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DANUBE HYDRO AUSTRIA Vienna, May 1991

# INTERNATIONAL BASIN MANAGEMENT ISSUES OF THE DANUBE RIVER

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## 1. Location and General Characteristics

With a total length of some 2850 km the Danube is the second-longest river in Europe. On its course from the Black Forest to the Black Sea it passes through 8 countries: Germany, Austria, Czechoslovakia, Hungary, Yugoslavia, Bulgaria, Rumania and the Soviet Union (Fig. 1). In accordance with its geographic layout the Danube Basin can be divided into 3 main units, i.e.

- the Upper Danube Basin, which covers the territory from the source area as far downstream as the Devin Gate east of Vienna, the Capital of Austria. As can be seen from Fig. 2, the lower end of this reach is characterized by a distinct change in average slope.

- the Middle Danube Basin, which is the largest of the three units discussed and which spreads from the Devin Gate down to the fault section between the Southern Carpathians and the Balkan Mountains near the Iron Gate.

- the Lower Danube Basin, finally, which comprises the Rumanian-Bulgarian Lowlands as well as the Siret and Prut basins.

Along its course towards the Black Sea the Danube is joined by several important tributaries, such as the Inn, the Enns, the Tisza and others. Accordingly, Danube mean flow rises from some 300 $m^3/s$ at Ingolstadt in Germany to appr. 1900 $m^3/s$ at Vienna, Austria, and finally amounts to ca. 6550 $m^3/s$ near the river mouth.

Climatic conditions in the Danube River Basin vary strongly. Values of mean annual precipitation range from 3000 mm in some mountainous zones to 400 mm in the delta region.

Flood events in the Danube Basin can be due to storms or to the combined action of snowmelt and rain. Flooding caused by ice jams formerly brought about considerable damage - this risk has, however, been reduced successfully by river training and regulation.

## 2. Macro-economy and the Water Sector

Politically, the basin was divided by the Iron Curtain until two years ago, a fact, which is still reflected by the strongly differing socio-economic conditions in the various riparian states.

Picture 1: Industrial Estate, Linz, Upper Austria

While Germany and Austria are among the developed industrial nations, all others still struggle with the heritage left by their previous regimes. Although dating back to 1985, the following table still gives a fairly adequate idea of the situation.

Table: GNP per capita in the riparian countries (Rado,1985):

| Country | GNP (US$) |
|---|---|
| FRG (former) | 13 450 |
| Austria | 10 210 |
| Czechoslowakia | 5 820 |
| Hungary | 4 180 |
| Yugoslavia | 2 790 |
| Rumania | 2 540 |
| Bulgaria | 4 150 |
| Soviet Union | 4 550 |

In consequence, and also due to differences in climate and topography, the main use of water in the Danube Basin varies considerably. In the upper part the water is primarily used for industrial und municipal supply as well as hydroelectric power generation, while irrigation dominates along the middle and lower reaches. A common factor of importance to the majority of the riparian states is, however, the transport of goods on the river. Fig. 3 gives a survey of the amount of cargo shipped on the Danube, broken down into the respective shares of the riparian countries. A sharp increase in the tonnage transported is expected after completion of the Rhine-Main-Danube Canal connecting the Black and North Seas.

The significant role of navigation on the Danube River dates back to the Middle Ages. Historically, the first authority for planning and implementing measures of river training and regulation with the purpose of improving inland navigation was founded by Empress Maria Theresa in 1773 (RZdD, 1986). It is only natural that close international cooperation first related to this field. Several agreements have been concluded since 1856, the most important of which is the "Danube Convention" ("Danube Declaration") of 1948, joined by Austria in 1960. This agreement is to promote and coordinate Danube River navigation, and it contains clear recommendations regarding waterway improvement and design, e.g. with respect to navigable depth, width, curvature, slope and the size of locks. Fig. 4 shows some of these standards to be observed.

On the Austrian stretch of the river, these recommendations have been implemented along 250 km out of a total of some 350 km. Picture 2 shows a typical locking operation, carried out at one of the Austrian hydropower plants, Abwinden-Asten, which was designed in accordance with the rules mentioned.

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Picture 2: Locking Operation at the Abwinden-Asten Hydropower Plant

The relative importance of hydroelectric power strongly varies between the riparian countries. While hydropower plants supply more than two thirds of Austria's electric power, the percentage is considerably lower in Czechoslovakia, Hungary, Bulgaria and Rumania. Fig. 5 illustrates the Austrian conditions and also shows Danube Hydro Austria's relative share (Österreichische Donaukraftwerke A.G., Annual Report 1988). The situation in some of the other riparian states is described by Fig. 6 (source: UN, Annual Bulletin of Electric Energy Statistics for Europe). It is obvious that these countries depend on fossile fuels to a large degree, which, as particularly in the case of Czechoslovakia, may create severe environmental problems. Since many Czechoslovakian thermal power plants do not meet modern standards, serious air pollution and acid rain result. Although the problems have by now been recognized by the authorities in charge, it will take many years, if not decades, to improve conditions markedly.

Looking at the power potential of the Danube River, Fig. 7, one can see that there are two distinct stretches which are particularly suited for hydropower development, i.e. the reach between the German/Austrian border and Gönyü in Hungary, and a stretch downstream of Belgrade, Yugoslavia. Although there is also a number of (smaller) German plants, the Austrian reach in particular has been subject to considerable planning and construction activity. Besides Jochenstein, which is half German and half Austrian, there are 8 run-of-river plants in operation, as can be seen from the Austrian Danube River Development Plan, Fig. 8. A ninth scheme is to be constructed in Vienna in the near future. All Austrian Danube plants are multipurpose schemes taking into account the issues of

- river navigation
- flood control
- improvement of environmental conditions
- irrigation and drainage
- and power generation.

Downstream of the Austrian reach, a conflict regarding Danube River development has arisen between Czechoslovakia and Hungary. In order to solve the severe problems posed on inland navigation by the river morphology on the Czechoslovakian - Hungarian stretch and to generate electric power, both countries entered into an agreement on the construction of the Gabcikovo-Nagymaros hydropower scheme. The complete project comprised a large reservoir downstream of the town of Bratislava, a weir structure at Dunakiliti, an approach canal, the power plant at Gabcikovo, an outlet canal discharging into the Danube river bed and a reservoir and power plant at Nagymaros (see Fig. 9). Gabcikovo, the upper plant, was intended to perform peaking operations with Nagymaros providing the necessary downstream reservoir. The Nagymaros part of the project, though already under construction, was, however, stalled in response to environmentalists' protests in 1989. Since then, a bilateral conflict exists between the former partners Czechoslovakia and Hungary. A resolution of this controversy has not been achieved so far.

Farther downstream, two Yugoslav-Rumanian schemes shall be mentioned. The Djerdap scheme (Portile de Fier I) with a dam of 32 m height was constructed in the period 1964-1972 and the Gruia plant (Portile de Fier II) was put into operation in 1984. Both schemes are linked insofar as the Gruia backwater acts as compensation reservoir for Djerdap peaking operations.

3. Flood Control

Another issue of general importance in the basin is flood control. Flood protection dykes (levees) along the Danube were built by the Germans from the middle of the 19th century onwards. In Austria, disastrous floods in 1830 and 1864 were followed by the decision to provide the City of Vienna with adequate flood protection. Comprehensive river training and regulation work was carried out, which implied moving the then enormous amount of 16.5 million m³ of earth (RZdD, 1986). Other measures included the erection of flood protection dykes. At present, the flood protection system for Vienna is being improved so as to be able to cope with a maximum peak runoff of 14 000 m³/s. In large parts of the Austrian Danube reach, flood control measures were taken in the course of hydropower development.

In Czechoslovakia flood control embankments have been built or strengthened since the second half of the 19th century. Due to topography, Hungarian territory is particularly liable to inundation. With its beginnings in the 1840s, the Hungarian flood protection system, mainly including dykes and river training, reached the stage of safety against the 60 years' event in the first half of this century.
Similar flood control measures characterize the situation in Yugoslavia, Bulgaria and Rumania, where extensive systems of flood protection dykes have been built.

## 4. Environmental Issues

Water quality standards on either side of the former Iron Curtain differ greatly, and these are therefore difficult to compare (WHO, 1982). It shall, however, be mentioned that the water quality of the Danube River is presently much better than that of the Rhine. Viewed against a scale of 4 grades, with grade I almost unpolluted and grade IV very heavily polluted, Danube river water is mostly accorded grade II (moderately polluted), only downstream of major settlements and/or industrial estates grade III may be encountered. Considerable effort has been taken to improve the situation, and a large number of wastewater treatment plants has been put into operation. In this context it may be added that a certain amount of recording as well as research in the field of hydrobiology has been conducted by an international agency named SIL-IAD (International Society for Limnology, International Working Community of the Danube Countries).

Apart from water quality, environmental problems in some unimpounded reaches of the river are caused by river bed degradation and corresponding decreases in the groundwater levels. Thus, riverine biotopes are threatened by drying up.

In Austria, some problems of this kind have been solved in connection with low-head hydropower development. Impoundment puts a stop to these detrimental trends and, moreover, permits riverine bottomlands to be irrigated in a way similar to former natural conditions. Picture 3 shows the irrigation channel "Giessgang" in the backwater reach of the hydropower scheme Greifenstein in Lower Austria.

Picture 3: Irrigation of Riverine Bottomland Forests by the "Giessgang" Channel

## 5. Conclusion

Passing through no fewer than 8 countries, the Danube is a truly international river. After the abolition of the so-called Iron Curtain, the division of the basin is a socio-economic rather than a political or ideological one. Although the use of Danube water differs between the various riparian states, river navigation, hydropower development and the construction of wastewater treatment plants can be identified as areas of common concern. In these fields considerable investment will be necessary, particularly in the newly democratic and formerly Soviet-dominated countries.

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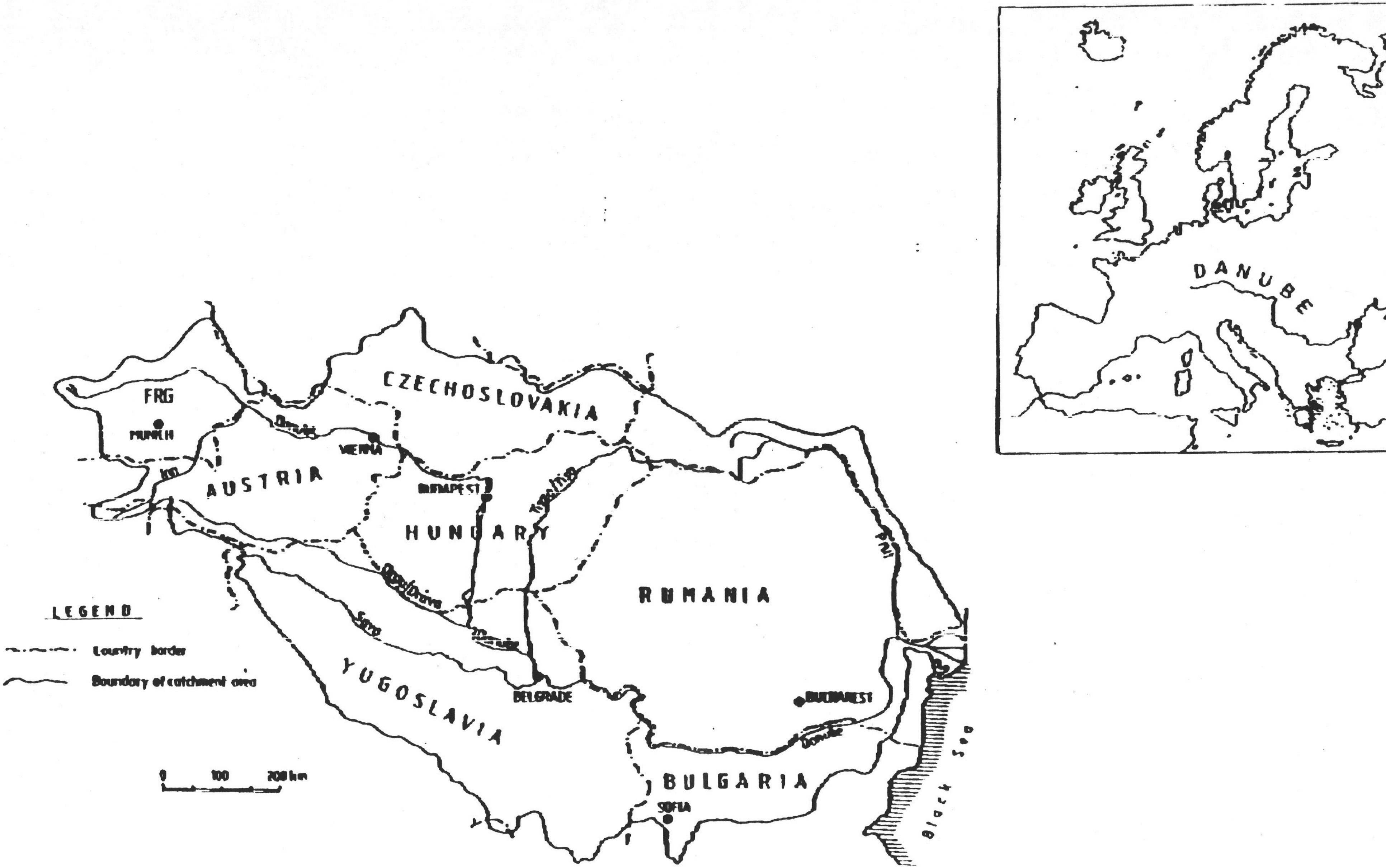



Figure 1: The Danube Basin (adapted from Kovacs et al., 1983)

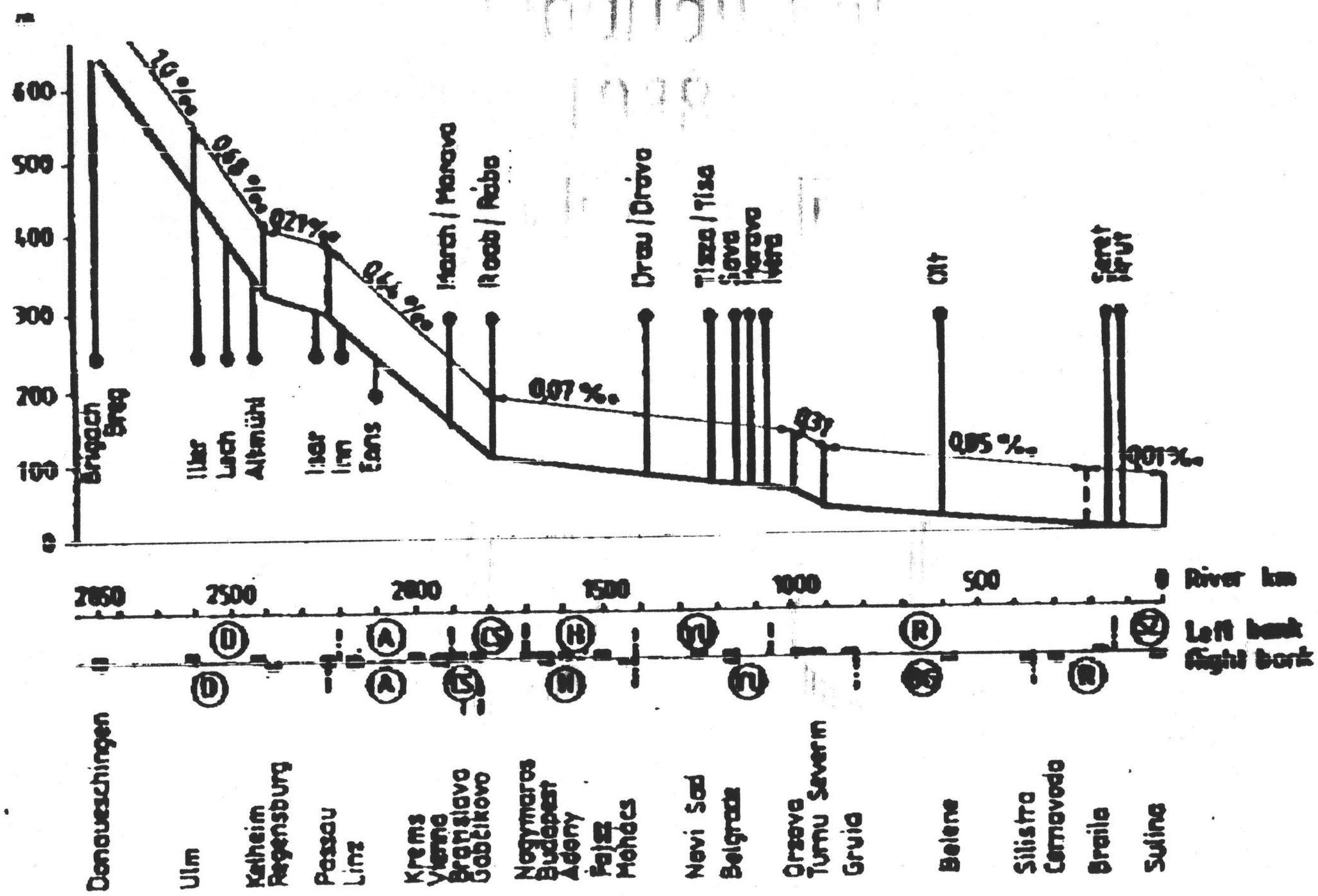


Figure 2: Danube River bed longitudinal section (adapted from Liepolt, 1967)

## Total of Goods Transported on the Danube (as of 1988)

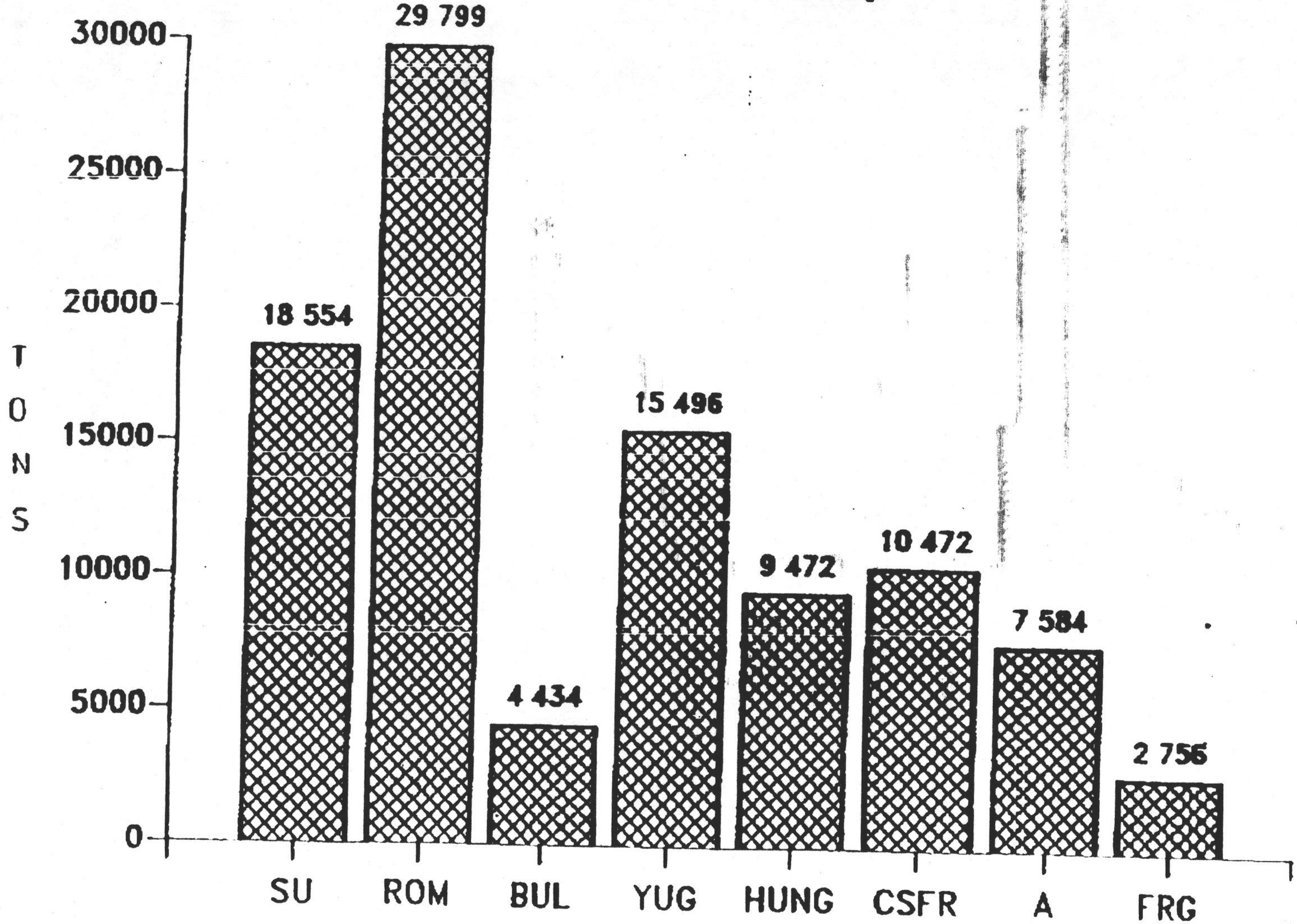
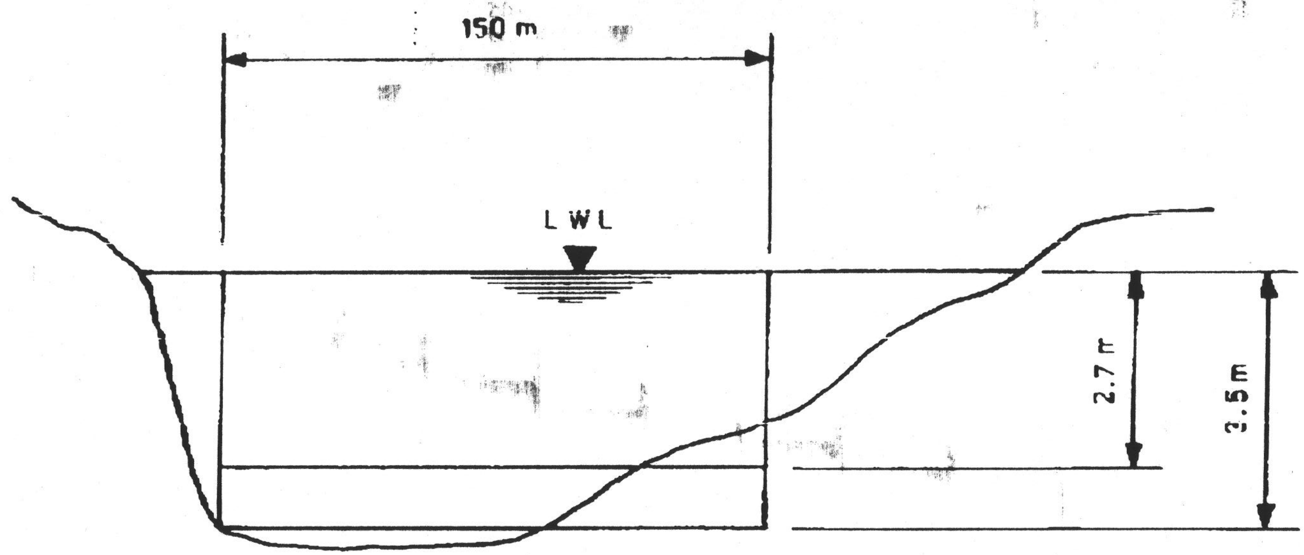



Figure 3

## Regulation Navigation Channel According to the Danube Convention



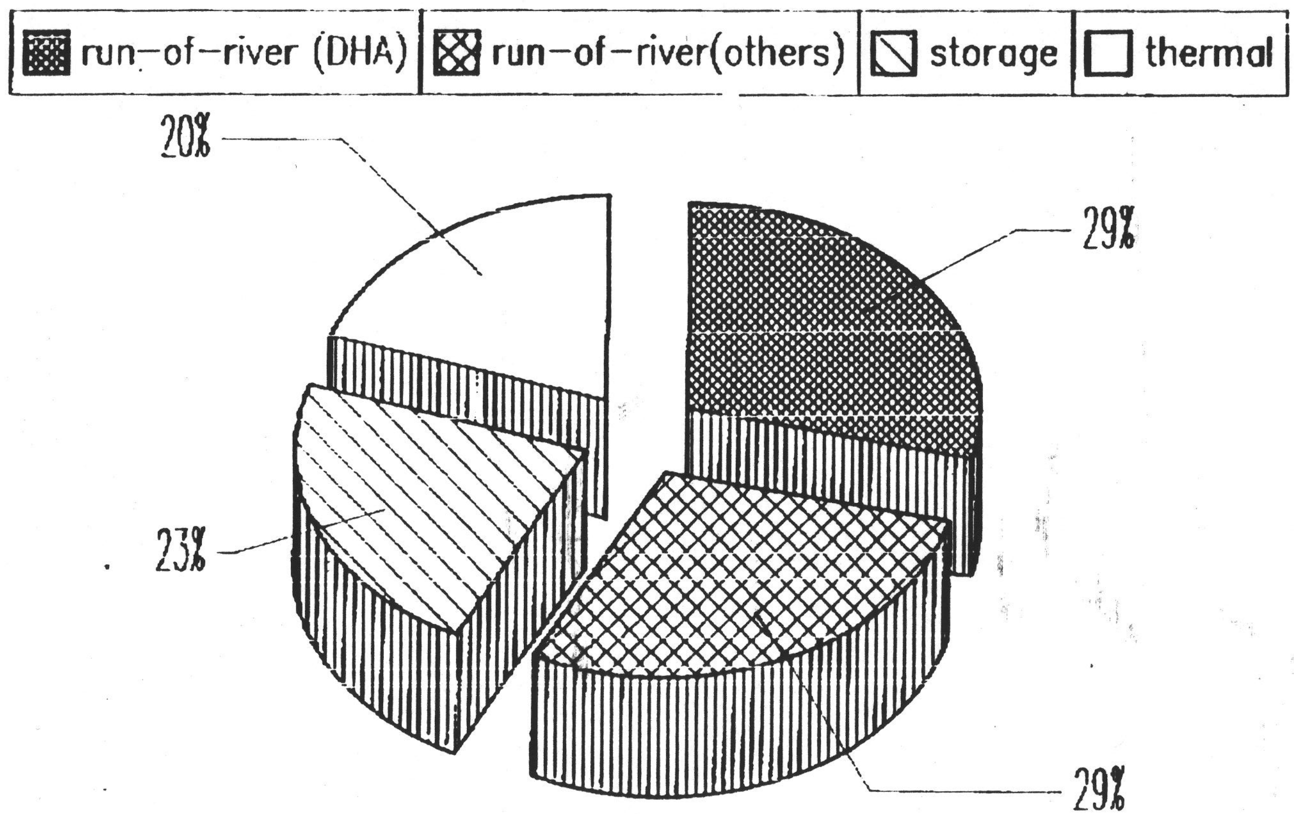

2.7 m ... minimum depth to be provided upstream of Vienna

3.5 m ... minimum depth to be provided downstream of Vienna

LWL ... regulation low water level
(probability of exceedance: 94 percent)

Figure 4

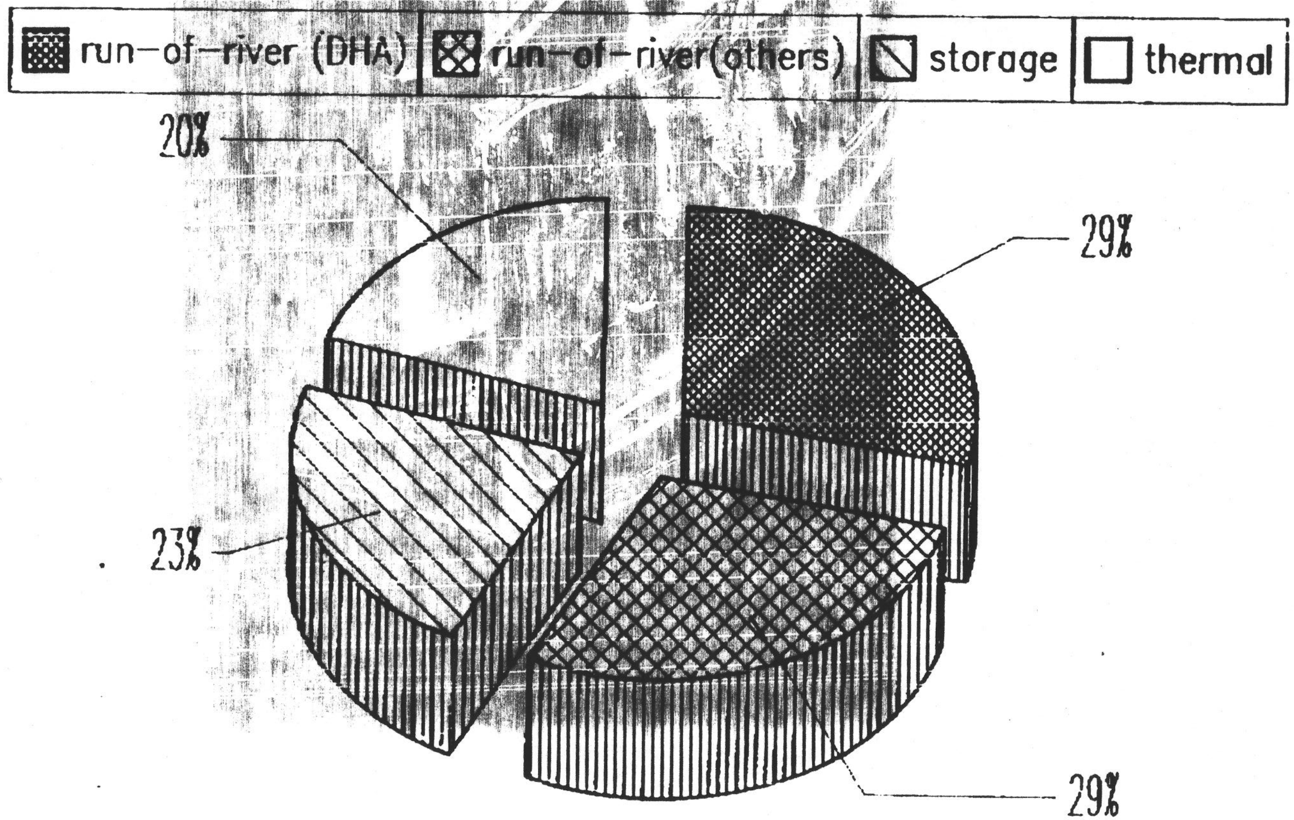
# Danube Hydro Austria's Share in the Austrian Electric Power Generation




1990

Figure 5

Danube Hydro Austria's Share in the Austrian Electric Power Generation




1900

Figure 5

# Electric Power Generation (Gross) in Some Riparian Countries 1988

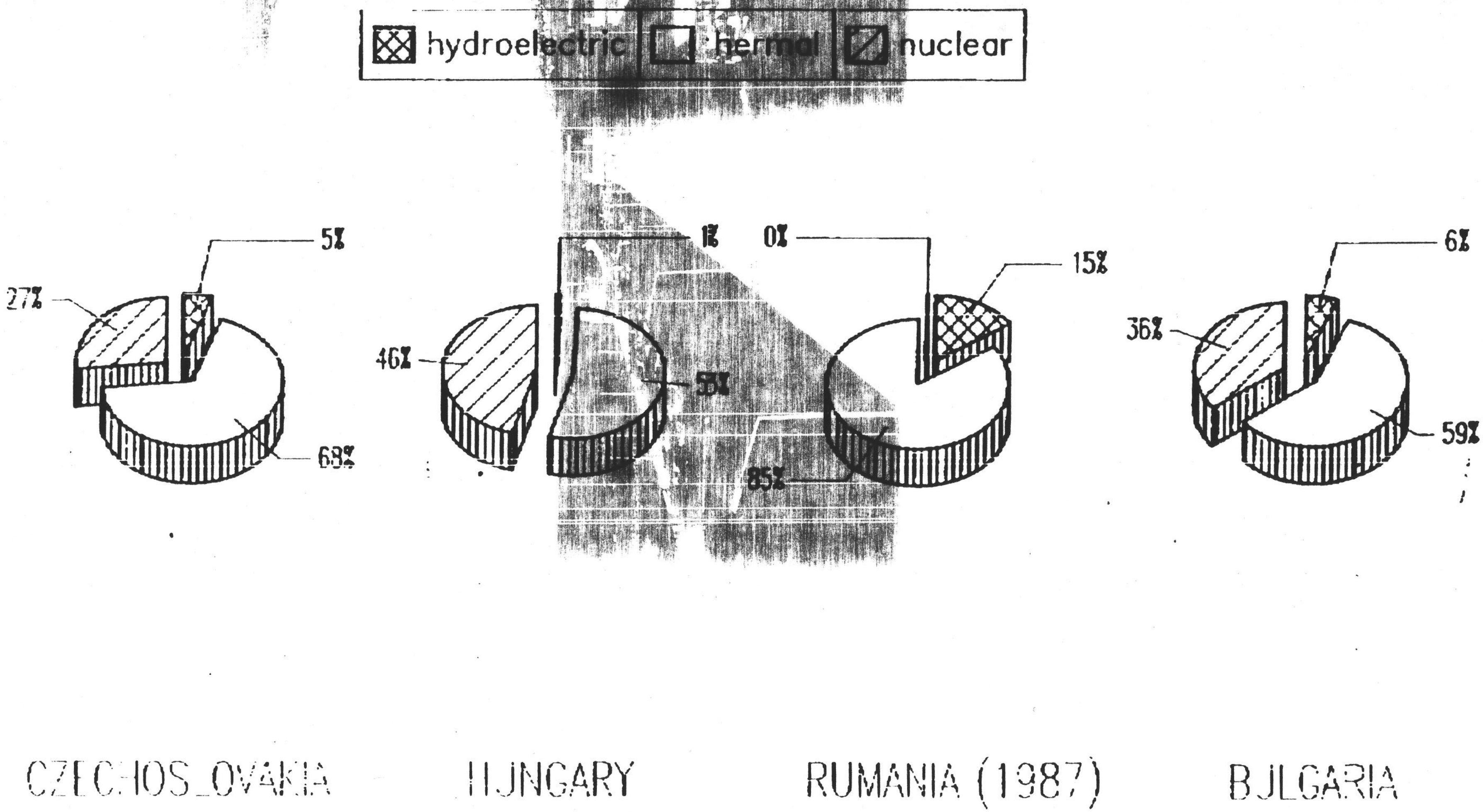



Figure 5

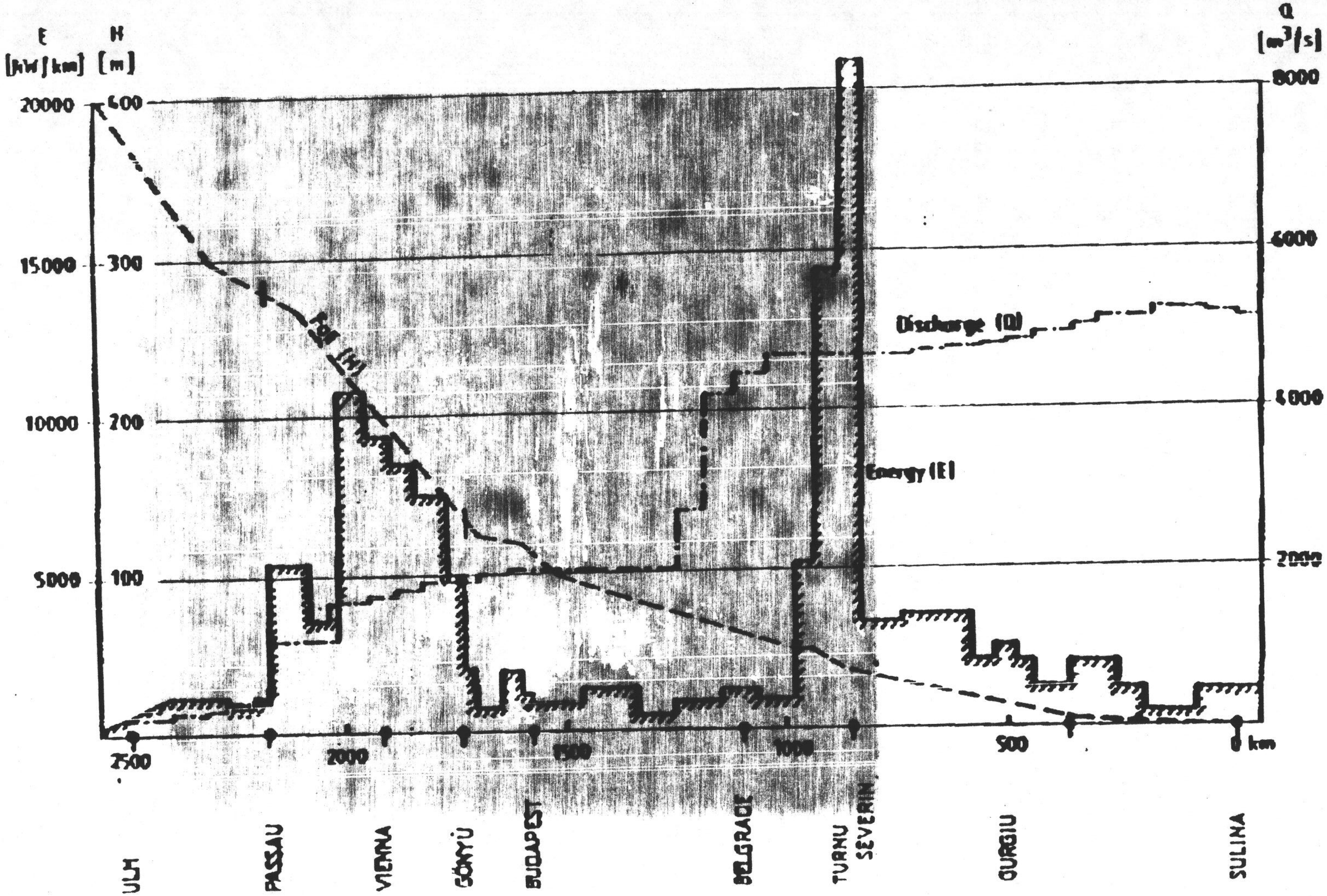
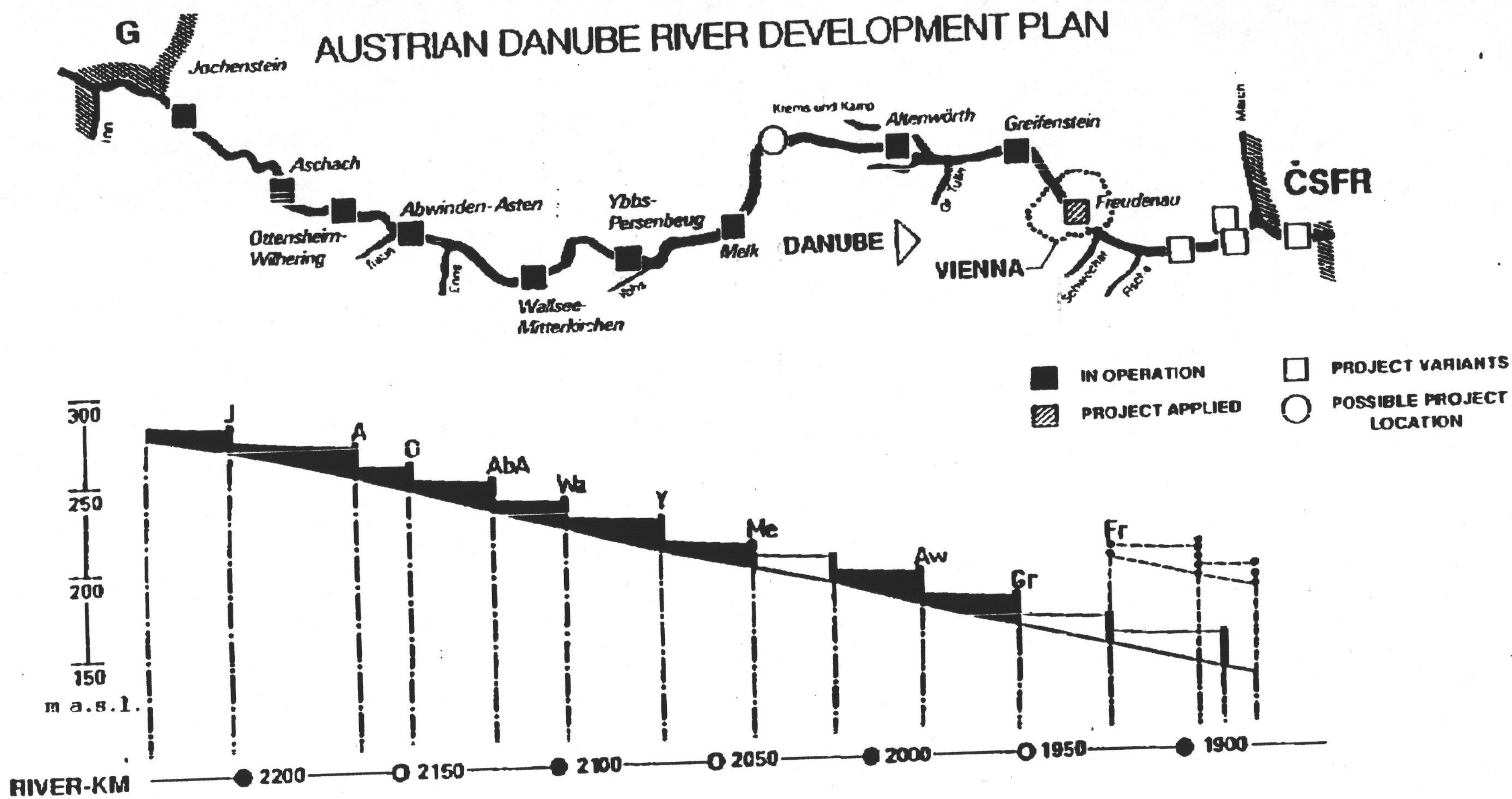



Figure 7: Danube power potential (adapted from Benedek and Laszlo, 1980)



AUSTRIAN DANUBE RIVER DEVELOPMENT PLAN
G
Jochenstein
Aschach
Ottensheim-Wilhering
Abwinden-Asten
Wallsee-Mitterkirchen
Ybbs-Persenbeug
Melk
DANUBE
Altenwörth
Greifenstein
Freudenau
VIENNA
ČSFR
IN OPERATION
PROJECT APPLIED
PROJECT VARIANTS
POSSIBLE PROJECT LOCATION
300
250
200
150
m a.s.l.
J
A
O
AbA
Wa
Y
Me
Aw
Gr
Fr
RIVER-KM
2200
2150
2100
2050
2000
1950
1900


Figure 8

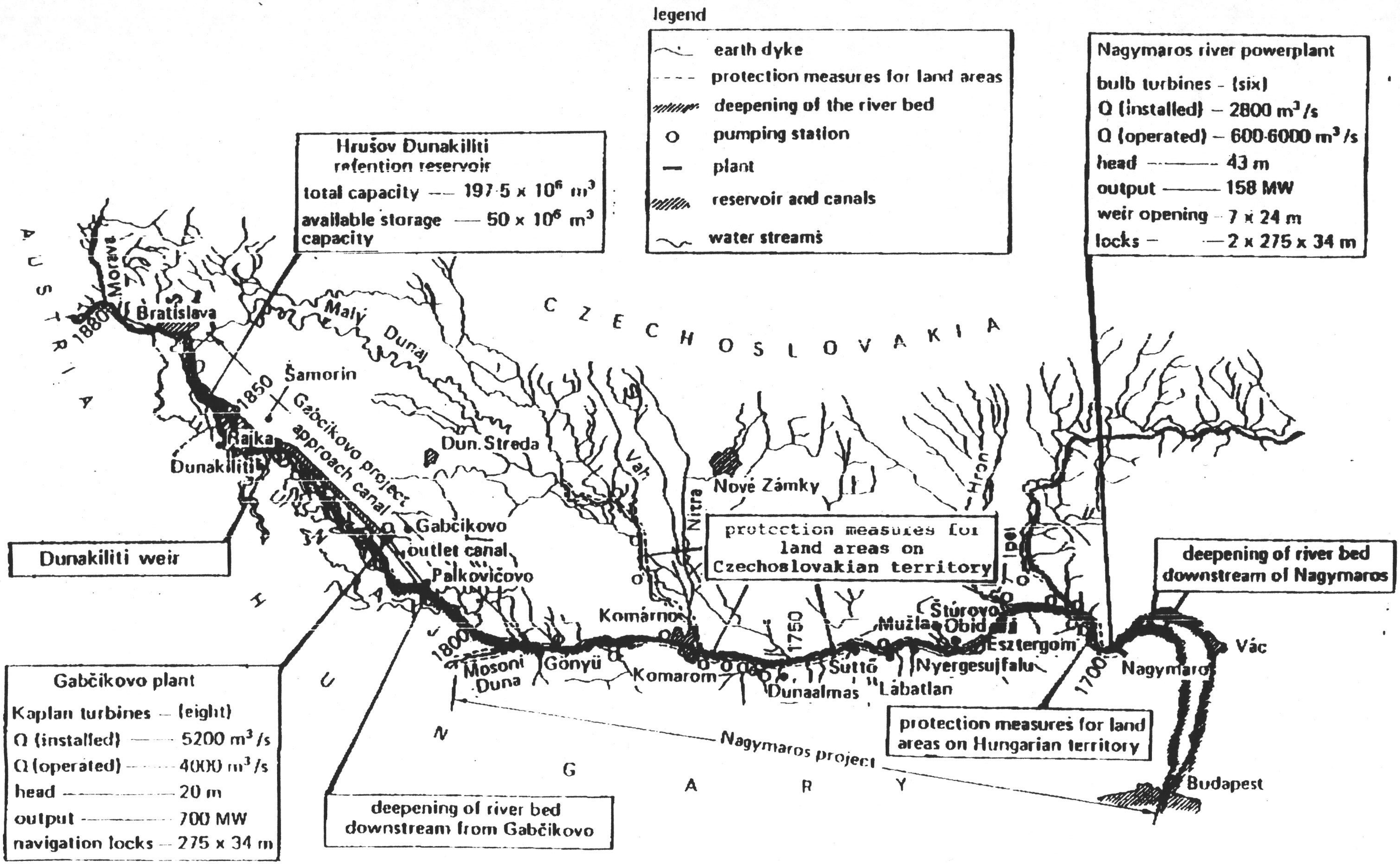
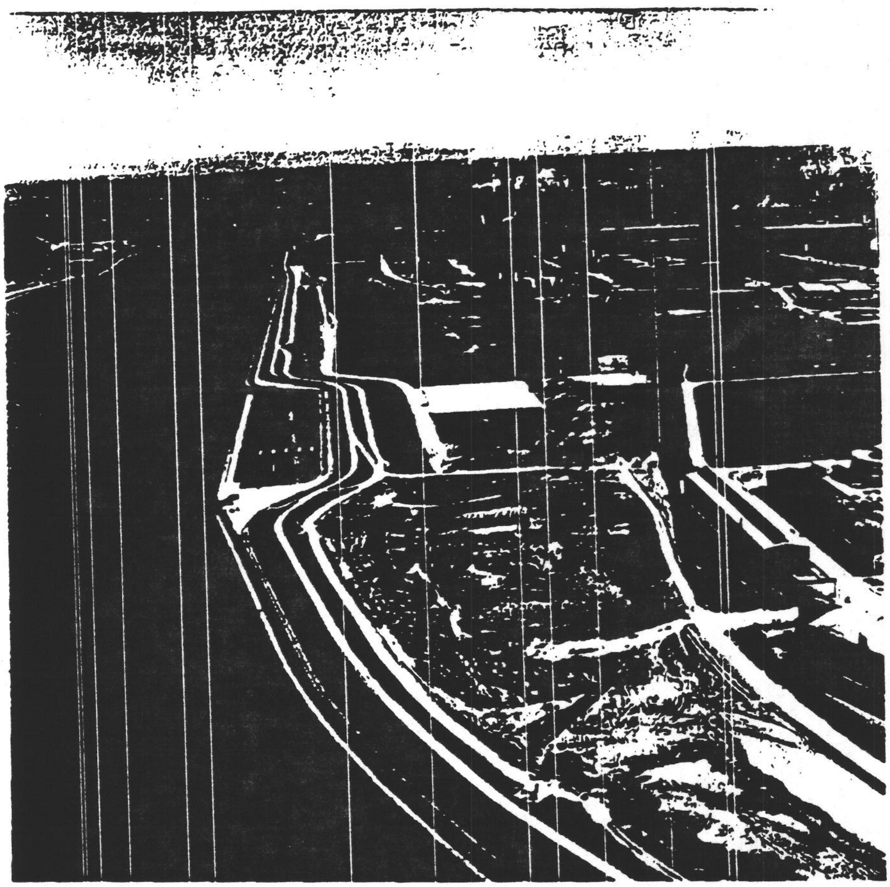



Figure 9: Layout of the Gabcikovo-Nagymaros scheme



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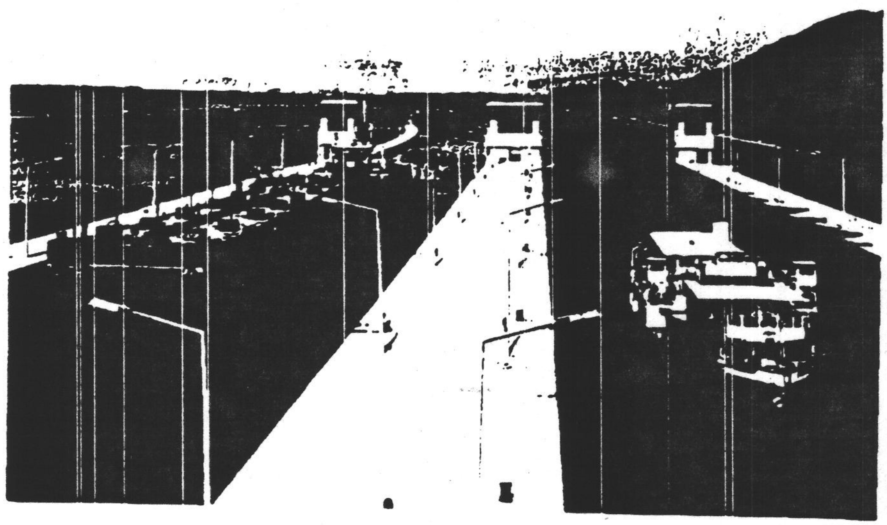

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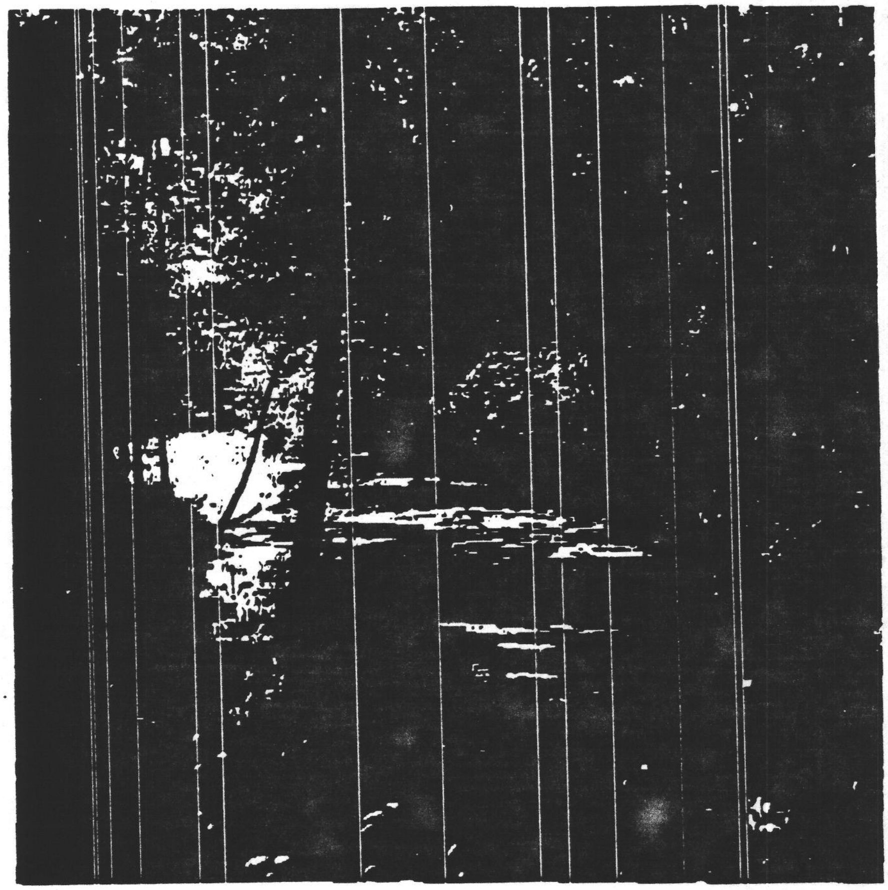

Picture 3: Irrigation of Riverine Bottomland Forests by the "Giessgang" Channel