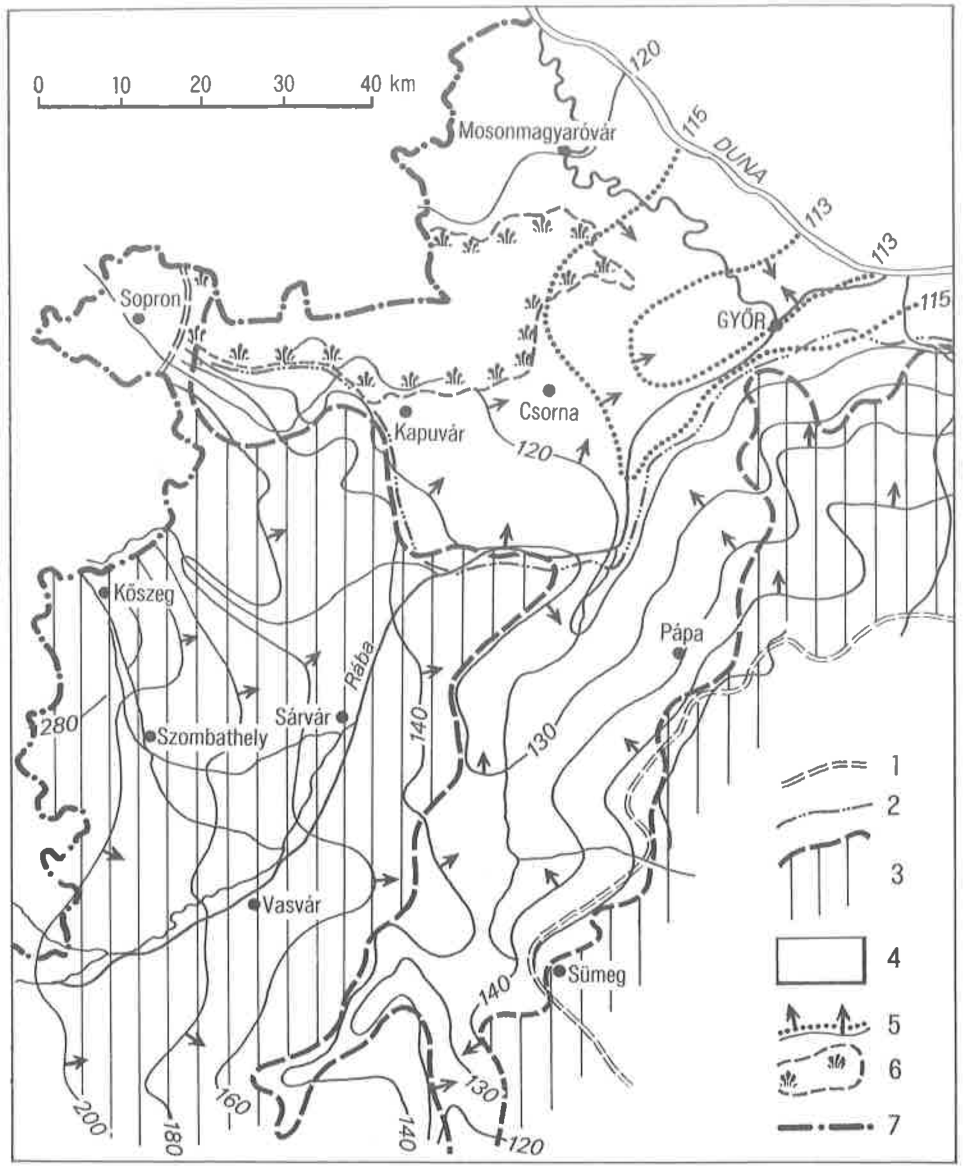


Fig. 23. Hydrodynamic map, southern part of the Little Plain (after Erdélyi 1990). *Explanation*: 1 = boundary of the mountains; 2 = boundary of the alluvium; 3 = original recharge area of the artesian water; 4 = original discharge area of the artesian water; 5 = original pressure of artesian water and flow direction; 6 = original boundary of the Hanság swamp in 1769; 7 = western frontier of Hungary

10

Structural geology

Neither seismicity nor the danger of earthquake induced flood disasters will be discussed here. Figures 24, 25 and 26 show most of the published tectonic features. Figure 26 depicts a part of the well-known "Mur-Mürz Linie", which is the main tectonic zone, where the Eastern Alps and the Western Carpathian mountain masses have repeatedly been trusted up, and pushed over the bordering Little Plain in the Neogene and Quaternary tectonic phases (Figs 24, 25 and 26).

Janácek documented very young ("Leventine" – Quaternary) structural movements inside the Little Plain (Fig. 27).

Fault line directions NW and SE from Gabčikovo proved that these faults were active up to the Upper Quaternary age (Janácek 1971). Owing to the recent tectonic movements the planned Gabcikovo barrage site was changed and the construction started 600 m away from the planned site.

The area of the planned Nagymaros barrage site is crossed by a seismotectonic line (Study... 1985). Cepek's map (Fig. 25) and figures 18*a,b* and 18*c* show more details of living tectonic lines at the westernmost part of the Danube gap zone.

10.1. Structural geology and river stage curves

Can the data of river gages be used in structural geological analysis for investigation of recent displacements in the subsurface space?

Data of a former systematic gaging may give valuable information even today.

Following a carefully planned geodetic survey temporary river-stations were installed. Provisional river-stations are stakes driven into the river bank in every kilometre between the already existing river stations. All the stakes were levelled by precise geodetic survey. When the carefully forecasted very low river stage arrived on 03.13.1943, the water levels were repeatedly marked on every river station exactly at the same time.

A river stage curve was later drafted by G. Edvy and S. Somogyi (Regional Geography of Hungary, No 3, Fig. 28, p. 87).

Compared the horizontal parts of the curve (Fig. 28) to the tectonic features of geological profiles and maps (Figs 2, 24, 25, 26 and 27) a striking similarity is apparent.

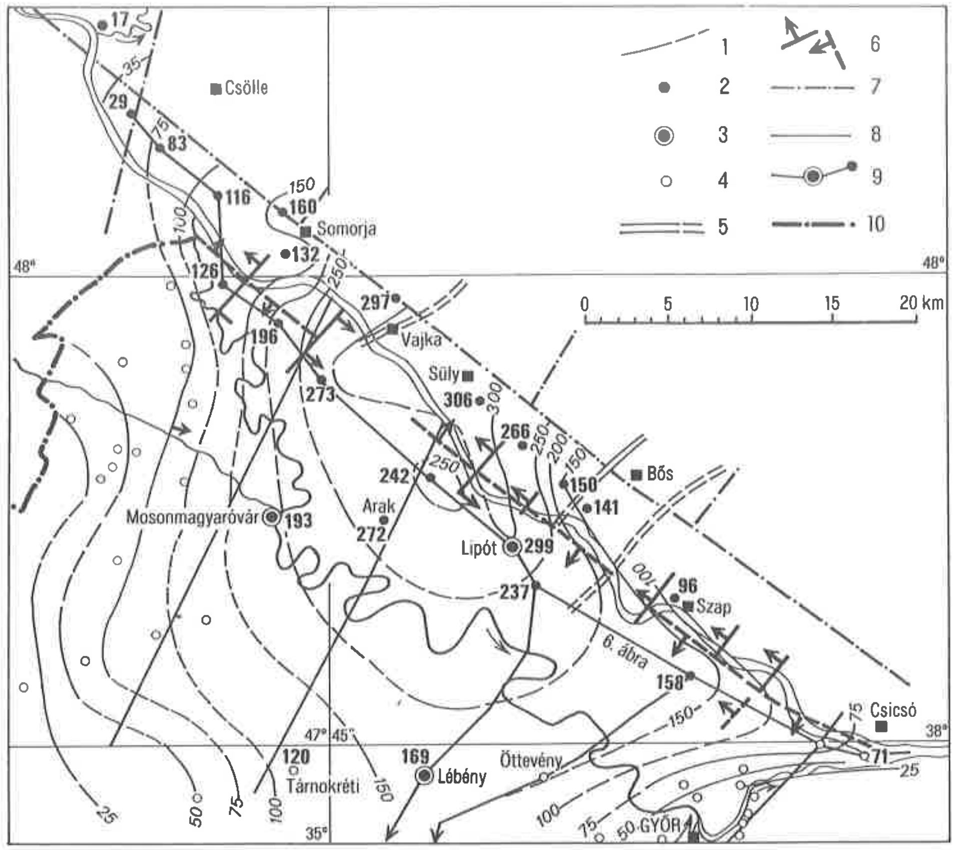


Fig. 24. Tectonic map of the Danube strip and thickness of the sand and gravel deposits, the Little Plain. *Explanation*: 1 = thickness of the deposit (m); 2 = pilot borehole; 3 = thermal well; 4 = bored well traversing the gravel deposit. Faults: 5 = by Janácek 1971; 6 = by Erdélyi 1983; 7 = by Vaskovsky 1977; 8 = based on deep seismic measurement of hydrocarbon prospection; 9 = trace of cross-section (Figs 2, 5 and 6); 10 = international border

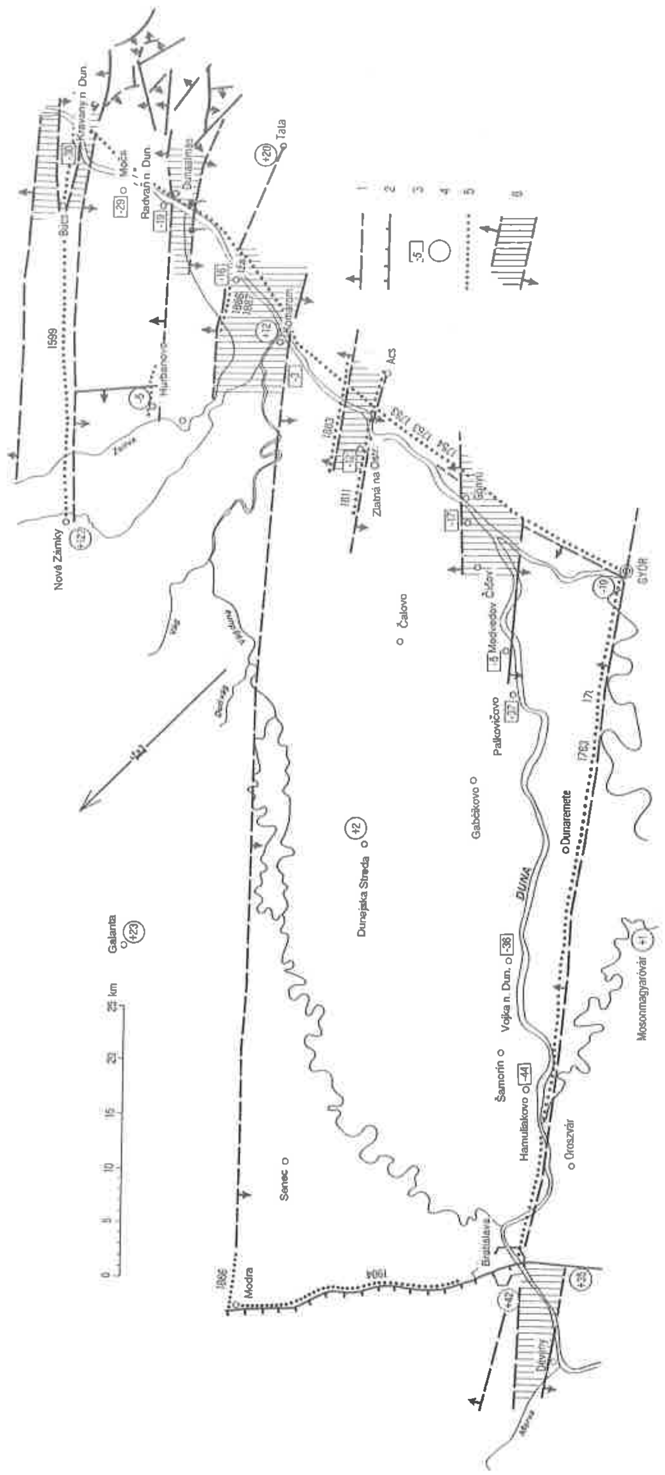


Fig. 25. Tectonic map of the Little Plain (after Cepek 1938). *Explanation*: 1 = fault; 2 = upthrust; 3 = difference between geodetic points surveyed in 1901 and 1932; 4 = gravity anomaly; 5 = fault and eathquake datum; 6 = ascending area

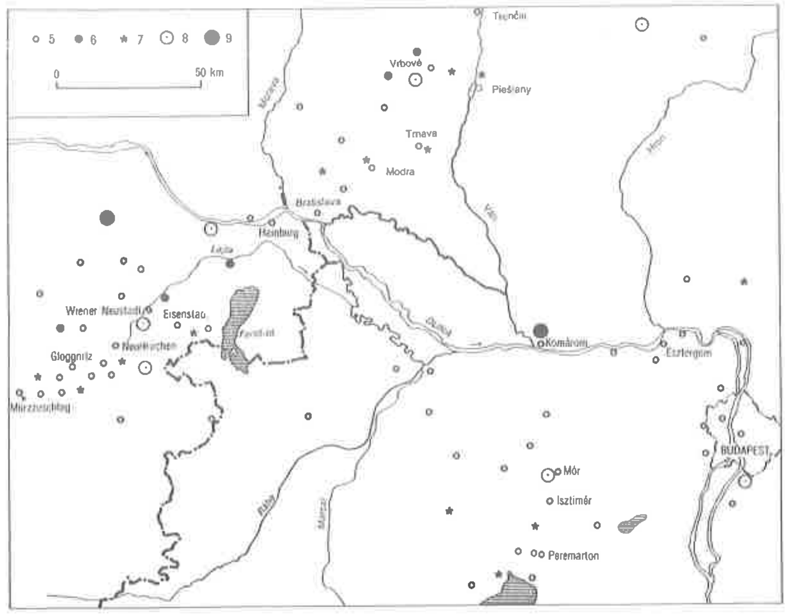


Fig. 26. Part of the seismic map of Hungary (after Mónus *et al.* 1979). *Explanation*: Points indicate the places where the degree of earthquake intensity (MSK) was higher than 5

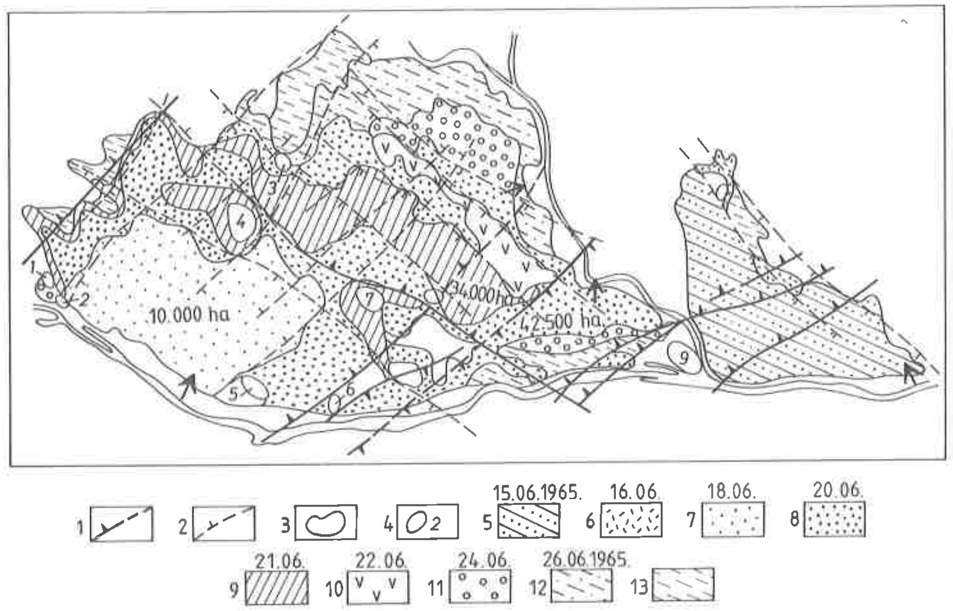
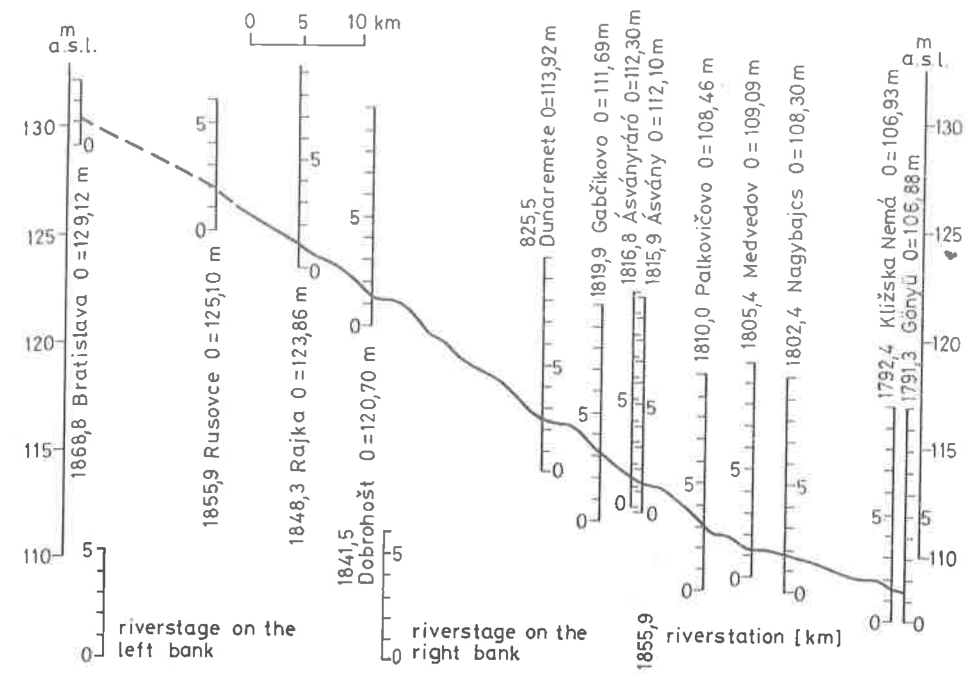


Fig. 27. Spread of the 1965 summer flood water on the Danube's left side (after Janácek 1971). *Explanation*: 1 = fault line; 2 = same supposed; 3 = area not flooded; 4 = protected area (settlements): 2 – Palkovicovo (Szap), 4 – Calovo (Nagymegyer), 9 – Komárno (Komárom); 5-12 = daily spread of the flood water; 13 = of the flooded for the longest period

Fig. 28. Multiannual lowest river stage of the Danube in 03.12.1943 (after Somogyi and Edvy 1975, in: *Regional Geography of Hungary*, Budapest, No 3, p. 87)



A multiannual lowest river stage is also suitable for structural geological analysis as well as the recent "live" faults, where the contemporaneous crustal movements are well documented (Figs 23, 25, 26 and 27).

Indirect structural geological approach was used by Janácek, who documented contemporaneous crustal movements (Fig. 27).

The investigations, started in 1943, cannot be repeated after the accomplished diversion of the Danube.

The structural activity of the Little Plain manifested itself not only in earthquakes, but very thick sedimentary structures deposited within a short time span (about 400 m during the Quaternary periods (Figs 2, 5 and 6)).

11

Disaster hazards

11.1. Geological and seismic hazards

Independent experts point out several geological and seismic hazards:

1. *"Geological and seismological documentation evaluating the Gabčikovo project as a whole is not available. The geological and seismological studies were insufficient and some necessary studies have not been undertaken at all."*

2. *"The seismic risks were underestimated. The seismicity values defined in the joint contractual plan are not acceptable."*

3. *"The Gabčikovo dam is built next to a geologically young fault. There are also additional uncertainties concerning the position of the frontier between the Alpine and Transdanubian tectonic plates.*

"The studies, dealing with the dimension design of the earth dam of the Gabčikovo Project, concluded that there are earth dam sections that would not be able to withstand an earthquake of the forecasted intensity." (Sibl, Ch. 4).

The Little Plain is prone to earthquake damages mainly in its westernmost zone, which is a part of the "Mur-Mürz Linie". This zone is the boundary between the Alps and the Western Carpathians, characterized by compression tectonics in connection with frequent earthquakes (Figs 24, 25, 26 and 27).

The deep central subsidence area of the Lowland is less prone to geological disasters. Location of fault line is uncertain because of the thick sedimentary rocks covering the rigid basement (Figs 24 and 27). Safety of the Gabčikovo barrage required the change of the planned site, and the construction was started 600 m away from a tectonic line located after the planning (Janácek 1971).

Hazards are connected also with the soil mechanical properties of the near-surface deposits. The recent and Holocene fluvial deposits are mechanically unsuitable for construction of heavy structures owing to their varied granulometric composition, which is unfavourably dense alternation of mud, silt, sand and coarse gravel. The sites of Danube barrages planned about 30 years ago were found unsafe. Granulometry of all recent Danube deposits is the same regardless whether the planned construction site is far or is just on the riverside or located even in the bed of the actual Danube.

11.2. Flood control disasters

Independent experts have found:

1. "– *New hazards will arise with the declared flood prevention advantages (e.g. dam heightening and strengthening or distribution of the large flood waters between the by-pass canal and the Old-Danube bed). One of these hazards is inherent to the permanent flooding of the reservoir area to a level higher than the all-time floodwater level.*"

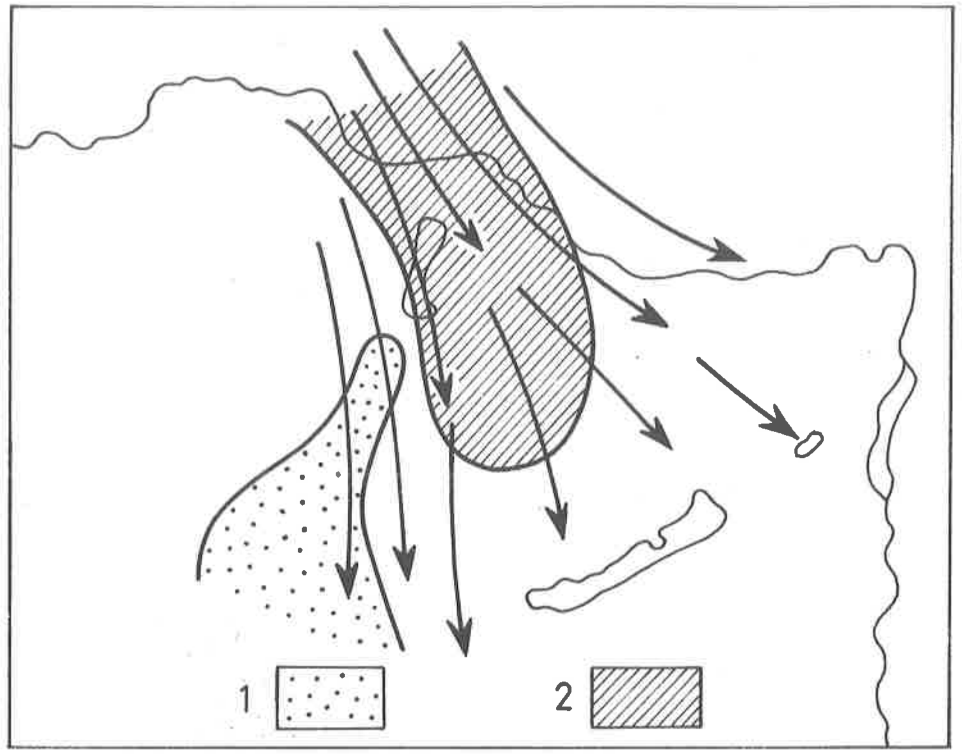


Fig. 29. Sketch of Western Hungarian wind system (after Péczely 1975, in *Regional Geography of Hungary*, Budapest, No. 3). *Explanation*: 1 = windless; 2 = windy

2. "– *Another hazard is related to the water mass of the reservoir and the elevation of the by-pass canal to 6–16 m above the surrounding terrain.*"

3. "– *The possibility of a canal bursting its banks or a dam bursting threatens the region with more disastrous flooding of undescribable dimensions.*"

4. "– *As experience from other regions shows (e.g. the Rhine, the Danube in Austria), peak floods and the danger posed by flooding will increase downstream from the power station.*"

5. "– *Because the power plant installation and river development, important natural areas that once held back the waters have now vanished. All small floods are rapidly channelled downstream. As a consequence, more frequent and higher floods occur downstream. In addition to the height of flood-waters, the form that the flooding takes also changes. Instead of a specific, given rate of flow, the sluices and floodgates at the power station are opened which causes a sudden rise of water and mud content downstream. The danger of damage increases accordingly*" (Sibl, Ch. 4).

11.3. Meteorological disaster hazards

The reservoirs, the upstream channel and the Gabčikovo barrage are critically situated from meteorological point of view (Fig. 29).

1. The direction of the straight line between the mouth of the Morava river and that of the tail-water channel is 129°–309°. This line is practically parallel to the axis of the reservoirs and the upstream channel, and perpendicular to the reservoir dams and the Gabčikovo barrage (Fig. 21). The structures were measured to resist at least to gusts of 100 km/h wind velocity.

The westernmost zone of the Little Plain is well known for frequent storms of high wind velocity.

Forty % of all winds come to the Little Plain from the NNW-N segment (315°–360°). Most of the high velocity winds of the Carpathian Basin come from the W-N segment.

The frequency and high velocity winds might be the sources of meteorological disasters.

Storm waves and ice driven by winds might cause disasters in the area of reservoirs, and the Gabčikovo barrage. The prevailing direction of high velocity winds in itself is a hazardous situation, which may be aggravated by the shallow water in the reservoirs and the power canal. Further hazards are the lack of the lock-gate on the upper end of the upstream channel and the unsafe connection to the old Danube; the danger is even greater when masses of water and ice must pass to the old bed in a short time and often in bad weather.

Multiannual data of the Danube ice at the Bratislava river station are as follows (Study... 1985).

Frequency of years with ice	94%.
Frequency of years with ice cover (ice jam)	32%.
Average duration of ice in years with ice	40 days.
Average duration of ice jam in years with ice	30 days.
Average date of the first ice	15th of November.
Average date of the last ice	15th of April.

Statistical analyses of wind directions measured at the following meteorological stations: Győr, Mosonmagyaróvár, Pápa and Dunakiliti

For estimation of maximum wind velocities of the various return periods (10, 20, 50, 100, 200 years) the design values were calculated with the best method available at present (Faragó and Katz 1990):

In the 10-year return period highest velocity of gusts may be 28–32 m/s (110–115 km/h) and in the 50-year period 33–40 m/s (120–140 km/h).

Near to the flat land surface winds coming from the W-N direction segment may also show higher velocities.

More than 90% of gusts over 25 m/s velocity belong to the W-N direction segment, but the majority of wind directions belongs to the NW-N segment.

Analyses of duration of 25–30 m/s gusts in the last 10 years has revealed:

1. Consecutive 25 m/s velocities occurred over 22 hrs, and the 30 m/s velocities over 5 hrs.

2. The 40 m/s gusts occur in tempests of a few hours duration or for 10–15 minutes at the peak of sudden wind storms. (I am indebted to Dr Cs. Nemes for his valuable advice and written expert opinion.)

11.4. Disaster hazards of human origin

The Gabčikovo-Nagymaros barrage project was a high level professional work in all respects.

The delays, disastrous situations etc., occurring in the course of construction, are mostly of human origin. Contraselection – not the right man on the right place, group interests (party, family, nationalistic) – prevailing laxity, imperfect control, frequent errors, negligence, undisciplined behaviour etc. were common in every communist regime (Finta 1990, Sibl 1993). Poor working conditions aggravated by bad weather are also responsible for many of the failures.

The forced tempo of construction was further aggravated by socialist competition in order to finish plans ahead of schedule. Number of delays and accidents

increased proportionally with the softening of the regime climaxed in the second half of the decade prior to 1989.

"The dam builders cite the high quality of construction works done at the Gabčikovo Project and their high safety standard."

Independent experts have found:

"... The manner of construction has been slipshod and, to some extent, unplanned or undertaken without due regard to the plans.

"... There are more indications and signs (e.g. flaws and cracks in the dam wall and canal, the halt in the prefilling of the canal with water in August 1991), which indicate that the project does not comply with the required specifications concerning structural stability."

"... Independent engineers and safety specialists, as well as people, formerly working on the project, have repeatedly expressed their misgiving in this respect, and considered an immediate examination and verification of the entire, installation to be an absolute necessity" (Sibl 1993, Ch. 4).

12

Short history of the Danube barrage concepts

Professor G. Pattantyús Ábrahám (Technical University, Budapest) said the following in 1937 while lecturing on turbines. The generation of electricity in Hungary is practically very far from being economical in spite of high discharge rates of the large lowland rivers. Cost of barrage construction is very high, quantity of the generated electricity is low compared with the costs, therefore uneconomical.

There is one exception, the Danube Bend area where construction of power plant seemed to be feasible, in spite of the low efficiency in generation of peak electricity. Costs of barrage construction amounts from 60 to 90% of the total expenditure. His lectures were later published in lecture notes.

12.1. Concept of barrages in the Danube bed at the Hungarian–Czecho-Slovakian boundary

The main obstacle of construction was allegedly the loose gravel ground, which was unfit for the safe foundation of large and heavy structures. The advanced packing methods and materials in the 1950s and 1960s were either unknown here or very expensive or inaccessible, and probably of strategic value. This project was given up. Instead of this scheme the alternative became the Gabčikovo-Nagymaros barrage system, based on the international treaty of 1977.

Another disadvantages are the high costs of operation and maintenance, yearly 2–3% of the total expenditure.

Professor E. Mosonyi, describing the known Krembs power plant on the Rhine, where the navigation lock and power plant are side by side, emphasized that the interests of the navigation were decisive in the selection of the building site. In this case political arguments decided in favour of an obviously uneconomical project (Mosonyi 1952, Vol. I. p. 152, Fig. 98).

12.2. Project of the pumped storage plant at Visegrád in the Danube Bend

This alternative project was prepared by a team headed by I. Szeredi of the VIZITERV planning bureau in Budapest. The plan of the project was finished in 1989 (Szeredi 1988, 1989).

The Prédikálószék project was qualified "confidential", therefore not accessible for outsiders. This measure was probably taken in order to prevent competition with the Gabčikovo project, which was then under forced tempo of construction. The Prédikálószék project has many advantages compared with the Gabčikovo system:

1. The selected site is a block of hard volcanic rocks without faults. The major fault lines and rock boundaries are far from the planned site of the power plant (Fig. 18).

2. Favourable rock mechanical properties guarantee safety during construction as well as later in operation.

3. Output of the 4 × 320 MW plant in a 8.3 hr/day operation time is 1200 MW. For comparison: maximal output of the Gabčikovo power plant is 740 MW at the beginning of the planned peak, and 630 MW at the end of the peak.

4. The production of peak energy is possible during the whole year, while in Gabčikovo the output depends on many unforeseeable factors. Other disadvantages of Gabčikovo: (1) in winter the output is low at a time when peak energy is badly needed, (2) high output in summer when there is lesser demand.

5. Lower construction and maintenance costs compared to Gabčikovo.

6. Less hazards of stopping or delaying the operation, contrary to the Gabčikovo barrage system, where natural factors, e.g. low flow rate and ice may interrupt or delay the output. Disastrous consequences may also occur there by break of thick ice accompanied by gusts of high-velocity wind (over 100 km/hr).

Construction of two other pumped storage plants seems also feasible (Table 2 in Szeredi 1988).

Table 2. The main date of the projected plants

Site	Elevation difference (m)	Specific costs of investments (%)	Value of energy (%)	Claim of area (%)
Öreg-Paphegy	400	121	92	162
Szt. László-hegy	460	121	92	144
Prédikálószék	510	100	100	100

12.3. Economic recession of the 1980s

The economic recession in the first half of the decade did not favour the building of large-scale water resource development structures. The Austrian concerns interested in hydraulic engineering were looking for future construction sites after executing building a number of excellent hydraulic engineering installations, among others a series of Danube barrages. Interests of the Czecho-Slovakian and Hungarian hydraulic engineering companies coincided with those of the Austrians. In this situation all welcomed the offered opportunity of a profitable large-scale project.

12.4. Optimistic presentation of the barrage project

The manual of effects on the environment is a long list of optimistic views concerning flood protection, power generation, navigation, water supply, agriculture and the general improvement of the natural and human environment (Study... 1985). The unforeseeable disastrous effects, which may occur during the construction and after the completion of the system, were concealed or overlooked. Few publication passed the control of redactors at the time of softening political atmosphere. In spite of the lessening pressure the principle "*Audiatur et altera pars*" was rarely accepted.

Authors in their restrained critiques discussed the predictable losses and disasters. The views expressed by L. Somlyódy in his expert opinion were less optimistic. He also discussed alternative solutions for problems already well known at that time (1990), when the Czecho-Slovakian–Hungarian international treaty could have been terminated under favourable condition, immediately after the stopping of construction at the Nagymaros barrage site (1989). Omission of this opportunity was comprehensible owing to the euphoria of the political change of regime as well as to the survival of personal and economic interests discussed above.

12.5. Overestimated potentials of power generation and navigation

The planned energy potential at the Gabčikovo barrage is low: 740 MW at the beginning, and 630 MW at the end of the period of the peak-energy production. The daily maximum at Nagymaros was planned 180 MW and the minimum 64 MW, depending on the flow rate of the Danube (Szeredi 1988).

The summer flow rates are high, when the energy demand is low. Low flow rates are characteristic for the winter half-year when the energy demand is high. The following data were taken from the Bratislava river discharge records 1955-64:

A) average monthly min.
- (1) below 1000 m^3/s: (I, II, X, XI, XII),
- (2) between 1000 and 2000 m^3/s: (III, IV, V, VI, VII, VIII, IX)

B) av. monthly max.:
- (1) between 2000 and 3000 m^3/s: (I, IX, X, XI, XII),
- (2) between 3000 and 4000 m^3/s: (II, III, IV, V, VI, VII, VIII).

Flow rate required for economical energy production is a minimum of 2000 m^3/s discharge. The minimum swallow of the turbine is 400 m^3/s.

Only 1.2% of the energy demand (3% of the electric energy) of Hungary will be supplied by the planned barrage system in 2000 (MTA 1983). Cost of building makes impossible the application of economical energy production. Owing to the specific structure of the Hungarian energy industry and the operation methods of the barrage system, the country requires use of surplus petroleum products equivalent of yearly 230,000 metric tons of fuel oil (MTA 1983).

The planned production of the Gabčikovo power plant is disproportionate to the enormous costs of construction and operation. (BME = Protocol of the meeting held at Budapest Technical University 18.03.1983, p. 72).

The annual Meeting of the Association of Hungarian Architects passed a resolution for revision of planning and deadline of the barrage systems treaty. This treaty was signed with the rational of an earlier extensive view of economic development, without considering the requirements of settlements and environment.

12.6. Navigation

Between Rajka and Gönyű (river stations 1869 km and 1792 km) the construction of local river ports will be impossible. Economic and touristic development of a 29 km riversection will be retarded.

When the Austrian barrages were compared with the Gabčikovo barrage project a common misleading official opinion was put forward. It is enough to consider the length of time and the mass of storage capacity of the Austrian barrages and compare them with the Gabčikovo system (Fig. 21). This practice served the misinformation of the general public. It is well known that the Austrian reach of the Danube river is a series of incised (antecedent) valley gaps with a number of canyon-like passes, which are extremely suitable for economically rewarding storage of the Danube water. In Austria there are no unforeseen disaster hazards. There is real danger in the Little Plain because of the elevated power canal on a lowland (discussed in Ch. 11).

12.6.1. Alternative navigation route of the Gabcikovo barrage system

Provisions are being made for alternative routes in projecting a speedway to connect the already existing roads.

The same should have been done with the new Danube navigation route of the Gabčikovo barrage system. At present the "new Danube" has no alternative navigation potential, although natural and other disasters cannot be excluded in this area (see Ch. 11).

All the Danube countries will be losers as a consequence of the lack of an alternative navigation route if some unpredictable natural disaster occurred and blocked the new Danube route through the Gabčikovo barrage system. Both Czecho-Slovakia and Hungary will be equally affected. Which partner will be responsible for the accidental disasters? Evidently the national planning bureaus and the builders as well as the authorities responsible for the operation of the system.

The old Danube bed should be preserved in its state at the end of 1992. The abandoned main bed may be an equivalent alternative navigation route if the planned rock-fill dams will not be built in the old Danube bed.

12.7. Miscellaneous

A long upsetting Soviet colour movie demonstrated the immense human miseries and environmental destructions derived from the construction of huge reservoirs. This movie was shown in Hungary only for a few times before 1989, and not at all since then. It was also a method of keeping the public uninformed. The same was the fate of a Hungarian picture titled "*Dunasaurus*".

Well-known Soviet scientists and scholars (e.g. Rushputin and Zaligin among others) turned the spotlight of publicity on the damages and misinformations concerning the reservoirs, published mainly in the periodicals "Soviet Science" and the "Soviet Literature". More Hungarian and fewer Czecho-Slovakian publications dealt with the same problems simultaneously, but with less success owing to long delays in printing of periodicals of limited circulation. Very often the redactors of technical papers were also responsible for the delayed publications in Hungary.

13

Losses and gains – Summary

Loss of the Danube river discharge without alternative river water reserves (Fig. 30).

Loss of 38 km riversection, one million m^3/day bank-filtered reserves (Hungary) and about two million m^3/day (Czecho-Slovakia) (Fig. 31).

Loss of groundwater recharge will induce substantial sinking of the water table (Fig. 32). The slow moving groundwater is practically unable to freshen up and carry the polluted groundwater to the discharge belts (Hanság and Maly Dunaj), and hence it is removed from the flow-system.

Water quality. There is a considerable time lag between the development of the piped water system and sewage treatment which might help to survive the most perilous current practice threatening large territories that is the disposal of sewage into unused dug and drilled wells.

The loss of 38 km riverside suitable for extraction of acceptable quality and large quantity of bank-filtered water, this will result in the almost total loss of the dynamic recharge of the groundwater reservoirs of 7–8 km^3 in Czecho-Slovakia and 5.4 km^3 in Hungary.

Czecho-Slovakia will gain:

1. 50 + 50 m^3/s groundwater from the seepage canals constructed along both sides of the power canal.

2. Withdrawal of planned 600,000 m^3/day from the gravel aquifers on the tail-water channel area in Czecho-Slovakia.

The pumped water should be treated because of the contaminants which took their origin in the upstream reservoirs and power canal. During the operation of the barrage, the water of the area downstream will also be polluted because of the slow seeping groundwater into the zone of the old Danube bed.

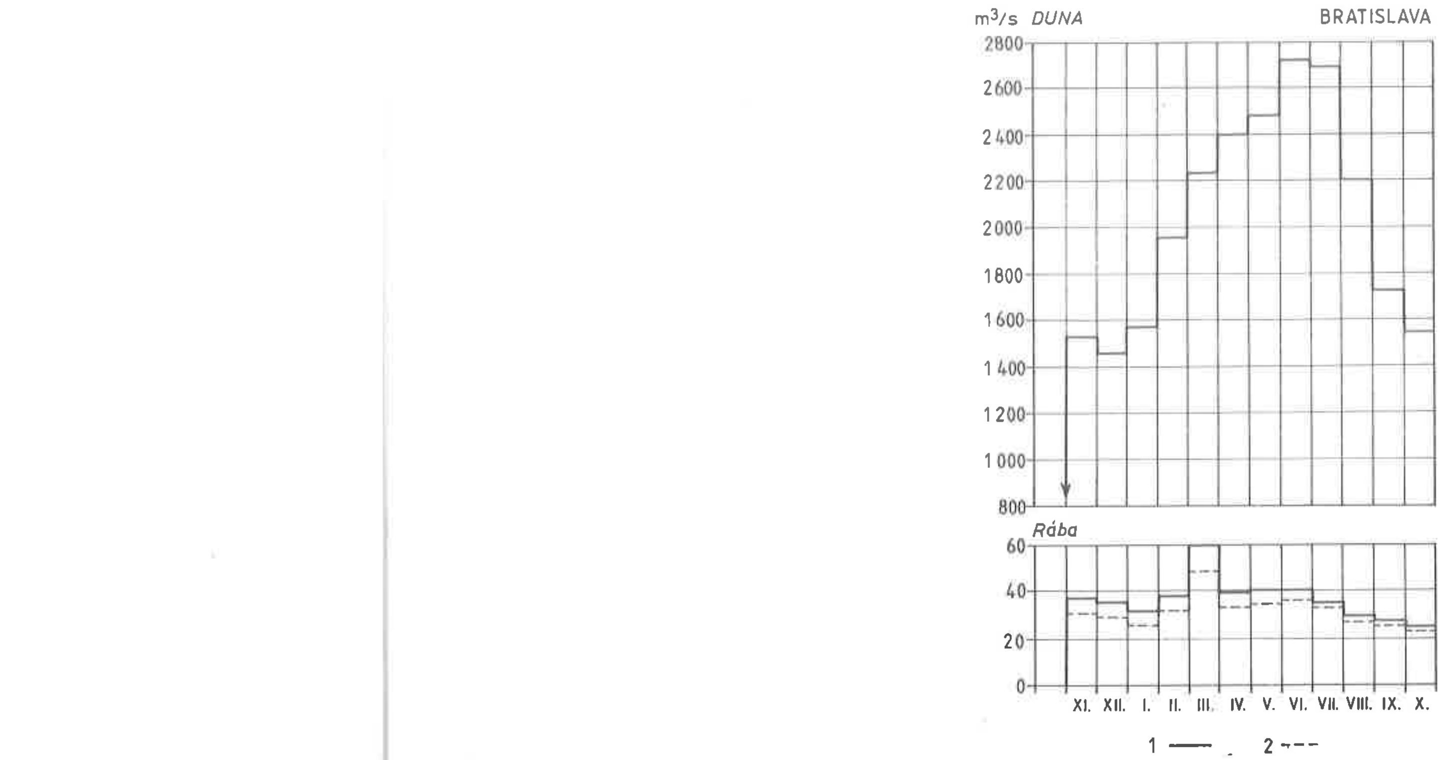


Fig. 30. Monthly average discharges at Bratislava and Rába river 1931-1958 (after Károlyi 1975, in *Regional Geography of Hungary*, Budapest, No. 3, p. 103). *Explanation*: 1 = at Sárvár; 2 = at Körmend

3. Possibility of taking water directly for Hungary out of the navigation canal will be impossible.

Hungary will have almost no gains:

1. Groundwater of the gravel will loose its high seepage velocity with its inevitable consequences: the quick quality deterioration and sinking water level.

2. Discharge of the Mosoni-Duna will also be little and uncertain.

3. The Dunakiliti reservoir, a shallow and almost standing water body will contain very low quality water. The lowest water quality of the reservoir is expected in a zone between the southern dike and the baffle built in the reservoir for navigation purposes. The former main river bed is the deepest zone of the reservoir, a trap, into which the current will carry proportionally the greatest part of the bedload silt. Will the Mosoni-Duna be supplied from this sluggish and very much polluted water?

The seepage canal along the southern dike of the Dunakiliti reservoir may supply acceptable quality water as long as the accumulating silt will stop the seepage from the reservoir basin.

Data of the Dunakiliti reservoir: area 45 km^2, capacity 180 million m^3, when the head-water level is 131.1 m a.s.l. The bedload carried to the reservoir is about 0.6 million m^3/yr. The mass of the deposited silt may be estimated at 2–3 million m^3/yr, depending on the rapid increase of the density of algal growth. The time of the upsilting of the reservoir cannot therefore be estimated.

The necessity of dredging the rapidly accumulating sludge on the bottom will be a burden on both parties. Where can we find a suitable place for disposal of the large mass of toxic sludge on the densely populated agricultural and industrial terrain? Hungary will loose more. The higher accumulation rate of the more toxic silt will produce disproportionately larger volume of sludge on the Hungarian side because of the sluggish water.

The toxic soil, and material imported to Hegyeshalom from Austria about a decade ago supply useful information concerning the future problems of reservoirs. In case this materials will be analysed soon.

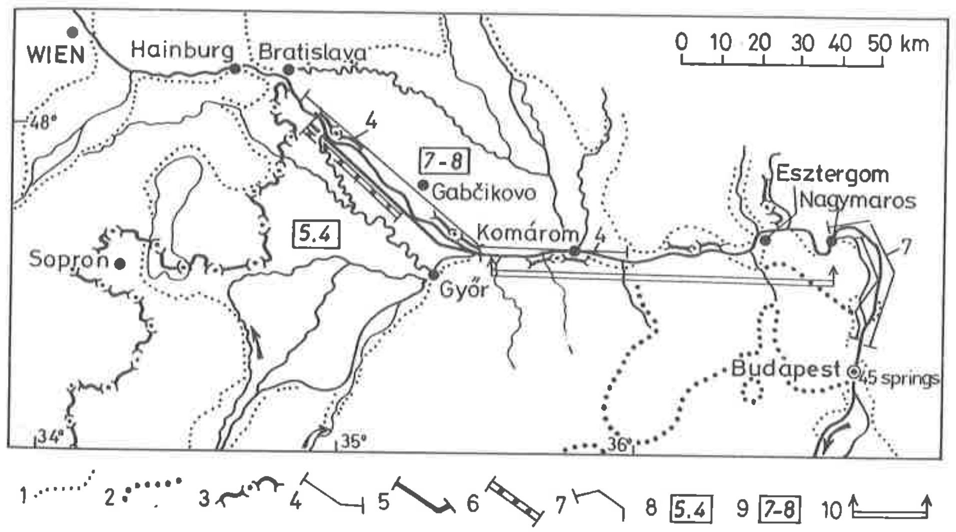


Fig. 31. Water reserves along the Danube river (Erdélyi 1989a). *Explanation*: 1 = border of the Little Plain; 2 = border of the karst water area; 3 = international boundary. River-bank-filtered reserves: 4 = northern Danube riverside (approximately 2 million m^3/day; 5 = southern Danube riverside: one million m^3/day; 6 = 0.75 million m^3/day (OVH 1984); 7 = Szentendre Island (upstream Budapest). Groundwater reserves stored in gravel aquifers: 8 = southern half, the Little Plain (5.4 km^3, Erdélyi 1983); 9 = northern half, the Little Plain (7-8 km^3, Erdélyi 1989*a*); 10 = riverside susceptible to water pollution by the planned Nagymaros barrage

13.1. Another disaster hazard for Hungary

In case of a sudden, unexpected flood coming from the upstream area, including both reservoirs (Dunakiliti and Čunovo), large areas will be covered by water.

The power canal will serve as flood protection levee for the Czecho-Slovakian left side area of the shut off main Danube bed with the exception of three villages on the left side of the old Danube bed.

Contrary to this favourable situation in Czecho-Slovakia, Hungary on the right side will suffer all the future losses.

Hungary will be compelled to maintain and improve the existing right side flood protection dam. This will be a continuous economical burden for Hungary.

Agriculture will be the main loser: Lack or shortage of cheap irrigation water, decreasing well pumping rates, progressing quality deterioration will compel the construction and operation of groundwater recharge systems. Source of common miseries in the future will be: (1) the dubious efficiency of the recharging networks, (2) increasing costs of the unavoidable irrigation.

The Hungarian agriculture will be the main loser owing to the loss of its cheep water reserves. Czecho-Slovakia will be in a much better position. Intake of water from the head-water power canal for agriculture will be a cheep source.

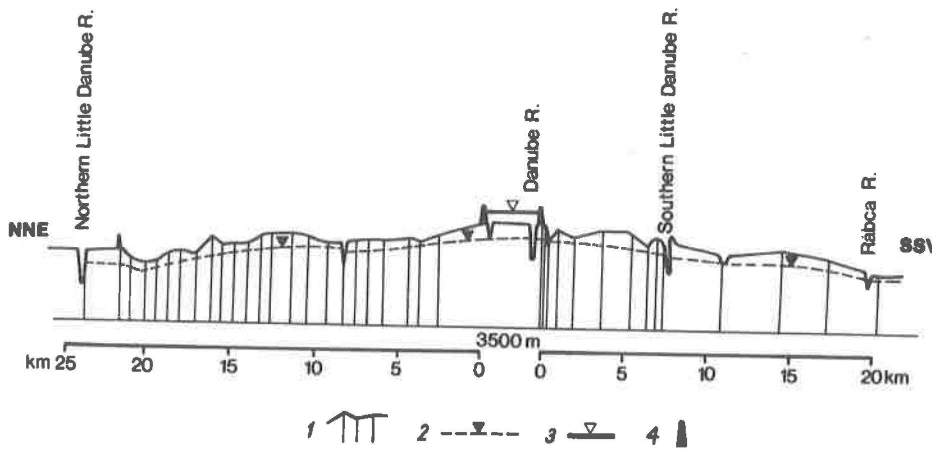


Fig. 32. Groundwater profile (Czecho-Slovakian source 1981, in Erdélyi 1990) based on testhole data. *Explanation:* 1 = testhole; 2 = average groundwater level; 3 = calculated groundwater level after completion of the Gabčikovo (Bős) barrage; 4 = flood protection levee

The great areal loss of high quality soils and the immense rehabilitation costs of the construction sites and the contaminated areas around the material depots will be long lasting burdens on the Czecho-Slovakian national economy. Salt accumulation in the topsoil appeared already in Czecho-Slovakia which is a concomitant phenomenon of the disturbed natural equilibrium. The Váh barrage and the Hungarian Tiszalök barrage both built on lowland terrain provided abundant proof of water contamination and other miseries, e.g. the rising groundwater level and accumulation of excess water and salt accumulation in the topsoil by capillary water transport.

13.2. Destruction of the Old Danube Zone

The aftermaths of the Danube diversion were already discussed above.

The unnatural and brutal change of the water regime of the Little Plain will also damage both national economies and the public health by making impossible to develop the needed areas of recreation, aquatic sports, fishing and angling as well as the construction of ports for purposes of local navigation.

The 1977 international treaty unfortunately did not make obligatory for the contracting parties the high technique sewage treatment of the Danube watershed on their respective territories.

The arrival of the highly toxic water of the Morava will be equally disastrous for both partners. After the split up of Czecho-Slovakia the sewage treatment of the total Morava watershed cannot be expected from the new Czech Republic. The main losers will be the Budapest Waterworks and to a lesser degree all downstream countries to the Black Sea.

The old Danube bed will soon be turned into a series of swamps with uncertain water regime dependent on the new Danube. It will soon be a neglected, mosquito infested area of overgrown river bed unsuitable for recreation, water sport, angling, hunting and commercial forestry.

It will also collect highly toxic water, will be a refuse dump of the local communities and used for disposing agricultural and industrial wastes and all kinds of rubbish.

Environmental impacts

"The dam builders conclude that the Gabčikovo project will enhance the environment."

Independent experts have found:

"... Nowhere in Europe is a more reckless or devastating river construction project than at Gabčikovo. According to the International Rivers Network (IRN), it is among the top ten most environmentally destructive hydraulic engineering projects in the world.

"*... No complex environmental impact assessment study has been done neither on Variant C nor on the original Gabčikovo project, although it was required by Czecho-Slovak Federal Environmental Act No 17/1992.*

... The Slovak dam-builders' conclusions are inadequate, misleading, and irresponsible because they intentionally neglected the extensive environmental destruction caused by the construction and operation of the Gabčikovo project" (Sibl, Ch. 4).

14

The state of the Hungarian water reserves – Summary

Quantity of freshwater reserves of the Earth is more or less constant and unevenly distributed.

"*More than half of fresh-water reserves of Hungary are located in or near the Danube. If these are lost or polluted, Hungary will be one of the countries hit by water deficit sometime after the year 2000, according to the WHO*" (Sibl, Ch. 6.4).

Quality of the freshwater reserves has rapidly been deteriorated in the last five-six decades as a consequence of a slow change of the public way of looking at water. Consequence of this attitude is the wide gap between the negligence and protection of water reserves.

There are considerable differences in the length of time needed for the fundamental improvement of water quality.

14.1. Surface waters

Stream and runoff water may show rapidly improving quality shortly after the contamination ceased.

Water of lakes, reservoirs, marshes, bogs, swamps as well as back-waters need a longer period for the improvement of the water body. Silt deposited on bottom of the lakes (etc.) contains the contaminants of the water, which flowed into the lakes and other standing water bodies, or contaminants originating locally in the aquatic environment (e.g. by way of algal growth). The toxic substances of the silt on the bottom of the reservoirs may be carried away in the case of a disaster (e.g. breaking of dike) or by way of the bottom outlet.

14.2. Subsurface waters

14.2.1. Shallow groundwater

The shallow groundwater may be contaminated directly by seepage of surface waters from the land and surface soil and from the polluted water of gutter, cesspool, septic tank, refuse dump etc., as well as from fertilizers and other toxic substances used in agriculture. Most susceptible is the groundwater for inflow from land surfaces, where there is no impermeable or poorly permeable soil on top of the aquifer, e.g. loose gravel and sand (e.g. dune sand) terrains (Fig. 1). Groundwater of such areas listed above, are also susceptible for long-lasting contamination where the groundwater moves downward in the subsurface space. These are the groundwater recharge areas characterized by negative hydrodynamic gradients.

14.2.2. Karst water

Water of karst terrains are the most susceptible for contamination where the soil and/or cover rock formations are thin or discontinuous. Most of the precipitation water flows down into the highly permeable subsurface space. The large cavities (sink holes, caves, karst tunnels etc.) are the paths of the moving karst water. There are karst terrains, e.g. chalk (friable limestone) or pulverized dolomite, where the karst water moves slowly, as does in the clastic sedimentary rocks (well sorted pure sand and loose gravel).

There are two types of karst water movement: turbulent movement in caves etc., and seepage in fault and similar tectonic features filled by rock debris.

The karst groundwater is being quickly exchanged owing to its high velocity movement. This way the pollutants may also be removed by way of the karst springs.

14.2.3. Deep groundwater

Deep (artesian) groundwater moves slowly, therefore in most cases a long geological time is needed to displace (push out, drive out) the polluted deep groundwater. The average seepage velocity of the deep groundwater of the recharge area is 20–25 m/yr in Hungary, but higher values are also very common. Isotope methods of absolute age determination supplied a number of more reliable data on the seepage velocities of deep groundwater (Slute and Deák 1989).

The author investigated man-made deterioration in a number of cases and summed up his findings as follows (Erdélyi 1980).

The most common quality deterioration of the deep groundwater has been caused by mixing of waters of various chemical composition and pressure owing to well failures.

The most common failures are:

1. Communication of water of different pressures occurs between the casing and the wall of the annular space of the borehole because of lacking or/and improper cementing.
2. Communication of waters due to the corrosion of casing.
3. Leaking through stuffing boxes.
4. Water moving down from the surface through leaking grouting and as a consequence of neglected well sites, which cause seepage from the polluted groundwater. The danger is more serious in areas where the pressure heads are decreasing with depth, which is typical for the groundwater recharge areas.

The effects of the above listed well failures may cause serious consequences both in water quality and in the well discharge rate if the pumping is being strained. The overcharge of extraction will soon lead to stopping of the pumping and closing the well.

5. The abandoned deep exploratory boreholes drilled for hydrocarbon prospecting may also cause serious pollution of deep groundwater. In such bores the water of higher pressure and salinity moves upward and mixes with the water of lesser pressure in the shallow aquifer. In many cases the salt content of the potable artesian water has been considerably increased and became unsuitable for drinking.

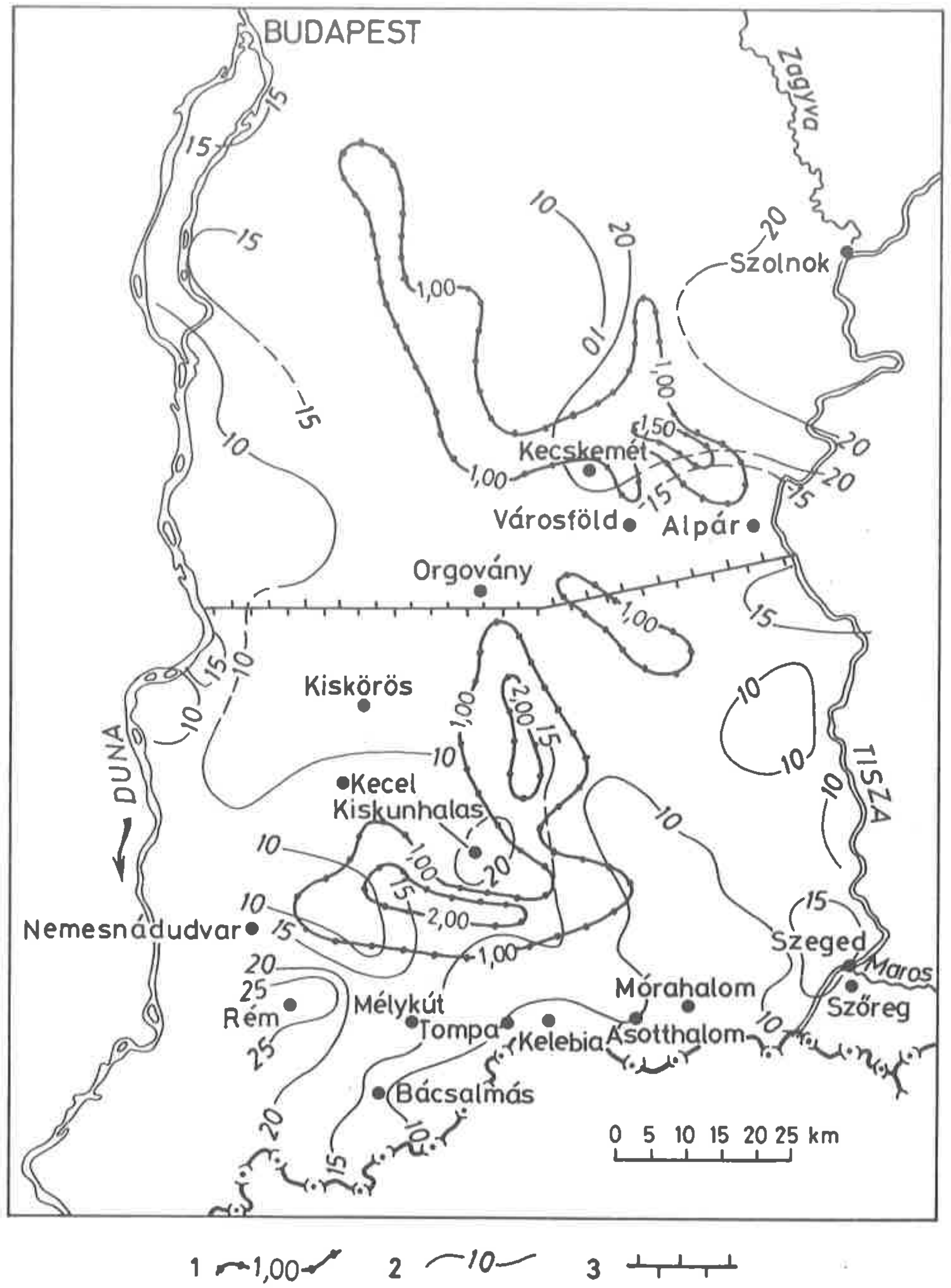
Nitrate content over 40 mg/l was also common in the water pumped from aquifers at 100–140 m depth in the recharge areas of the deep groundwater (Erdélyi 1980). I suppose that this kind of deterioration of the deep groundwater has been increased since the 1970s, when the author investigated the quality of artesian groundwater in the Danube–Tisza interfluve (Erdélyi 1980).

14.3.4. Excessive arsenic content of the artesian water

The newest known health hazard in Hungary is the excessive arsenic content (above 50 μg/l) of the artesian water in the 5700 km^2 Trans–Tisza area (Figs 35 and 36) and within the Danube–Tisza interfluve in a 1270 km^2 belt parallel to the Yugoslavian–Hungarian frontier (Erdélyi 1986, 1991). The arsenic content of the deep artesian water is of geological origin and known from the early nineteen seventies but was declared "secret material" up to about 1980.

The allowed highest arsenic content of the drinking water is 50 μg/l (US EPA 1976). The arsenic content may be increased by the overpumping of the aquifer according to water management experts (discussed in Erdélyi 1991*b*).

Fig. 33. Decreased level (m) of the shallow and deep groundwater (after Berényi and Erdélyi 1990). *Explanation*: 1 = shallow groundwater; 2 = deep groundwater; 3 = trace of a planned Danube-Tisza canal



14.3. Losses caused by long lasting drought

The drought, started in 1980–81, had also grave consequences. The vertical distance between the shallow groundwater table and the pumping level of the deep groundwater was increasing according to weekly head measurements of a 10-year-long monitoring program, Figure 33 (Berényi and Erdélyi 1990). Considerable areas of vineyards, orchards and planted woods suffered serious losses.

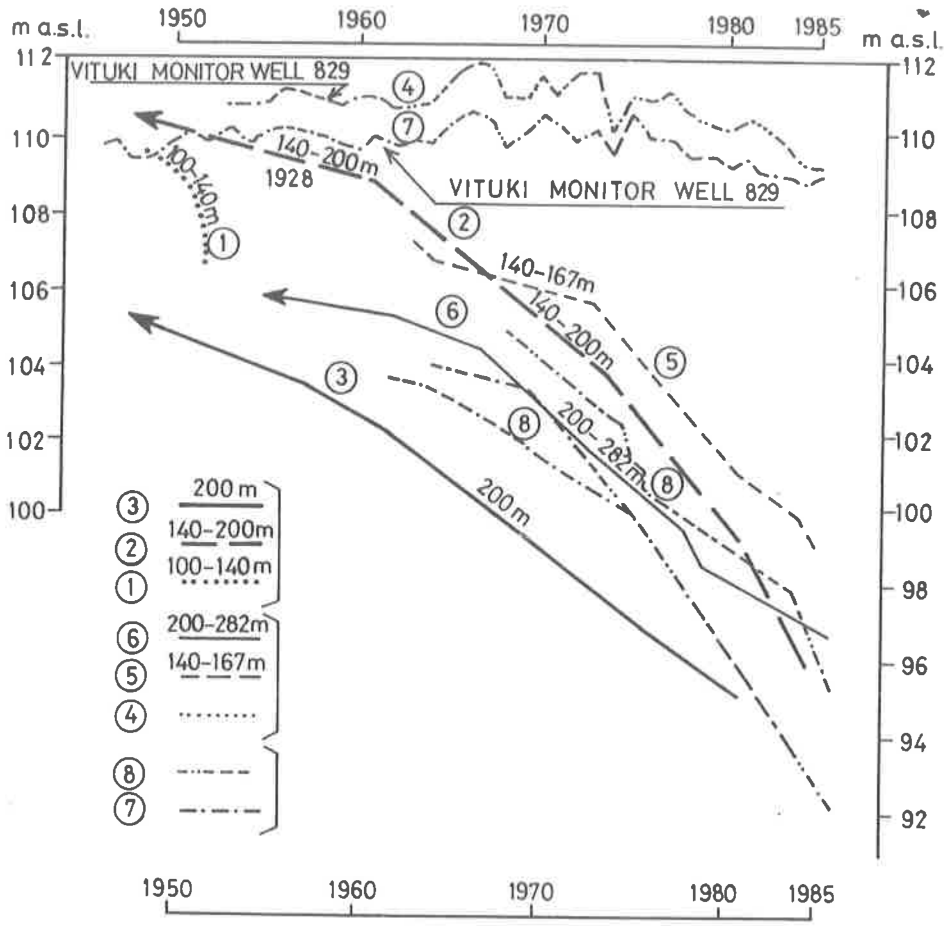


Fig. 34. Sinking of groundwater level in the monitor wells above sea level, Kecskemét Waterworks (Berényi and Erdélyi 1990). *Explanation*: Town area: 1-3 = artesian water. Western Waterworks: 4 = shallow groundwater; 5 and 6 = artesian water. Southeastern Waterworks: 7 = shallow groundwater; 8 = artesian water (starting point of piped water supply is indicated by an upright-down arrow on the scale of years)

Yields were decreasing with the passing of time. Year after year the area of drying out vineyards, orchards and woods increased. At present it is impossible to stop these losses because of lack or scarcity of irrigation water, and long drought.

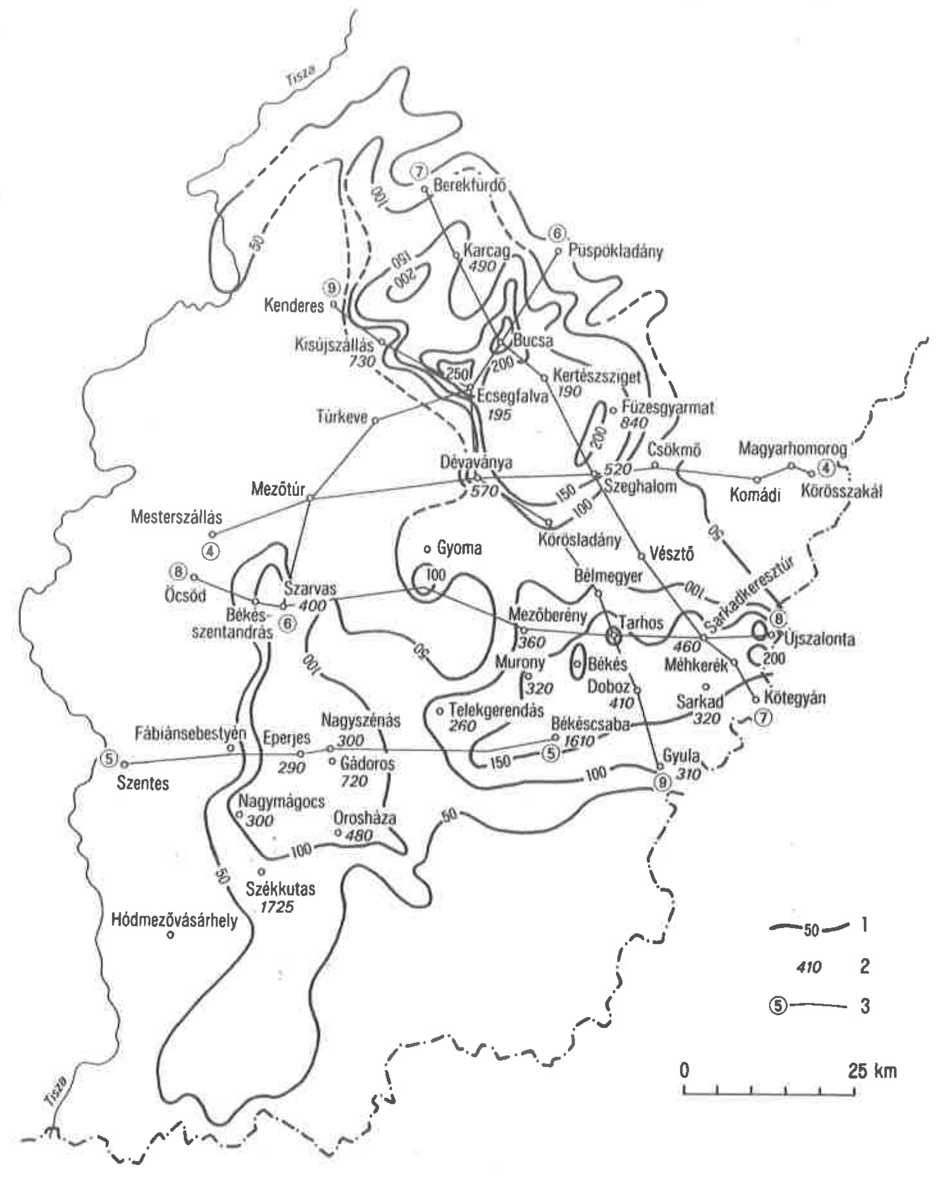


Fig. 35. Arsenic content of the artesian water, the Great Plain (Erdélyi 1991). *Explanation*: 1 = arsenic content (μg/l); 2 = known depth (m) of arsenic content over 50 μg/l; 3 = trace of cross-sections: 4 – Fig. 36*a*; 5 – Fig. 36*a*; 9 – Fig. 36*c*.

The natural loss of infiltration combined with increased water demand started in Hungary around the second half of the 1950s, when the development of piped water supply networks was rapidly increased (Fig. 33).

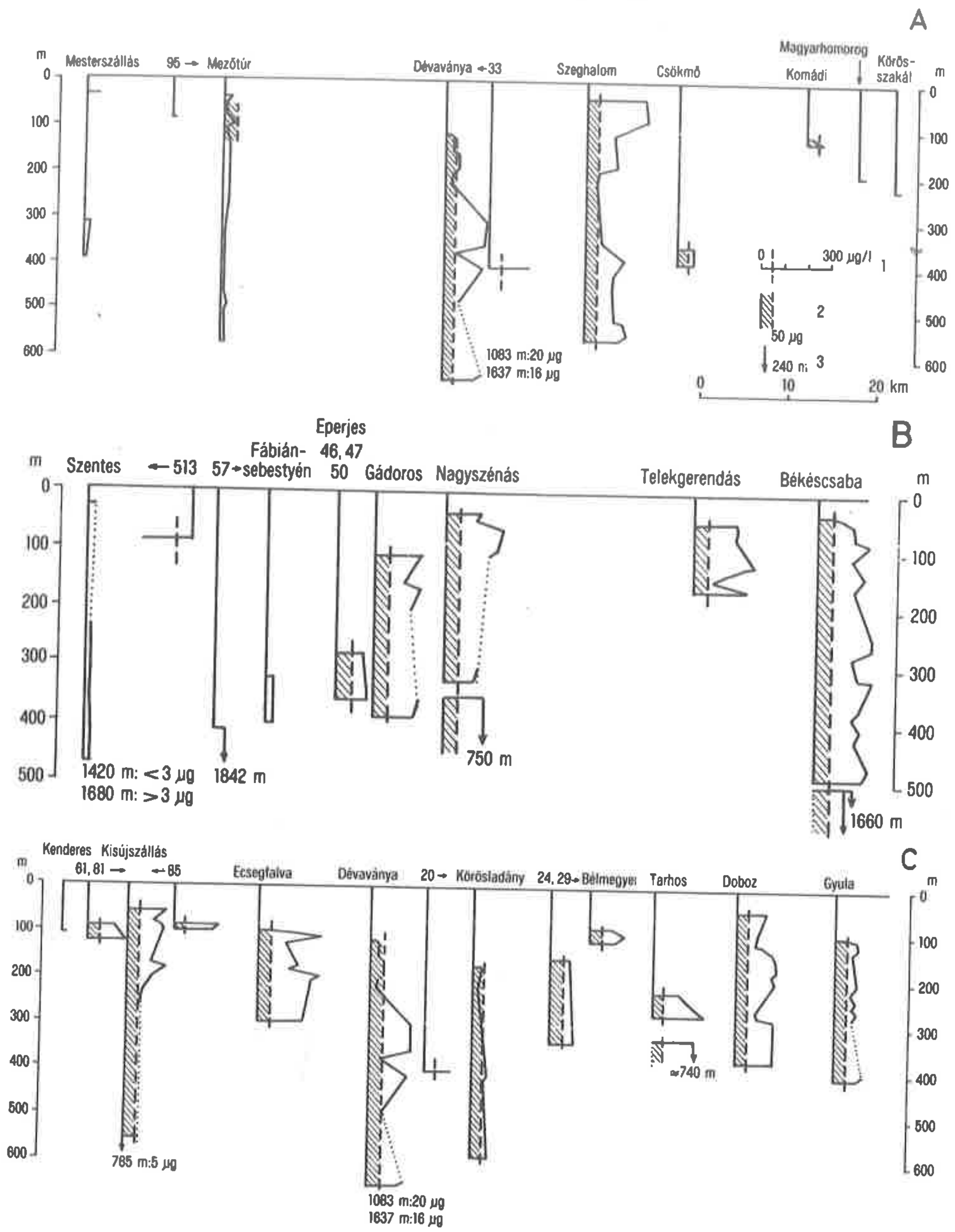


Fig. 36. Distribution of the arsenic content in the subsurface space, the Great Plain (Erdélyi 1991). *Explanation*: 1 = arsenic content (μg/l); 2 = acceptable arsenic content (μg/l); 3 = depth of bored well (m)

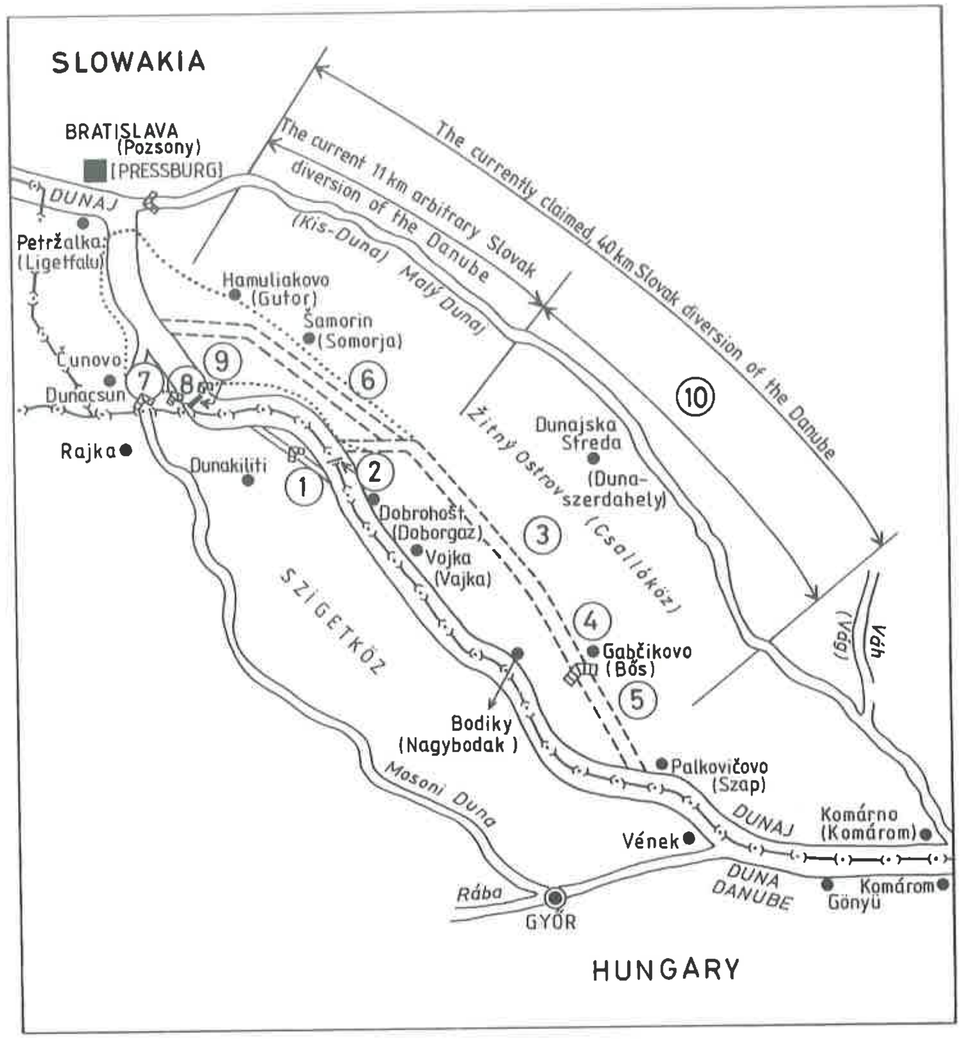


Fig. 37. General layout of the diversion of the Danube, the Variant C. *Explanation*: 1 = the Dunakiliti dam completed but not in operation; 2 = the planned but stopped Dunakiliti river-bed closure; 3 = the Gabčikovo upstream canal; 4 = the Gabčikovo barrage; 5 = the Gabčikovo downstream canal; 6 = the arbitrary extended Gabčikovo upstream canal, built illegally; 7 = the new flood-gate of the Mosoni-Duna; 8 = the Čunovo dam, built not in accordance with the agreement; 9 = the arbitrary planned Čunovo river-bed closure; 10 = the proposed 29 km diversion of the Danube in accordance with the 1977 agreement

The declining pressure head was contemporaneous with the rapid decrease of specific yield of the drilled wells.

Drought and overpumping will cause grave water shortage in the near future. At the present difficult situation we extract more water than the natural groundwater recharge (Berényi and Erdélyi 1990). This is a typical case of upsetting the natural equilibrium (Figs 33 and 34).

14.4. State of Lake Balaton

The Lake Balaton is the largest and shallowest lake in Central Europe. Some characteristic data of the Lake area as follows: surface area is approximately 600 km^2, the average depth is 3.3 m, the volume of water is 2 km^3, the catchment area is about 5200 km^2.

The main inflow comes from the Zala river, which drains half of its catchment. The only outflow is the Sió canal, which regulates the water-level.

Earlier the area of the lake was larger. In front of its former indented shore line sand bars (Nehrung) were built up by the prevailing wind and the action of the shore drift. The shut off bays became peat marshes, which were earlier famous for their rich aquatic life, wild-fowl habitats.

The large-scale canalization of the marshes began in the late 1870s. The consequences were catastrophic:

a) The water of the canal drains quickened the silting up of the lake basin.

b) The former wetland area, famous for its wild-fowl habitats, are now practically dead.

c) The peat were burned out and the winds carried large quantity of light marsh soil into the lake hence contributing to its silting up.

d) The reclaimed areas became useless for agriculture. The transfer of property were flatly refused by foresters because the area is unsuitable even for low quality trees.

Canalization of the Little Balaton carried out in the 1920s was also unsuccessful. Earlier the bedload of the Zala river settled in the marsh, but after the canalization this sub-basin of the Lake Balaton became almost eutrophic. The efforts made in the latest decades were partly successful for the restoration of the wild-fowl habitat. Although the silting up of the southwestern sub-basin (Keszthely) was not totally stopped.

The Lake Balaton will be discussed as an example owing to its economic value being one of the main source of hard-currency earning of Hungary and the main recreation area too.

Main eutrophication hazards for the Lake Balaton and other shallow freshwater bodies are:

1. Decrease of the water depth owing to deposition of silt on the bottom.

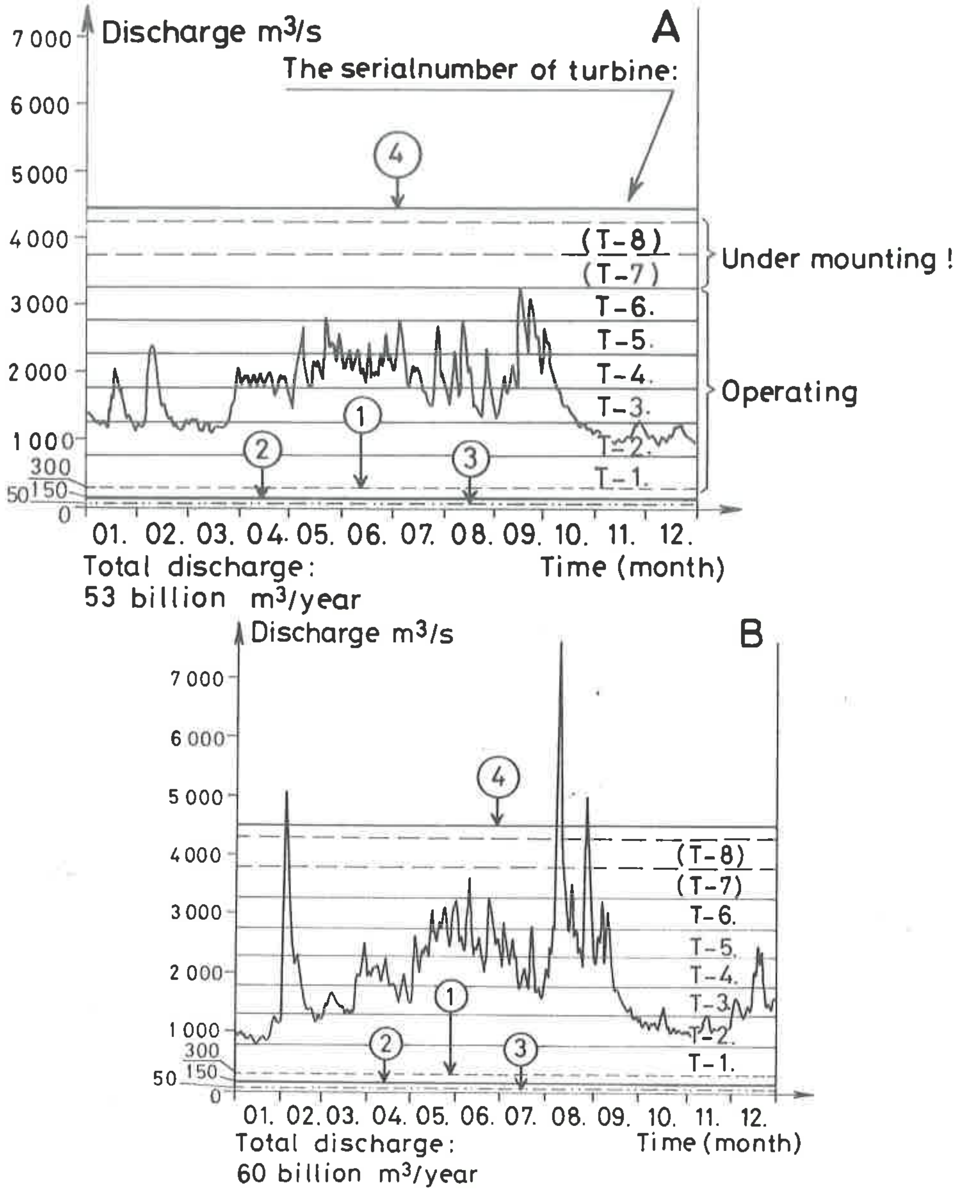
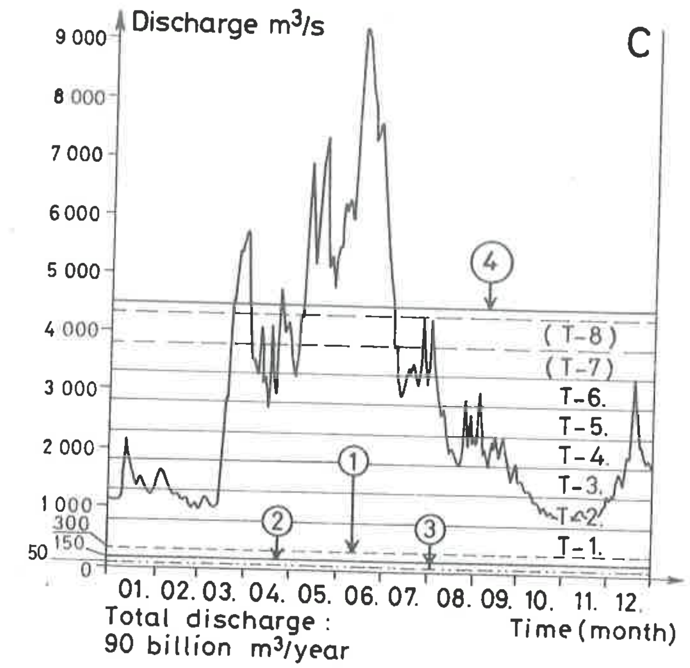


Fig. 38. Flow rates of the Danube at the Bratislava river station. Drafted by I. Molnár civ.eng. May 1993. – **38A** = characteristic medium little stage year, 1984; – **38B** = characteristic medium mean stage year, 1985; – **38C** = characteristic medium high stage year, 1965. *Explanation*: 1 = about 300 m^3/s discharge given into the main river bed by Slovakia; 2 = half of it is the share of Hungary; 3 = 50 m^3/s discharge allocated to Hungary; 4 = capacity of the Slovakian upstream canal is 4500 m^3/s and that of the turbine is about 500 m^3/s. (Remark: The Danube discharge at Gabčikovo can keep only one turbine in unbroken operation.) by the 1977 Czechoslovakian-Hungarian Treaty: Gabčikovo-Nagymaros Dam System (GNDS). Abrogated in 1992; (continued on page 88)



2. Algal growth is favoured by transparent shallow water and its warming up in the semiarid continental climate with high day temperatures.

3. Accumulation of toxic metals and organic wastes of agriculture, industry and the people.

The deterioration of the Balaton area began when the building of summer houses on the shore started. All the villages were then some distance away from the lake shore.

The Balaton's capacity for maintaining its biological equilibrium is depending among others on the number of the summer population, which from the 1920s is much more than that of the permanent inhabitants. Until the late 1940s the equilibrium has been more or less maintained.

As early as the middle 1930s the Tihany Limnological Research Institute (established a few years earlier) warned that the Balaton is able to "digest" the contaminants of no more than 500,000 non-permanent summer-residents yearly. The number of non-permanent residents of the early 1950s was quickly risen within a few years to a steady 1.5–2 million up to 1989. The disposal and treatment of the communal waste water started with a slow tempo in the 1960s, when the tepid water together with unpleasant smell became annoying in the bright midsummer weeks.

From the beginning of the 1970s the eutrophication increased at an exponential rate. The water quality was the poorest in 1982. Then the chlorophyll content reached the hypertrophic level in three sub-basins and the eutrophic level in the fourth one.

Since the late 1970s the sewage of all major summer resorts and permanent settlements have been treated.

There is no hope of restoration of the Lake Balaton as long as the silting is not stopped. The treatment of all sewage and wastes should be carried out in the total watershed. The natural equilibrium of the unsuccessfully "reclaimed" swamps should be restored. The wild-fowl habitat should also be helped to come to life. The efforts for this purpose might also be economically rewarding.

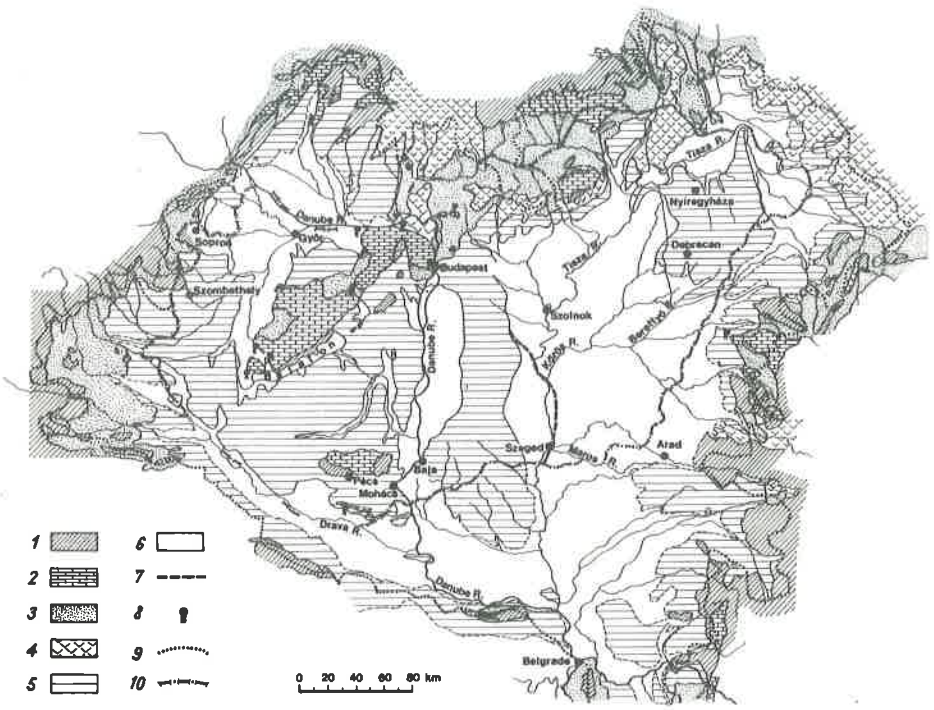


Fig. 39. The hydrodynamic map of the Hungarian Basin. *Explanation*: 1-5 – Recharge areas: 1 = crystalline rocks (Palaeozoic), 2 = karstic rocks, Mezozoic limestones and dolomites, 3 = non-karstic sedimentary deposits of the Eocene, Oligocene and Miocene, 4 = Neogene volcanics, 5 = sedimentary deposits of the Pliocene and Quaternary. 6-8 = Discharge areas: 7 = zero hydraulic gradient at depth between 400 and 600 m below ground; 8 = high discharge karstic spring; 9 = inner divide of the Hungarian Basin (The basin is a hydrogeological unit, its boundary runs along the surface divide connecting river gaps cut into impermeable bedrock, where there is no underflow, consequently the entire amount of surface water flowing into the basin can be assessed by river discharge measurements); 10 = state boundary

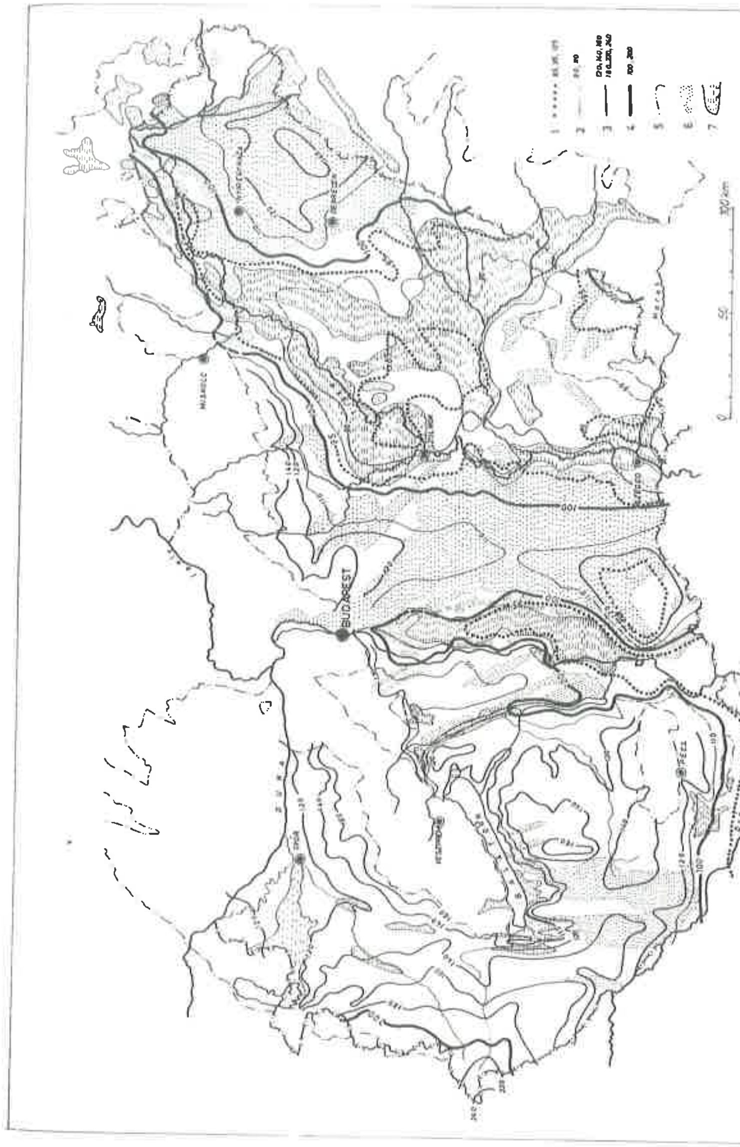


Fig. 40. Piezometric contours of the original (undisturbed) pressure head distribution at depth of 150 to 300 m below ground datum mean sea-level (intermediate flow-region) (Erdélyi 1972). *Explanation*: 1-4 = piezometric contours; 5 = boundary of the mountainous regions; 6 = highly permeable soils (dune sand and sandy loess over 85% of the area shown); 7 = originally undrained and poorly drained areas (prior to the water regulations of the XVIIIth and XIXth centuries)

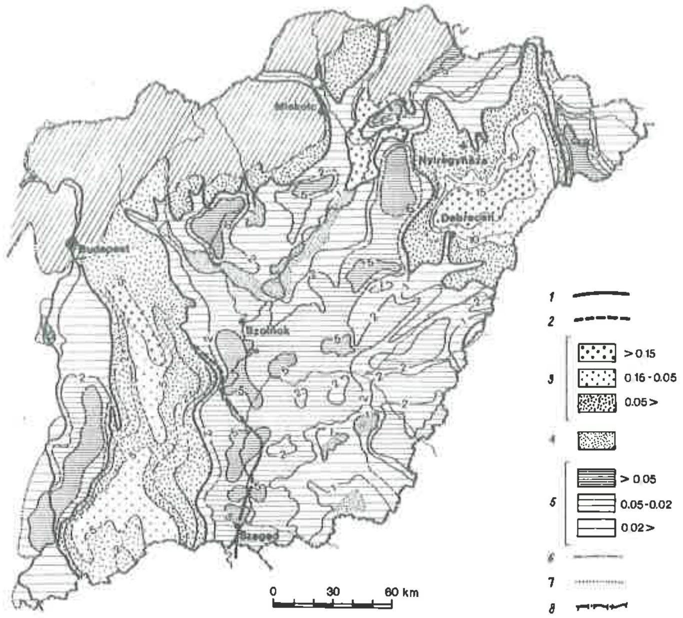


Fig. 41. Map of vertical hydraulic gradients (depth of aquifers between 100 and 400 m below ground), the Great Plain. *Explanation*: 1 = zero vertical hydraulic gradient near to the ground surface; 2 = zero vertical hydraulic gradient at depth of 400-600 m below ground surface; 3 = negative hydraulic gradients; 4 = area of weak near-surface vertical hydraulic gradients within the discharge area; 5 = positive vertical hydraulic gradients; 6 = northern; and 7 = western boundary of the Great Plain; 8 = international border (Erdélyi 1978)

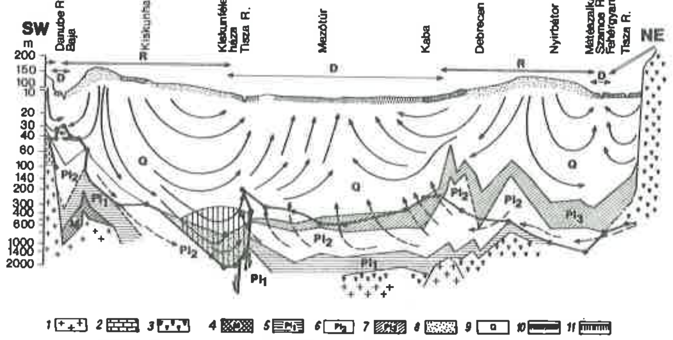


Fig. 42. Diagrammatic flow-pattern of the Great Plain. *Lithology and stratigraphy*: 1 = crystalline basement; 2 = Mezozoic limestones; 3 = Miocene volcanics; 4 = Miocene sedimentary deposits; 5 = Lower Pannonian (Pliocene), impermeable or poorly permeable; 6 = Upper Pannonian (Pliocene); 7 = Upper Pliocene, impermeable or poorly permeable; 9 = Quaternary. *Surface deposits*: 10 = poorly permeable, impermeable; 11 = moderately permeable; 12 = highly permeable; 13 = intermediate flow-region; 14 = regional flow-region; 15 = mixing of the intermediate and regional flow-regions; 16 = interface between the freshwater and brackish water; 17 = recharge area; 18 = discharge area; 19 = fault (Erdélyi 1972, revised 1979)

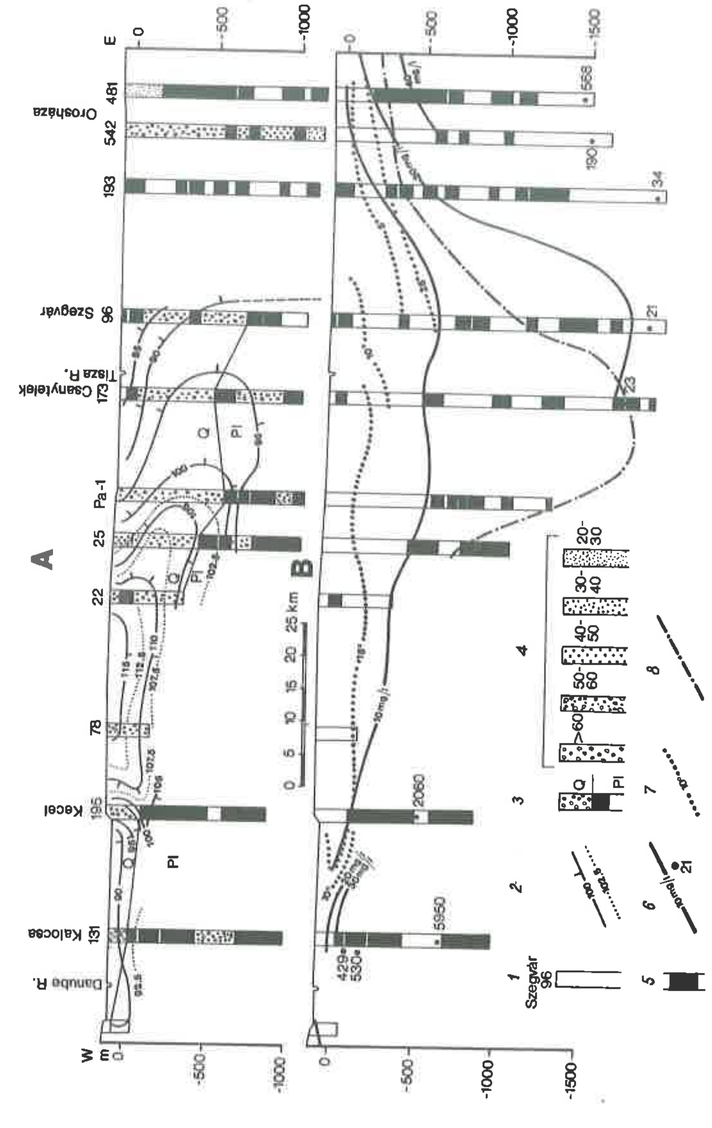


Fig. 43. Cross-section shows recharge extending deep into the discharge area of groundwater by potential distribution (A) and water chemistry (B). *Explanation*: 1 = drilled well profile; 2 = equipotential contours; 3 = Quaternary-Pliocene interface; 4 = sand percentage (The sand percentage is calculated from the total thickness of the clean sand and gravel beds of an individual thickness over 1.5 m; this is well discernible on geophysical logs. The actual sand percentage is higher than that shown on maps and profiles, because not only the sand layers less than 1.5 m of thickness but also the silty and clayey sands (dirty sands) are omitted); 5 = aquitard, aquiclude; 6 = chloride content (mg/l); 7 = total hardness (German hardness grade); 8 = freshwater and brackish water interface (TDS more than 1000 mg/l (Erdélyi and Gálfi 1988)

14.5. Miscellaneous information concerning the state of the whole Hungarian water reserves

We have to break with the often optimistic official views concerning the really deplorable state of all our water. The Carpathian Basin is a sink, which collects the larger part of all waterborne pollution carried with the surface flow or moving underground.

The treaty of 1977 did not make obligatory the total treatment of all polluted waters for Czecho-Slovakia and Hungary in the Danube watershed. The treaty recommended the treatment as a national obligation. It is lamentable that Hungary was unable to achieve the compulsory waste water treatment according to the West-European standards.

Professor E. Mosonyi repeatedly stressed from the start that this is the most solid basis of the economic development and public health of the contracting parties. At that time the Hungarian Government did not realise that Hungary situated downstream will be the loser, and mainly Budapest. The bulk of the pollution is coming from abroad. This was well known already thirty years ago. The highly toxic contamination of the Morava river will remain unsettled after the split-up of Czecho-Slovakia into two states.

In 1992 the diversion of the Danube practically stopped the recharge of groundwater in the gravel deposits.

According to official views the branches of the old bed should recharge the groundwater.

The rehabilitation of the old main Danube bed for alternative navigation route will be impossible or very expensive and long lasting if the rock-fill dams will be built in it.

An alternative safe navigation route requires also the building of new riverports.

The whole region is coming near to the gradual collapsing of the water supply.

It is well known that according to the European Economic Committee around 2000 Hungary will be one of the countries deficient in drinking water.

The Danube zone upstream from Budapest is a part of a greater and well defined hydrogeological region. This is the Middle Danubian Basin, which is a unique hydrodynamic flow-system in operation (Figs 39, 41 and 42). Its characteristics are: temperate climate (500–900 mm/yr precipitation), pressure distribution (shown by piezometric contours) (Figs 40 and 41), large area of highly and moderately permeable deep-reaching clastic and karst formations (Figs 42 and 43). All these make possible the recharge, movement and storage of underground water which serve as high quality and large amount of drinking water (less than 1000 mg/l total dissolved solids) (Figs 42 and 43), as well as thermal water of low (Fig. 43) and high salt content (Fig. 42).

15

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16

Appendices

1. Damming of the Danube river was completed on the October 31st 1992 and the operation of Variant C was started on the Slovak territory (Fig. 37).

The author followed the series of events in 1993, and hence was able to document the disastrous consequences for Hungary, which were formerly predicted by both Czecho-Slovakian (and Slovak) and Hungarian experts.

After October 1992 the water level in the old river dropped below the lowest ever recorded. The river discharge rates recorded by Hungarian hydrologists were 200–350 m^3/s, far from the minimum of 600 m^3/s flow rate repeatedly declared by Slovak sources.

Millions of fishes and large masses of other aquatic creatures died not only in the old bed, but also in the drying branches and lakes.

2. The groundwater regime also changed disastrously. On the apex area of the alluvial fan the groundwater table rose to a higher level than expected earlier. Rising groundwater level damaged foundations of buildings and hindered construction of big structures planned earlier.

Majority of hundreds of local dug and shallow tube wells dried out as the sinking of groundwater table progressed. This process turned back after March, 1993 and the groundwater table reaches now the normal level.

3. Hydrogeological consequences (e.g. changing levels and quality of groundwater) of the unilateral diversion of the Danube river cannot reliably assessed for a longer period of time partly owing to the incomplete or unfinished state of the groundwater monitoring system.

4. The following documents give the chronology of main events concerning the Danube zone in 1992 and between 01.01.1993 and 12.08.1993.

MEMORANDUM

of the Danube Regions' Mayors Conference on the Danube Dunaszerdahely, 25 April 1992.

The protection of the environment, nature and of the living conditions of people is the foremost priority of every society, and to assert this is the basic duty of the existing political power.

The people of the Danube Regions are anxious for the fate of the river, of their potable water, of their living conditions and of the beauty of scenic nature. Without asking the regions' residents a gigantic series of dams is being constructed at Gabcikovo, as a consequence, devastating 5800 hectares of forest, a few thousand hectares of arable land, endangering the potable water of millions, not to mention the disregarding the arising irreversible environmental damages, which are not being situated.

In the past the residents of the regions protested against the environmental destruction, however, it was not ever taken into consideration in the decision making process.

The Danube Regions' self-governments, following the generally accepted customs of the developed countries, shall co-operate in solving their common problems.

On today's conference we call repeatedly for the protection of our living conditions and our homeland.

1. We call upon the Government of the Czech and Slovak Federal Republic to stop immediately the construction work of the 'C' variant, respectively of its temporary technological substitute.

2. We urge the governments of the Czech and Slovak Federal Republic, the Slovak Republic and the Republic of Hungary to render the start of the reaches of Danube affected by the series of dams. The realization of the decades neglected flood control and navigation problems retaining the Danube bed should start, as well.

3. We demand the success of the priority of the protection of ecological-environmental values in connection with the realization of river planning, and the reformation of the Danube Commission that it will lay down the conditions of the navigation with respecting the protection of the ecological values of Danube.

4. We also demand the release of continuous and credible information about the matters concerning the Danube, the plans determining the future, respectively about the consequences of the financial burden, so that based upon this, we can assert our rights to decide about the destiny of this region.

5. We request the Parliaments of the respective countries to assert out requests and demands.

6. If the aforementioned demands shall not be accepted, respective self-governments will hold a referendum on this matter.

The environmental protection does not have international boundaries, thus the residents of Danube Regions through their self-governments themselves wish to deal with the problems concerning them. Therefore a Preparation Committee shall be formed with tasks to work out the constitutional framework of the regional co-operation, which is an important milestone of the road to the common European home.

RESOLUTION

Vienna Conference on the Ecological Reconstruction of Central and Eastern Europe 15-17. Nov. 1992.

On the Construction and Operation of the Gabcikovo Hydropower Plant (CSFR)

Addressing the governments of CSFR, Slovak Republic, Republic of Hungary, the Commission of the European Community and the United Nations Organization.

Bringing to the attention of the public and the governments of the European Community, the EFTA and the former East Bloc countries (respectively their successors) as well as Canada and the USA.

Recognizing that the unilateral diversion of the Danube caused not only environmental, social and economic problems for the region, but increased the existing political tensions in a very unstable part of the world.

The signing persons and organizations are most seriously criticizing the unilateral diversion of the Danube into the Gabcikovo canal and the putting into operation of the Gabcikovo power plant:

- the diversion is violating international law (principle of good neighbourliness, principle of equitable utilization) and several boundary agreements, also contradicts the spirit of many legally nonbinding international declarations on the environment, which were supported by Czecho-Slovakia.
- the unilateral diversion of the Danube into an artificial and sealed concrete canal is changing not only the natural riverine landscape of international importance, but will destroy one of the last large floodplain ecosystems of 200 km^2 including many rare and specialized species.
- the reduction of the Danube water volume to only 10–20% of its present amount is causing the lowering of the river and groundwater level to a mark which was never witnessed by man since the last ice age. This results in the drying up of hundreds of local wells and of agricultural and forest land of ca. 1400 km^2. Within only 2 weeks, many villages along the Danube are facing serious drinking water shortages.

Furthermore, this large-scale impact on the hydrology of the Danube system can result in the releasing and removing of many pollution sources located near the Danube downstream of Bratislava. The self-purification capacity will be significantly reduced, anaerobic conditions in the canal and storage lake will result in the production of new pollutants.

This is not only threatening the drinking water supply of presently 1.4 million people, but of up to 5 million people, which in both CSFR and Hungary could be provided with drinking water from the reservoir below Gabcikovo.

- This mega-project prevents the possibility to use environmentally sound small-scale measures for the protection against high waters and river bed erosion as well as for improved navigation.
- Due to the giant former and future investment costs for Gabcikovo, CSFR and Slovakia are missing the opportunity to improve other parts of their energy sector where higher profits and less environment damages could be resulting from even less financial commitments.
- Contrary to the statement of Premier Meciar of Slovak Republic, Gabcikovo cannot replace the dangerous nuclear power plant Bohunice VI; the first produces ca. 1700 GWhr/a while the latter supplies ca. 5500 GWhr. With only 6.5–7.5% of the Slovak electricity production Gabcikovo will not solve the Slovak energy problems.
- Even though we were pleased that the European Community offered its services as mediator in this dispute, we were dismayed at the process. We consider in particular that the choice of 3 hydrological experts was insufficient to integrate the complexity of the whole project.

The many deficiencies, weaknesses and discrepancies in the concept, planning, justification and construction of the Gabcikovo project, which led already to the termination of the Hungarian sister project Nagymaros and to the cancelling of the joint treaty by Hungary, give cause to the undersigning to state the following demands:

- Complete re-establishment of the traditional Danube, i.e. return of the whole amount of water in the old river bed until the end of November 1992.
- Immediate stopping of all works and of the power production at Gabcikovo.
- Making public of all bilateral and international negotiations defining the fate of the project.
- Making public of all relevant documents and examinations produced for the planning, construction and economic justification of the project.
- Beginning of a serious environment impact assessment including involvement of affected people and communities as well as a zerovariant.
- Completion of all lacking or yet ongoing studies on environmental, social, technical, hydrological and economic aspects before a new decision-making process concerning the future fate of the project.
- Completion of an energy concept for Slovakia aiming at environmentally and economically sound measures. Decision and beginning of realisation of this concept must happen until July 1, 1993.
- Protection of ground- and drinking water both in CSFR/Slovakia and Hungary.

- Protection and rehabilitation of the inundable floodplains along the Danube and establishment of a Trilateral National Park between CSFR, Hungary and Austria.
- Enhancement and support for a regional, transboundary sustainable development of the Central Danube becoming a European model region.
- The undersigning urge that an opportunity be given by the present mission to take evidence from representative NGOs before the end of their enquiry (scheduled for November 23, 1992).
- The undersigning persons and organizations demand that the addressed governments and governmental institutions aim at realisation of the above and expect that the addressed will answer to this Resolution.

Decision 9/1993. (III.5.) OGY of the Parliament on protestation against the unilateral diversion of the Danube, contrary to the international law*

Whereas the Government of the Slovak Republic, or that of its legal predecessor, the Czech and Slovak Federal Republic, dammed up the bed of the Danube by way of its unilateral measure:

stating the fact that it did not countermand its wrongful decision despite the repeated protests of the Government of the Republic of Hungary, the Parliament makes the following decisions:

1. The Parliament of the Republic of Hungary calls upon the legislative bodies of all the member states of UNO. The Hungarian Parliament directs the attention of the legislative bodies to the fact that the Slovak Republic, or its legal predecessor, the Czech and Slovak Federal Republic, violates in a manner unprecedented in Europe the territorial integrity of Hungary and a whole series of international treaties by diverting our common boundary river, the Danube, from its course onto its own territory.

The Government of the Slovak Republic, or that of its legal predecessor, the Czech and Slovak Federal Republic, damming up the original river-bed at a point on its own territory, about a kilometre from the Hungarian border – whence the river serves as a common boundary covering nearly 150 km – diverts the Danube from its former course, leading its water first into a huge reservoir then, in turn, into a 25 km long canal built on Slovak territory.

As a consequence, the quantity of water in an approximately 30 km stretch of the original bed of the boundary river decreases to one-fifth, or one sixth, of the former, the river becomes unnavigable, and it gets dried up on Hungarian territory on the right bank, triggering off damage causing adverse ecological and economic effects. As a further consequence, the instances of interference seriously endanger the subsurface stock of drinking-water, which serves as a basis for the water supply of millions of people. Besides, processes of irredeemable deterioration are generated in the nature conservation area called Szigetköz, an island wedged between the two branches of the Danube, a unique geological formation in East Central Europe and an invaluable common treasure of mankind.

The unilateral wrongful act carried out contrary to the international law by the Government of the Slovak Republic, or that of its legal predecessor, the Czech and Slovak Federal Republic, gravely violates not only the territorial integrity of the Republic of Hungary and all the international treaties concerning the Danube, but it is also fraught with the above-mentioned ecological and economic damage and risks.

* The decision was passed by Parliament at its session on February 23rd, 1993

The Republic of Hungary is firmly determined to attempt to settle this serious problem trough lawful remedies, in order to prevent that a new international conflict should crop up in the area. With this end in view, and appealing to the competent organs and its forums of the European Communities and the Danube Commission, it strives to lodge the case with the International Court of Justice at the Hague in the interest of a final and comprehensive settlement of the dispute.

As a result of the negotiations carried on through the mediation of the Committee of the European Communities there has been significant progress in making both parties mutually want to resort to the International Court, simultaneously, however, it has also come to light that the Slovak Government, until the judgement of the International Court is passed, makes every effort to conserve the present state of affairs brought about unilaterally, or to settle the issue through arbitrary dictates.

Hence the Parliament of the Republic of Hungary appeals to the legislative bodies of the member states of the United Nations Organization and requests them to support the Republic of Hungary in its efforts against the violation of the international law, in its efforts aimed at the soonest possible settlement of the wrongful situation, taking the interests of both parties into consideration.

2. Parliament requests the Speaker of the House to cause the appeal under item No. 1 to be dispatched forthwith to the legislative bodies of the member states of the United Nations Organization.

Szabad, György m.p., Speaker of the House
Dr Szabó, Lajos m.p., Record-keeper of Parliament
Glattfelder, Béla m.p., Record-keeper of Parliament

26-27.02.1993. Conference of the Hungarian Hydrological Society on "Future of the Danube"

The Gabcikovo lock does not guarantee safe operation for river boats of under 40 metric tone weight. The Danube Commission of Belgrade (1947) guaranteed safe navigation on the Danube.

February 1993. Let's Save the Danube Now!

Edited by the SZOPK, Central Danube Regional Group, Bratislava

1. (Jaromir Sibl, European Environmental Bureau, Bruxelles, Belgium; Luba Trubiniova, Bratislava, Klara Benkovics, Eurodanube Samorín, Slovakia, Ivan Dejmal, Prague.)
2. WWF Austria, Wien (Alexander Zinke)
3. Global 2000, Wien, Austria, Christian Richter and Peter Drössler, Wien
4. Danube Circle, Budapest (György Droppa)
5. Ister, Budapest (János Vargha)

The National Meeting of the Hungarian Environmental, Nature Protection and Green Movements in Mosonmagyaróvár accepted the following

Statement on the Danube situation

1) We demand that the Danube be allowed to flow in its own bed. Furthermore that the Government of Hungary should take steps to reach this goal, and if necessary, appeal to the authorized international organizations and/or to the Security Council of the United Nations.

2) We are for the settlement of the dispute between the two countries by the International Court of Justice at the Hague.

3) The Government should put fully into effect all the decisions of the Hungarian Parliament concerning the Danube. Furthermore it should elaborate its program of rehabilitation for the resolution of environmental, river control and shipping problems without dikes and damming.

4) We continue to propose the creation of international nature reserves along the Danube.

5) In order to protect the water sources, sewage systems and waste water plants should be built in the Szigetköz; the amount of pollution should be decreased and freshwater and temporary irrigation supplies for the settlements of the region should be secured.

Taking the European importance of the water resources into account, these activities should be financed solely by the national budget in order not to force hardships on the inhabitants of the region.

Mosonmagyaróvár, March 7, 1993.

12.03.1993. Resolution of the European Parliament on the power station at Gabcikovo–Nagymaros (B3–0350, 0352, 0382, 092 and 0428/93).

26.04.1993. Appeal of the Equipe Cousteau to the Ministries of Environment of Europe for saving the biggest groundwater resource of Europe.

26.04.1993. WWF appeals for urgent action by European Ministers to avert further disasters at Gabcikovo.

Spring 1993. Information Bulletin (of the Regional Environmental Center for Central and Eastern Europe). Vol. 3. No. 1 (Spring 1993).

a) A. Farkas (Győr, Szigetköz, Hungary): In the path of destruction pp. 3–4.

b) Luba Trubiniova (SZOPK, Bratislava): Gabcikovo Dam Slovak opposition p. 4.

17.06.1993. Update on Gabcikovo. International Conference "Ecology of Danube" – 7–10 June, 1993. Organized by the City University of Bratislava, the Slovak Ministry for Environment, the Christian Democratic Union of Slovak Ecologists, the European Democratic Union and the Gabcikovo Investor VVsP.

The manuscript "Update of Gabcikovo" is the best summary on the state of the Danube area after the river diversion. A considerable part of it was not published, therefore the essentials are worth quoting.

p. 1. "The Hungarian floodplain lies mainly dry, groundwater levels are very low. Impacts on forests, wetland ecosystem, agriculture and other water-dependent activities are visible but can hardly be quantified at present."

"On the Slovak side, the Gabcikovo constructor has built and opened a large-scale inflow-system which provides 20–50 m^3/s of storage lake water into the floodplain, which itself was turned into a chain of 7 interconnected cassettes. As this artificial inflow is actually not fulfilling the legal conditions set by the Slovak Ministry for Environment, it was agreed with the Gabcikovo constructor that this system will be reviewed in October 1993 until when all other construction activities will be interrupted."

"WWF criticizes that this system does not fulfil the CEC 66% proposal, it is violating the London 95% agreement and can't replace the vital surface and groundwater fluctuations in the Danube." "... this will force the Hungarian side to build now a similar artificial system for the Szigetköz taking 50 or 100 m^3/s from the remaining Danube water and building 2–4 underwater weirs as suggested from Slovak side to lift the groundwater table: this will drive Hungary towards a compromise-like position without restoring the vital hydrology because the delay of such works by waiting for the political agreement on the interim water management, it will only aggravate the ecological and economic damages in the region."

p. 2. "Following the secret decision of the Hungarian government on 26 April, 1993, to allow using the Dunakiliti weir and to build underwater weirs for diverting Danube water into the Szigetköz", – it resulted in the conclusion – that this government decision is bad for Hungarian interests and should be withdrawn. In the meantime, many Szigetköz mayors are more and more dissatisfied with the present situation and want the water back, no matter how."

"The Slovak side (and the Hungarian water lobby) strongly emphasize that it is a big mistake if Hungary does not build the underwater weirs which are the only way to prevent further damage in the Szigetköz."

Note: The following text is a copy of a personal conclusion on the international conference "ECOLOGY OF DANUBE" (7–10 June, 1993, at Casta–Papiernicka near Bratislava) of Dr G. P. Hekstra, project leader in the Risk Assessment and Environmental Quality Division at thee Ministry for Housing, Physical Planning and Environment of The Netherlands. This text was drafted for the conference conclusions, but (except for point B 3) was rejected by the majority of conference participants, as most of them (80–90%) belonged to the pro–Gabcikovo lobby. Over the 4 days, Dr Hekstra experienced the Gabcikovo problems and argued from a truly independent and non-biased view, expressing a lot of sympathy and concern for the difficult Slovak situation. He is certainly competent to assess the environmental risks resulting from Gabcikovo. We feel it important to spread his view among other involved politicians and observers, AZ, WWF-A.

General remarks and conclusions by Dr G. P. Hekstra:

The existence of the dam and what belongs to it has to be accepted as a fact. Attempts to have it removed or undone are irrealistic. Under the given circumstances one has to make the best of it:

a) ecologically, i.e. hydrologically, up to systems ecology;

b) economically, i.e. resources use, maintenance and auditing;

c) socially, including social psychology regarding the Hungarian minority being encroached and impacted.

A. Ecological valuation

– The site is impressive and full of positive achievements but also pending risks, as the situation is far from stability. Periodic reviews at 3 years intervals are needed.

– The overall groundwater quantity is likely to improve and will benefit the entire region, but the quality is likely to decline, due to time-delayed effects of pollutants, nutrients and toxicants, in soils and sediments under the influence of climatic and landuse changes. This requires intensified and often costly monitoring not foreseen in the planning.

– Baseline data are likely available for a limited number of parameters but not put systematically together in advance of the dam construction and independent of the constructors. A catch-up of baseline data collection has high priority.

– The PHARE-evaluation should have been completed before the construction, but is still welcome. However, the programme should be extended with a system ecology component, notably the ecological cycling of C, N, P and S, changes in redox-potential and buffering capacity and salinity in components of the system, foodchain accumulation of toxical materials, shifts in the foodweb, and in biodiversity of species and their population dynamics.

– Scientific facts, literature and monitoring date should be freely accessible for critical investigation and systematic research. They should be discussed in an open atmosphere, free from antagonism to the Hungarian part. Critical questions have to be answered neutrally and not with intensified propaganda, which is counterproductive.

– Informative material like the booklet and leaflets distributed at the excursion, should be freed from agonistic rhetoric against Hungarian and NGO viewpoints.

B. Economics and resource use valuation

– Serious doubts, but often insufficiently documented, about the overall cost-benefit analysis of the dam, including electricity production and agriculture, tourism, property prices, compensation for losses and prospect of employment, were often answered in a way that increases suspicion that negative facts are kept secret. An independent international audit is needed.

– The vehementous defense of some really positive aspects regarding the overall hydrology and subsequent positive environmental aspect, notably by Dr Liska (note: the PR director of the investor), was rather polemic than constructive towards the Hungarian part. This is not in the interest of a better cooperation and understanding.

– A founded fear was expressed that the area is going to be used for attracting investors and enterprises from countries with more stringent environmental regulation and legislation, notably obsolete technologies from the West.

– The quality of the constructions is poor (often done hastely) and will likely require high maintenance costs. It is unclear how this will be funded, and how it will weigh on the national budget.

C. Social and psychological valuation

– Impacts are usually presented and defended from the viewpoint of the proponents, not from the viewpoint of the local community, which in this specific area is specifically sensitive, as it is encroaching on the Hungarian minority in an already stressed atmosphere. The community feels squeezed into even more marginality, seeing their property more and more lost to alien rich newcomers who use it for weekend and leisure uses.

– This irritation, though not fully discussed at the conference, is an undercurrent leading to emotional criticism on the dam and disturbance of cooperation. This, and the fierceful rhetoric of the dam proponents, have created a negative climate both for the Hungarian minority and for negotiations with Hungary. The government may consider the composition of their delegation with regard to this aspect.

– It is recommended that a consequent and coherent programme on social impact be established, taking human perception and the position of the local population with its special cultural background into account.

– The "Gabcikovo-issue" is distracting public attention, as well as investments, away from other positive opportunities of the new young state of Slovakia, putting it in an internationally negative perspective, which also has to be considered in the perspective of joining the European Community.

25.06.1993. Resolution of the European Parliament on the Gabcikovo–Nagymaros Dam (B3–0946, 0954, 0955 and 0956/93)

29.06.1993. Expertise of Gy. Habel and I. Molnár on the weirs planned in the old Danube bed for recharging the groundwater of the Hungarian Danube Zone (Fig. 38).

Not long after the expertise the Hungarian Government (Ministry of Environment) withdraw the permission to build underwater weirs, which is more or less a replica of the Slovak and Hungarian dam proponents and might prevent that the old Danube bed be an alternative future waterway suitable for the traffic of small boats.

This planned groundwater recharge scheme is unsuitable for compensating the losses caused by the diversion of the Danube (Variant C) (Fig. 38). The planned recharge is only a very low percentage of the original 2000 m^3/s discharge rate of the Danube, which is needed to recharge the total groundwater stored in its alluvial fan.

April, 1993. Publication of the "Damming the Danube, Critique of the Gabcikovo Dam Project" (April, 1993)

Edited by Jaromir Sibl, SZOPK
Slovak Union of Nature and Landscape Protection
and SRN (Slovak Rivers Network).

This outstanding professional work lists the events of the Gabcikovo and Nagymaros Project in chronological order.

While this book concentrates mainly on the hydrogeological aspects of the Gabcikovo–Nagymaros Project, the work of Jaromír Sibl discusses the biological (including human) aspects of it. The author was fortunate to get to know this book in time, so he was able to complete the appendix before the final closing of the manuscript. The author could not get earlier hydrochemical and biological data (whether they were "secret" or not) through the official channels as he already explained it in the Preface.

Its main virtue is the unbiased and high-level professional attitude not only in discussing critically the past events, but also the prospects of future rehabilitation of the total area affected.

An important part is the chapter "Perspectives of the Central Danube National Park" written by Jaromir Sibl. He discusses the history of the preliminary concept of the park which may be the most effective means of the rehabilitation of Austrian, Czech, Hungarian and Slovakian riverine zones downstream from Vienna to Budapest.

This book summarises the destruction of one of the most important riverine ecosystems of Europe. Its revival is an inevitable requirement of the future, without the biological balance the total area of the Danube watershed will suffer irrecoverable losses (Fig. 39).

"As a result of the construction of the Gabcikovo and Nagymaros projects the natural ecosystems have been disturbed along almost the whole course of the Danube in the Slovak Republic, i.e. between Bratislava and Stúrovo, as well as along the lower parts of its tributaries in the region." (This statement is valid also for Hungary.)

"A great number of biotopes has been completely destroyed as a result of the construction of some parts of the Gabcikovo–Nagymaros Project, while others have been disturbed to different extent. However, the ability of the water and wetland ecosystems to regenerate themselves is extremely high. If the basic conditions for an optimal water regime are given, further negative impacts are avoided, and a suitable management is introduced and spontaneous return of the area into the state of ecological balance could be reached in a relatively short time (10–20 years). The proclamation of the Natural or International Central Danube Park should be an important contribution to this revival."

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Appel aux Ministres de l'Environnement des pays d'Europe présents à la conférence de Lucerne "Un environnement pour l'Europe"

La résolution du problème du barrage de Gabcikovo est un défi lancé à l'Europe tout entière.

Le barrage de Gabcikovo est un héritage du passé, d'une période révolue. Mais cet héritage ne doit pas dispenser d'une réflexion réaliste sur l'intérêt de cet ouvrage qui tienne compte du présent et du futur de la Slovaquie. De nombreuses études démontrent que le barrage n'est pas un atout, ni d'un point de vue énergétique ni pour la navigation. A l'opposé, les impacts de Gabcikovo sur l'environnement sont sérieux. Beaucoup auront des conséquences économiques néfastes sur l'agriculture et sur l'approvisionnement en eau potable.

La mise en eau du barrage, le 24 octobre 1992. a provoqué l'assèchement de l'une des plus grandes plaines alluviales d'Europe et menace la plus grande nappe phréatique d'Europe.

Les impacts réels sur l'environnement risquent de faire échouer le processus de conciliation enclenché par la République Slovaque et la République de Hongrie devant la Cour internationale de La Haye.

Nous demandons aux Ministres de l'environnement présents à la Conférence internationale de Lucerne, d'exiger du gouvernement slovaque l'interruption des travaux en cours jusqu à l'obtention d'un accord temporaire entre la Hongrie et la Slovaquie sur la gestion de l'eau.

Les Européens attendent des actes montrant que les gouvernements intègrent réellement dans leur politique la protection de l'environnement et l'amélioration de la qualité de la vie.

Paris, 26 avril 1993