COMMISSION OF THE EUROPEAN COMMUNITIES
REPUBLIC OF HUNGARY
SLOVAK REPUBLIC

WORKING GROUP OF MONITORING AND WATER MANAGEMENT EXPERTS FOR THE GABCIKOVO SYSTEM OF LOCKS

REPORT ON TEMPORARY WATER MANAGEMENT REGIME

Bratislava
December 1, 1993

EXECUTIVE SUMMARY

BACKGROUND

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Group of Monitoring and Water Management Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC).

The tasks of the Working Group fall in two parts:

* On the basis of available data to assess the impacts of the Gabcikovo Project and to prepare recommendations for strengthening the monitoring system in the area.
* Preparation of recommendations for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures.

The present Data Report is the Final Report of the Working Group dealing with the Temporary Water Management Regime. The first aspect was dealt with in the Data Report, finalized in Budapest on November 2, 1993.

The Working Group has obtained all the relevant data and information requested from the two Governments. The report is based on this information.

ELABORATION OF FIVE SCENARIOS

In the present report five scenarios with different characteristics on discharge regime and remedial measures have been elaborated. All the five discharge regimes are dynamic and characterized by the below average values. The five scenarios and their most important impacts can be summarized as follows:

Scenario 0: November 1993 Situation

* Old Danube: 400 m^3/s
* Slovakian side branches: 40 m^3/s
* Hungarian side branches: 10 m^3/s

The key impacts are as also described in the Data Report:

* The environmental conditions on the Hungarian inundation area are bad due to lack of water.

* The flow velocities and water levels in the Old Danube are too low for providing suitable living conditions for typical flora and fauna.

* The lack of connections between the main channel and the side branches prevents migration of wetland species.

Scenario 1: Increased water supply to the Hungarian Side Branches

* Old Danube: 400 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur each year in the Old Danube.

The key impacts as compared to Scenario 0 are:

* Improvements of the environmental conditions for the Hungarian inundation area.

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

* Old Danube: 800 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

The key impacts as compared to Scenario 1 are:

* Improvements of the main river environment to a level where species requiring higher flow velocities (e.g. fish) have suitable living conditions.

Scenario 3: Construction of some Underwater Weirs

Scenario 3 is basically identical to Scenario 2 except for construction of a number of underwater weirs.

The key impacts as compared to Scenario 2 are:

* The connections between the main channel and the side branches on both sides are maintained or even improved as compared to pre-dam conditions.

* For discharge not exceeding 1000 m^3/s the flow velocities in the Old Danube are not sufficient for

maintaining the typical flora and fauna.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches

In Scenario 4 as much water as technically possible will be diverted into the Old Danube and the side channels. However, this will technically not be possible until after the summer of 1996.

CONCLUSIONS

None of the described scenarios are free from key environmental problems. Furthermore, different scenarios result in different environmental problems, which are not directly comparable. Scenario 2 and Scenario 3 show that some environmental problems can be reduced by increasing discharge and remedial measures.

In addition to the environmental aspect also economical aspects should be considered. In this respect it may be noticed that the value of the present electricity production of 2000 GWh/year is in the order of 50 - 100 million ECU/year. For comparison the electricity production will be reduced by about 30 % in Scenario 2 and 3. The costs for implementation of the remedial measures range between 2 and 12 million ECU depending on the scenario.

RECOMMENDATIONS BY THE EC MEMBERS OF THE WORKING GROUP

None of the described scenarios can be recommended without modifications. Therefore the three EC members of the Working Group will recommend a combination of elements from different Scenarios.

Objectives

The overall objective of the recommended Temporary Water Management Regime is a minimization of any irreversible developments.

The primary objectives are to enable as good environmental conditions as possible within the given discharge constraints, whereas the secondary objective is electricity production.

Discharge regime

* Old Danube: 800 m^3/s
* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

* 1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

Remedial measures

* Improvement of the daily discharge capacity of Variant C structures from the present 600 m^3/s to 940 m^3/s by May 1994.

* For environmental purposes an underwater weir at RKM 1835 enabling direct contact between the main river and the Slovakian side branches at one upstream point of the Slovakian floodplain.

* For operational purposes an underwater weir at RKM 1845.5. This underwater weir will significantly improve the reliability of the day-to-day water supply through the inundation weir and it will ensure water supply to the Hungarian floodplain.

Day-to-day Operation

Improved operation rules for the day-to-day operation of the water management within the above given discharges has be implemented in order to obtain as good environmental conditions as possible.

Environmental Impacts

The recommended Temporary Water Management Regime is believed to ensure that minimum irreversible environmental developments take place during the few years the temporary regime is supposed to last.

It is furthermore recommended to maintain a detailed environmental monitoring including taking the steps to strengthening the present monitoring system as recommended in the Data Report.

Design Review of Spillway of Inundation Weir

The spillway of the inundation weir is a key issue in terms of discharge possibilities, reliability, time schedule and costs. As no comprehensive design exists for its daily use a design review is recommended to be carried out by an independent, specialized institute.

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1. INTRODUCTION

1.1 Background and Objectives for the Working Group

As a follow-up of the 'Special Agreement for Submission to the International Court of Justice of the differences between the Republic of Hungary and the Slovak Republic concerning the Gabcikovo-Nagymaros Project' a Temporary Water Management Regime for the Danube has to be established and implemented.

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures a Group of Monitoring and Water Management Experts for the Gabcikovo System of Locks (Working Group) was established by the Republic of Hungary, the Slovak Republic and the Commission of the European Communities (CEC). The Terms of References for the Working Group are enclosed in Appendix A.

The Working Group is composed of the following five experts:

CEC: Professor Johann Schreiner (primus inter pares), Director, Norddeutsche Naturschutzakademie, Germany.

Mr. Jan M. van Geest, Director, DHV Environment and Infrastructure, The Netherlands.

Mr. Jens Christian Refsgaard, Chief Hydrologist, Danish Hydraulic Institute, Denmark.

Slovakia: Professor, Dr. Igor Mucha, Faculty of Natural Science, Comenius University, Bratislava.

Hungary: Professor, Dr. Gabor Vida, Head of Department of Genetics, Eötvös L. University, Budapest.

The five experts were assisted by colleagues as listed in Appendix B. The Working Group had its first formal meeting on September 8-9, 1993 in Bratislava. The second meeting was held in Budapest during the period October 27 - November 2, 1993. Field inspections were carried out on October 30 both in Slovakia and in Hungary. The third and final meeting was held in Bratislava during the period November 28 - December 1, 1993. In between the formal meetings comprehensive work on data collection and analyses were carried out by the Slovak and Hungarian experts and interaction with the CEC experts also took place during this period.

The Working Group had to prepare two reports. The first one, denoted the Data Report, was finalized on the second meeting in Budapest on November 2, 1993. The Data Report comprised an assessment of the impacts of the Gabcikovo project with regard to discharges, surface water levels and quality, sedimentation and erosion, ground water levels and quality, flora and fauna, agriculture, forestry and electricity production. Furthermore, recommendations for strengthening of the monitoring system in the area were given.

The present report is the second and final report of the Working Group. It contains recommendations for the governments for a Temporary Water Management Regime as well as for necessary discharges, water levels and remedial measures to be taken.

The Working Group has obtained all the relevant data and information requested from the two Governments. The report is based on this information.

1.2 Temporary Water Management Regime

The dispute concerning the Gabcikovo-Nagymaros Project has been submitted to the International Court of Justice (ICJ). Pending the final Judgement of the ICJ there is a need to establish and implement a Temporary Water Management Regime (TWMR) for the short term period until a final regime is implemented. Thus it can be expected that the TWMR will be applied for a period of 3 - 5 years.

The present report deals exclusively with the TWMR and does not address the permanent, long term solutions. It is outside the terms of References of the Working Group to analyse and predict long term impacts. Such assessments will for some aspects require more thorough studies.

2. DESCRIPTION OF EXISTING WATER SYSTEMS

2.1 Variant C Structures

2.1.1 Brief description of structures and status of works

The structures for the Gabcikovo part of the Gabcikovo-Nagymaros project are completed in both countries with some exceptions, for example the closure of the Danube river at Dunakiliti, deepening of the outlet canal and measures in the Danube downstream Sap/Palkovicovo.

Variant C consists of a complex of structures located in Slovakia. A sketch of the Variant C structures is shown in Fig. 2.1. The structures include the following elements:

(1) Hydropower station and ship locks at Gabcikovo.
(2) Dam closing the Danubian river bed.
(3) By-pass weir controlling the daily flow into the river Danube.
(4) Inundation weir.
(5) Intake structure for the Mosoni Danube.
(6) Intake structure for Slovak inundation area at power canal at Dobrohost.
(7) Earth barrages/dikes connecting structures
(8) Ship lock for smaller ships (24 m x 125 m).
(9) Spillway weir.
(10) Hydropower station.

Structures 1 + 6 are part of the original project. The construction of the structures 2 - 5 and 7 are included in Phase 1 of Variant C, while the remaining 8 - 10 are a part of Phase 2 of Variant C. The main part of Phase 1 structures have been completed by now, while Phase 2 is scheduled for construction 1993-96.

The progress of the work up to November 21, 1992 has been reported in ref /1/, and the status as per May 1993 is reported in ref /3/. The present status is as follows:

(1) Hydropower station (HEP) and ship locks at Gabcikovo

The HEP is designed for peak power production. The planned 8 turbines have a nominal capacity of 4,000 m^3/s. At present five turbines and generators are installed. The sixth turbine and generator are in stock, while the remaining two turbines are planned for completion in future. The maximum capacity is approximately 610 m^3/s per turbine. At the designed operational water level of 131.1 m asl. (reference Baltic msl) the design head is 19 m in average.

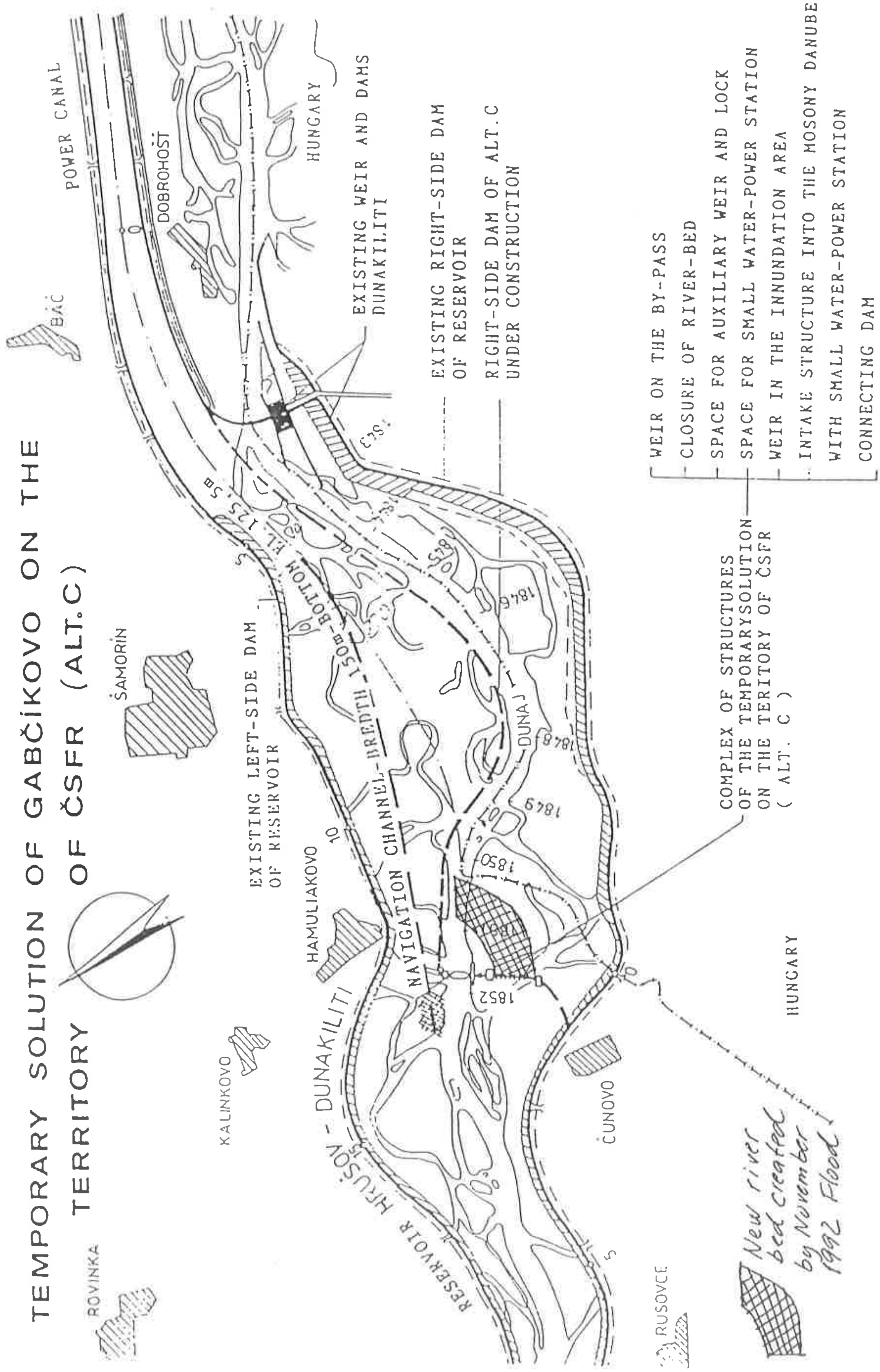


Fig. 2.1 Sketch of the Variant C Structures

The two ship locks (each 34 m wide and 275 m long) have been in operation since November 1992. They have a total hydraulic capacity of 1970 m^3/s when open. The capacity of the canal in flood situations is approximately 4500 m^3/s, limited by the velocity in the power canal.

(2) *Closure of the Danube*

The closure of the Danube river bed started on October 23 and was completed on October 27. All works including protection works, a vertical clay-cement protection wall (for preventing seepage) and a system for technical monitoring (of seepage) are now completed.

(3) *By-pass weir controlling the flow into the river Danube*

The daily flow into the river Danube from the reservoir is lead via this weir.

The weir consists of four tainter gates each 18 m wide with sill level at 126.5 m asl. The maximum hydraulic capacity of the weir was originally designed at 1460 m^3/s. However, due to a fault in design, the discharge is limited in all cases to 600 m^3/s. Otherwise the spillway will be destroyed. The weir, including machineries, is completed and in operation.

(4) *Inundation weir*

The weir consists of 20 tainter gates each 24 m wide with sill level at 128.0 m asl. Each of the gates has a hydraulic capacity of 230 m^3/s (total capacity of the weir is 4600 m^3/s) at the maximum water level of 131.1 m asl. The capacity at a water level of 129.0 m asl is estimated to be 60 m^3/s per gate.

The inundation weir and the bottom protection were originally designed for use only in flood situations (few days per year). This design was in October/November 1992 modified as a result of the London Meeting with the aim to allow daily use. Along the Danube right bank a spillway was being constructed and the downstream bed was planned to be protected with additional 100,000 m^3 stone. This work was scheduled to be completed by January 1, 1993.

The flood on 25 November 1992 changed the whole area downstream the weir. Between two and three mill m^3 of soil, sand and gravel were eroded. Hence, also the protection dike disappeared. Just behind the weir scour holes of 11 m depth developed locally and caves were formed underneath some downstream parts of the weir. The average surface level downstream the weir dropped by 5-6 m to about 122 m asl.

At present the spillways of the openings 1, 2, 3 and 4 are completed for flood purposes, whereas the spillways of the other 16 openings are not yet completed.

The right embankment of the canal between the inundation weir and the Danube needs fortification. At present 80 % of this work is completed.

Since the November 1992 flood, the weir has been used only in connection with flood events in January, March, May, July and August 1993.

(5) Intake structure at entrance to the Mosoni Danube

A supply canal on Slovak territory is connected to the Mosoni Danube on Hungarian territory. This structure has since November 1992 supplied 20 m^3/s to Mosoni Danube. In the intake structure for the Mosoni Danube a small hydropower station with two turbines is planned to be installed with a bypass capacity of 25 m^3/s corresponding to a water level of 131.1 m asl and 20 m^3/s at 129 m asl. The turbines and generators will be installed next year. Their combined capacity will be 40 m^3/s.

(6) Intake structure into Slovak inundation area at power canal at Dobrohost.

The intake structure located in the power canal allows for a maximum discharge of 234 m^3/s to be supplied to a river arm in the left bank of the floodplain downstream the Dunakiliti weir close to Dobrohost. A canal connecting the structure and the downstream river arm on the Slovak side has been dug. The structure has been in operational use since the end of April 1993. The entire works are not yet completed and hence the maximal capacity at present is 140 m^3/s.

(7) Earth dams/dikes connecting structures

A dike between the downstream part of the reservoir and the left bank of the Danube connecting the Cunovo structures with the righ bank of the power canal has been constructed.

On top of the structures (dam, dikes, weirs) a road has been constructed for connecting the three villages in the area between the power canal and the Danube with Bratislava. The part of the road on top of the inundation weir is not yet ready. Instead a temporary earth road on top of the spillway is being used.

(8) Ship lock
(9) Spillway weir
(10) Hydropower station (HPS)

Between the by-pass weir and the inundation weir a temporary dike has been established with a crest level of 133.8 m asl. Behind this temporary dike the structures (8), (9) and (10) are planned under Phase two of the Variant C. At maximum water level the hydraulic capacity of the ship lock and spillway weir will be 4000 m^3/s. The capacity of the HPS has not been decided but is likely to be about 1300 m^3/s. The sill level of the spillway weir will be at 120.5 m asl., which is the same as in the existing river bed.

2.1.2 Slovak plans for future works near the inundation weir

The following works are planned:

(a) The road on the top of the inundation weir is planned to be opened in May 1994.

(b) The remaining part of the protection works on the right embankment of the canal between the inundation weir and the Danube is scheduled to be completed in May 1994.

(c) It is planned to start the reconstruction of the spillways of the 16 remaining openings in May 1994. These works are scheduled to be completed in July 1995 (for flood conditions).

(d) It is planned to fortify the left embankment of the canal between the inundation weir and the Danube. The fortification is planned to be carried out during the coming 14 months.

(e) To prevent erosion of the canal between the inundation weir and the Danube, it is planned to excavate the bed of the canal to a level corresponding to the average bottom level of the Danube (122 m asl.). This excavation is scheduled to be carried out over the coming 14 months.

(f) The construction of Phase 2 is planned to be carried out during the next three years. Water discharge will be possible ½ year before the completion.

The discharge capacity of the Variant C structures for daily use as it develops with the gradual completion of the remaining parts of the structures according to the Slovak plans are shown in Table 2.1. As appearing from the table more discharge than the presently maximum of 600 m3/s is not planned to be possible before the Phase 2 weir become operational in the summer of 1996.

Table 2.1 Discharge capacity of the Variant C structures for daily use according to Slovak project plans

	November 1993	Summer 1996
By-pass weir	600	600
Phase 2 weir	-	5300
TOTAL	600	5900

2.1.3 Daily use of the inundation weir

The spillway behind the inundation weir is not designed for daily use. It is estimated that it will be possible to use it for passing a limited amount of discharge even for daily use. The following options are available (as pointed out in Appendix E):

(1) Using four openings of the inundation weir which are constructed alternatively and hence have a spillway in a better condition. The discharge capacity is limited to 340 m^3/s, and it is necessary to inspect the fortifications each week and make frequent repair work. The implementation time is six months and the maintenance costs are estimated to 1.0 mill ECU/year.

(2) Reinforce the spillway for daily use. The discharge capacity will be limited to 1350 m^3/s. Maintenance will be required. The implementation time is one year. The construction cost is estimated to 3.3 mill ECU. The maintenance costs are estimated to 5 mill ECU/year. These maintenance costs will be significantly reduced by a downstream water level higher than 124.0 m asl.

To execute each of the two options the plans mentioned in 2.1.2 should be modified.

The discharge capacity for daily use assuming is as shown in Table 2.2 if additional work is carried out according to options (1) or (2) above.

In general the time schedule will depend on weather conditions.

Table 2.2 Discharge capacity of the Variant C structures for daily use assuming additional works carried out

	Nov 1993	May 1994 1)	Dec 1994 2)	Summer 1996 1)	Summer 1996 2)
By-pass weir	600	600	600	600	600
Inundation weir	-	340	1300	340	1300
Phase 2 weir	-	-	-	5300	5300
TOTAL	600	940	1900	6240	7200

1) Assuming execution method (1) above.
2) Assuming execution method (2) above.

2.2 Main River

River cross-sections are regularly surveyed for the main Danube by Hungary. Such measurements have also been made in 1993 for comparison with pre-dam conditions (September 1992). These data are presently partly processed and eight cross-sections are shown in Figs 2.2-2.4 for present and pre-dam conditions.

As evident from the figure significant changes have occurred in the six cross-sections shown in Figs 2.2 and 2.3, where the river bed now generally is higher than in pre-dam conditions. The main reason for this is believed to be the erosion of 2-3 mill m^3 of sand and gravel material from just downstream the inundation weir during the November 1992 flood and subsequent deposition of this material further downstream. The cross-sections from Rajka (RKM 1848.4) and Dunaremete (RKM 1825.5), Fig 2.4, show only small changes of the same order of magnitude as usually occurred from one year to another in pre-dam conditions.

The relationship between discharge, water level and cross-sectional average flow velocities are shown in Table 2.3 for Rajka and Dunaremete, where discharge and water level measurements are made regularly. The figures in the table originate from a rating curve, which has been derived directly from measurements. From this table it is noted that only very small changes have occurred at the two sites. This indicates that the changes in river cross-sections in general have had only very small influence on the flow conditions in the Old Danube.

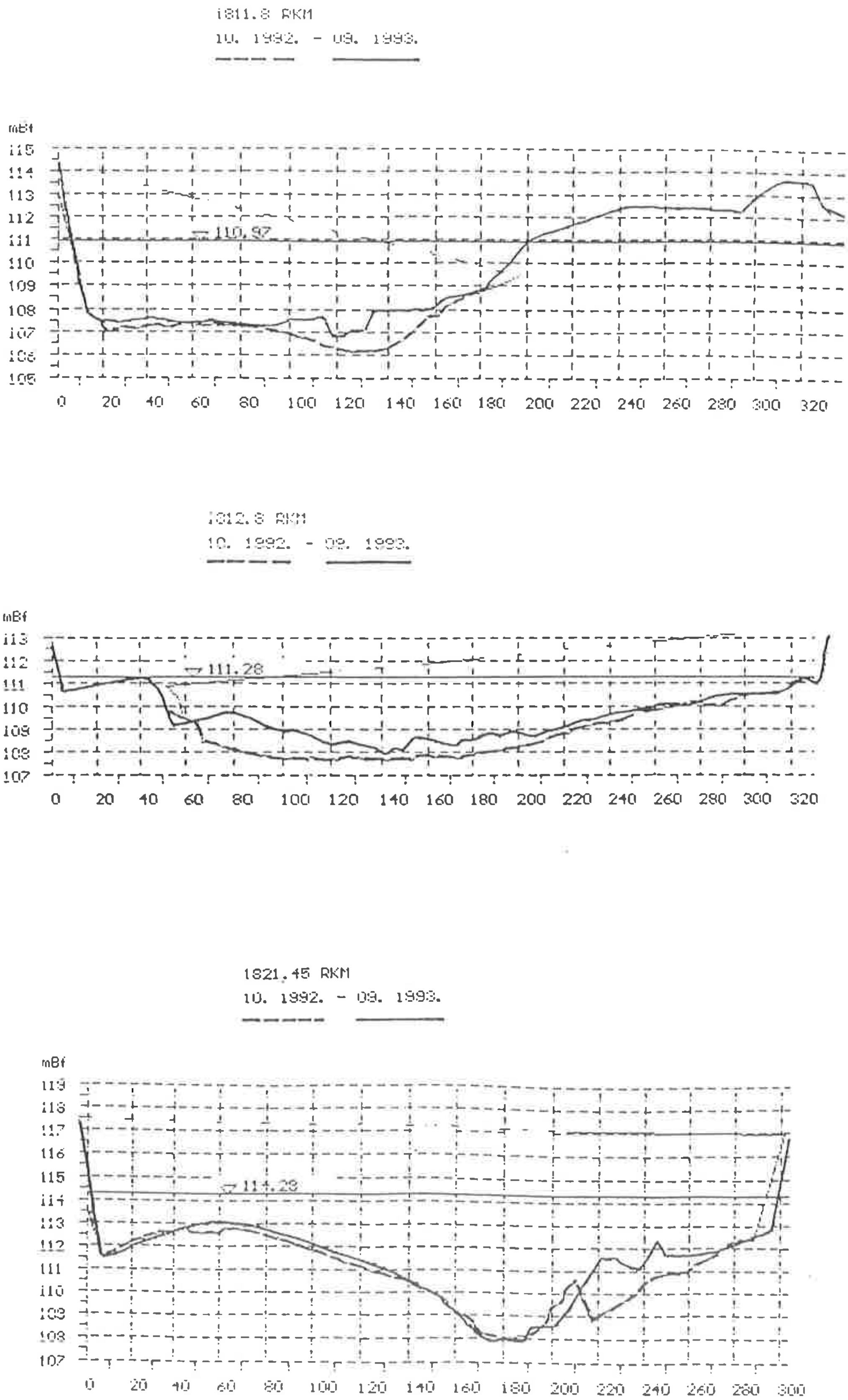


Fig. 2.2 River cross-sections measured at three sites (Rkm 1811.8, Rkm 1812.8 and Rkm 1821.45) before and after the damming of the Danube

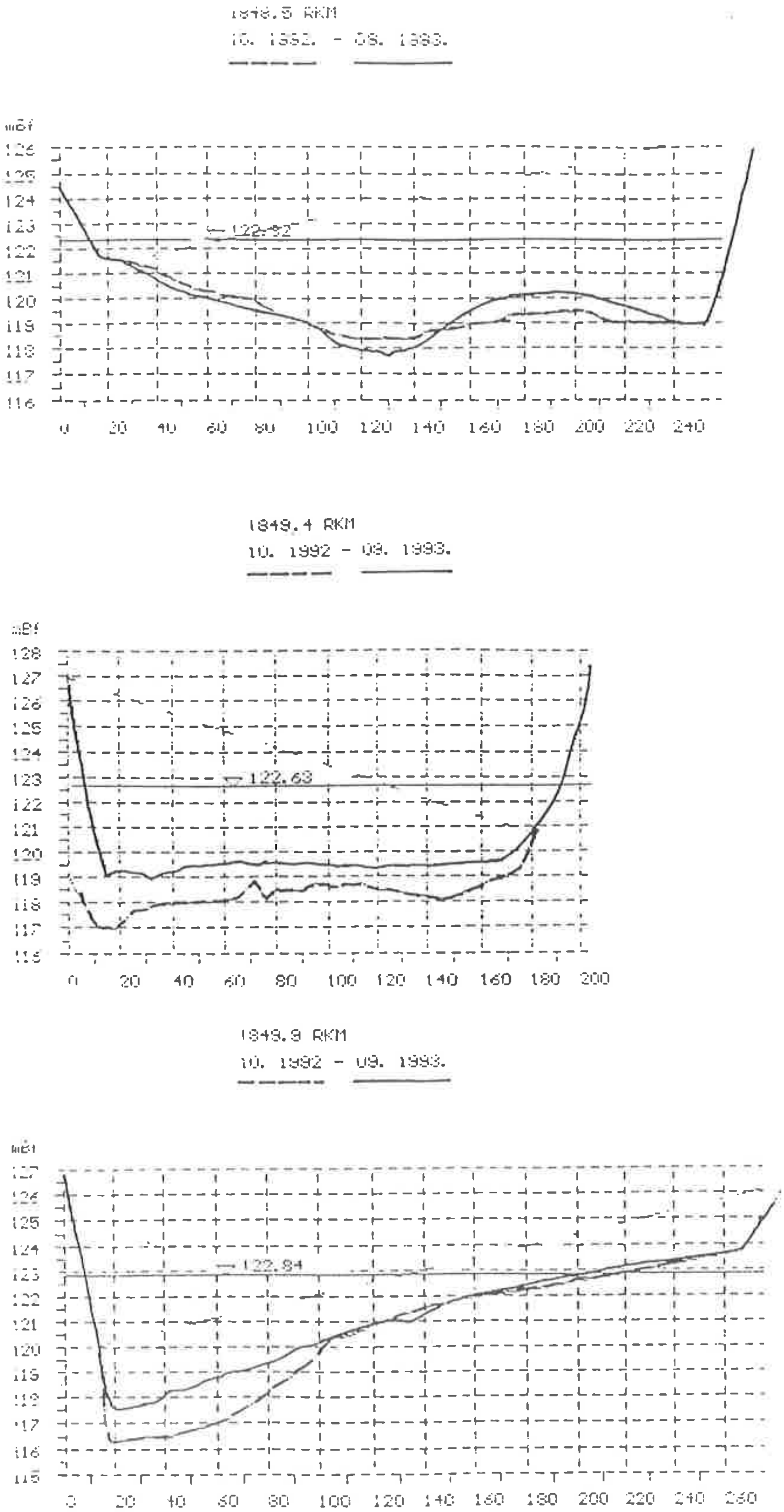
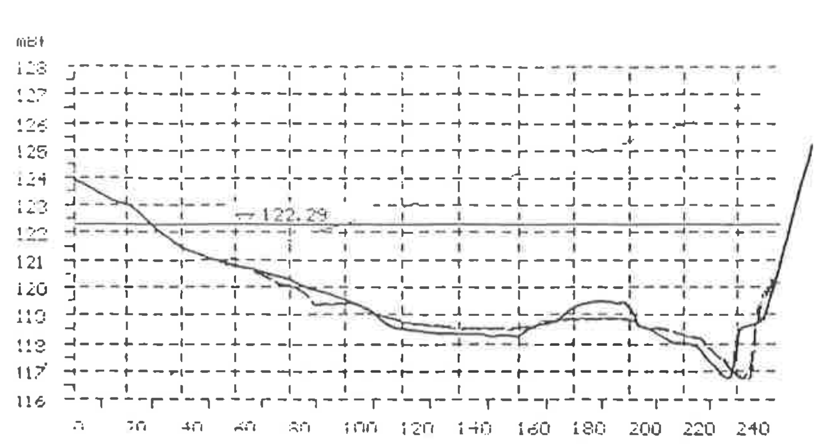


Fig. 2.3 *River cross-sections measured at three sites (Rkm 1848.5, Rkm 1849.4 and Rkm 1849.9) before and after the damming of the Danube*



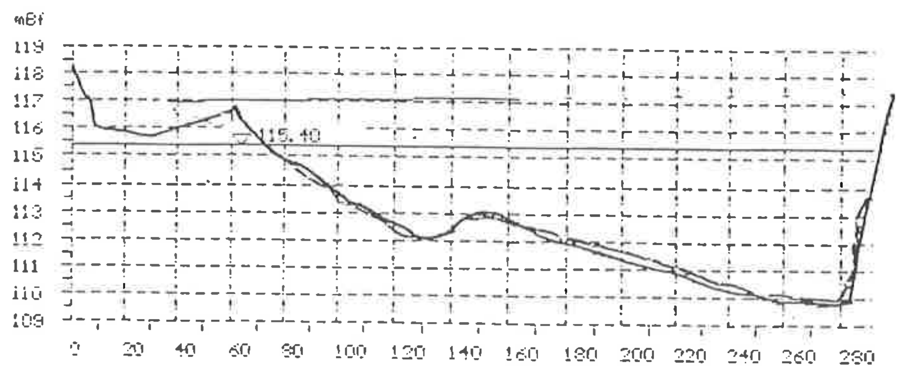


Fig. 2.4 *River cross-sections measured at the two gauging stations at Rajka and Dunaremete before and after the damming of the Danube*

For analysing the hydraulics of the main river a mathematical model, based on DHI's MIKE11 modelling system, has been set up under the PHARE project "Danubian Lowland - Ground Water Model", ref /4,5/. The data on river cross-sections used in the model corresponds to pre-dam conditions. For comparison with the measured data shown in Table 2.3 the results from model calculations for Rajka and Dunaremete are shown in Table 2.4.

Table 2.3 Water levels and cross-sectional average flow velocities at Rajka and Dunaremete for different discharges for the present and for pre-dam conditions.

	Rajka 1993		Rajka Pre-dam condition		Dunaremete 1993		Dunaremete pre-dam condition	
Discharge (m^3/s)	Level (m asl)	Velocity (m/s)	Level (m asl)	Velocity (m/s)	Level (m asl)	Velocity (m/s)	Level (m asl)	Velocity (m/s)
200	120.3	1.04						
400	120.9	1.08			114.2	0.87		
600	121.3	1.13			114.7	1.03		
800	121.8	1.19	121.8	1.19	115.1	1.20	115.0	1.23
1000	122.3	1.29	122.4	1.31	115.4	1.28	115.3	1.29
2000	124.0	1.59	124.3	1.65	117.2	1.63	117.2	1.63
3500			126.3	2.08				

Table 2.4 Water levels and cross-sectional average flow velocities at Rajka and Dunaremete for different discharges calculated by the MIKE11 model for pre-dam conditions.

	Rajka		Dunaremete	
Discharge (m^3/s)	Water level (m asl)	Velocity (m/s)	Water level (m asl)	Velocity (m/s)
200	120.2	0.60	113.8	0.77
400	121.0	0.88	114.4	1.12
600	121.6	1.07	115.0	1.22
800	122.2	1.23	115.4	1.28
1000	122.7	1.35	115.9	1.34
2000	124.4	1.66	117.4	1.65
3500	126.1	2.04	119.1	2.00

By comparison of the figures in Table 2.3 and Table 2.4 it is noticed that the model simulated and the rating curve water levels show an average deviation of 20 cm. With respect to flow velocities the average deviation for discharges of 800 m^3/s or higher is 4 cm/s, while larger deviations occur for smaller discharges. Thus for small discharges the simulated velocities are smaller than the rating curve values at Rajka, while it is opposite for Dunaremete. No attempt has been made to analyze the exact reason for these deviations; instead it is noticed that the right order of magnitudes of flow velocities is simulated also for small discharges. More thorough validations of the model are provided in ref /5/. On this basis it can be stated that the model can represent water level and flow velocity conditions in the Old Danube to a level of accuracy sufficient for the present purpose.

Hence, estimates given later in this report on flow velocities in the Old Danube under different discharge conditions, both with and without underwater weirs, are based on model calculations.

In order to assess the impacts of different discharges on flow velocities at different locations in the Old Danube a number of model calculations have been made with constant discharges. Some key results are shown in Table 2.5. Furthermore the variation of flow velocities along the Old Danube is shown in Fig. 2.5 for a discharge of 600 m^3/s.

From Table 2.5 and Fig. 2.5 it is evident that the velocities vary considerably along the river. In the upstream part (Rkm 1825 - 1850) the variation is determined mainly by variations in local river cross-section. In the downstream part (Rkm 1810 - 1825) the backwater effect fromthe confluence with the outlet power canal is seen. In the model calculation the discharge in the outlet canal has been taken as 2000 m^3/s minus the discharge in the Old Danube. Due to backwater effects the water depths are higher in the downstream part and hence the resulting flow velocity is correspondingly lower.

Table 2.5 Average cross-sectional flow velocities calculated at different locations along the river for different discharges. The values have been calculated with the MIKE11 model using pre-dam river cross-sections.

Discharge (m^3/s)	Velocity RKM 1814.8 1)	Velocity RKM 1822.1	Velocity RKM 1826.6	Velocity RKM 1834.8	Velocity RKM 1838.8	Velocity RKM 1845.6	Velocity RKM 1849.8
200	0.21	0.37	0.83	1.34	0.87	0.57	0.90
400	0.42	0.67	1.07	1.59	1.02	0.83	1.15
600	0.62	0.91	1.18	1.66	1.17	1.03	1.30
800	0.81	1.12	1.24	1.72	1.26	1.19	1.42
1000	1.00	1.29	1.29	1.77	1.35	1.32	1.51
2000	1.81	1.74	1.58	2.00	1.69	1.66	1.77

Note 1): RKM 1814.8 is just upstream the confluence with the outlet canal at Sap/Palkovicovo, which in the calculations has a discharge of 2000 m^3/s minus the discharge in the Old Danube. Hence this site is significantly influenced by backwater effects resulting in higher water levels and lower flow velocities.

It is noticed that the flow velocities given in Tables 2.3-2.5 and in Fig. 2.5 are average cross-sectional values. For estimation of maximum flow velocities in a given profile at e.g. 7 cm above the river bed as required by certain fish species (see Section 3.4 point (b)) the following two factors must be taken into account:

* Velocity variations at a given cross-section exist in the direction across the river, so that places with higher water depths have higher velocities and vice

versa. The velocity variation across the river depends mainly on the shape of the river cross-section. Simple calculations on the basis of the cross-sections at Rajka and Dunaremete indicate that the velocities in the deepest profile are respectively 35 % and 28 % higher than the cross-sectional average values for these two sections.

* Velocity varies vertically within a given cross-section with maximum velocity at (or close to) the surface water table and velocity close to zero at the river bed. Based on standard hydraulic assumptions (logarithmic velocity profile, Manning no = 33) and assuming typical water depths it can be estimated that the velocity 7 cm above the river bottom will be only about 50 % of the average velocity of a vertical profile.

Combining these two counteracting effects, it may be estimated that a multiplication factor of 1.3 * 0.5 = 0.65 has to be applied to convert a cross-sectional average velocity to the velocity 7 cm above the river bed in the vertical profile with the largest velocity.

In this report velocities refer to cross-sectional average flow velocities unless specifically stated otherwise.

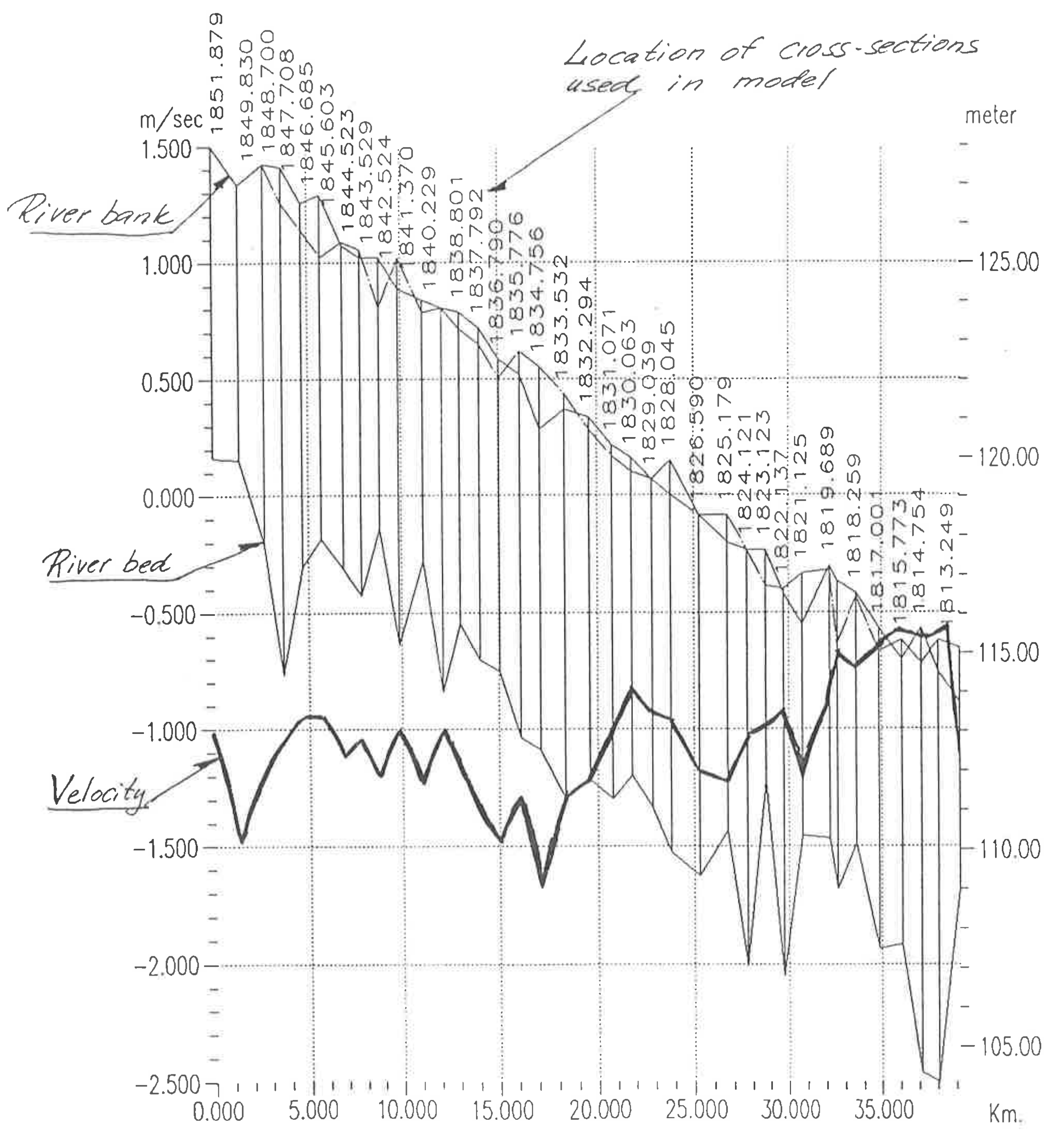


Fig. 2.5 *Velocity profile between Cunovo and Sap/Palkovicovo simulated with the MIKE11 model with a discharge of 600 m^3/s*

2.3 Inundation Area on the left Side

The socalled inundation area or flood plain is the area between the main Danube and the flood dikes. On the left river side in Slovakia this flood plain covers the main part of the area between the main Danube and the power canal.

The inundation area is characterized by a large number of river branches of different sizes and interconnected in a complex way. A sketch of the area is given in Fig. 2.6, which also shows the location of the remedial measures implemented in the beginning of 1993.

Until about 30 years ago the side branches carried a substantial part of the total discharge. Measurements carried out in 1960 and 1961 showed that in the area near Gabcikovo the river branches carried about 20 % of the total discharge, also for low discharges. In the following years the connection between the river branches and the main river were closed in order to ensure high water depths for navigation. As described in ref /1/ this resulted in a pre-dam situation with total lack of connection about half the year and full connection only for about 20 days per year.

After damming of the Danube the water level in the upstream part of the Old Danube has been reduced so much that water now flows from the main river to the side branches only in flood situations a few days per year, while usually there is a water level difference of a couple of meters. In order to remedy this situation and the processes described in the para above Slovakia has implemented a project with the following key elements:

* Intake of water at an intake structure in the power canal at Dobrohost. Through a new canal this water is diverted into one of the river branches.

* Construction of a number of hydraulic structures in the side channels. As a result the flood plain is divided into seven compartments with almost constant water levels and separated by hydraulic structures.

* More efficient closing of the connections between the side channels and the main Danube in order to minimize loss of water.

Thus the water flows over a distance of about 20 km over seven cascades until it enters the Danube at RKM 1821. There is a loss of water of several m^3/s, due to infiltration to ground water, evaporation and flow to the Danube.

It is possible to regulate the intake of water from 0 to at present 140 m^3/s (234 m^3/s when the structure is completed). The system was taken into operation at the end of April 1993, and the discharges has since then varied between 10 m^3/s and 70 m^3/s. Monthly average values are

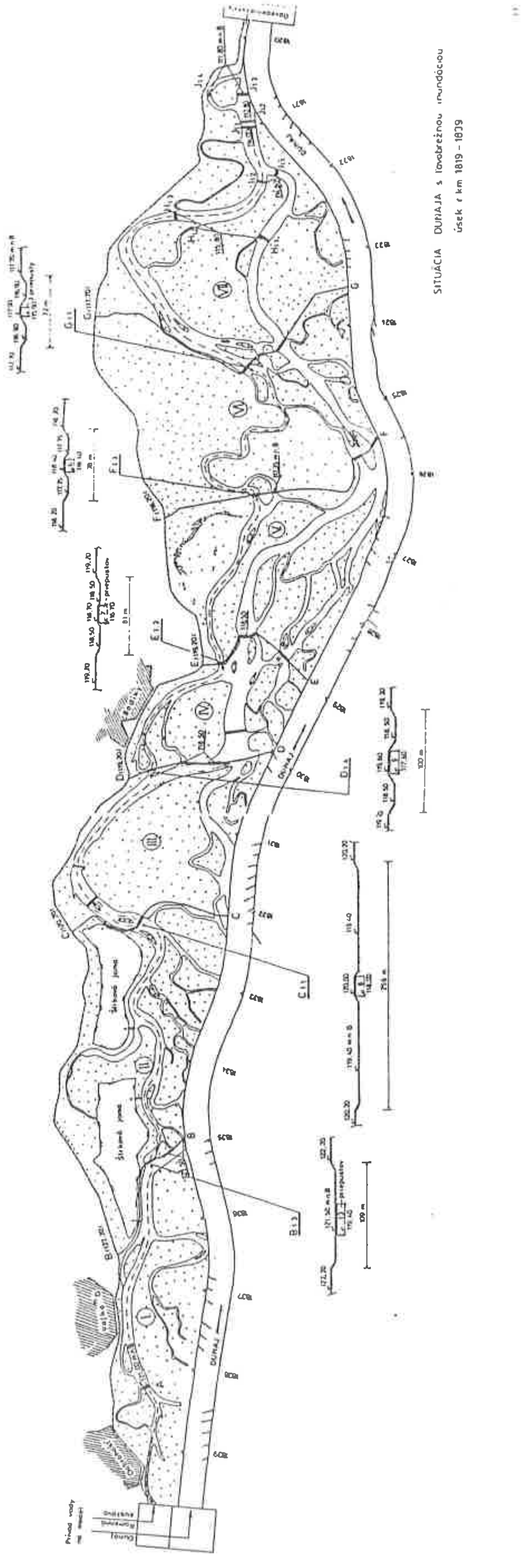


Fig. 2.6 Branch system on the Slovakian flood plain.

given in ref /2/.

More details on the remediation project is given in ref /6/.

The flow velocities vary very much in the area due to very large variations in cross-sections and bifurcations/junctions of flow paths. Simulation of the area with the MIKE 11 model, ref /5/, indicate that at a discharge of 40 m^3/s typical cross-sectional velocities are in the order of 0.05 - 0.25 m/s. These velocities have been confirmed by recent field measurements.

As a result of the discharges of up to 70 m^3/s the fine material/mud, which previously covered the bottom of the side channels, has been washed away at many locations. As described in ref /2/ it can be seen from ground water observations that a significant infiltration takes place now.

2.4 Inundation Area on the right Side

The inundation area on the right side forms part of the Szigetköz. The main part of the alluvial forest in Szigetköz is located in the inundation area. Like on the Slovakian side the area is characterized by a large number of river branches of different sizes and interconnected in a complex way. A sketch of the area is given in Fig 2.7.

As a result of river regulation during the past 30 years merely a limited number of side branches succeeded in preserving virtual connection with Danube. Thus the pre-dam situation was similar to the pre-dam situation on the Slovakian side.

After damming the Danube the connection between the Danube and the side channels virtually disappeared. In order to provide the branches with water Hungary has carried out considerable engineering efforts in 1993. They included the reduction of the elevation of closing dams and bypass weirs as well as cleaning some new channel sections. The most significant change related to the transformation of the branch system resulted from closing its previously open lower endings except for the ones in Asvanyi and Bagomeri. Branch systems have been connected by cut-offs creating thus the flood plain main channel stretching parallelly to Danube from Dunakiliti to the confluence of the Asvany branch system.

The water supply to the branch system presently comes from the outlet structure at Cunovo reservoir (22 m^3/s) and the right side seepage canal (3 m^3/s). This water is divided between the Mosoni Danube (10 m^3/s), a water supplying canal for protected area (5 m^3/s) and the flood plain main channel (10 m^3/s). This is illustrated in Fig 2.8. The water supply system to the Hungarian flood plain was put into operation in August 1993.

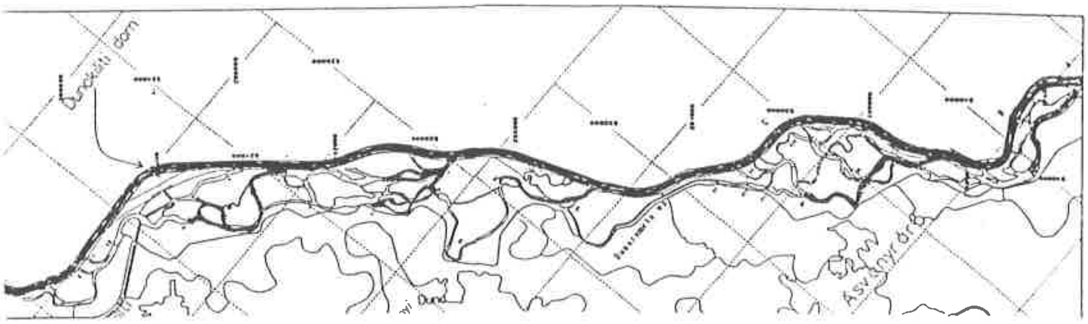


Fig. 2.7 *Branch system on the Hungarian flood plain.*

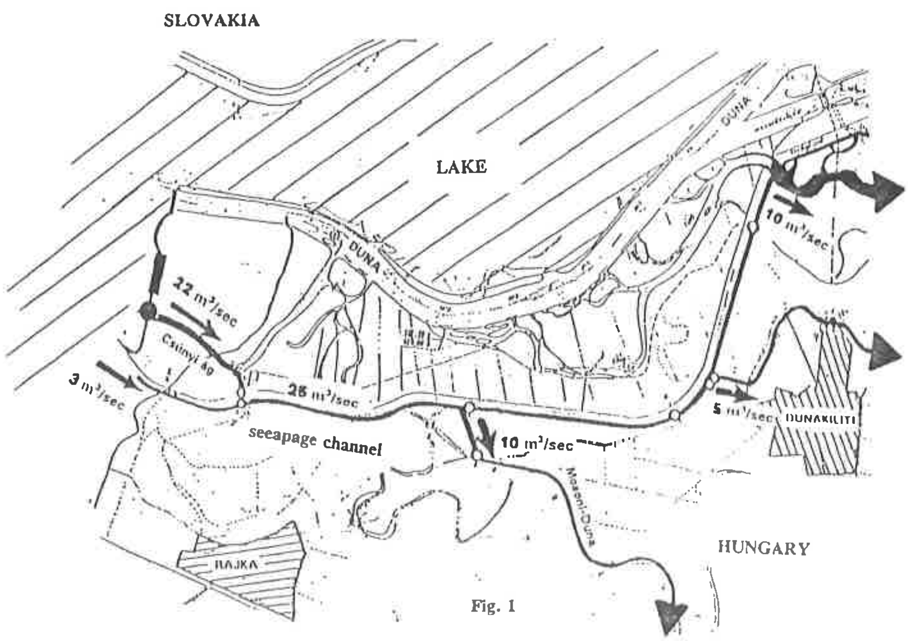


Fig. 2.8 *Water supply system for the Hungarian flood plain.*

The velocities vary very much in the area due to very large variations in cross-sectional area. The few existing point measurements indicate a velocity range from 0.02 m/s up to more than 1 m/s. However, calculations of cross-sectional average velocities for at three cross-sections in the flood plain main channel show velocities between 0.05 m/s and 0.09 m/s. Unlike on the Slovak side the velocities have not been high enough to remove the fine bed material so much that a significant infiltration to the ground water system has been initiated.

The capacities of the channel/canal system (see Fig. 2.8) are as follows:

* The seepage canal before the confluence with the outlet canal: 5 m^3/s.

* The outlet canal from the structure at Cunovo reservoir: 25 m^3/s.

* The canal between the confluence of the seepage canal and the outlet canal and the start of Mosoni Danube: 50 m^3/s.

* The canal between the start of the Mosoni Danube and the start of the flood plain main channel: 25 m^3/s.

* The flood plain main channel: 50 m^3/s.

In the original plans for the Gabcikovo-Nagymaros project the water supply to some part of the right side branches was suggested to be taken care of by pumping around Asvanyraro. In 1993 the Lipot morotva had the worst situation of water quantity and quality at the outside of the dikes, and therefore some water was pumped from Danube to a canal of oxbow lake. An operation of 18 hours per day (a single pumping engine) provided 0.5 - 0.7 m^3/s for 90 days. This resulted in a water level of 0.6 - 0.9 m. The cost of this operation was 0.04 mill ECU. Based on this experience the Nature Conservancy plans to extend this system to other protected areas too.

3. FORMULATION OF SCENARIOS

In this chapter five different scenarios for TWMR are briefly outlined. The scenarios are based on different characteristics with regard to discharges and water level regimesets as well as to remedial measures. It is emphasized that the members of the Working Group not necessarily agree to these characteristics. However the Working Group agrees to the subsequent descriptions of technical possibilities, environmental impacts etc. For each scenario the following aspects are described in details in the subsequent chapters 4-8:

* Characteristics of the scenario
* Technical and water management aspects
* Possible time schedule for implementation
* Impacts on discharges, water levels and flow velocities
* Impacts on erosion/sedimentation
* Impacts on surface water quality
* Impacts on ground water regime
* Impacts on ground water quality
* Impacts on flora and fauna
* Impacts on agriculture and forestry
* Impacts on electricity production
* Cost estimate for remedial measures

Unless specified otherwise, the impacts are described in comparison to the pre-dam conditions. Similarly the discharges and the technical remedial measures are, unless specified otherwise, described in relation to the November 1993 situation (Scenario 0). A summary of the quantitative impacts for the five scenarios is provided in tabular form in Appendix C.

3.1 Outline of the five Scenarios

Scenario 0: November 1993 Situation

The present situation is characterized by:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.

* 30-50 m^3/s into the side channels on the left side flood plain.

* 10 m^3/s into the side channels on the right side flood plain.

Scenario 1: Increased water supply to the Hungarian Side Branches

This situation can be characterized by the following discharge condition:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30 - 70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (if hydrologically possible).

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

This scenario can be characterized by the following discharge regime:

* Increase of discharge into the Old Danube to in average 600 m^3/s immediately and to somewhere between 600 m^3/s and 940 m^3/s after May 1994 with an average value of 800 m^3/s.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30 - 70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (if hydrologically possible).

Scenario 3: Construction of some Underwater Weirs

This scenario consists in construction of some underwater weirs for increasing the water level in the Old Danube and for enabling interconnection between the main river and the branch system. The impacts of the underwater weirs on key parameters are demonstrated for different discharges ranging from 200 m^3/s to 2000 m^3/s. Construction of underwater weirs is possible along with any discharge regime. In Scenario 3 the impacts of constructing eight underwater weirs are elaborated in details for the discharge regime corresponding to Scenario 2.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches.

In this scenario as much water as technically possible will be diverted into the Old Danube and the side channels. This scenario will have two different discharge regimes according to the status of the Variant C structures:

* Phase 1 structures.

* Phase 2 structures after 1996.

Scenario elaborated by the Slovak Expert:

In addition to the above five scenarios the Slovakian expert has prepared a separate scenario, which is included as Appendix D.

3.2 Approach in Assessment of Environmental Impacts

The assessment of environmental impacts follows the same procedure as already used in previous reports from the Working Group (ref /1,2/). The approach for the assessments of environmental impacts will be to separately consider the following impacts in respect of the:

(a) Reservoir.

(b) Navigation canal.

(c) Main river (Old Danube).

(d) Inundation area with the side branches on the left side (Slovakia).

(e) Inundation area with the side branches on the right side (Hungary).

(f) The connections in the total system.

3.3 Environmental Impacts common to all five Scenarios

Certain impacts caused by the new reservoir are identical for all five scenarios. Hence, they will not be described repeatedly for the individual scenarios in Chapters 4-7. These impacts are, as already described in ref /2/, the following:

* The discharges in the Little Danube and the Mosoni Danube have been increased by 10-20 m^3/s. This implies approximately a doubling of the discharge in the Little Danube. With regard to the Mosoni Danube, this means that it now carries discharge permanently.

* The surface water levels at Bratislava have during low flow periods been increased by 1-2 m as compared to pre-dam conditions, ie to a level corresponding to the situation 40 years ago. The amplitude of the water level fluctuations has been reduced.

* Sedimentation of the total bed load and a certain part of the suspended load will take place in the reservoir.

* The ground water levels in areas close to the reservoir have increased by up to 2½ m. This has occurred in the areas, which were most negatively affected by the long term trend of decreasing ground water levels of up to 2 m during the past 40 years. The fluctuations of the ground water levels have been reduced.

* Upstream the dam the river changed to an impounded lake for a length of 10 km with significantly smaller flow velocities. This causes a loss of many habitats for rheophile organisms.

* About 4,500 ha of floodplain forest on Slovakian and Hungarian territory have been removed under the construction phase. 570 ha of forest in Slovakia is now under afforestation.

* Fish migration along the Danube river is interrupted by the Variant C structures. At present only limited fish passage is possible through the spillway of the bypass weir.

In addition, the international navigation has been removed from the Old Danube to the navigation canal.

Furthermore, the Variant C structures have impacts on the flood management. As described in ref /1/ the discharge capacity of the power canal is required in all cases in order to have sufficient capacity to pass large floods.

3.4 Assumptions

In assessments of the impacts some assumptions have been made. They are described together with their justifications as follows:

Main river

(a) *A discharge of 3500 m^3/s twice per year will be enough to clean the river bed sufficiently for fine material deposited during low discharge conditions and to spread this material in the whole inundation area.*

3500 m^3/s is more than recorded maximum annual flows for some years. Hence, two such floods per year will not be possible every year. Realistically, two such floods per year routed through the Old Danube may be possible in average every second year, while at least one such flood per year may be possible in average four years out of five.

At 3500 m^3/s the flow velocities will be around 2 m/s in pre-dam conditions, see Section 3.2. Such flow velocities during a couple of days is more than sufficient to erode fine material from the river bed.

(b) *To provide sufficient living conditions for typical fish species living in the Danube under pre-dam conditions a pattern of different flow velocities in the river bed is necessary. Flow velocities near the river bottom of at least 0.6 m/s must occur at several places all over the year.*

Different fish species have different requirements to flow velocities. The species with low flow velocities will still be able to find such conditions, whereas the species requiring the largest flow velocities may have problems if the discharge and hence the flow velocities are too low. Therefore, the requirements of the fish species requiring the highest flow velocities are important. According to a study in the Austrian part of the Danube (ref /7/) flow velocities of 0.5 - 0.7 m/s are required for the fish species (*Zingel streber*) requiring highest flow velocities. This fish species is according to the Slovakian Data Report (ref /8/) also the fish species in this area, which require the highest flow velocity.

Streber should be seen as an indicator for species having requirements for large flow velocities.

It is noticed that the above required flow velocity refer to velocities 7 cm above the river bottom (ref /7/), where the fishes live. As described in Section 2.2 a multiplication factor of 0.65 can be applied to convert cross-sectional average velocities to specific point values 7 cm above the bottom. Thus in order to get 0.6 m/s for the fish *a cross-sectional average velocity of about 0.9 m/s* is required.

Inundation areas

(c) *A variation of the water level within 2 m will be enough to ensure the dynamic character including the floodings according to the pattern in pre-dam conditions.*

According to ref /1/ the difference in water level at Dunaremete for the following two flow conditions: "Flow in main channel and permanent branches (several times per year)" and "Complete inundation of flood plain (once per year)" is 1.9 m. Hence, a 2 m variation will be sufficient to ensure the dynamic conditions characterizing the pre-dam conditions.

(d) *If the river bed at some of the main side branches is free from mud the water can infiltrate sufficiently and the conditions for the biocenosis will be sufficient.*

According to the experience from supplying discharge to the Slovakian branches after May 1993, 70 m^3/s corresponding to a typical flow velocity in the main side channels of 0.1-0.3 m/s (cross-sectional average values) was apparently sufficient to clean the river bottom from mud at so many places that a very significant infiltration to the ground water system started (ref /2/). Correspondingly, such condition will be sufficient for the biocenosis.

(e) *To remove the mud from the bottom of the branches a flow velocity of 0.2 - 0.4 m/s is required.*

In the literature on sedimentation/erosion of cohesive sediments uncertainty exists on critical flow velocities. According to some references (Ref /9,10,11/) a flow velocity of 0.2 m/s will normally be sufficient to initiate erosion/resuspension of fine cohesive sediments like e.g. mud. According to other references (Ref /12,13,14/) flow velocities of at least 0.3 m/s are required for this purpose. This will in general depend on local conditions.

Field data from the Slovakian inundation area in 1993 show that a substantial part of the bottom of the Slovakian river branches were eroded under average cross-sectional flow velocities not much higher than 0.2 m/s.

(f) *To keep the bottom of the branches free from mud requires a minimum flow velocity of 0.1 - 0.3 m/s.*

According to some literature on sedimentation/erosion of cohesive sediments a flow velocity of 0.1 m/s will normally be sufficient to prevent sedimentation of fine cohesive sediments like e.g. mud. (Ref /9,10,11/). According to other literature sources (Ref /12,13,14/) flow velocities of at least 0.2 - 0.4 m/s will be required for this purpose.

Total system

(g) *To ensure ecological conditions which are as good as pre-dam conditions migration of wetland species between the main river and the side branches should be possible all over the year in both directions.*

Migration can be made possible either through fish passes or through direct flows between the main river and the side branches during some periods. Fish passes enable fish to migrate to some extent, while direct flow connections enable migration of all wetland species.

4. ELABORATION OF SCENARIO 0

Scenario 0 is a continuation of the present situation existing in November 1993 (ref /2/).

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

4.1 Characterization of the Scenario

This scenario is characterized by the following discharge regime:

* In average 400 m^3/s into the Old Danube consisting of a base discharge of 250 - 300 m^3/s supplemented with more discharge during some flood events.
* 30-50 m^3/s into the side channels on the left side flood plain.
* 10 m^3/s into the side channels on the right side flood plain.

No remedial measures additional to the already existing will be implemented.

4.2 Technical and Water Management Aspects

Technically, this scenario is possible with the existing structures. It is assumed that the water management continues as experienced during the past months. This will result in the discharge pattern given in Table 4.1.

Table 4.1 Annual average discharge values in Scenario 0.

	Average annual discharge (m^3/s)
Danube, Bratislava	2.025
Inflow to Little Danube, Bratislava	30
Inflow to Mosoni Danube, Cunovo	25
Seepage canal, right side	2
Seepage canal, left side	5
Seepage from reservoir to Danube	20
Seepage to ground water	30
Intake to Slovakian river branches, Dobrohost	40
Bypass weir plus inundation weir, Cunovo	380
Ship locks, Gabcikovo	25
Turbines, Gabcikovo	1.468

4.3 Possible Time Schedule for Implementation

This scenario has already been in operation for several months by now.

4.4 Impacts on Discharges, Water Levels and Flow Velocities

The impacts on discharges and water levels, as already measured are described in ref /2/, and shown in Table 4.1. They can be characterized as follows:

* The discharges in the Old Danube will in average be about 20% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2-4 m as compared to pre-dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will continue to be significantly reduced as compared to pre-dam conditions.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

The split of the discharges can in a year with average discharge be described by the figures given in Table 4.1

The flow velocities have been estimated to be as described in Table 4.2. From the table it appears that the cross-sectional velocities at minimum discharge in the main river are 0.6 - 0.8 m/s corresponding to velocities near the bottom of 0.4 - 0.5 m/s.

4.5 Impacts on Erosion/Sedimentation

The impacts on erosion and sedimentation as already measured are described in ref /2/. Due to lack of specific measurements there is some uncertainty with regard to the development over the coming years. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material may be washed away during flood events.

* The river bed in the main branches on the Slovakian side will continue to be free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will continue to be clogged with fine material/mud and prevent significant infiltration to the ground water system.

Table 4.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 0.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	200	0.60
	Average	400	0.88
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	200	0.77
	Average	400	1.12
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	40	0.05 - 0.25
	Typical annual maximum	70	0.07 - 0.35
Right side branch, main channel	Typical minimum	0	0
	Typical average	10	0.05 - 0.09
	Typical annual maximum	15	0.06 - 0.10
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		5-10 days/year
	Flow from main river into almost all river arms		< 5-10 days/year

4.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

4.7 Impacts on Ground Water Regime

The impacts on ground water levels as already measured are described in ref /2/. This pattern is expected not to change, ie:

* Ground water levels on the Slovakian territory will be higher or equal to the pre-dam conditions.

* Ground water levels on the Hungarian territory will, as compared to pre-dam conditions, be higher close to

the reservoir (Rajka - Dunakiliti region), whereas the levels will be lower in the middle part of Szigetköz between Dunakiliti and Asvanyraro in areas up to a few km from the Old Danube.

* The ground water level fluctuations have decreased significantly as compared to pre-dam conditions. This could be influenced by implementation of improved operational rules for day-to-day water management.

4.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, local changes are expected in areas close to the reservoir in certain parameters, such as total dissolved solids, nitrate, etc due to changes in flow pattern. These changes are not expected to lead to a worsening in the ground water quality.

4.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area (side branches plus forests) the decrease of the water level fluctuations makes the site conditions worse for floodplain biocenoses.

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile

organisms, especially of fish species spawning on gravel ground.

* The flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

4.10 Impacts on Agriculture and Forestry

The impacts on agriculture and forestry as already observed are described in ref /2/, ie:

* Due to the increase of ground water tables on the Slovak territory an increase in the capillary water supply for the Slovakian agricultural areas has taken place. In Hungary, the impacts on agriculture are positive in areas with increase in ground water level and negative in areas with decrease in ground water level, see Section 4.7.

* As a result of the changes in ground water level the forestry is mainly positively effected in Slovakia and mainly negatively in Hungary.

As the ground water levels are not expected to change further, these impacts are not expected to be changed.

4.11 Impacts on Electricity Production

In a year with average discharges as outlined in Table 4.1 the electricity production can be estimated to about 2,000 GWh/year.

4.12 Cost Estimate for Remedial Measures

The remedial measures already implemented are the works on the Slovakian and Hungarian flood plains. The costs of these are approximately (excluding the intake structures at the power canal at Dobrohost and the outlet structure for Mosoni Danube at Cunovo):

* Slovakian flood plain: 12.0 mill ECU.

* Hungarian flood plain: 2.0 mill ECU.

5.

5.2 Technical and Water Management Aspects

5.2.1 Additional remedial measures

The following technical measures are considered under this scenario:

Inundation area on the left side

* Construction of 7 fish passes connecting the main Danube to the side branches.
* Construction of fish passes within the inundation area.

These fish passes can be constructed in three months and is estimated to cost 0.54 mill ECU.

Inundation area on the right side

In order to achieve sufficient flow velocities in the channels on the Hungarian side it is estimated that the present 10 m^3/s have to be increased to the same level as the one presently existing on the Slovakian side, i.e. up to 70 m^3/s with average values in the order of 50 m^3/s. Such discharges will most likely result in sufficiently high flow velocities to ensure removal of mud from a substantial part of the river bottom.

The supply of these up to 70 m^3/s can be achieved by four technically alternative solutions:

(a) Construction of a supply canal from the inundation weir to the first side branch. This work can be completed within three months and is estimated to cost 2.4 mill ECU. In addition, the reconstruction work on the spillway of the bypass weir is neccecary and is expected to be completed in May 1994.

(b) Construction of an underwater weir between RKM 1843 and 1847. Previously such a project has already been designed. Implementation of a new project, including fullfilment of all legal procedures, is expected to be possible within a year and to cost 1.5 mill ECU.

(c) Using the supply canal and additional construction of syphons between the reservoir and the first side branch. The syphons, which need to have a total capacity of about 50 m^3/s, have to cross the river. Taking into account a length of 450 m and a 7 m difference in level, a water pipe of 1 m diameter enables transmission of 0.6 m^3/s. Hence about 80 syphons are required for transmitting 50 m^3/s. The best technical way of crossing the Danube is put the pipes in a trench below the river bottom. The cost of the syphon system is estimated to be in the order of 5 mill ECU.

(d) Increase of the capacity of the supply canal from 25 m^3/s to 70 m^3/s. This can be implemented within six months and is estimated to cost 5 mill ECU.

From a technical and economical point of view, the simplest alternative is the underwater weir (b). This solutions also provides the best water management possibilities and the minimum risk of damage during floods. From an

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	Average annual discharge (m^3/s)
Danube, Bratislava	2.025
Inflow to Littl Danube, Bratislava	30
Inflow to Mosoni Danube, Cunovo	25
Seepage canal, right side	2
Seepage canal, left side	
Seepage from reservoir to Danube	20
Seepage to ground wate	30
Intake to Slovakian river branches, Dobrohost	40
Intake to Hungarian river branches, Danube	50
Bypass weir plus inundation weir, Cunovo	380
Ship locks, Gabcikovo	25
Turbines, Gabcikovo	1.418

5.4 Impacts on Discharges, Water Levels and Flow Velocities

The impacts on discharges and water levels, as already measured are described in ref /2/, and shown in Table 5.1. They can be characterized as follows:

* The discharges in the Old Danube will in average be about 20% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2-4 m as compared to pre-

dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will continue to be significantly reduced as compared to pre-dam conditions. This could be influenced by implementation of improved operational rules for day-to-day water management.

* Water level variations on the Slovakian inundation area will vary by 1.8 m at a difference in water supply from the intake canal at Dobrohost from 0 to 140 m^3/s.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

The split of the discharges can in a year with average discharge be described by the figures given in Table 5.1

The flow velocities have been estimated to be as described in Table 5.2. From the table it appears that the cross-sectional velocities at minimum discharge in the main river are 0.6 - 0.8 m/s corresponding to velocities near the bottom of 0.4 - 0.5 m/s.

5.5 Impacts on Erosion/Sedimentation

The impacts on erosion and sedimentation as already measured are described in ref /2/. Due to lack of specific measurements there is some uncertainty with regard to the development over the coming years. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material may be washed away during flood events.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

5.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

Table 5.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 1.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	200	0.60
	Average	400	0.88
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	200	0.77
	Average	400	1.12
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	40	0.05 - 0.25
	Typical annual maximum	70	0.07 - 0.35
Right side branch, main channel	Typical minimum	0	0
	Typical average	10	0.05 - 0.09
	Typical annual maximum	15	0.06 - 0.10
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		5-10 days/year
	Flow from main river into almost all river arms		< 5-10 days/year

5.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions.

* Ground water levels on the Hungarian territory are expected to be not lower than in the pre-dam conditions.

* Reestablishing the dynamics of ground water level fluctuations will to large extent be possible downstream the reservoir.

5.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, some local changes are expected in areas close to the reservoir in certain parameters, such as total dissolved solids, nitrate, etc due to changes in flow pattern. These changes are not expected to lead to a worsening in the ground water quality.

5.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms, especially of fish species spawning on gravel ground.

* The flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring the higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

5.10 Impacts on Agriculture and Forestry

Due to the increase of ground water tables on both the Slovakian and Hungarian territory an increase in the capillary water supply for as well agricultural as forestry areas can be expected.

5.11 Impacts on Electricity Production

In a year with average discharges as outlined in Table 5.1 the electricity production can be estimated to about 1,930 GWh/year.

5.12 Cost Estimate for Remedial Measures

The remedial measures already implemented in addition to Scenario 0 are estimated to cost as follows:

* Fish passes on the Hungarian flood plain: 0.54 mill ECU

* Water supply plus fish passes on the Hungarian flood plain: 2.0 mill ECU.

6. ELABORATION OF SCENARIO 2

Scenario 2 represents an increase in discharge in the Old Danube and in the Hungarian side branches as compared to Scenario 0.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

6.1 Characterization of the Scenario

This scenario is characterized by the following discharge regime:

* Increase of discharge into the Old Danube to in average 600 m^3/s immediately and to somewhere between 600 m^3/s and 940 m^3/s after May 1994 with an average value of 800 m^3/s.

* 30-140 m^3/s into the side channels on the left side flood plain with an average value of 50 m^3/s.

* 30-70 m^3/s into the side channels on the right side flood plain with an average value of 50 m^3/s.

* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (to the extent hydrologically possible).

Remedial measures (structures) will be implemented for the following purposes:

* Obtaining increased discharge to the Old Danube.

* Obtaining increased water supply into the side channels on the right side.

* Ensuring some migration of wetland species between the main river and the side branches.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

6.2 Technical and Water Management Aspects

<u>6.2.1</u> <u>Additional remedial measures</u>

The following technical measures are considered under this scenario:

Main River

* Improvement of the daily discharge capacity of the Variant C structures from the present 600 m^3/s to 940 m^3/s and 6240 m^3/s according to Subsection 2.1.3.

The time schedule and cost estimates are as follows:

* Discharge capacity: 940 m^3/s is possible from May 1994 and 6240 m^3/s is possible from summer 1996. The reconstruction of the spillway for the inundation weir enabling 340 m^3/s as a daily discharge can be implemented by May 1994 and is expected to cost 1 mill ECU/year in maintenance.

Inundation area on the left side

* Construction of 7 fish passes connecting the main Danube to the side branches.
* Construction of fish passes within the inundation area.

These fish passes can be constructed within three months and is estimated to cost 0.54 mill ECU.

Inundation area on the right side

In order to achieve sufficient flow velocities in the channels on the Hungarian side it is estimated that the present 10 m^3/s have to be increased to the same level as the one presently existing on the Slovakian side, i.e. up to 70 m^3/s with average values in the order of 50 m^3/s. Such discharges will most likely result in sufficiently high flow velocities to ensure removal of mud from a substantial part of the river bottom.

The supply of these up to 70 m^3/s can be achieved by five technically alternative solutions:

(a)-(d) See description in Subsection 5.2.1

(e) Dredging of a side branch at RKM 1845 - 1848. With discharges in the Old Danube of 800 m^3/s the water level will then be sufficiently high to enable diversion of 50 m^3/s to the right side branch system. This can be implemented in two months and is estimated to cost maximum 1 mill ECU.

From a technical and economical point of view, the simplest alternatives is the dredging (e).

In addition to the water supply fish passes between the main Danube and the side branches should be constructed. These works have not been designed but can according to designs on the Slovakia side be estimated to cost 0.5 mill ECU.

6.2.2 Water management regime

The water management regime will be characterized by the average annual discharge values shown in Table 6.1.

Table 6.1 Annual average discharge values in Scenario 2.

	Average annual discharge (m^3/s) Preliminary regime implemented now	Average annual discharge (m^3/s) Regime implemented May 1994
Danube, Bratislava	2.025	2.025
Inflow to Little Danube, Bratislava	30	30
Inflow to Mosoni Danube, Cunovo	25	25
Seepage canal, right side	2	2
Seepage canal, left side	5	5
Seepage from reservoir to Danube	20	20
Seepage to ground water	30	30
Intake to Slovakian river branches, Dobrohost	50	50
Intake to Hungarian river branches, Danube	40	40
Bypass weir plus inundation weir, Cunovo	580	780
Ship locks, Gabcikovo	25	25
Turbines, Gabcikovo	1.218	1.018

6.3 Possible Time Schedule for Implementation

The possible time schedule for implementation of the various elements are given in Section 6.2 above. In summary, it can be estimated that the scenario can be implemented in May 1994.

6.4 Impacts on Discharges, Water Levels and Flow Velocities

The split of the discharges can in a year with average discharge be described by the figures given in Table 6.1

The impacts on discharges and water levels, can be characterized as follows:

* The discharges in the Old Danube will in average be about 40% as compared to pre-dam condition.

* The water levels in the upstream part of the Old Danube will be reduced by 2 - 2.5 m as compared to pre-dam conditions.

* The characteristic dynamics of water level and discharge fluctuations in the Old Danube will be somewhat reduced as compared to pre-dam conditions.

* Water level variations on the Slovakian inundation area will vary by 1.8 m at a difference in water supply from the intake canal at Dobrohost from 0 to 140 m^3/s.

* The difference in water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under the flooding conditions expected to occur 1-2 times per year.

* The discharge through the downstream part of the reservoir will as compared to Scenario 0 be reduced from in average 1533 m^3/s to 1093 m^3/s resulting in a decrease in velocity of 29 % and an increase in retention time of 40 % respectively.

The flow velocities have been estimated to be as described in Table 6.2. From the table (and Table 2.5) it appears that the minimum flow velocities at minimum discharge are about 1 m/s corresponding to 0.6 -0.7 m/s as point velocity 7 cm above the river bottom (fish location). It is also noticed that the flow velocities on the Hungarian flood plain will be so large that erosion of the fine bed material can be expected.

6.5 Impacts on Erosion/Sedimentation

The development of the erosion and sedimentation over the coming years is somewhat uncertain due to shortage of specific measurements. The best estimate is as follows:

* No major net erosion and sedimentation in the Old Danube. During some events sedimentation of fine material will take place. This fine material will be washed away during flood events.

* Sedimentation in the downstream part of the reservoir of fine material will increase as compared to Scenario 0.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

6.6 Impacts on Surface Water Quality

The impacts on the surface water quality are expected to be insignificant.

Table 6.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 2.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	400	0.88
	Average	800	1.23
	Typical annual maximum	3500	2.04
Main river, Dunaremete	Minimum	400	1.12
	Average	800	1.28
	Typical annual maximum	3500	2.00
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river	365 days/year	
	Flow from main river into a few river arms	5-10 days/year	
	Flow from main river into almost all river arms	< 5-10 days/year	

6.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions.
* Ground water levels on the Hungarian territory are expected to be not lower than in the pre-dam conditions.
* Reestablishing the dynamics of ground water level fluctuations will to large extent be possible downstream the reservoir.

6.8 Impacts on Ground Water Quality

The impacts on the ground water quality are in general expected to be insignificant. However, there is a risk that fine material may sediment at the downstream part of the reservoir and cause problems to ground water quality infiltrating from here.

6.9 Impacts on Flora and Fauna

Nature conservation values can by this scenario be preserved to a larger extent than under Scenario 1. However, if the scenario continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* On the Hungarian inundation area the reduction of deposition of fine material (nutrients!) by floods in the alluvial forests makes their growing conditions worse.

* On the Slovakian inundation area the decrease of water level changes due to flooding from the main river can be compensated for management of discharge intake from the navigation canal at Dobrohost. The net effect of this combination is not yet proven in pratise.

* On the Slovakian inundation area the reduction of deposition of fine material (nutrients!) by floods will be counteracted by deposition of smaller concentrations originating from artificial flooding by discharge from the navigation canal. The net effect of this combination is not yet certain.

* Reduction of discharges in the Old Danube leads to reduction of the water body, the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms.

* The flow velocities in the main river could from May 1994 onwards in the major part of the Old Danube and of the year be large enough to provide adequate living conditions for the species requiring the higher flow velocity, for example fish species like Streber (0.6 m/s 7 cm above ground).

6.10 Impacts on Agriculture and Forestry

Due to the increase of ground water tables on both the Slovakian and Hungarian territory an increase in the capillary water supply for as well agricultural as forestry areas can be expected.

6.11 Impacts on Electricity Production

In a year with average discharge through the turbines of 1018 m^3/s as outlined in Table 6.1 the electricity production can be estimated to be about 1390 GWh.

6.12 Cost Estimate for Remedial Measures

The remedial measures to be implemented in addition to the ones in Scenario 0 and Scenario 1 is the reconstruction of the spillway for the inundation weir, which is estimated to cost 1 mill ECU/year in maintenance. Thus the total costs in addition to the ones already implemented in Scenario 0 are estimated as follows:

* Slovakian side: 0.54 mill ECU + 1 mill ECU/year.

* Hungarian side: 2.0 mill ECU.

7. ELABORATION OF SCENARIO 3

Scenario 3 as described below is basically identical to Scenario 2 except for construction of a number of underwater weirs. Hence, the discharge regime and many of the impacts are identical to those of Scenario 2.

In addition to the impacts described in this chapter reference is made to Section 3.3, where environmental impacts common to all five scenarios are described.

7.1 Characterization of the Scenario

This scenario consists in construction of some underwater weirs for increasing the water level in the Old Danube and for enabling interconnection between the main river and the branch system. Construction of underwater weirs is possible along with any discharge regime. The impact of the underwater weirs on key parameters are demonstrated for different discharges ranging from 200 m^3/s to 2000 m^3/s.

In Scenario 3 the impacts of constructing eight underwater weirs are elaborated in details for the discharge regime and the remedial measures corresponding to Scenario 2.

All the remedial measures are technically reversible.

In addition improved operation rules for the day-to-day operation of the water management within the above given discharges will be implemented in order to obtain as good environmental conditions as possible.

7.2 Technical and Water Management Aspects

7.2.1 Design of underwater weirs

Underwater weirs are technically visible and it is possible to remove them with heavy equipment. The effort required for removing underwater weirs is estimated to be the same or less as for the construction both with respect to time and costs. Hence, they can be considered as reversible technical measures.

As an example a specific design with 8 underwater weirs of about 4 m height is shown in Fig 7.1 and Table 7.1.

It should be emphasized that no attempt has been made in the Working Group to identify the optimal design for the specific discharges considered in this scenario. For instance the present design example may not be sufficient for local navigation. The particular design and the calculations made in the following aim at illustrating the effects of inundation weirs.

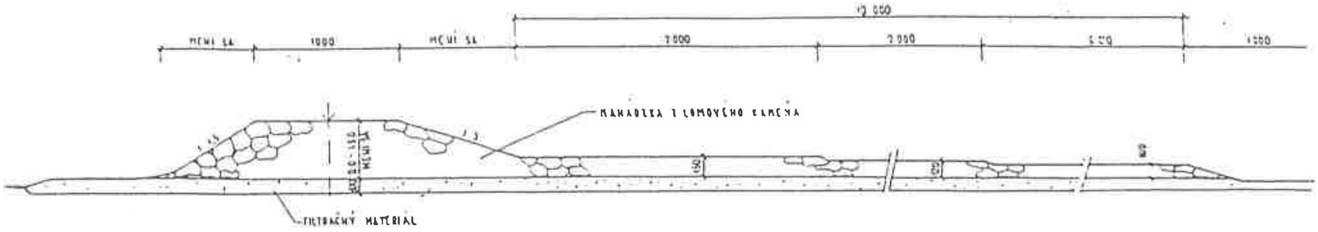

Fig. 7.1 Example of design of underwater weir constructed of large stones

The impacts of this particular design of underwater weirs on water levels and flow velocities have been assessed by calculations with the MIKE 11 mathematical model. The water level and velocity profiles for a discharge of 600 m^3/s is shown in Figs. 7.2a+b for the situation with underwater weirs. The velocity profile in Fig. 7.2a can be compared to the corresponding profile without underwater weirs shown in Fig. 2.5. Fig. 7.2b also shows the water level for the same discharge without under water weirs.

Table 7.1 Design parameters for a system of eight underwater weirs.

Location (RKM)	Crest (m.asl)	Bottom (m. asl)	Height (m)
1814.21	111.85	106.00	5.85
1818.60	113.10	110.00	3.10
1821.30	114.35	110.55	3.80
1824.43	115.50	110.55	4.95
1828.35	116.75	112.70	4.05
1831.70	117.65	113.70	3.95
1834.90	118.85	114.70	4.15
1843.00	121.25	117.20	4.05

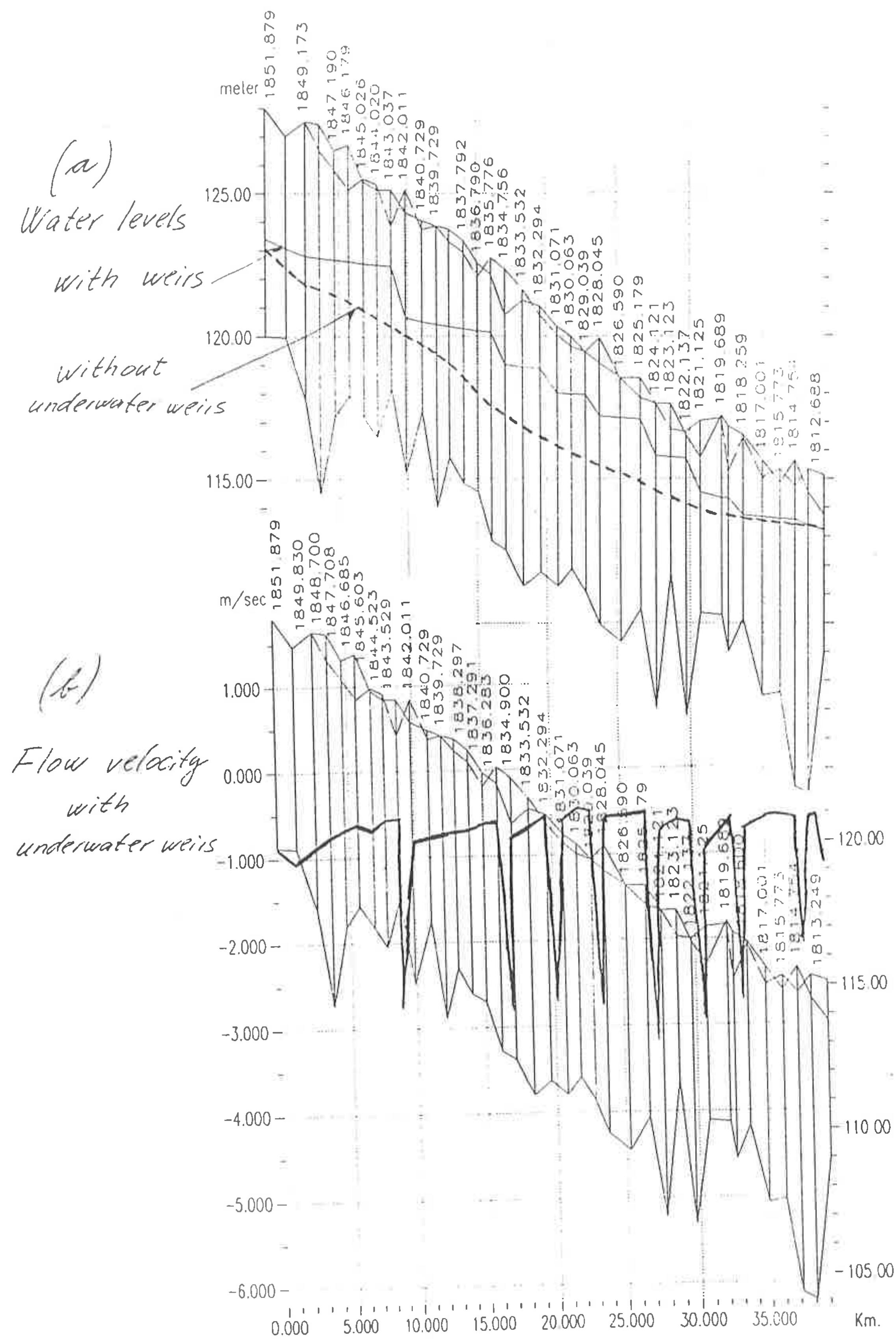

Fig. 7.2 *Model calculations of water level profile with and without underwater weirs (a) and of velocity profile with underwater weirs (b) between Cunovo and Sap/Palkovicovo.*

Water depths and flow velocities at Dunaremete for different discharges for Scenario 3 compared with the situation without underwater weirs.

200		
	2	

For Dunaremete model results
velocities for different disc
7.2 both without and with
figures and the tables it is e
have major impacts. Thus the w
1.5 - 2.5 m, which in turn results in large decreases of
e for example the water levels
m, while the velocities for
^{3}/s are reduced to less than
such as e.g. Rajka, where the
less the impacts on velocities

7.2.2 <u>Opening of connection to side branches</u>

A few of the dikes presently closing the
the main river and the side branches
enable a small flow (few m^3/s) also
conditions in the main Danube.

7.2.3 <u>Water management regime</u>

The water management regime will be as described under Scenario 2, see Subsection 6.2.2.

7.3 Possible Time Schedule for Implementation

According to a similar, specific Slovakian design with nine underwater weirs one weir can be constructed in two months and all nine can under favourable conditions be constructed in five months. In addition to the time for construction some time will be required to fulfill the necessary legal procedures. The cost of the Slovakian project is estimated to 6.3 mill ECU.

Table 7.3 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 3.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Minimum	400	0.61
	Average	800	0.97
	Typical annual maximum	3500	
Main river, Dunaremete	Minimum	400	0.40
	Average	800	0.66
	Typical annual maximum	3500	
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river	365 days/year	
	Flow from main river into a few river arms	>195 days/year	
	Flow from main river into almost all river arms	> 21 days/year	

7.6 Impacts on Surface Water Quality

The impacts on the surface water quality is expected to be insignificant.

7.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are as under Scenario 2:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions and also higher than or equal as compared to Scenario 0.

* Ground water levels on the Hungarian territory will be higher than or equal to the pre-dam conditions and also higher than or equal as compared to Scenario 0.

* If the underwater weirs have constant crest level across the river it will not be possible to reestablish the dynamics of the ground water level fluctuations.

7.8 Impacts on Ground Water Quality

The impacts on the ground water quality are, with the discharge regime as under Scenario 2, in general expected to be insignificant.

7.9 Impacts on Flora and Fauna

The impacts on flora and fauna as already observed are described in ref /2/. However, if the present situation continues for some years an increased effect will result with regard to changes in alluvial ecosystems as follows:

* Decrease of the water level fluctuations in the inundation area (side branches plus forests) makes the site conditions worse for floodplain biocenoses.

* Reduction of discharges in the Old Danube leads to reduction of the flow velocity and to sedimentation of fine material. This will cause the loss of species typical for streams, of rheophile organisms, especially of fish species spawning on gravel ground.

* Under minimum discharge conditions (400 m^3/s) the flow velocities in the main river are not large enough to provide adequate living conditions for the species requiring the higher velocities, for example fish species like Streber. In order to have adequate living conditions for this fish species the minimum discharge should be about 1000 m^3/s.

7.10 Impacts on Agriculture and Forestry

As under Scenario 2 the impacts on agriculture and forestry are expected to be an increase in the capillary water supply for as well agricultural as forestry areas both in Slovakia and in Hungary.

7.11 Impacts on Electricity Production

In a year with average discharges the electricity production can, with the discharge regime as under Scenario 2, be estimated to about 1390 GWh.

7.12 Cost Estimate for Remedial Measures

The costs of construction of a system of nine underwater weirs can be estimated to be between 6 and 12 mill ECU.

In this scenario the only n
implemented are finalisation of
structures, which enable divers
Danube and reconstruction of the spillway of the inundation weir enabling up to 1300 m^3/s to pass this structure in daily use. When these works are completed the navigation canal will be used for navigation only and no electricy

* From now until May 1994: max 600 m^3/s.
* Between May 1994 and December 1994: max 940 m^3/s.
* Between December 1994 and summer 1996: max 1900 m^3/s.
* After summer 1996: max 7200 m^3/s.

The above discharge figures represent the capacity for daily use. In addition it will be possible to pass more water in flood situations. Thus, in practise it will technically not be possible until the summer of 1996 to divert all water to the Old Danube.

The water management regime will be characterized by the average annual discharge values shown in Table 8.1. The impacts assessed in the following part of this chapter refer to the conditions after the full implementation of the scenario, i.e. after the summer of 1996.

8.3 Possible Time Schedule for Implementation

The time schedule is described in Section 8.2 above.

Table 8.1 Annual average discharge values in Scenario 4.

	Average annual discharge (m^3/s) Between December 1994 and Summer 96	Average annual discharge (m^3/s) After Summer 1996
Danube, Bratislava	2.025	2.025
Inflow to Little Danube, Bratislava	30	30
Inflow to Mosoni Danube, Cunovo	25	25
Seepage canal, right side	2	2
Seepage canal, left side	5	5
Seepage from reservoir to Danube	20	20
Seepage to ground water	30	30
Intake to Slovakian river branches, Dobrohost	50	50
Intake to Hungarian river branches, Cunovo	50	50
Bypass weir plus inundation weir, Cunovo	1451	1785
Ship locks, Gabcikovo	25	25
Turbines, Gabcikovo	337 1)	3 2)

Notes: 1) Discharge to the turbines in average about 130 days/year
2) Discharge to the turbines in average about one day/year

8.4 Impacts on Discharges, Water Levels and Flow Velocities

The split of the discharges can in a year with average discharge be described by the figures given in Table 8.1

After the summer of 1996 the impacts on discharges and water levels, can be characterized as follows:

* The discharges in the Old Danube will be 90 - 95% as compared to pre-dam condition.

* The water levels in the Old Danube will be 10 - 40 cm lower than in pre-dam conditions. The dynamics of the water level fluctuations will be maintained.

* Due to the small reduction in water levels, the flow

connections between the main river and the side branches will be slightly reduced as compared to pre-dam conditions.

* The discharge through the downstream part of the reservoir will as compared to Scenario 0 be reduced from in average 1533 m^3/s to 78 m^3/s resulting in a decrease in velocity and an increase in retention time by a factor of 20 respectively.

The flow velocities have been estimated to be as described in Table 8.2. From the tables it appears that the flow velocities have only been marginally changed as compared to pre-dam conditions.

Table 8.2 Estimated discharge and flow velocity values in the main river and in the side branches under Scenario 4.

Location	Discharge characteristic	Discharge (m^3/s)	Cross-sectional average velocity (m/s)
Main river, Rajka	Typical annual minimum	625	1.09
	Average	1800	1.58
	Typical annual maximum	5100	> 2.0
Main river, Dunaremete	Typical annual minimum	625	1.23
	Average	1800	1.57
	Typical annual maximum	5100	> 2.0
Left side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	140	0.10 - 0.40
Right side branch, main channel	Typical minimum	0	0
	Typical average	50	0.06 - 0.30
	Typical annual maximum	70	0.07 - 0.35
Connection between main river and side branches	Flow from inundation area into main river		365 days/year
	Flow from main river into a few river arms		<165 days/year
	Flow from main river into almost all river arms		< 19 days/year

8.5 Impacts on Erosion/Sedimentation

The conditions with regard to erosion and sedimentation is expected to be as follows:

* In the Old Danube increased erosion will take place, because the sediment concentrations in the water passing the structures will be significantly reduced and the velocities in the Danube will be almost the

same.

* The river bed in the main branches on the Slovakian side will continue to be sufficiently free from mud, so that good infiltration conditions exist.

* The river bed in the main branches on the Hungarian side will become sufficiently free from mud, so that good infiltration conditions will exist.

8.6 Impacts on Surface Water Quality

Directing in average 4% of the discharge through the downstream part of the reservoir, it can be expected that stagnant water with algae growth and sedimentation of organic material will occur in this water body. This may also have some negative impact on the surface water quality in the navigation canal and further downstream in the main Danube as well as in the Slovakian flood plains where the side branches now will be fed with eutrophe water from the navigation canal.

8.7 Impacts on Ground Water Regime

The estimated impacts on the ground water regime are as follows:

* Ground water levels on the Slovakian territory will be higher than or equal to the pre-dam conditions. However the ground water levels close to the downstream part of the reservoir will be lower than in Scenario 0.

* Ground water levels on the Hungarian territory will be higher than or equal to the pre-dam conditions.

* As compared to Scenario 0 it will be possible to reestablish a substantial part of the dynamics of ground water level fluctuations downstream Cunovo on the right side and downstream Dobrohost on the left side of the Danube.

8.8 Impacts on Ground Water Quality

The impacts on the ground water quality will in most of the area continue to be insignificant. Due to eutrophication in the downstream part of the reservoir the groundwater quality is likely to be threatened at the Samorin Water Works, which produces about 40 % of the water supply for Bratislava. This threat is associated to sedimentation of organic material due to stagnant water and algae growth in the downstream part of the reservoir. A layer of organic material at the reservoir bottom, from where the infiltration to the aquifer takes place, may result in anoxic groundwater conditions.

8.9 Impacts on Flora and Fauna

The impacts on flora and fauna are expected in most respects to be small compared to pre-dam conditions.

8.10 Impacts on Agriculture and Forestry

As under Scenario 2 and 3 the impacts on agriculture and forestry are expected to be an increase in the capillary water supply for as well agricultural as forestry areas both in Slovakia and in Hungary.

8.11 Impacts on Electricity Production

After Summer 1996 no electricity will be produced at Gabcikovo.

8.12 Cost Estimate for Remedial Measures

The cost for reconstruction of the spillway of the inundation weir is estimated to 3.3 mill ECU. The maintenance costs are estimated to 5 mill ECU/year. These maintenance costs will be significantly reduced if the downstream water level is higher than 124.0 m asl.

9. CONCLUSIONS AND RECOMMENDATIONS REGARDING TEMPORARY WATER MANAGEMENT REGIME

9.1 Summary of the five Scenarios and their most important Impacts

In the present report the existing water system has been described and various possibilities for implementing remedial measures have been outlined. On this basis five scenarios with different characteristics have been elaborated and the impacts expected to occur within the time horizon of the Temporary Water Management Regime (3 - 5 years) have been described.

The five scenarios and their most important impacts that exceed the common environmental impacts, as described in Section 3.3, can be summarized as follows:

Scenario 0: November 1993 Situation

The November 1993 situation is characterized by the following average discharges:

* Old Danube: 400 m^3/s
* Slovakian side branches: 40 m^3/s
* Hungarian side branches: 10 m^3/s

The impacts result in the following key figures:

* The difference in the water levels between the main river and the side branches will generally be so large that water flows from the main river to the side branches will only be possible under flooding conditions expected to occur 1-2 times per year.
* The ground water levels on the Hungarian territory will, as compared to pre-dam conditions, be higher close to the reservoir (Rajka-Dunakiliti region), whereas the levels will be lower in the middle part of Szigetköz between Dunakiliti and Asvanyraro in areas close to the Old Danube.
* The flow velocities in the main river are not large enough to provide adequate living conditions for species requiring higher flow velocity, for example representative fish species like Streber.
* The electricity production at Gabcikovo can be estimated to about 2,000 GWh/year.

Scenario 1: Increased water supply to the Hungarian Side Branches

The Scenario is characterized by the following average discharges:

* Old Danube: 400 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

1-3 floods of more than 3500 m^3/s are expected to occur each year in the Old Danube.

The impacts result in the following key figures:

* The ground water levels on the Hungarian flood plains are expected to be not lower than in pre-dam conditions.

* The flow velocities in the Old Danube are not sufficient for the typical biocenosis.

* The connection between the Old Danube and the side channels is not sufficient to allow migration of wetland species.

* The electricity production at Gabcikovo is estimated to about 1,930 GWh/year.

Scenario 2: Increased Discharge in Main River and in Hungarian Side Branches

Scenario 2 is characterized by the following average discharges:

* Old Danube: 800 m^3/s

* Slovakian side branches: 50 m^3/s

* Hungarian side branches: 50 m^3/s

1-3 floods of more than 3500 m^3/s are expected to occur every year in the Old Danube.

The impacts result in the following key figures:

* The connection between the Old Danube and the side channels is not sufficient to allow migration of wetland species.

* The electricity production at Gabcikovo is estimated to about 1390 GWh/year.

Thus, Scenario 2 represents significant improvements of the environmental situation of November 1993.

Scenario 3: Construction of some Underwater Weirs

Scenario 3 is basically identical to Scenario 2 except for construction of a number of underwater weirs. Hence, the discharge regime and many of the impacts are identical to those of Scenario 2.

The impacts result in the following key figures:

* The connections between the main channel and the side branches on both sides are maintained or even improved as compared to pre-dam conditions.

* The flow velocities in the Old Danube are (up to 1000 m^3/s minimum discharge) not sufficient for maintaining the typical biocenosis

* The electricity production at Gabcikovo is estimated to about 1390 GWh/year (with the same discharge regime as under Scenario 2).

Thus, as compared to Scenario 2 one key problem has been substituted by another one if the minimum discharge does not exceed 1000 m3/s.

Scenario 4: Full Capacity of Variant C Structures used for Water Supply of the Main River and the Branches

In Scenario 4 as much water as technically possible will be diverted into the Old Danube and the side channels. Thus, after summer 1996 the discharge in the Old Danube will be 90 - 95 % of the pre-dam conditions.

The impacts result in the following key figures:

* The water quality in the downstream part of the reservoir will be affected by stagnant water and hence significant algae growth and sedimentation of organic matter will occur in this water body.

* The ground water quality is likely to be threatened at the Samorin Water Works due to sedimentation of organic matter in the downstream part of the reservoir.

* The connection between the Old Danube and the side channels is reduced as compared to pre-dam conditions.

Thus, although most of the key problems occurring under the other three scenarios do not exist in Scenario 4, other key problems are created.

9.2 Conclusions

As appearing from Section 9.1 above none of the selected scenarios are free from key environmental problems. Furthermore, different scenarios result in different environmental problems, which are not directly comparable. Scenario 2 and Scenario 3 show that some environmental problems can be reduced by increasing discharge and remedial measures.

In addition to the environmental aspect also economical aspects should be considered. In this respect it may be noticed that the value of the present electricity production of 2000 GWh/year is in the order of 50 - 100 million ECU/year. It is noticed that the costs for implementation of the remedial measures range between 2 and 12 million ECU depending on the scenario.

9.3 Recommendations by the EC Members of the Working Group

None of the described scenarios can be recommended without modifications. Therefore the three EC members of the Working Group will recommend a combination of elements from different Scenarios.

Objectives

Considering that the Temporary Water Management Regime shall be valid only for a short period until the conclusions from the judgement of the International Court of Justice can be implemented it is obvious to choose the overall objective for the regime as minimization of any irreversible developments.

The primary specific objectives are assumed to be as follows:

* The water level and velocity regime in the inundation area should at least approach the pre-dam conditions.
* The ground water regime on both sides of the river should be at least as good as in pre-dam conditions.
* The water quality in the reservoir and the main river should be as good as possible.
* The flow velocity in the main river should be sufficient to provide living conditions for species (especially fish) typical for pre-dam conditions.
* Migration of wetland species between the main river and the side branches should be possible in both directions at least some places.
* No irreversible technical measures should be implemented.

The secondary objective is assumed to be maximum electricity production within the discharge constraints imposed by the primary objectives.

Discharge regime

* Minimum discharge in Old Danube of 400 m^3/s.
* Average discharge in Old Danube of 800 m^3/s.
* 1-3 floods of more than 3500 m^3/s per year into the Old Danube (to the extent hydrologically possible).
* 30 - 140 m^3/s into the side branches on the Slovakian side.
* 30 - 70 m^3/s into the side branches on the Hungarian side.

Remedial measures

* Improvement of the daily discharge capacity of Variant C structures from the present 600 m^3/s to 940 m^3/s by May 1994.
* Construction of an underwater weir at RKM 1835 enabling direct contact between the main river and the Slovakian side branches at one upstream point of the Slovakian floodplain and to improve the water supply to the Hungarian floodplain at rkm 1845.5. This underwater weir mainly serves an environmental purpose.
* Construction of an underwater weir at RHM 1845.5 for improving the operational reliability of water supply from the inundation weir (less maintenance of the spillway). This underwater weir is sufficient without other measures to ensure the water supply to the Hungarian floodplain.
* Deposition of gravel between the inundation weir and the underwater weirs in the main channel.
* Construction of fish passes at Cunovo.

Day-to-day Operation

Improved operation rules for the day-to-day operation of the water management within the above given discharges has be implemented in order to obtain as good environmental conditions as possible.

Environmental Impacts

The recommended Temporary Water Management Regime is seen to be a combination of Scenario 2 and Scenario 3, each of which had one key problem.

By only constructing one "environmental" underwater weir at RKM 1835 the velocities in the main part of the Old Danube will be high enough to provide living conditions for the typical flora and fauna.

Similarly, by constructing this underwater weir a direct connection between the main river and the side branches is established for both sides. This is essential for enabling migration of wetland species in the total system.

Hence the recommended Temporary Water Management Regime is believed to ensure that minimum irreversible environmental developments take place during the few years the temporary regime is supposed to last.

It is furthermore recommended to maintain a detailed environmental monitoring including taking the steps to strengthening the present monitoring system as recommended in the Data Report, ref /2/.

Reliability

Construction of a second underwater weir at RKM 1845.5 significantly improves the reliability of the day-to-day water supply through the inundation weir. Without this there is a large risk that the inundation weir spillway will be under repair most of the time.

The spillway of the inundation weir is a key issue in terms of discharge possibilities, reliability, time schedule and costs. As no comprehensive design exists for its daily use a design review is recommended to be carried out by an independent, specialized institute.

10. SUGGESTION FOR OPERATION MANUAL FOR TEMPORARY WATER MANAGEMENT REGIME

Two key elements of a Temporary Water Management System are a Water Management and Monitoring Committee and an Operation Manual

10.1 Possible Roles and Functions of Temporary Water Management and Monitoring Committee

Composition, Mode of operation, Organisation

* To be considered.

Scope of work

* Monitor the day to day operation and report to the two governments on a monthly basis.
* Plan, coordinate and review joint activities on monitoring, modelling and studies related to the water management and its impacts on environment, navigation and hydropower.
* Review studies on and decide on optimal design of remedial measures (e.g. underwater weirs, opening of a few connections to side arms, arrangements in flood plains) by March 1994.
* Prepare recommendations for adjustments to the water management and the Operation Manual whenever required on the basis of the operational experiences and the results from the activities on monitoring, studies and modelling. Justifications for proposed adjustments should be based on the degree of fulfilment of the set of environmental criteria described in the Operation Manual. In November 1994 an analysis of the results from the water management until then should be carried out and recommendations prepared accordingly.
* Prepare recommendation for urgent measures to be taken in case of emergency situations.

10.2 Operation Manual

The aims of the Operation Manual are to describe how the day-to-day operation should be carried out and how the operation should be monitored and controlled.

10.2.1 Monitoring System

The monitoring to be reviewed by the Committee will include measured variables on the following aspects:

* Discharges
* Surface Water Levels
* Surface Water Quality
* Ground Water Levels
* Ground Water Quality
* Flora and Fauna

Discharge

(a) The following discharges shall be measured daily and form the basis for the water management control:

(1) At Devin, Q_{Devin}
(2) At Rajka, Q_{Rajka}
(3) At Dunaremete, $Q_{Dunaremete}$
(4) At Medvedov, $Q_{Medvedov}$
(5) At Komarom, $Q_{Komarom}$
(6) At the by-pass weir, $Q_{bypass\ weir}$
(7) At the inundation weir, $Q_{inundation\ weir}$
(8) At the shiplocks, $Q_{shiplocks}$
(9) At the turbines, $Q_{turbines}$
(10) Intake to Little Danube, $Q_{Little\ Danube}$
(11) Intake to Mosoni Danube, $Q_{Mosoni\ Danube,\ intake}$
(12) At Mosoni Danube, Rajka, $Q_{Mosoni\ Danube,\ Rajka}$
(13) Seepage from reservoir to seepage canals, $Q_{Seepage}$
(14) Intake to Slovakian river branches, $Q_{Dobrohost}$

The "discharge" measurements can follow today's routine, i.e. as water level measurements and subsequent conversion to discharge values by use of "rating curves", which are updated regularly on the basis of real discharge measurements.

The discharge measurements at the above 14 sites are the responsibility the respective countries, i.e. Slovakia for 1, 4, 6, 7, 8, 9, 10, 11, 13, 14 and Hungary for 2, 3, 5, 12. However, Hungarian and Slovakian specialists have free access to check and participate in the measurements and the subsequent data processing for the above discharge measurement points in the other country.

(b) Discharge values shall be exchanged daily as preliminary values. Final values shall be presented and approved at the regular meetings of the Joint Committee.

(c) Check the consistency of the measurements, i.e.

$Q_{a1} = Q_{a2} = Q_{a3} = Q_{a4}$

where

$Q_{a1} = Q_{Bratislava} - Q_{Little\ Danube}$

$Q_{a2} = Q_{Turbines} + Q_{Shiplocks} + Q_{Dobrohost} + Q_{Seepage} + Q_{Mosoni\ Danube,\ intake} + Q_{Rajka}$

$Q_{a3} = Q_{Medvedov} - Q_{Mosoni\ Danube,\ intake}$

$Q_{a4} = Q_{Komarom}$

and

$Q_{b1} =< Q_{b2} =< Q_{b3}$

where

$Q_{b1} = Q_{Bypass\ Weir}$

$Q_{b2} = Q_{Rajka}$

$Q_{b3} = Q_{Dunaremete}$

The equation $Q_{a1} = Q_{a2} = Q_{a3} = Q_{a4}$ should be fulfilled within +/- 10% on a daily basis and within +/- 5% on a weekly basis. The inequality $Q_{b1} =< Q_{b2} =< Q_{b3}$ should always be valid. If the accuracy is not satisfactory the Joint Committee can decide to carry out special studies by use of independent experts in order to achieve technical consensus.

Surface Water Levels

The three EC experts and the Slovakian expert recommend that data on surface water levels from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Surface Water Quality

The three EC experts and the Slovakian expert recommend that data on surface water quality from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Ground Water Levels

The three EC experts and the Slovakian expert recommend that data on ground water levels from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Ground Water Quality

The three EC experts and the Slovakian expert recommend that data on ground water quality from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

Flora and Fauna

The three EC experts and the Slovakian expert recommend that data on flora and fauna from the national monitoring networks should be exchanged.

The Hungarian expert in theory agrees to exchange all relevant environmental data. Further agreement is necessary, however, on the detailed elaboration of this after the political decision has been made on which TWMR should be implemented.

10.2.2 Description of day-to-day operation

The day-to-day operation will depend on which scenario is implemented. This decision is taken at a political level. Hence, it is not possible at this stage to prescribe this operation in details. Therefore only some general comments will be given here.

The water management regimes described in the scenarios should be seen as frameworks setting overall goals for the distribution of water and implementation of remedial measures. Within these frames there is possibilities to optimize the daily operation with regard to environmental conditions.

A very essential element in such optimization of the daily operation is to ensure that the dynamics of the regime become as close to the pre-dam conditions as possible with regard to temporal fluctuations of surface and ground water levels, inundation of flood plains, interaction between the main river and the side channels. For some aspects it may also be possible to achieve conditions which represent improvements as compared to pre-dam conditions.

With the already existing hydraulic structures and the additional technical measures proposed in the various scenarios there are very large management possibilities and identifying the "optimum" way of operating these is not trivial. There are two fundamentally different approaches in defining operation rules:

(a) Detailed operation rules can be prescribed. For example by relating the regulated discharges such as $Q_{Bypass\ Weir}$, $Q_{inundation\ Weir}$, $Q_{Dobrohost}$, $Q_{Turbines}$, etc on a given day to the incoming discharge recorded at Devin. The operation rules in the Slovakian Scenario (Appendix D) are based on this approach.

(b) A mathematical model can be used to forecast the next few days-ahead conditions, as they would have been under pre-dam conditions e.g. with regard to water level regime and utilize the management possibilities to establish the same conditions as far as possible.

It is recommended that a detailed Operation Manual be prepared after the political decision has been made on which TWMR should be implemented.

Bratislava, 1. December 1993

For the entire report including the recommendations:

Johann Schreiner   Jan M. van Geest   Jens Christian Refsgaard

For the report excluding the recommendations in Section 9.3:

Igor Mucha   Gabor Vida

11. REFERENCES

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APPENDIX A: Terms of References for the Working Group

COMMISSION OF THE EUROPEAN COMMUNITIES
DIRECTORATE-GENERAL
EXTERNAL ECONOMIC RELATIONS

Brussels, 26 August 1993
Service/L-3/hcs

Establishment of a Group of Monitoring and Water Management Experts for the Gabcicovo system of locks

I. Introduction

In order to provide reliable and undisputed data on the most important effects of the current water discharge and the remedial measures already undertaken as well as to make recommendations for appropriate measures the Republic of Hungary and the Republic of Slovakia will establish a Group of Monitoring and Water Management Experts (Group of Experts).

The Group of Experts shall consist of one expert appointed by Hungary and one expert appointed by Slovakia. Three independent experts appointed by the Commission of the European Communities will participate in the Group. The meetings will be chaired by one of the EC experts. The EC experts will have expertise in hydrology, including monitoring of hydrological data, ecological issues and water based constructions. The Slovak andd Hungarian experts can be supported by associate experts if necessary.

The monitoring will cover the whole area surrounding the Gabcikovo system of locks, and monitoring and measuring systems will be established both at Slovak and Hungarian territory.

No recommendations or activities arising from the establishment of the Group of Experts or its operation will effect, or reflect upon, any of the issues of legal liability which, in accordance with the Special Agreement, must be determinated by the International Court of Justice.

The Group of Experts will submit reports and recommendations based on consensus between the experts. In cases of disputes in the Group of Experts the Slovak and Hungarian experts as well as the EC experts can submit separate reports and recommendations.

2. Objectives

The Group of Experts will:

I. Collect and assess data on all relevant aspects and effects of the current water discharge including the effects of the various remedial measures already put in place. The data to be collected will be defined by the Group of Experts within three days after its formal establishment. The methodology to be applied in the subsequent data analysis will be defined by the Group of Experts in connection with its first report 17 days after its formal establishment. The data to be collected will at least include:

* water discharge at all relevant places;

* surface water level and quality including sedimentation at all relevant places.

* ground water level and quality;

* impact on flora and fauna in the region;

* impact on agriculture and forestry;

* electricity production

* other possible essential aspects.

The data collection will be based on the existing data currently at the disposal of both sides as a result of regular measuring made jointly or separately by each side. Further the Group of Experts will decide on new or harmonised monitoring procedures and identify possible need for additional monitoring to be carried out in the future.

II. On the basis of the data collection (I) prepare recommendations for submission to the two Governments on the following aspects, with a view to safeguard the environment and the ecological conditions in the region:

A. A Temporary Water Management Regime including a detailed manual with specifications for the day-to-day operation and different water discharge situations:

B. The necessary water discharge and water level in the old riverbed and in the adjacent area and remedial measures to be taken.

c. The establishment of a Water Management and Monitoring Committee for the operation of the Temporary Water Management Regime. The main task of the Water Management and Monitoring Committee would be to:

- propose modifications in the Temporary Water Management Regime or new remedial measures to be taken on the basis of the operational experience and continued monitoring,

- initiate and supervise additional studies, measurements and research required; and

- prepare recommendations for urgent measures to be taken in case of emergency situations.

3. Activity and time schedule

The Group of Experts will work in accordance with the annexed time and activity schedule.

4. Mode and place of operation

A detailed activity and meeting plan will be prepred at the first meeting in the Group of Experts. Place of meetings will alternate between Slovakia and Hungary and secretarial support will be provided by the host country.

5. General

All proceedings, data collected by and recommendations from the Group of Experts will be confidential until the two Governments and the Commission decide otherwise. The Experts will make no public statements on the work of the Group.

DATE	ACTIVITY
September 8, 1993	First meeting to develop a detailed action and meeting plan.
September 13,1993	Report by the EC Experts on the need for clarification or adjustments in the Working Document
September 30,1993	Report on the assessment of existing data, the preliminary findings from analysing the data and the recommendations regarding modifications to the present monitoring practice. The report will be submitted to the two Governments and the Commission.
November 19, 1993	Final report, including recommendations for: 1. Temporary Water Management Regime, including a detailed manual with specifications for the day-to-day operations and different water discharge situations; 2. The necessary water discharge and water level in the old river bed and in the adjacent area and remedial measures to be taken; 3. The establishment of a Water Management and Monitoring Committee re. item 2.II.C.

APPENDIX B: Members of the Working Group and the Associate Experts

Members of the Working Group

Johann Schreiner, EC (primus inter pares)
Jan M. van Geest, EC
Jens Christian Refsgaard, EC
Gabor Vida, Hungary
Igor Mucha, Slovakia

Associate experts from Hungary

Károly Baross, North Transdanubian District Water Authority, Györ

Adrienne Hajosy, Ministry for Environmental and Regional Policy, Budapest

Lajos Horvath, North Transdanubian District Environmental Authority, Györ

Ferenc Meszaros, Hungarian Natural History Museum, Budapest

Zoltán Nagy, North Transdanubian District Environmental Authority, Györ

János Szekeres, Water Resources Research Center, Budapest

György Toth, Hungarian Geological Survey, Budapest

Associate experts from Slovakia

Vaclav Mikulka, Law Expert, VUB, Prague

Maria Holobrada, Water Research Institute, Bratislava

Ing. Ferdinand Kubicek, Institute of Ecobiology, Slovak Academy of Sciences, Bratislava

Miroslav Liska, Vodohospodarska Vystavba, Bratislava

Ivan Uhlar, Hydroconsult, Bratislava

APPENDIX C: Summary of quantitative impacts for different scenarios

Summary of quantitative impacts for different scenarios

Characteristic	Pre-dam condition (historical data)	Scenario 0	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Date for possible start of specified water management operation		Ongoing	May 1994	May 1994	Second half of 1994	Summer 1996
Discharges as average annual values (m^3/s)						
Danube, Bratislava	2025	2025	2025	2025	2025	2025
Old Danube	1965	400	400	800	800	1800
Side branches, left side	?	40	40	50	50	50
Side branches, right side	?	10	10	50	50	50
Turbines	0	1468	1468	1008	1008	0
Water levels for typical discharge situations at Dunaremete (m asl)						
At minimum discharge	115.4	113.8	113.8	114.4	116.8	115.0
At average discharge	117.2	114.4	114.4	115.4	117.5	117.1
Flow velocities for typical discharge situations (m/s)						
Danube, Dunaremete At minimum discharge At average discharge	 1.3 1.6	 0.8 1.1	 0.8 1.1	 1.1 1.3	 0.4 0.7	 1.2 1.6
Side branch, left side Typical average	< 0.1	0.05-0.25	0.05-0.25	0.06-0.30	0.06-0.30	0.06-0.30
Side branch, right side Typical average	< 0.1	0.05-0.09	0.05-0.09	0.06-0.30	0.06-0.30	0.06-0.30
Flow connections between main river and branches (days/year)						
Flow from inundation area into main river	195	All	All	All	All	All
Flow from main river into a few river arms[1]	195	5 - 10	5 - 10	5 - 10	> 195	165
Flow from main river into almost all river arms[2]	21	5 - 10	5 - 10	5 - 10	> 21	19
Electricity production at Gabcikovo (Gwh/year)	0	2000	1930	1390	1390	0
Cost of remedial measures (Mill ECU)[3]	0	SK: 12.0 H : 2.0	SK: 0.5 H : 2.0	SK: 0.5 + 1 per year H : 2.0	SK+H: 6 - 12	SK: 3.3 + 5 per year

Notes:
1) The definition corresponds to the flow situation "flow in a few river arms" which according to ref /1/ in the pre-dam condition occurred at a discharge around 1800 m^3/s.
2) The definition corresponds to the flow situation "flow in almost all river arms" which according to ref /1/ in the pre-dam condition occurred at a discharge around 3500 m^3/s.
3) The costs of Scenario 1-4 are in addition to the costs already spend on Scenario 0.

APPENDIX D: **Scenario submitted by the Slovak Expert**

See seperate Volume

APPENDIX E: Statement by Ing. I. Uhlar, Ing. J. Frankovsky and Ing. J. Cabel: "Possibility of everyday discharge through inundation weir Cunovo into the old Danube"

Appendix E

Possibility of everyday discharge through inundation weir Čunovo into the old Danube

1. The inundation weir was designed and constructed for temporary use (discharge of floods), until the definitive weir (with the sill in the level of the river-bottom) is constructed in the second phase (by the end of 1996). Under these presumptions, also the fortification of the spillway was designed and partially already realised. It was supposed that after each use (flood) necessery reparation of the fortification will be realised.

2. The first four fields of the weir could be used from May 1994, for everyday discharge at these conditions :

- the completion by May 1994 of the relevant part of the fortification works (the whole fortification is scheduled to be completed in December 1994);
- the discharge of 340 cumecs will not be exceeded (hydraulic stability of the water-jump in the stilling basin is assured only up to this limit);
- inspection and reparation of the outlet canal downstream of the spillway and of its fortification must be ensured (there will be damages after certain time of use, presumably each week), even with the discharge mentioned above (the costs of reparation at such periodical use - one week of use and one week of reconstruction - are estimated to 3 mill.Sk/month).

It should be noted, that the everyday use of four fields will complicate the rest of remaining works.

3. For daily use of the weir with higher discharges, an additional heavy fortification of the spillway would be necessary, similarly as downstream of the bypass weir.

The additional costs of such fortification are estimated to 120 mill.Sk. As there is not enough experience with such a construction, the risk of damage remains high. If such a decision is taken by the end of 1993, the fortification for the daily use of the inundation weir could be completed by the end of 1994.

The maximum discharge capacity in this case is 1300 cumecs and all openings have to be used, to avoid uneven distribution of flow. The estimated maintenance costs are 15 mill.Sk/month.

4. A higher water level downstream of the spillway, reduces the risk of damages caused by the everyday use of the inundation weir. The relationship between the possible safe discharge and the downstream water level could be established only by means of hydraulic research on a model.

Bratislava, November 30, 1993.

Estimated by Ing.I.Uhlár, Ing.J.Frankovský, Ing.J.Cábel

APPENDIX F: Seperate Statement by the Hungarian Expert

APPENDIX F

SEPARATE STATEMENT OF HUNGARY

More than a year has been spent with futile negotatioations on water distribution due to the unilateral diversion of the Danube at Cunovo. The dispute is rooted in the fact that the water discharge of the frontier river, which formerly was shared equally by the two countries, now exhibit a 80%+1/2*20% = 90% Slovak and 10% Hungarian proportion. Consequently, most of the positive effects are on the Slovak side, while all the negative ones occur in our country.

During the last 13 months there has been no Slovak indication of willingness to reach a compromise. Instead, there are some signs which give us reason to deny the credibility of the Slovak or Czechoslovak party (see London Agreed Minutes signed by Czechoslovakia on 28 October, 1992). On the contrary, Hungary was ready to accept the very unfavourable minimum ecological conditions of directing roughly two third of the total discharge into the shared Slovak-Hungarian main riverbed (and the operation of Gabcikovo Hydropower plant) as a temporary water management regime.

Each time in the long series of negotiations Hungary was prepared to accept smaller proportion of discharge, while the Slovak side recommended correspondingly lower and lower values. The last Slovak offer is already a further reduction of the present discharge into the shared main river (cf. Appendix about Slovak Proposal).

During the present Working Group sessions started on 8 September 1993. It has been stated at the onset of our WG that recommandations of Temporary Water regime will be based on the technical realities. One day before the end of the working group meeting new statement was given to us by the Slovak party on the state of the C variant structures. This made almost impossible to formulate realistic recommendation. It was finally declared by the Slovak party that at present they cannot satisfy the request of providing water continuously through the variant C structures more than 600

m^3/sec, but they perhaps will be able to give 940 m^3/sec (less than 1/2 of the total discharge) after May 1994 under some conditions. The daily operation of the floodweirs which were promised to be finalized by 1 January 1993 (!) (see ref. Working Group Report, November 23, 1992, page 7-8) are now in a distant future. This unexpected announcement upset many time schedules worked out under the scenarios in the present report.

It cannot be excluded therefore, that the signing of another temporary water distribution agreement much worse than before can only be regarded as an accepted humiliation without <u>any</u> improvement of the present environmental situation in Hungary. It has become also clear, that the approach of collecting and evaluating environmental impacts of the unilateral action with the present method is insufficient. Obviously major negative effects can be differenciated into "insignificant" changes in several single factors, especially considering relatively slow gradual processes. Many such damages are practically very difficult or impossible to measure. It is undisputable from analogous situations, that we cannot avoid the followings (unless rapid return towards the original conditions is provided):

- decreasing the biodiversity;
- loss of natural habitats and beauty;
- loss of the ability of self-maintenance of the flood plain ecosystems;
- loss of long-term evolutionary-ecological experience so far stored in genetic informations of the natural communities;
- loss of genetic diversity within the diminishing populations.

In addition, the risk of contamination of our unique, large drinking water reservoir cannot be excluded for the following reasons.

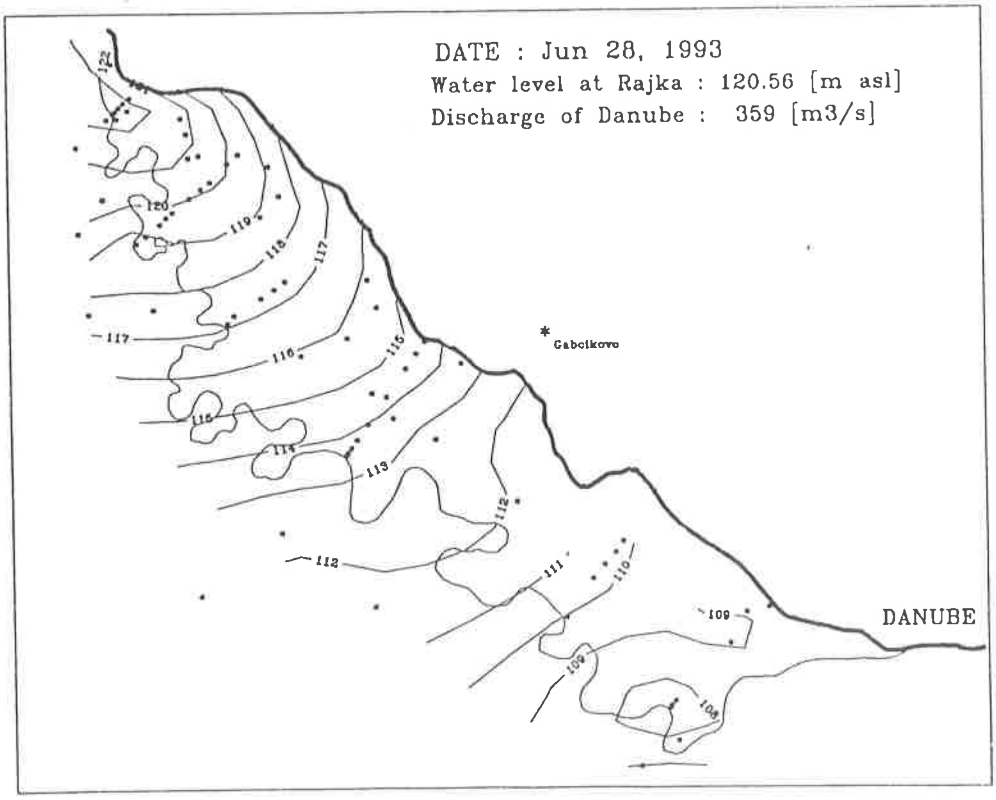
After damming the pattern of groundwater recharge (infiltration) and discharge-zones, and this way the total three dimensional flow system has changed basically. Infiltration rate its dynamics and the infiltrated raw water are also different, then they were at pre-dam conditions.

This changed situation is shown in the figure, where the groundwater levels indicate that after the damming, the

Danube became a major discharge zone between Rajka and Ásványráró, while Mosoni-Danube and water supply channel on the flood protected aera are now major recharge zones. The groundwater movement now directed to the Danube.

This change could have been important inconnection with vulnerability of the drinking water reserve.
The present proposal cannot guarantee even the average 40% discharge into the shared reach of the main Danube. It actually aims to improve variant C structures, known to be unacceptable to Hungary.

Fig to Appendix F



Bratislava, December 1, 1993

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