Figures

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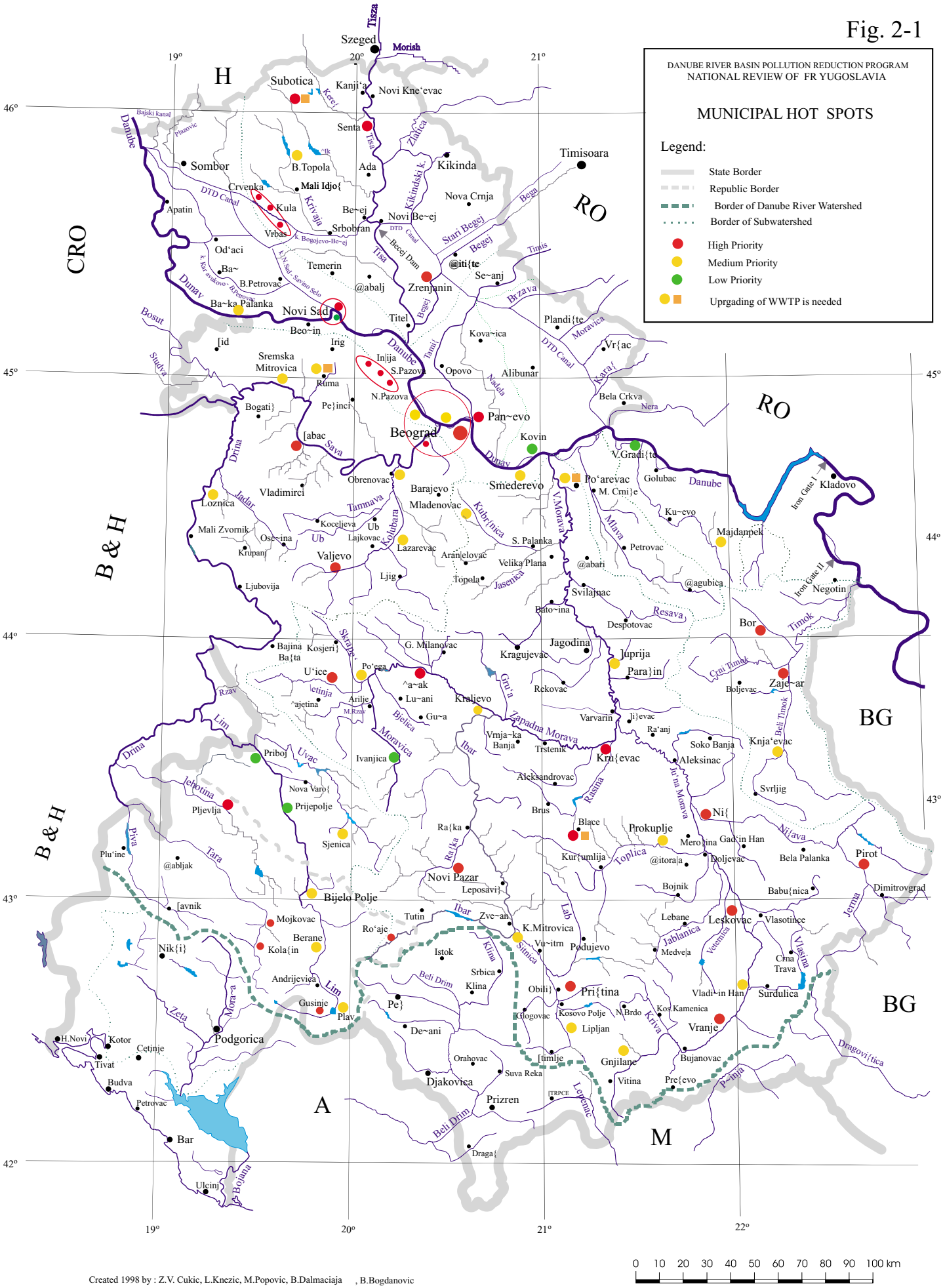
Fig. 2-1



Created 1998 by : Z.V. Cukic, L.Knezic, M.Popovic, B.Dalmaciaja , B.Bogdanovic

Fig. 2-2

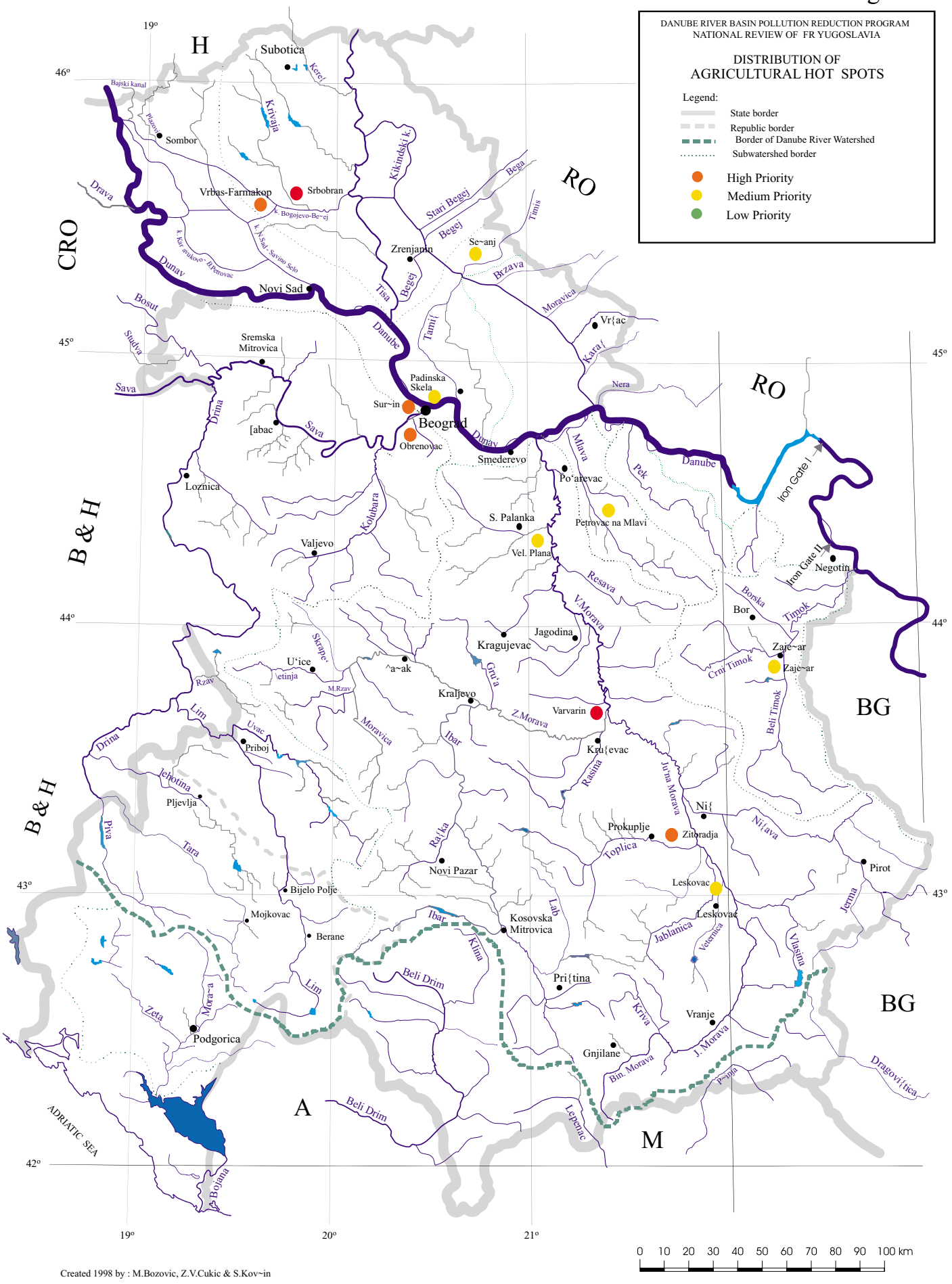


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Fig. 2-3

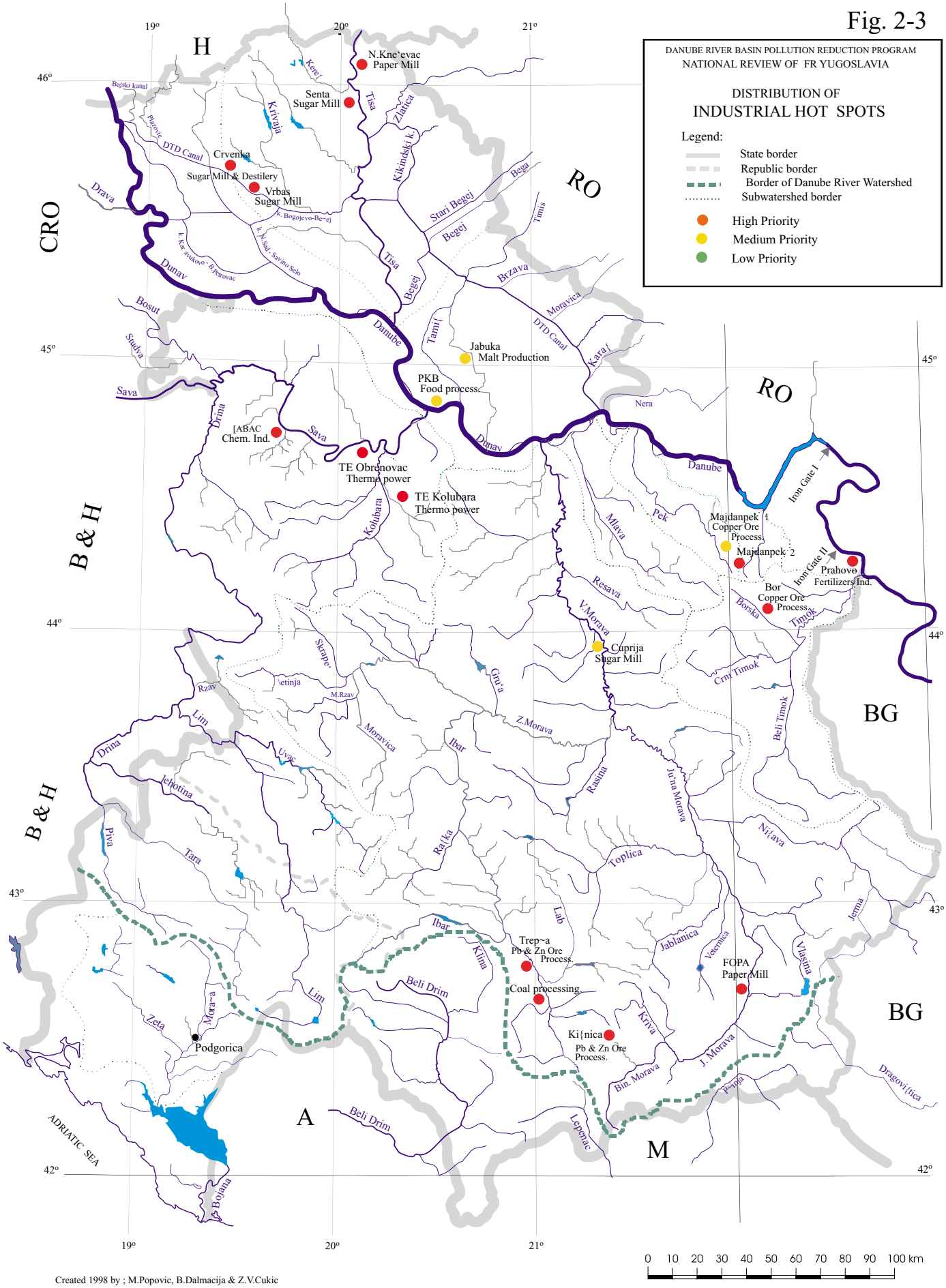

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Fig. 2-4

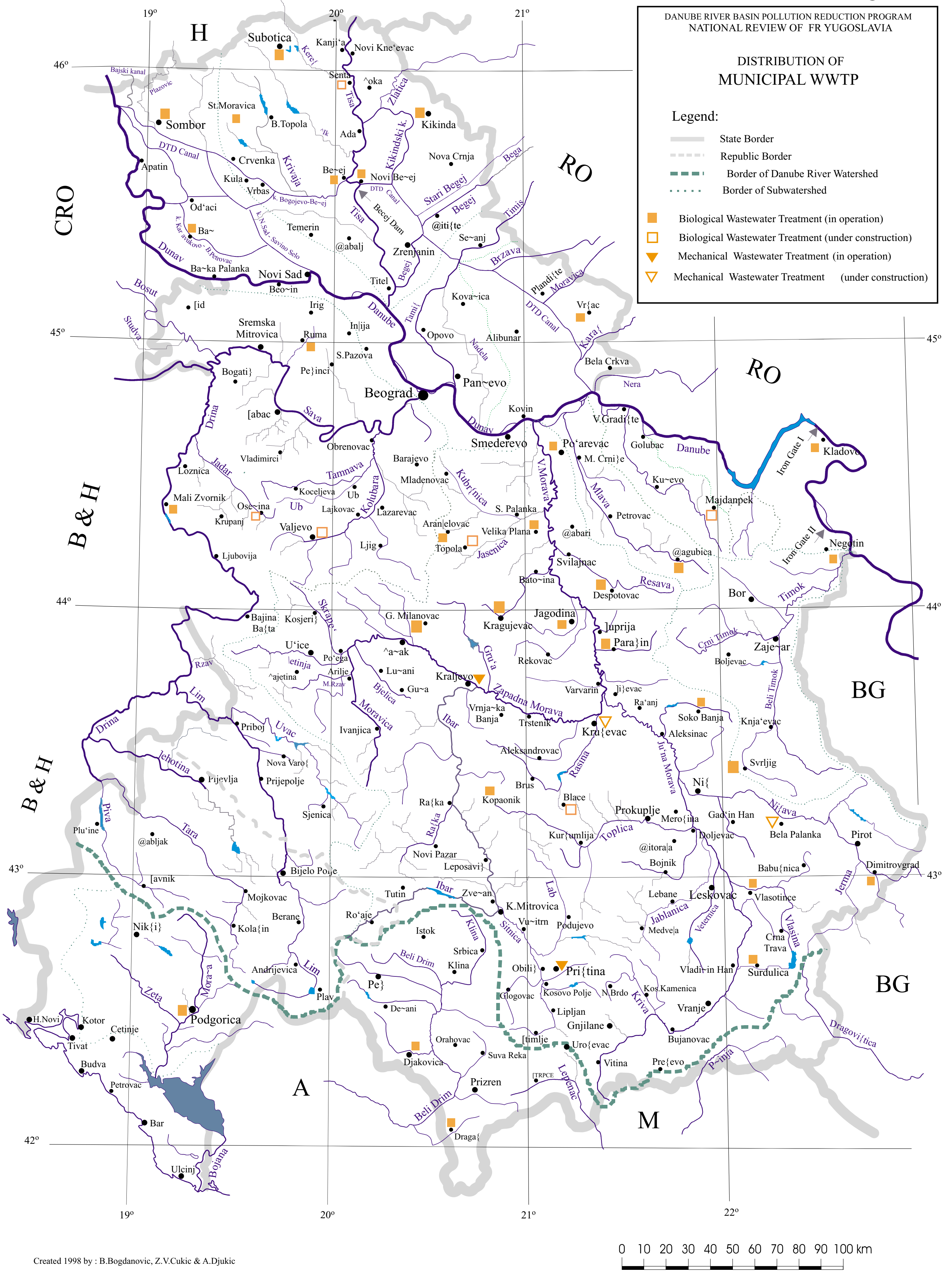

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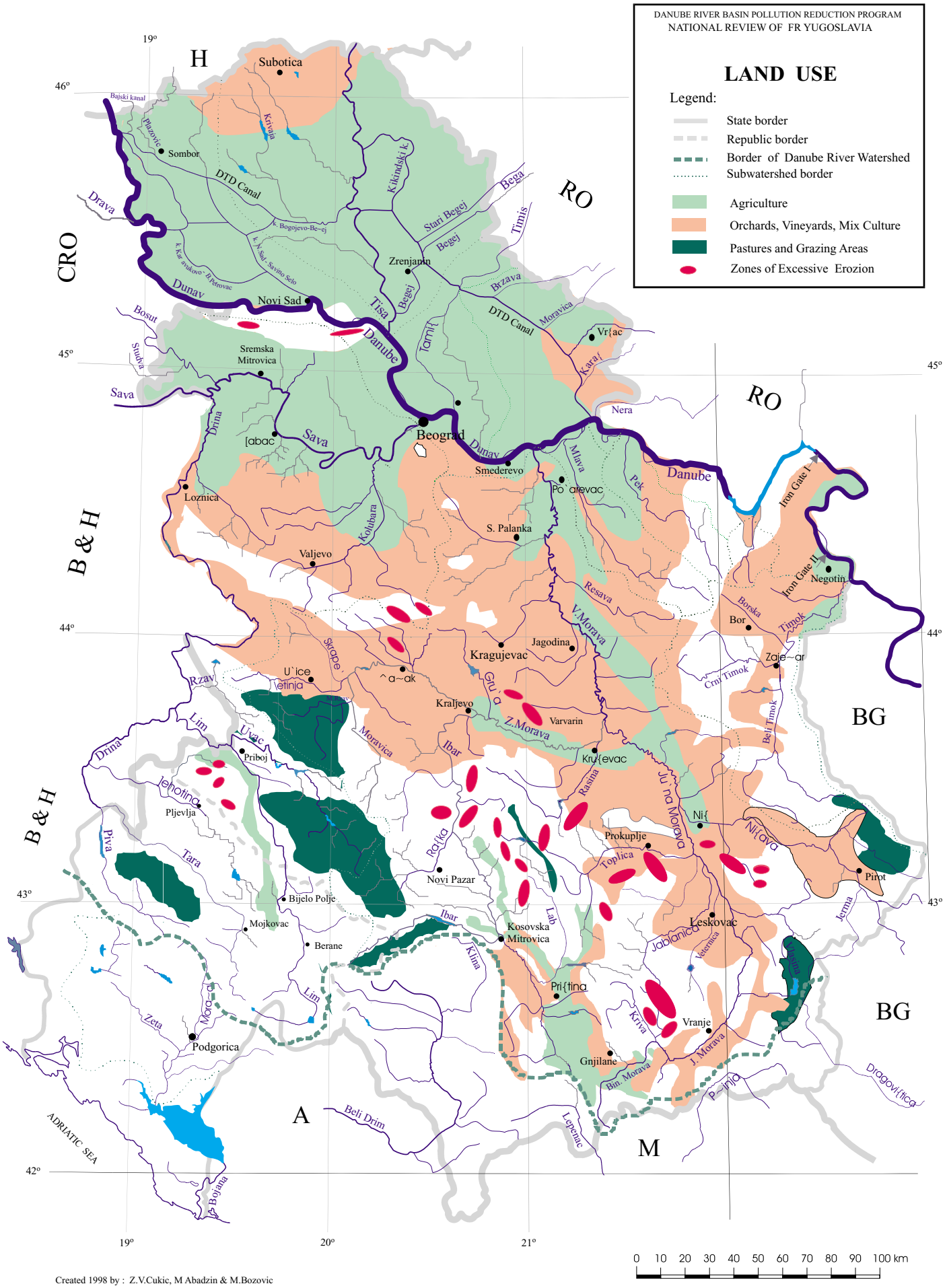
Fig. 3-1



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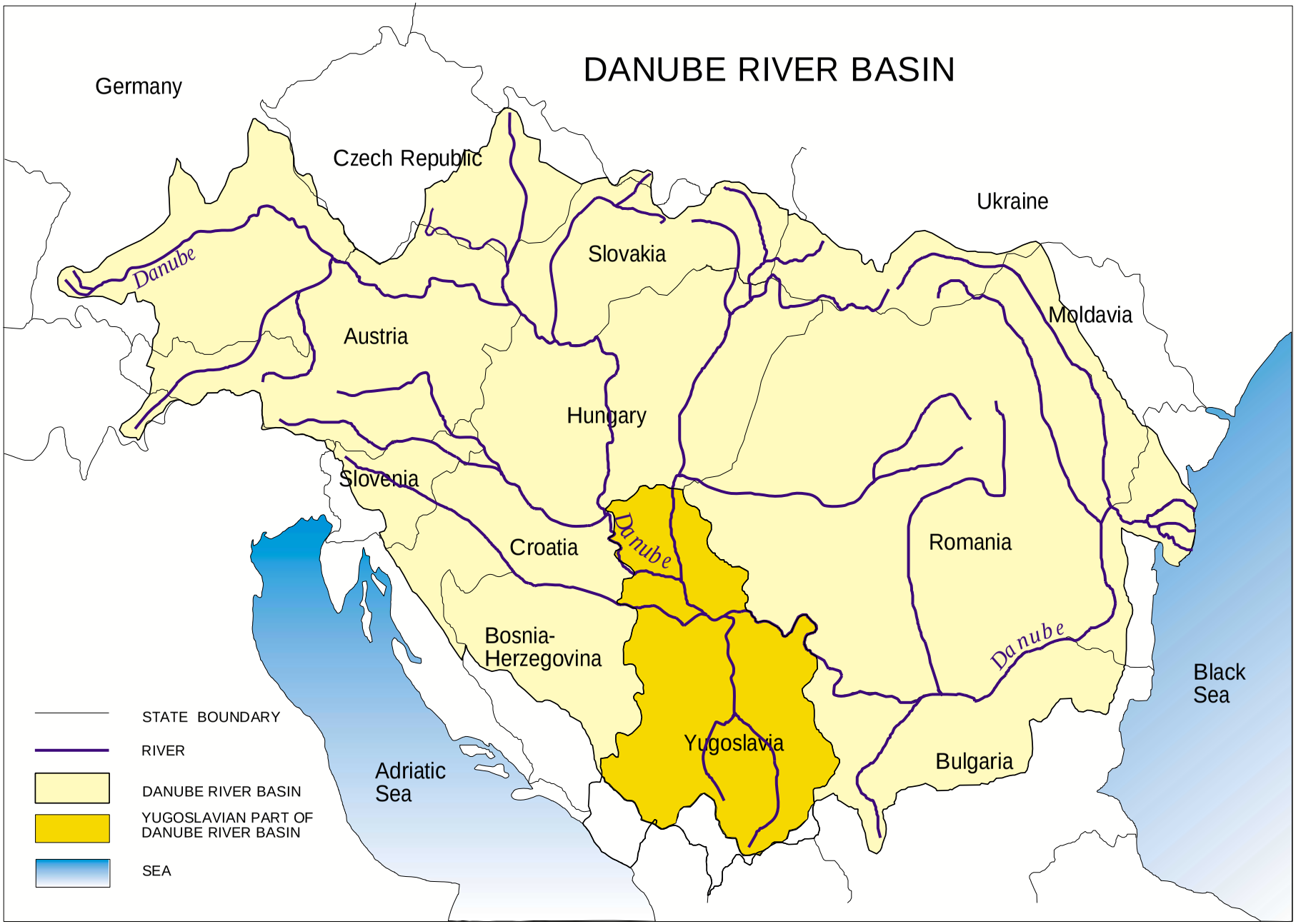
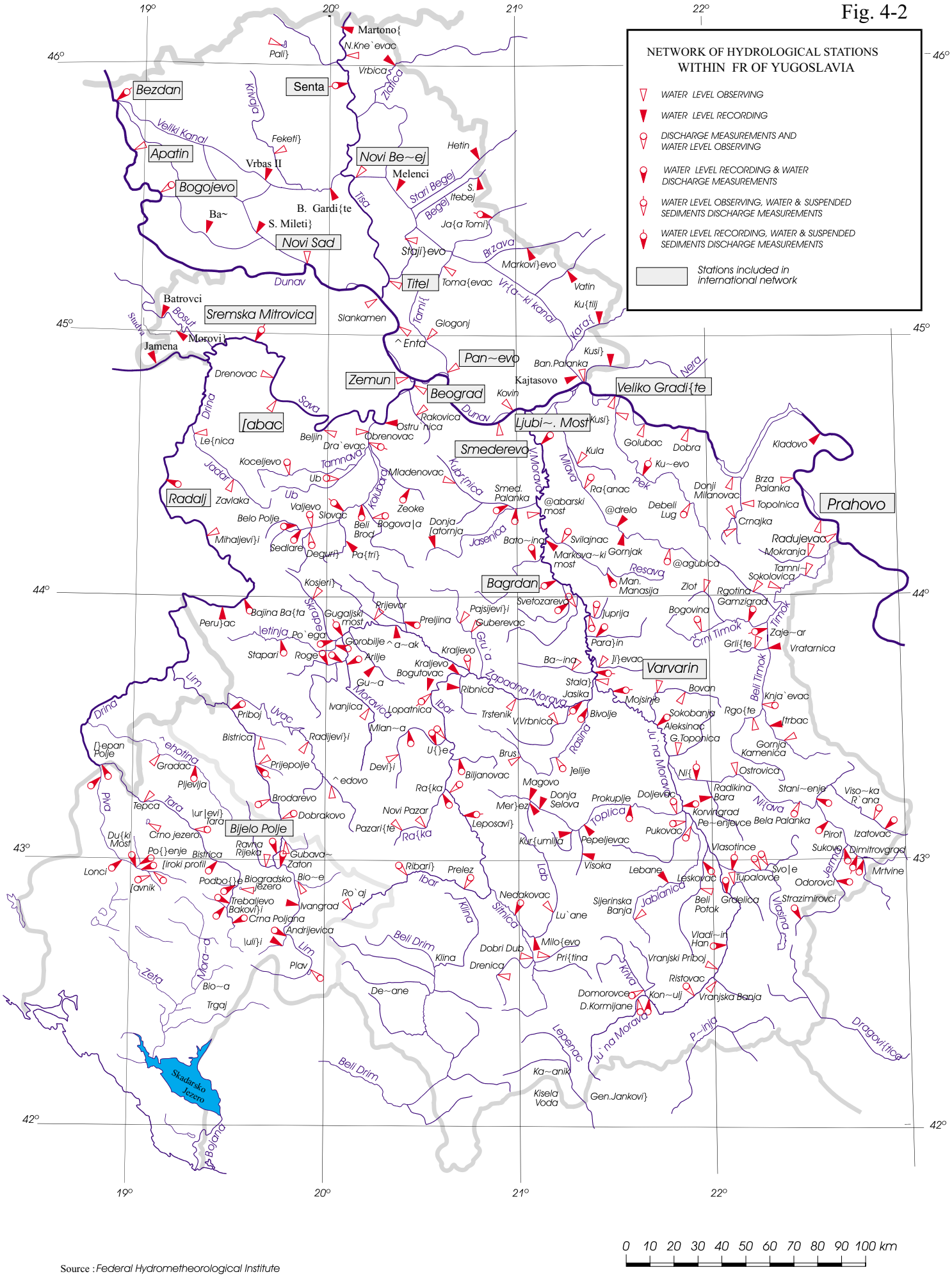

DANUBE RIVER BASIN
Germany
Czech Republic
Slovakia
Ukraine
Moldavia
Danube
Austria
Hungary
Slovenia
Croatia
Danube
Romania
Danube
Bosnia-
Herzegovina
Black
Sea
Yugoslavia
Bulgaria
Adriatic
Sea
STATE BOUNDARY
RIVER
DANUBE RIVER BASIN
YUGOSLAVIAN PART OF
DANUBE RIVER BASIN
SEA

Fig. 4-2



Source : *Federal Hydrometheorological Institute*

Fig. 4-3

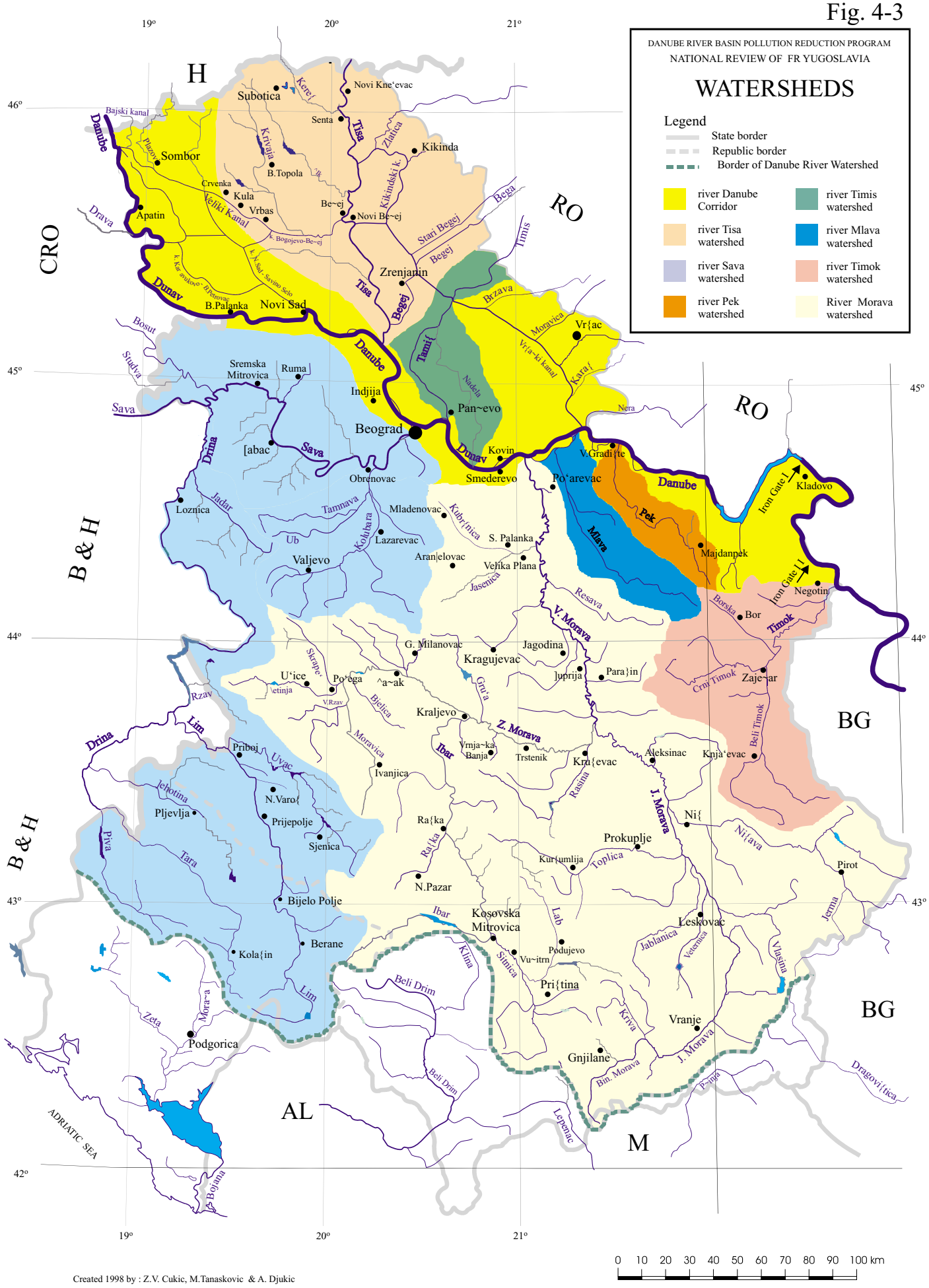
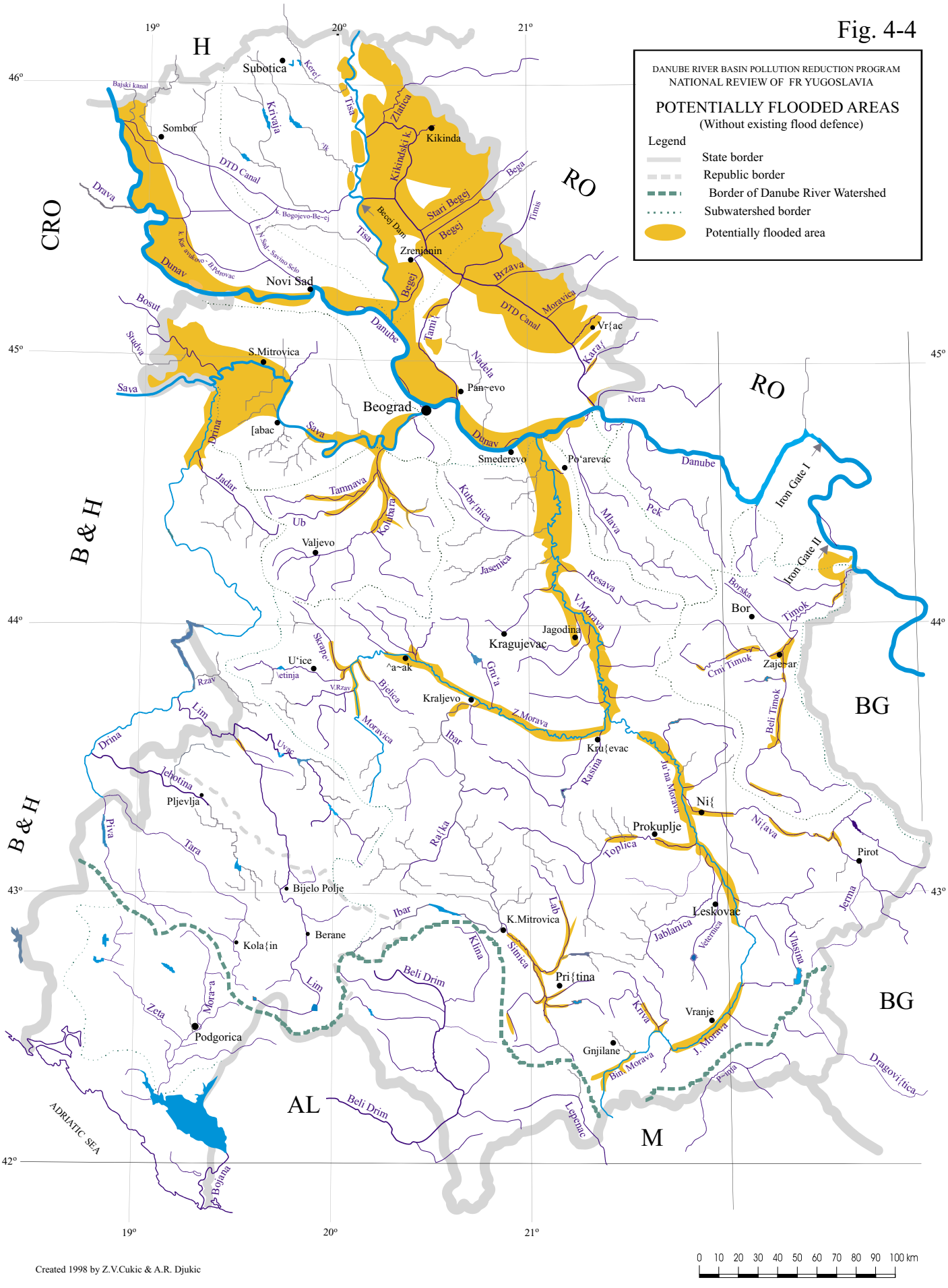
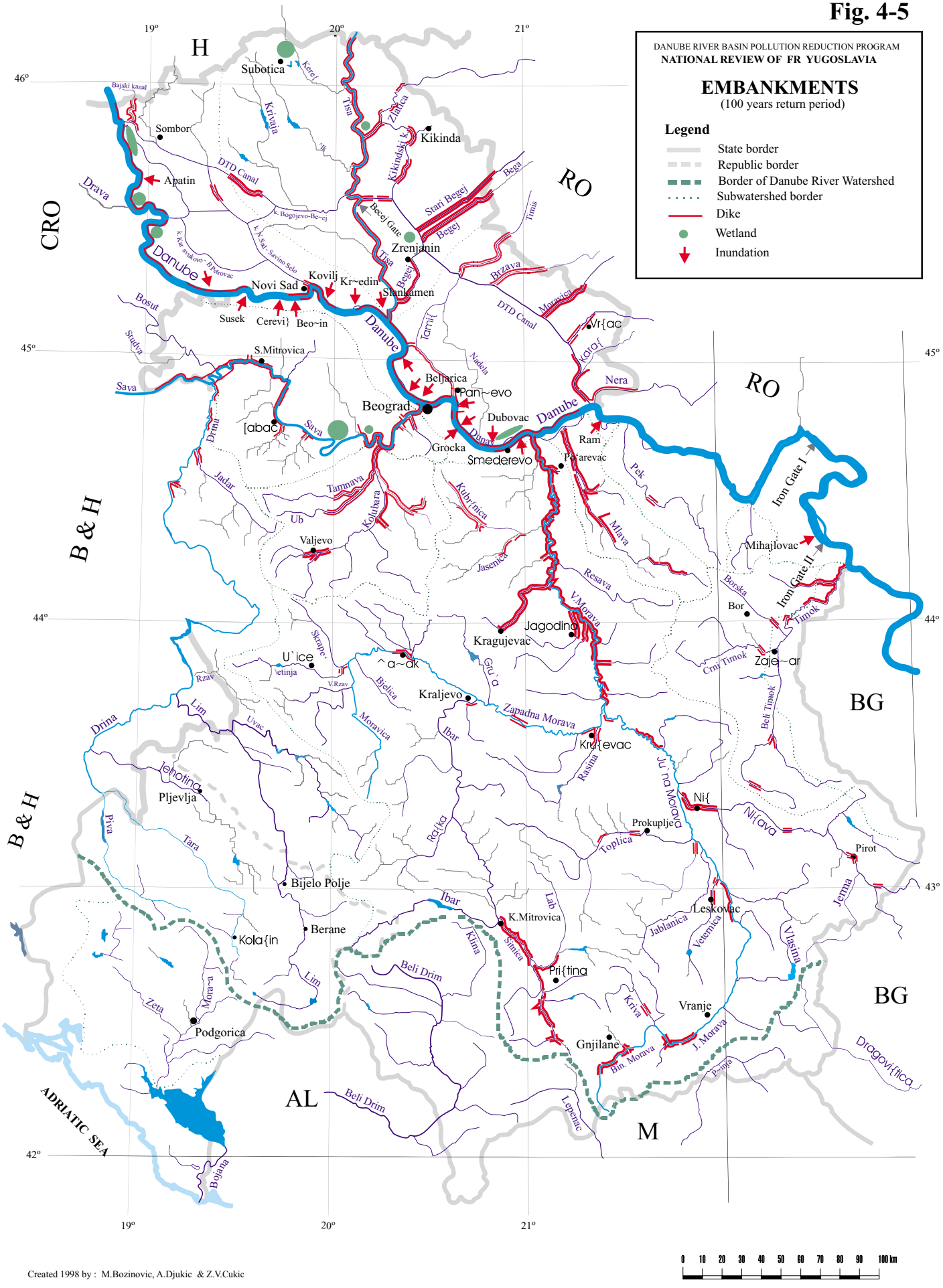

DANUBE RIVER BASIN POLLUTION REDUCTION PROGRAM
NATIONAL REVIEW OF FR YUGOSLAVIA
WATERSHEDS
Legend
State border
Republic border
Border of Danube River Watershed
river Danube Corridor
river Tisa watershed
river Sava watershed
river Pek watershed
river Timis watershed
river Mlava watershed
river Timok watershed
River Morava watershed
H
CRO
RO
B & H
BG
AL
M
ADRIATIC SEA
Subotica
Novi Kne~evac
Senta
Kikinda
Sombor
B.Topola
Kula
Vrbas
Apatin
Novi Be~ej
Zrenjanin
B.Palanka
Novi Sad
Sremska Mitrovica
Ruma
Indjija
Pan~evo
Beograd
[abac
Obrenovac
Smederevo
Kovin
V.Gradi{te
Vr{ac
Po~arevac
Kladovo
Majdanpek
Negotin
Bor
Loznica
Valjevo
Mladenovac
Lazarevac
S. Palanka
Aran|elovac
Velika Plana
G. Milanovac
Kragujevac
Jagodina
U~ice
Po`ega
^a~ak
Kraljevo
Para}in
Zaje~ar
Knja~evac
Aleksinac
Ni{
Prokuplje
Pirot
Leskovac
Vranje
Pri{tina
Podujevo
Kosovska Mitrovica
Gnjilane
N.Pazar
Ra{ka
Kur{umlija
Trstenik
Vrnja~ka Banja
Kru{evac
Ivanjica
Priboj
Pljevlja
N.Varo{
Prijepolje
Sjenica
Bijelo Polje
Berane
Kola{in
Podgorica
Danube
Tisa
Sava
Drina
Dunav
Begej
Tami{
Timis
Morava
Ibar
Lim
Ni{ava
Iron Gate I
Iron Gate II
0 10 20 30 40 50 60 70 80 90 100 km
Created 1998 by : Z.V. Cukic, M.Tanaskovic & A. Djukic

Fig. 4-4



Created 1998 by Z.V.Cukic & A.R. Djukic

Fig. 4-5



Created 1998 by : M.Bozinovic, A.Djukic & Z.V.Cukic

Fig. 4-6

Water Budget for DRB in FR Yugoslavia :

EXTERNAL INFLOW - 155 billion m^3 / y

INTERNAL RUNOFF - 20 billion m^3 / y

DANUBE RIVER BASIN POLLUTION REDUCTION PROGRAM
NATIONAL REVIEW OF FR YUGOSLAVIA

WATER TRANSFERS
WITHIN THE DANUBE RIVER BASIN
IN FR YUGOSLAVIA

Water transfer

River Stretch making State Border

Qg - withdrawal by gravitation

Qp - withdrawal by pumping

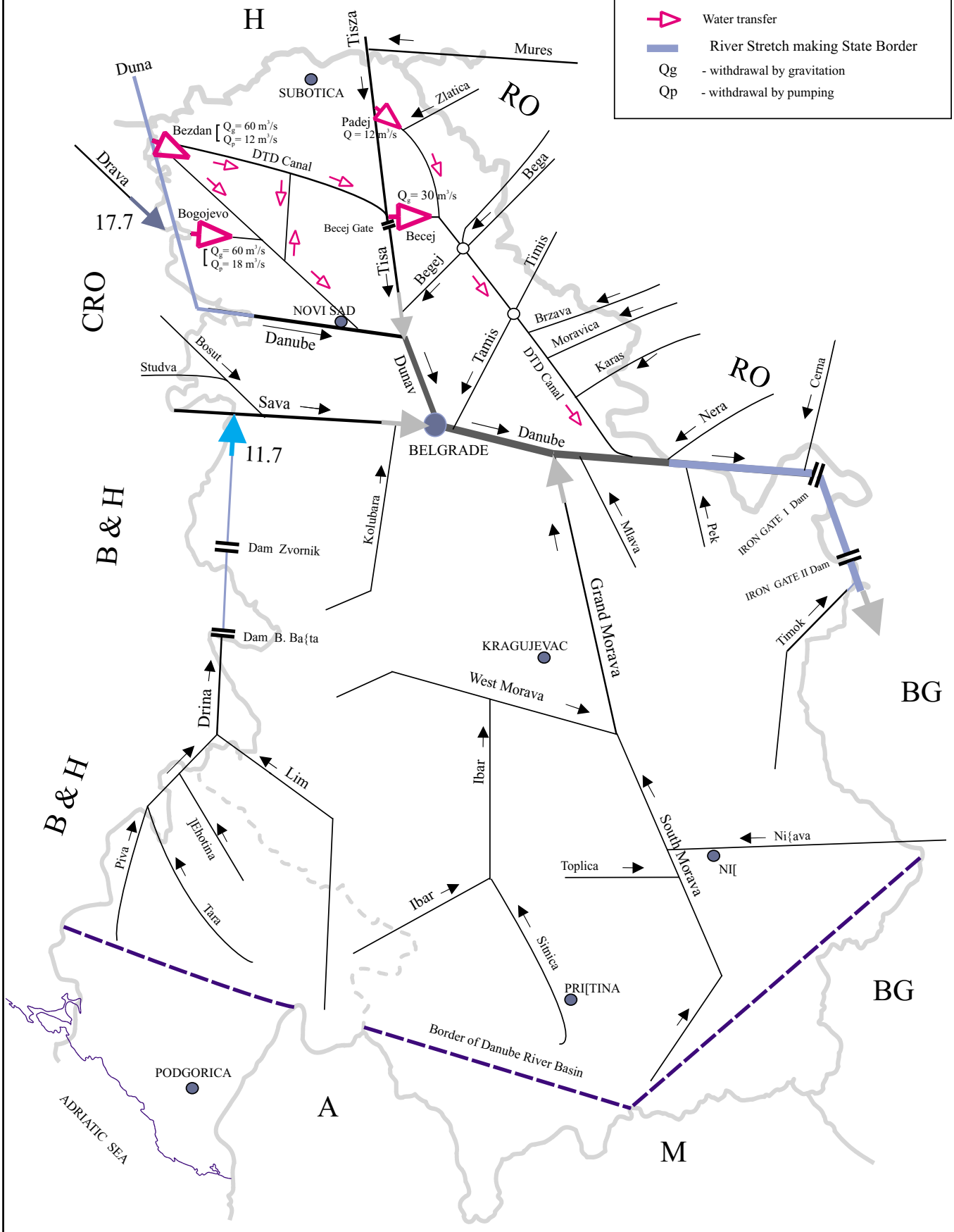
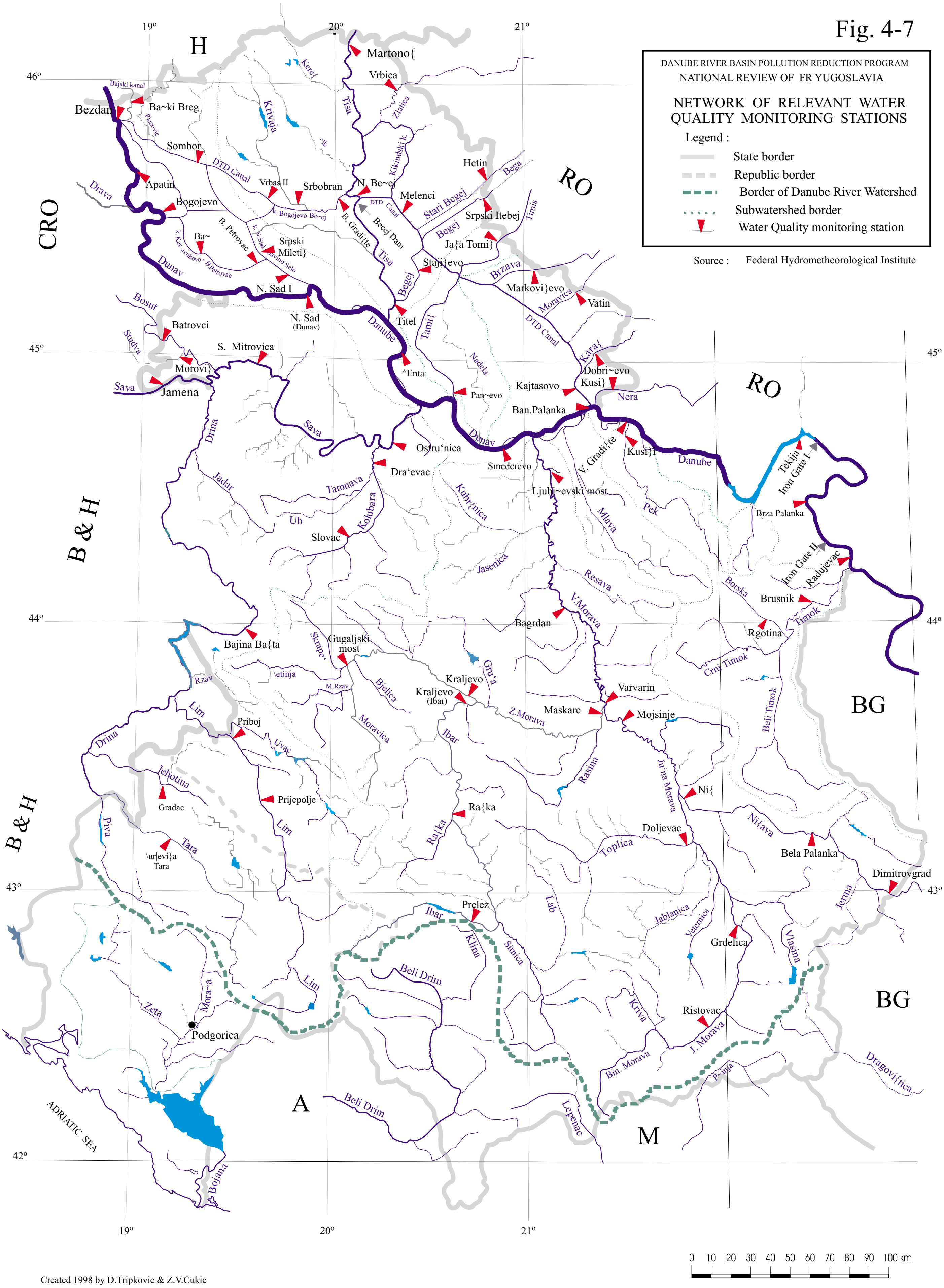


Fig. 4-7



Created 1998 by D.Tripkovic & Z.V.Cukic

Fig. 4 - 8

Water Budget for DRB in FR Yugoslavia :

EXTERNAL INFLOW - 155 billion m^3 / y

INTERNAL RUNOFF - 20 billion m^3 / y

DANUBE RIVER BASIN POLLUTION REDUCTION PROGRAM
NATIONAL REVIEW OF FR YUGOSLAVIA

WATER BUDGET
FOR THE DANUBE RIVER BASIN
IN FR YUGOSLAVIA

15 → Average annual water discharge (in billion m^3 per year)

River Stretch making State Border

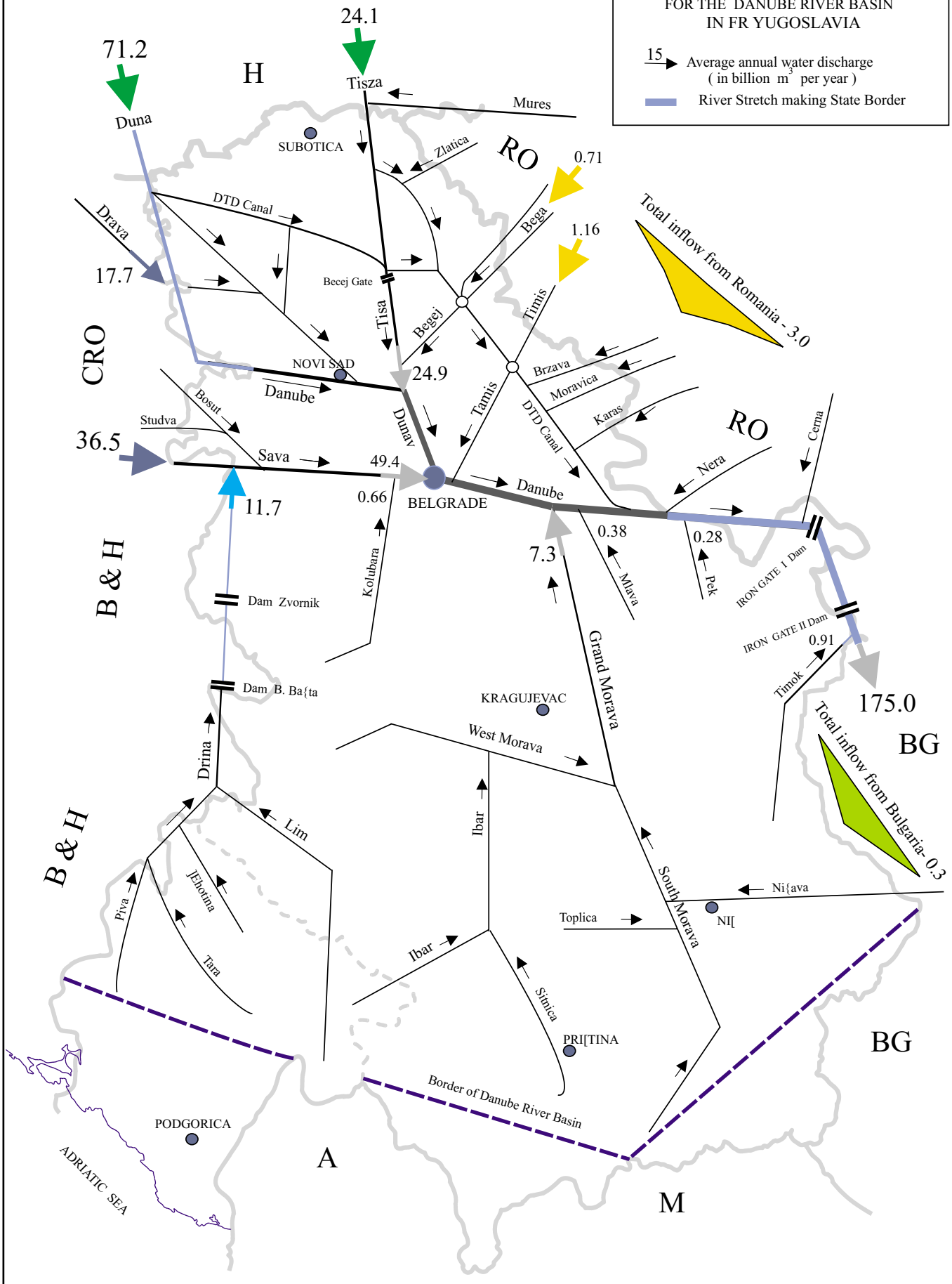


Fig. 4-9

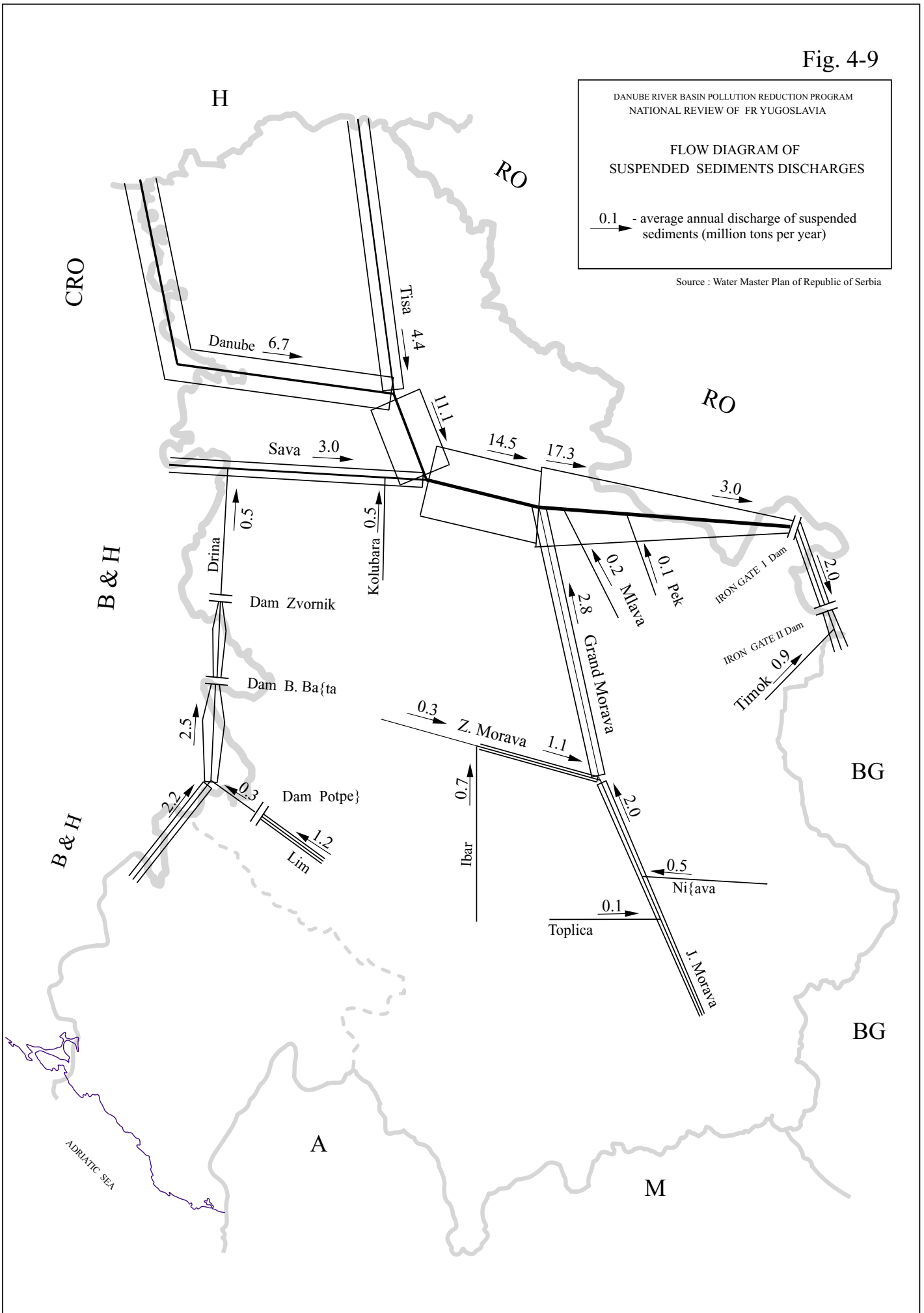
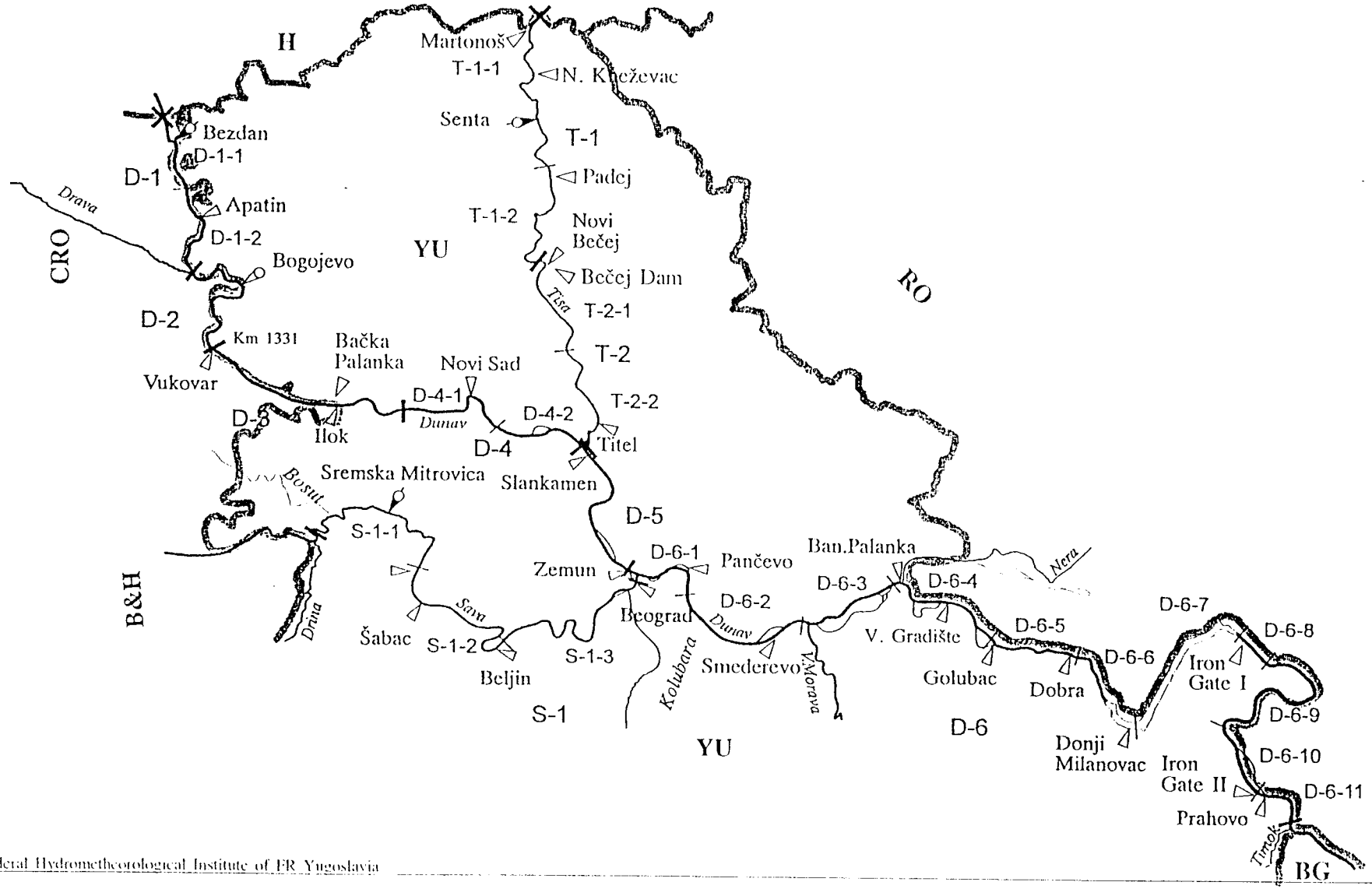

DANUBE RIVER BASIN POLLUTION REDUCTION PROGRAM
NATIONAL REVIEW OF FR YUGOSLAVIA
FLOW DIAGRAM OF
SUSPENDED SEDIMENTS DISCHARGES
0.1 - average annual discharge of suspended sediments (million tons per year)
Source : Water Master Plan of Republic of Serbia
H
RO
CRO
RO
Tisa 4.4
Danube 6.7
11.1
Sava 3.0
14.5
17.3
3.0
Drina
0.5
Kolubara 0.5
B & H
Dam Zvornik
0.2 Mlava
0.1 Pek
IRON GATE I Dam
2.0
2.8 Grand Morava
IRON GATE II Dam
Timok 0.9
Dam B. Ba{ta
2.5
0.3 Z. Morava 1.1
BG
0.7
Ibar
2.0
2.2
0.3
Dam Potpe}
1.2
Lim
B & H
0.5
Ni{ava
0.1
Toplica
J. Morava
BG
ADRIATIC SEA
A
M

Figure 4.4.2-1 : ANALYZED REACHES AND SECTIONS OF DANUBE AND TRIBUTARIES



Source: Federal Hydrometheorological Institute of FR Yugoslavia

Figure 4.4.2-2 : Z-F Curve (Danube river km 1159+540)

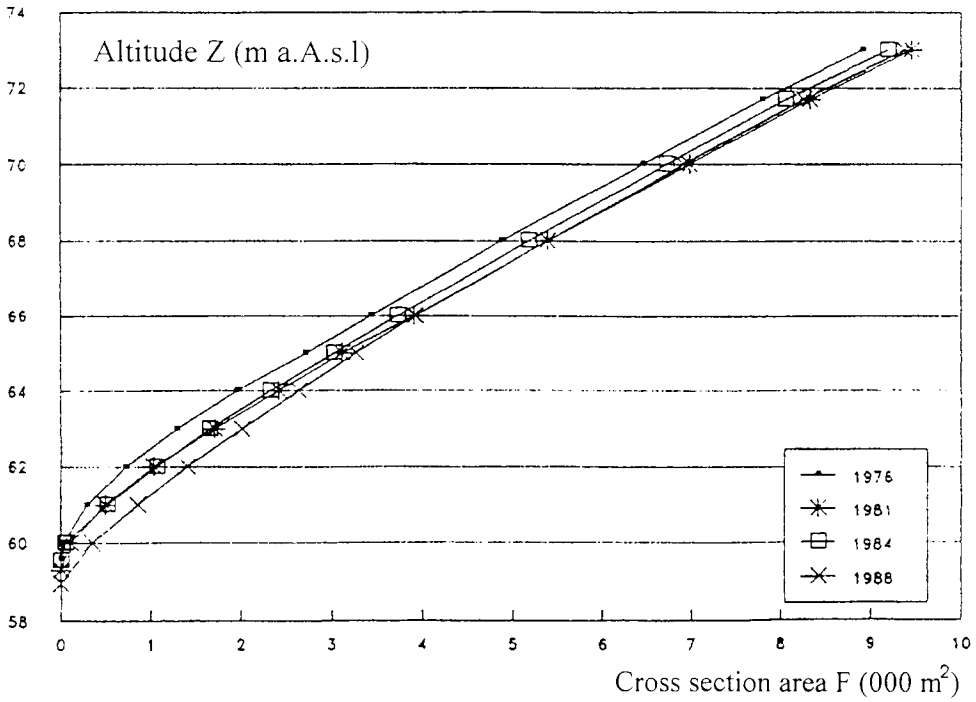
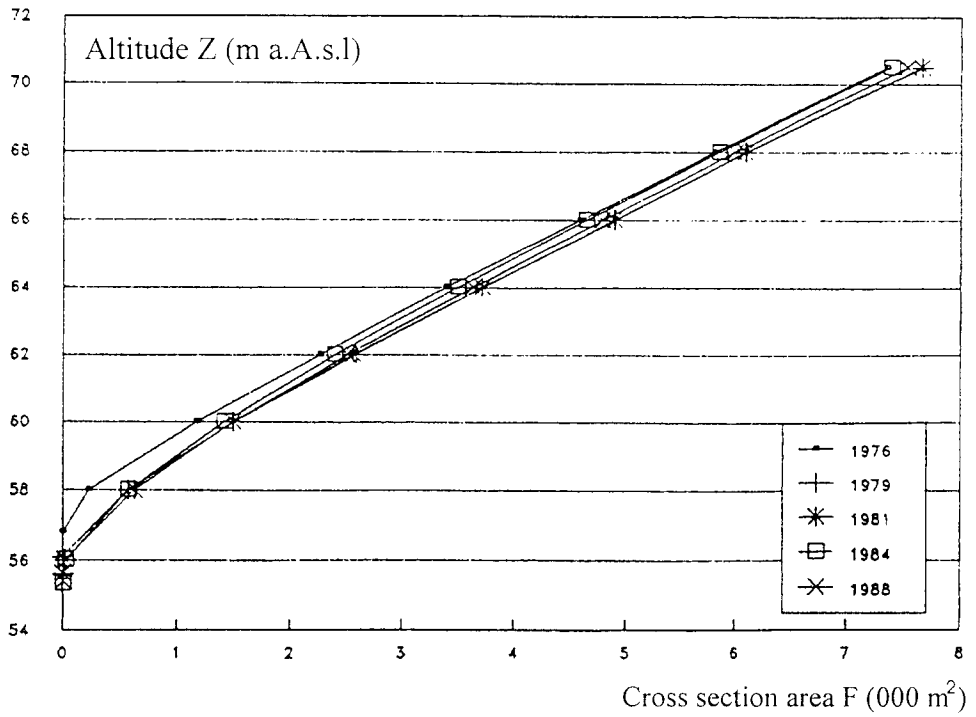


Figure 4.4.2-3 : Z-F Curve (Danube river km 1120+600)



Remark : m a.A.s.l - m above Adriatic sea Level

Figure 4.4.2-4 : Z-F Curve (Danube river km 1106+350)

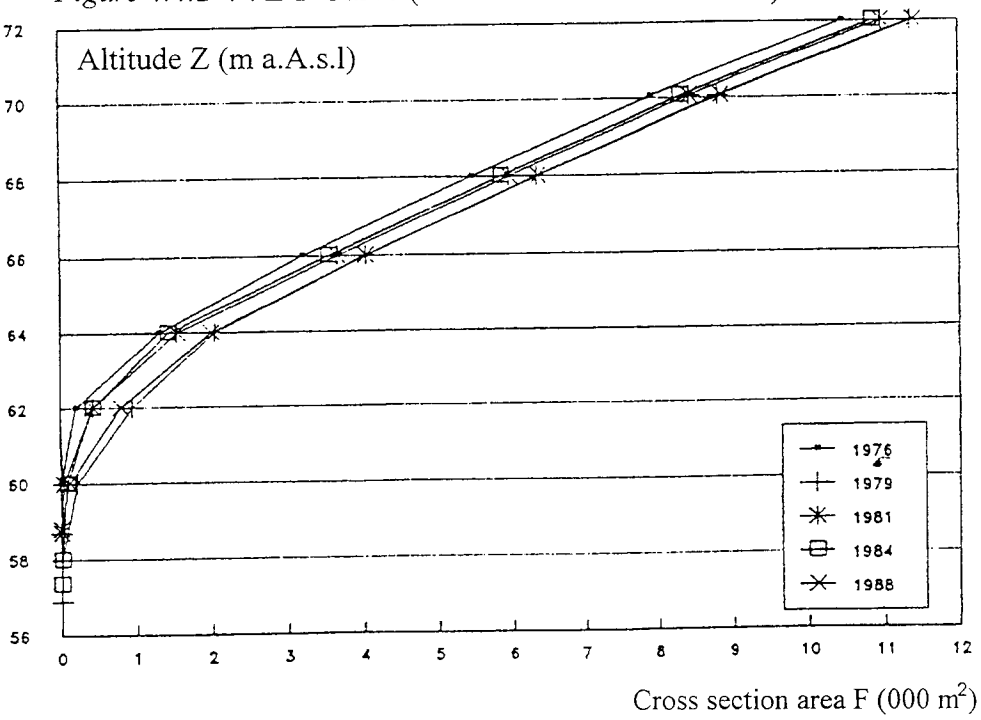
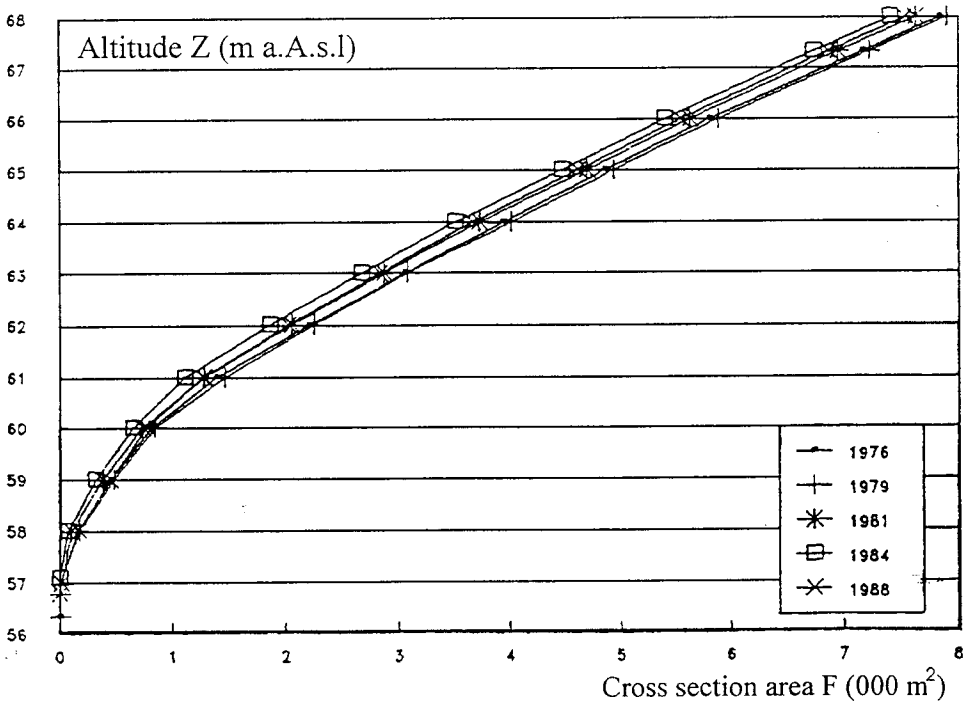


Figure 4.4.2-5 : Z-F Curve (Danube river km 1051+500)



Remark : m a.A.s.l - m above Adriatic sea Level

Figure 4.4.2-6 : Z-F Curve (Danube river km 995+200)

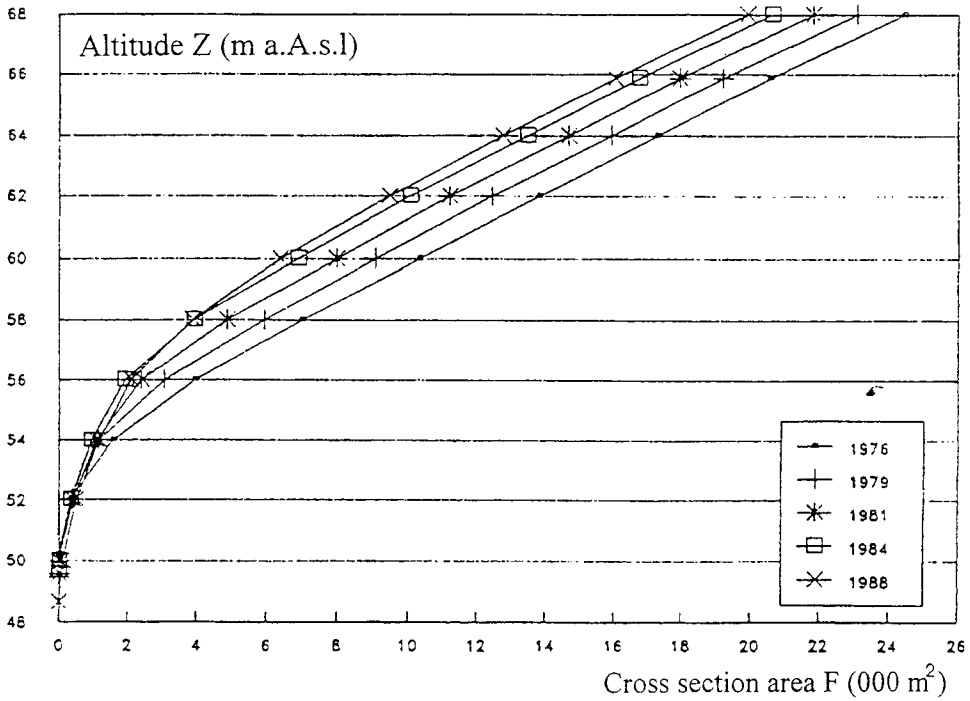
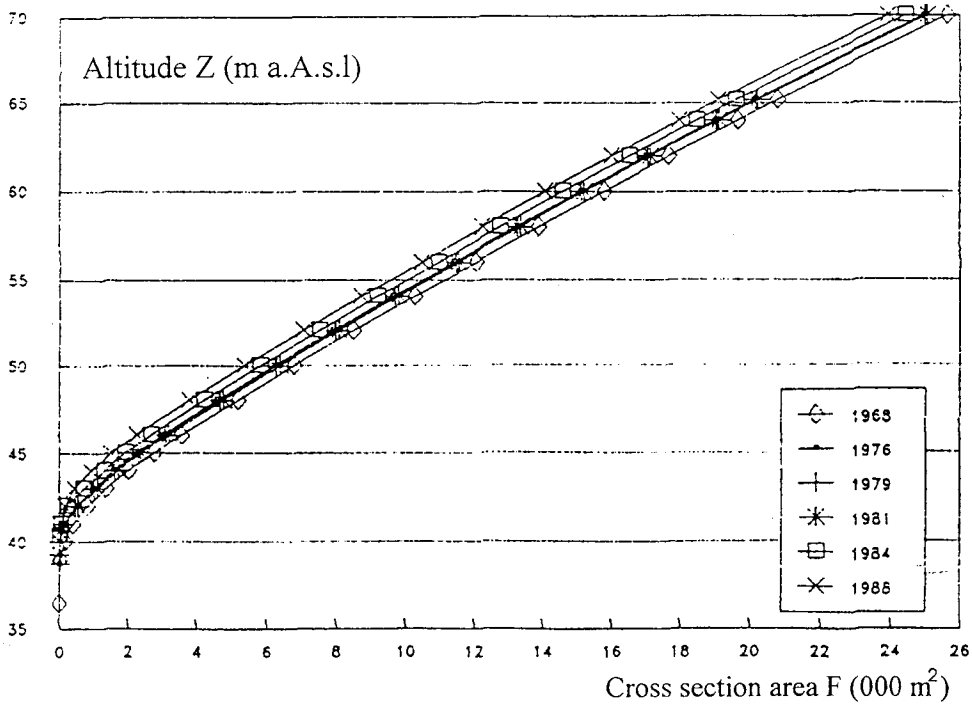
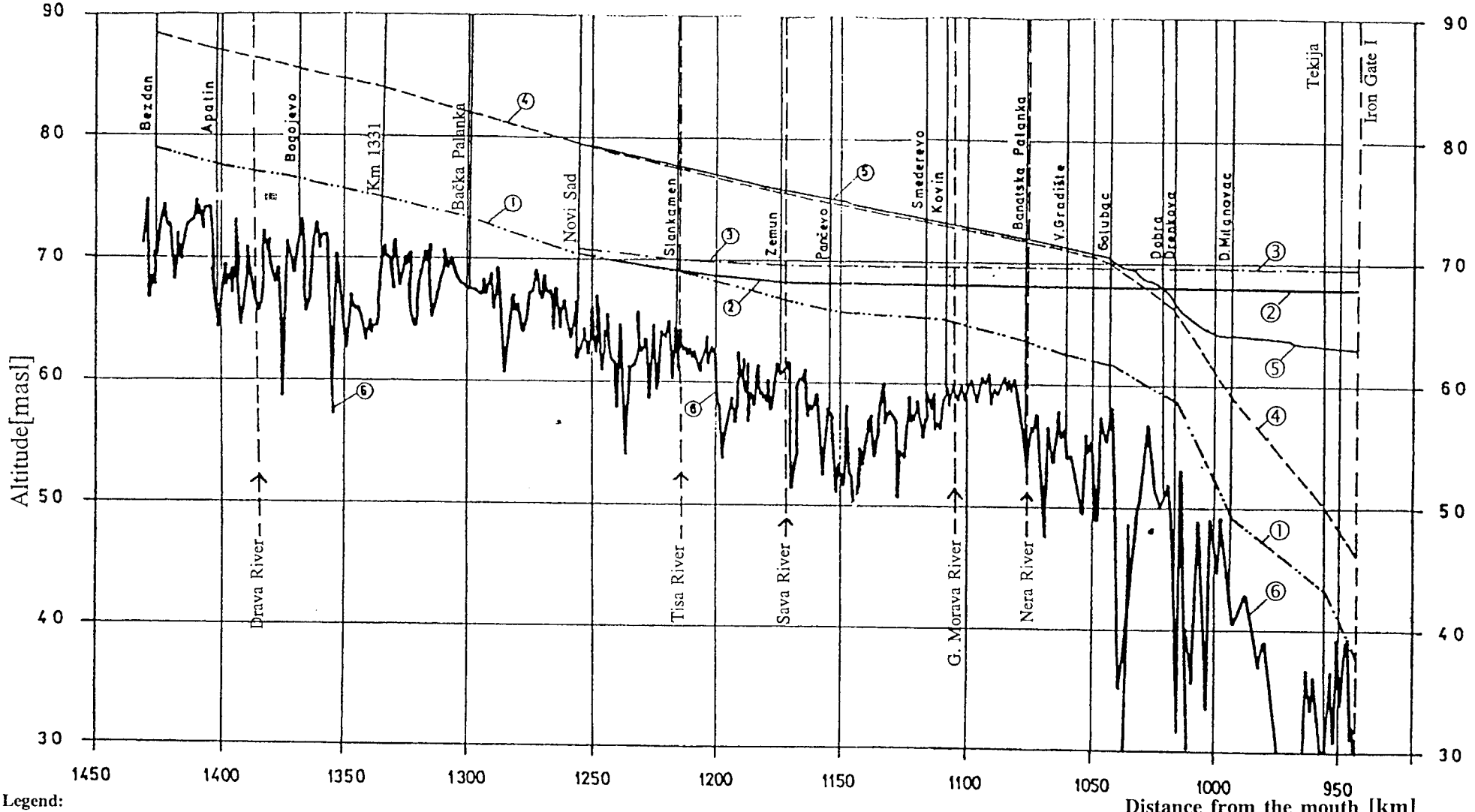


Figure 4.4.2-7 : Z-F Curve (Danube river km 952+400)



Remark : m a.A.s.l - m above Adriatic sea Level

Figure 4.4.3-1 : **LONGITUDINAL PROFILE OF DANUBE RIVER** (Section: Iron Gate I - Bezdan)

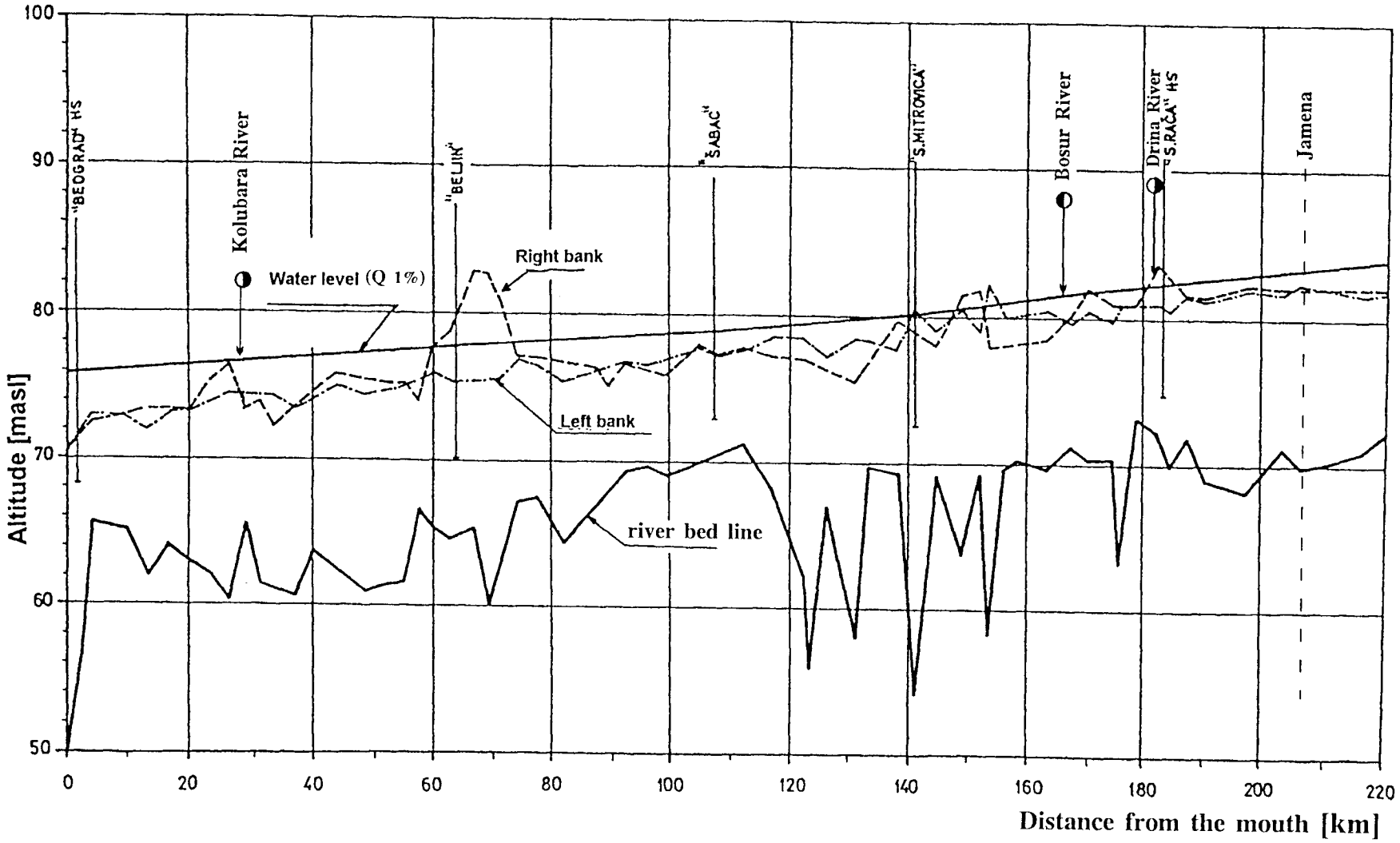


Legend:

1. The line of opserved minimal water level under the natural regime
2. The line of low flow level under the regine of operation of HPP Iron Gate I 68/63
3. The line of low flow level under the regine of operation of HPP Iron Gate I 69.5/63
4. The line of opserved maximum water level in the natural regime
5. The line of high flow level under the regine of operation of HPP Iron Gate I 68/63
6. The bottom line folowing the river-bed axis

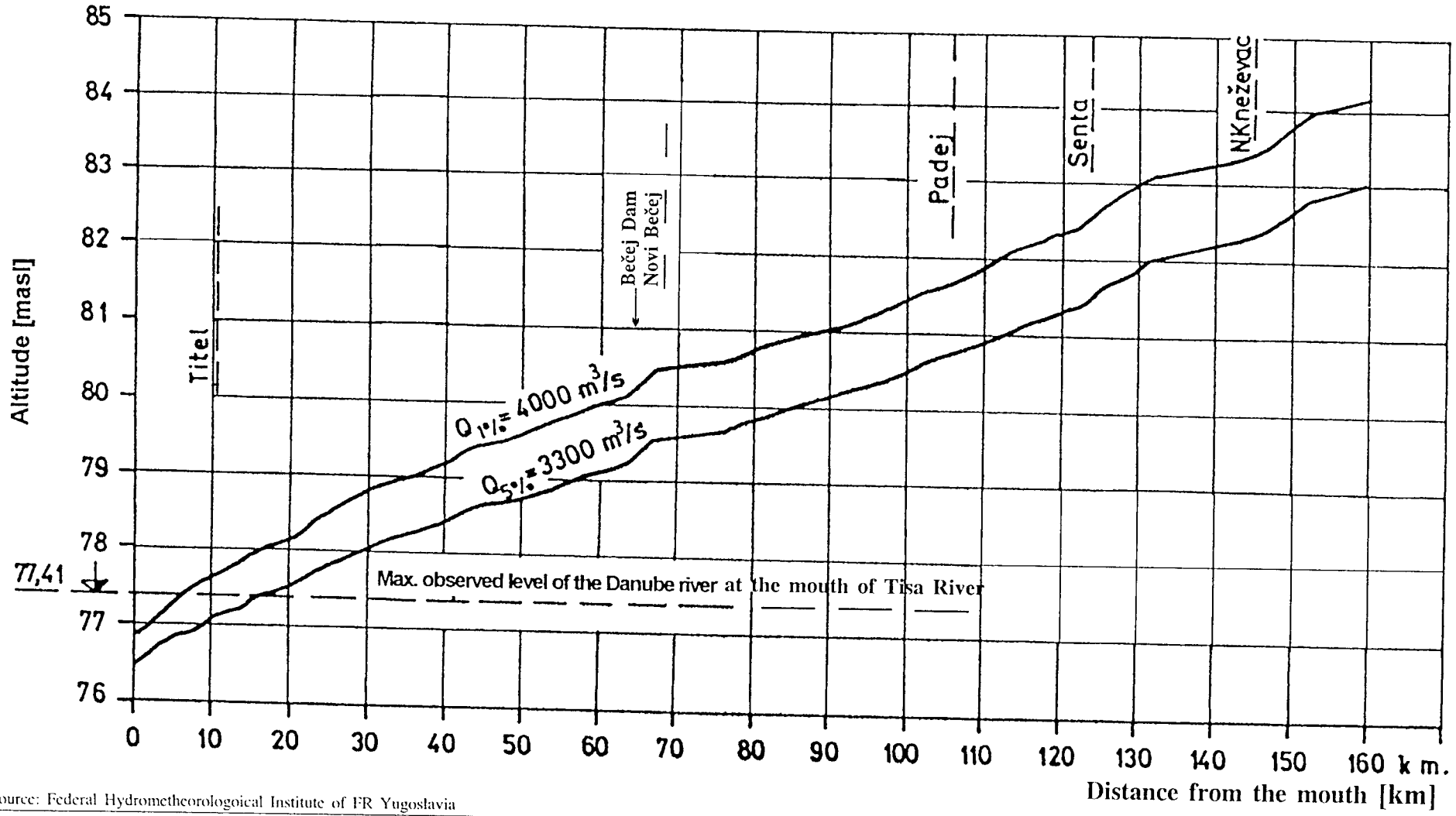
Source: Federal Hydrometheorological Institute of FR Yugoslavia

Figure 4.4.3-2 : **LONGITUDINAL PROFILE OF SAVA RIVER** (Section: Mouth - Brčko)



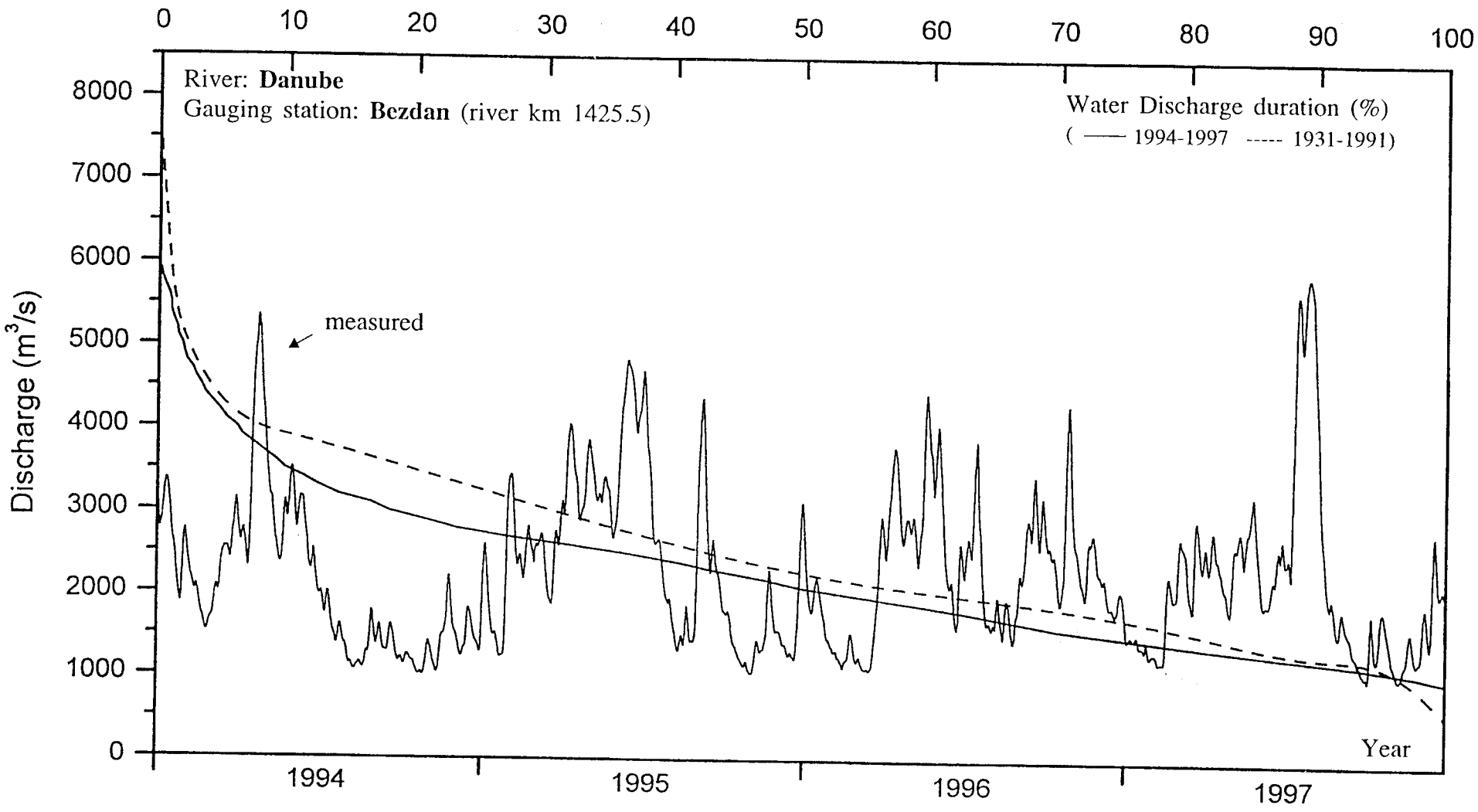
Source: Federal Hydrometeorological Institute of FR Yugoslavia

Figure 4.4.3-3 : **LONGITUDINAL PROFILE OF TISA RIVER** (flow for 100 and 20 year return period)



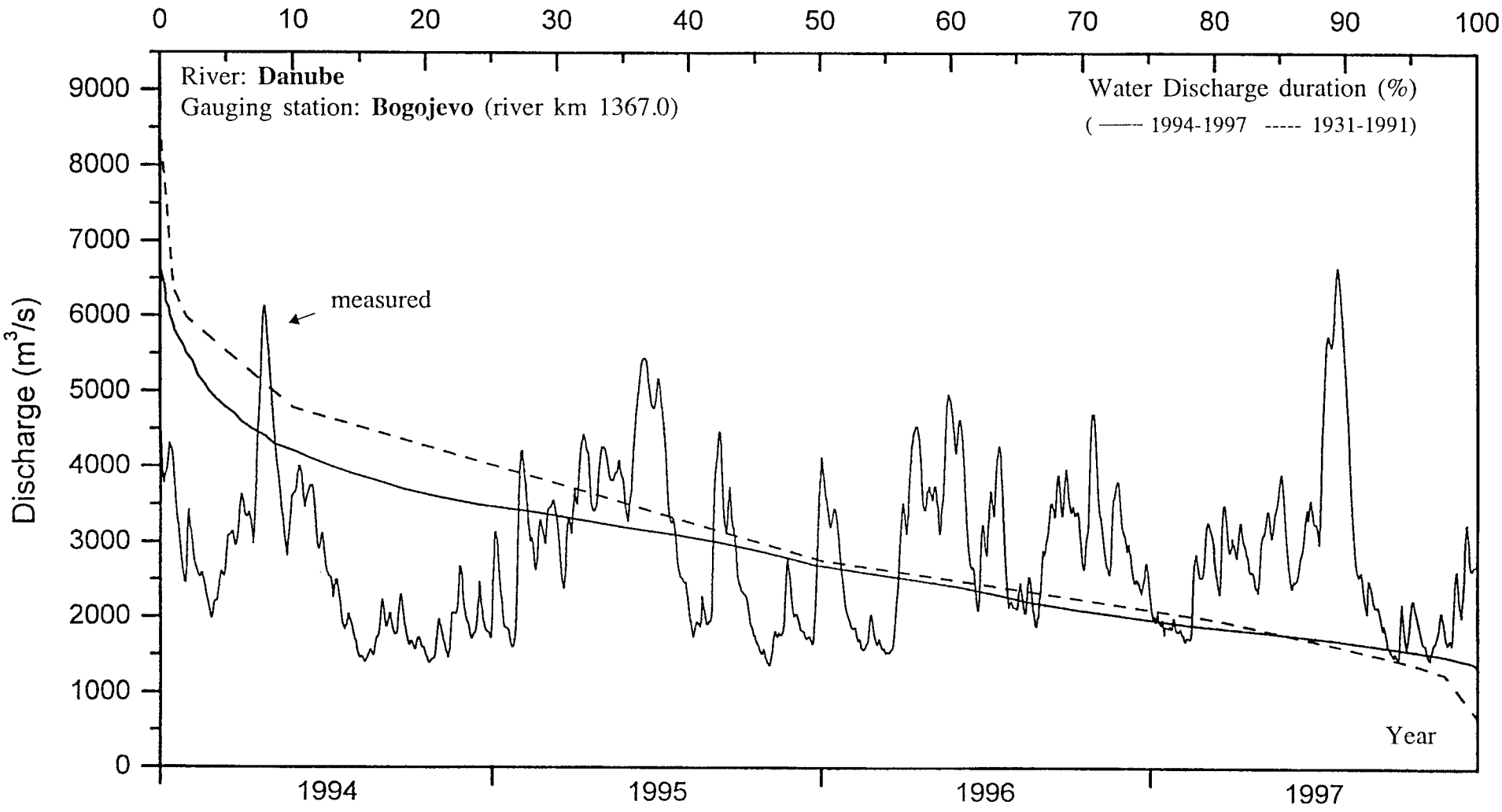
Source: Federal Hydrometheorologoical Institute of FR Yugoslavia

Figure 4.9-1 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



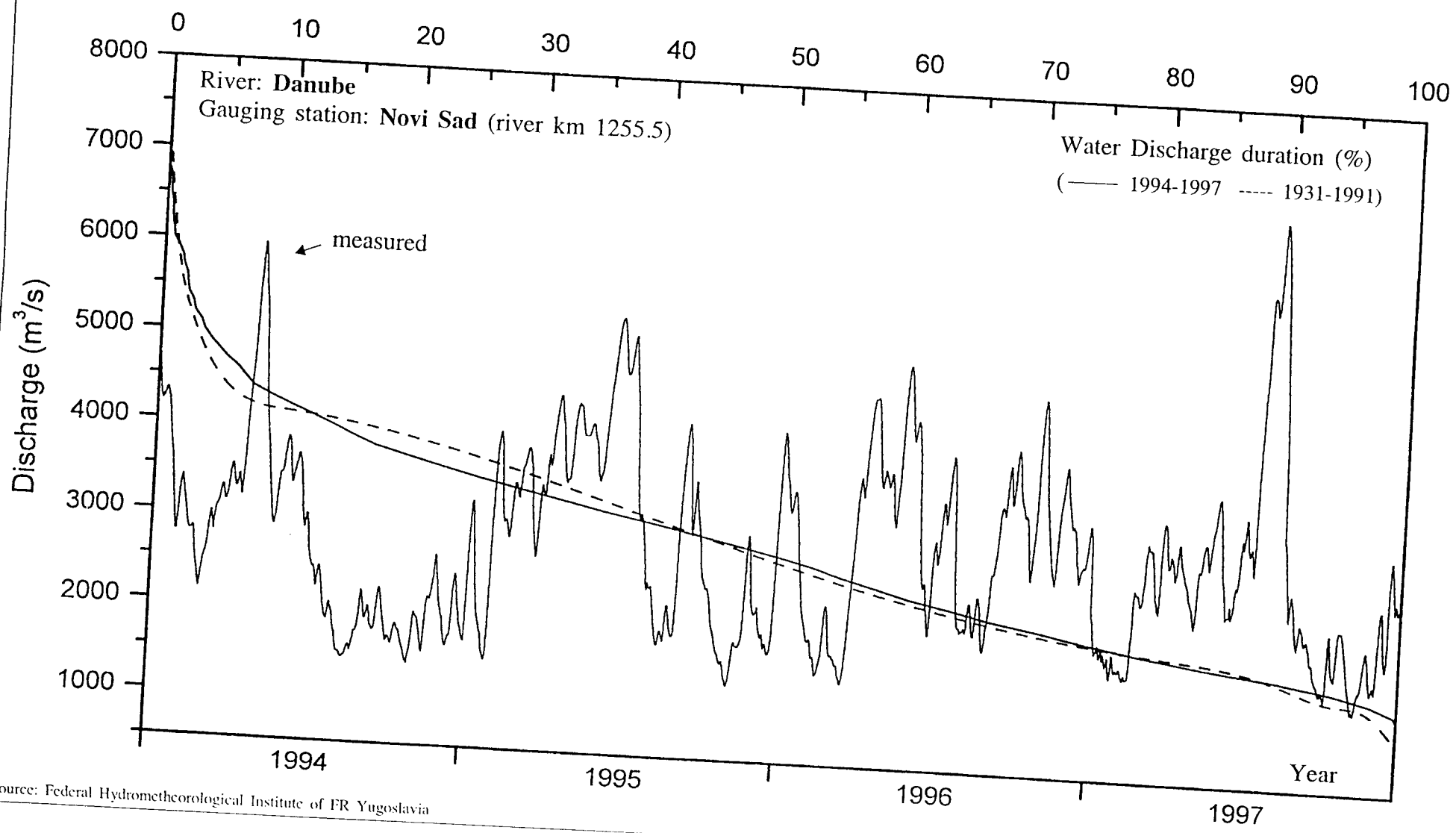
Source. Federal Hydrometheorological Institute of FR Yugoslavia

Figure 4.9-2 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



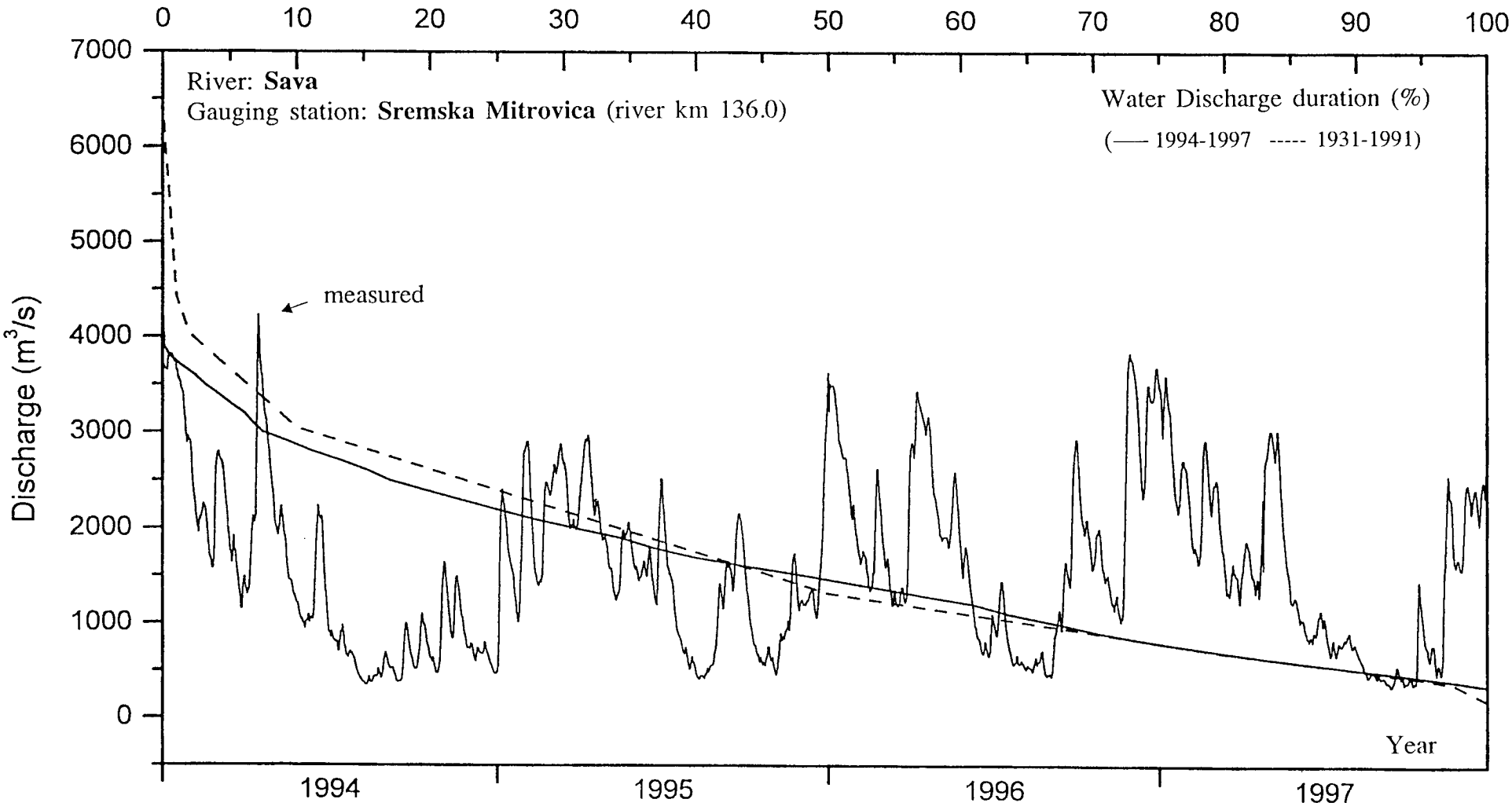
Source: Federal Hydrometheorological Institute of FR Yugoslavia

Figure 4.9-3 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



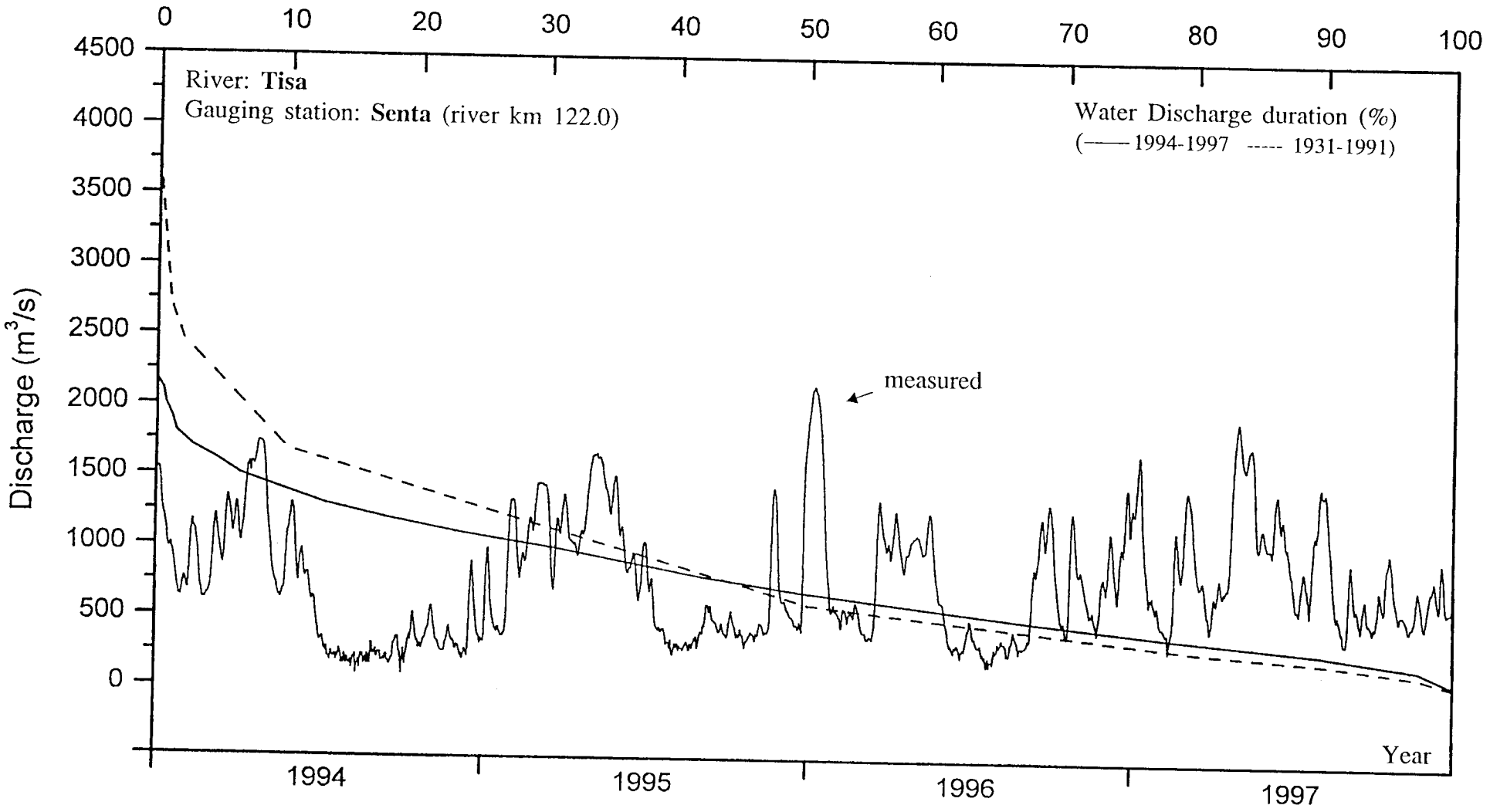
Source: Federal Hydrometheorological Institute of FR Yugoslavia

Figure 4.9-4 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



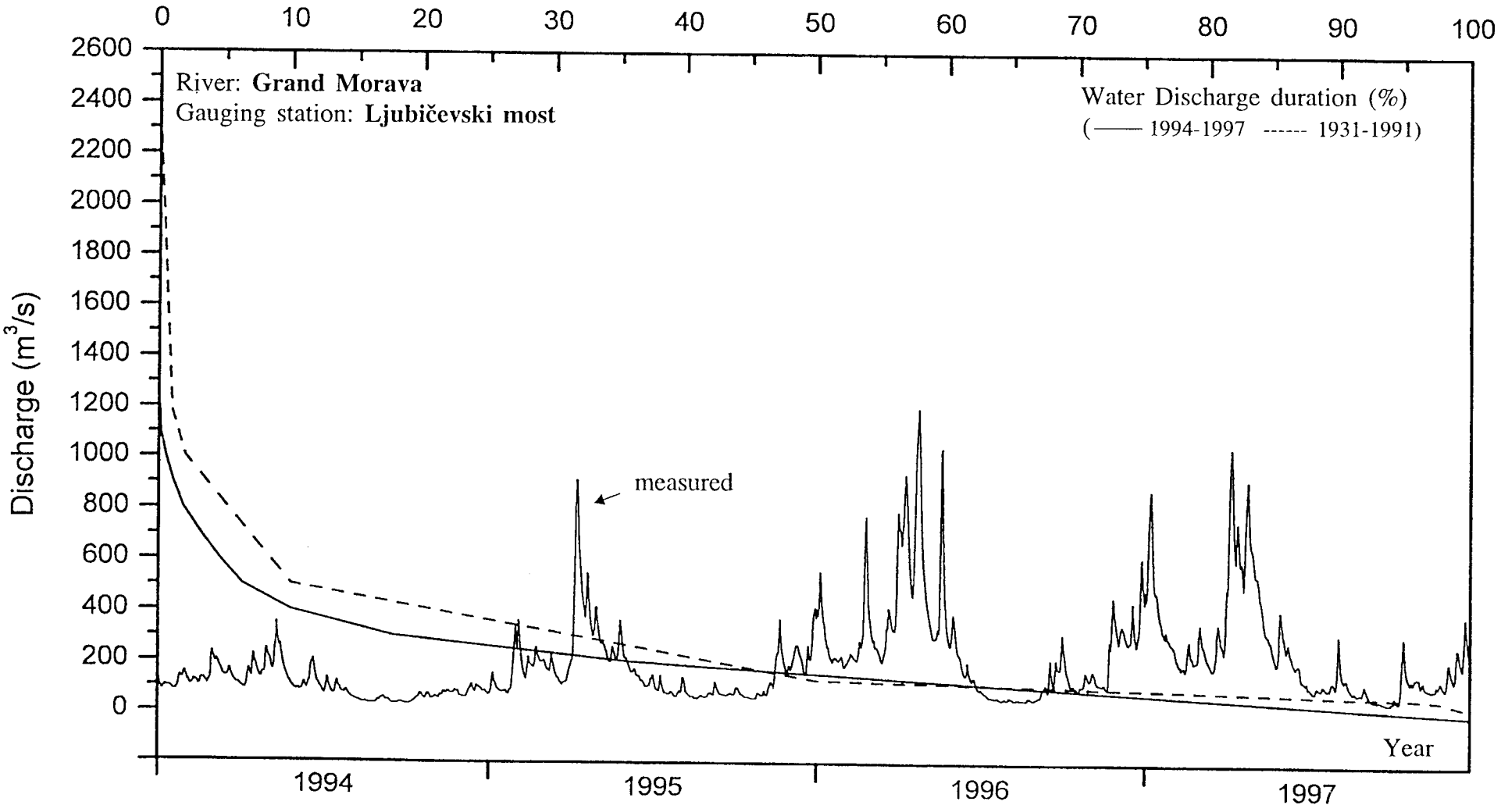
Source: Federal Hydrometeorological Institute of FR Yugoslavia

Figure 4.9-5 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



Source: Federal Hydrometeorological Institute of FR Yugoslavia

Figure 4.9-6 : **HYDROGRAPH (1994-1997) AND WATER DISCHARGE DURATION CURVES**



Source: Federal Hydrometheorological Institute of FR Yugoslavia

Summary of Information for the Municipal High Priority Hot Spots

Name of the Hot Spot:	**City of Belgrade** (Central Sewage System)
Name of the receiving water :	Danube River
River km of the effluent discharge :	1165
Critical Emissions	Discharge (m^3/y) 146,000,000 BOD_5 (t/y) 35,040 Tot N (tN/y) 5,840 Tot P (tP/y) 1,314 Susp. Solids (t/y) 28,850
Seasonal Variations	The CDF-critical dilution factor (Q_{95}:Q_{effl}), is rather high (i.e. 450-500) accounting at whole river flow but in the mixing zone after bank outlet of sewage, CDF is around 80-120. The emission affects water quality but doesn't change it dramatically even in the mixing zone.
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there are several sewage outlets distributed along 5 km river stretch. It is planned to connect all of its to main collector (i.e. Interceptor).
Root Causes of Water Quality Problems	The emission of pollution from a large Metropolitan area located on the riverbank. The lack of money for investment.
Receiving Waters	Direct outflow in the Danube River (right bank)
Nearby Downstream Uses	The impoundment of surface water for the Small Water Treatment Plant (capacity ~ 5000 m^3/d) supplying the southern suburban area of the City is located 10 km kilometers downstream of the planned sewage outflow. Also, there is a large recreational area downstream of sewage outlet.
Transboundary Implications	There is no direct transboundary implications (the beginning of the stretch making the State border with Romania is 100 km downstream of Belgrade) but rather indirect ones because of large emission of pollution.
Rank	**High**

Name of the Hot Spot:	**City of Belgrade** (Sewage System "Ostru`nica")
Name of the receiving water :	Sava River
River km of the effluent discharge :	15
Critical Emissions	Discharge (m3/y) 5,000,000 BOD5 (t/y) 1,205 Tot N (tN/y) 201 Tot P (tP/y) 45 Susp. Solids (t/y) 925
Seasonal Variations :	The CDF-critical dilution factor (Q_{95}: Q_{effl}), is rather high (i.e. 250-300) accounting at whole river flow but in the mixing zone after bank outlet of sewage, CDF is around 50-60. The emission affects water quality but doesn't change it dramatically.
Immediate Causes of Emissions	There is no WWTP. Actually, there are several outlets, which are planned to be connected in one.
Root Causes of Water Quality Problems	The emission of pollution from a part (mixed urban/rural) of large Metropolitan area. Actually, there are several smaller outlets of sewage distributed along the riverbank. Just a part (55%) of users is connected on the sewage system in this horizon.
Receiving Waters	Direct outflow in the Sava River (right bank).
Nearby Downstream Uses	Several withdrawals (wells) of bank filtrate for two Water Treatment Plant (total capacity ~ 250000 m^3/d) as well as the withdrawal of surface water for the "Maki{" Water Treatment Plant (actual capacity ~ 250000 m^3/d) supplying the largest part of Metropolitan Area are all located along the riverbank downstream of planned sewage outlet. Also, there is a large recreation area downstream of planned sewage outlet.
Transboundary Implications	There are no direct transboundary implications but indirect ones.
Rank	**High**

Name of the Hot Spot:	**City of Novi Sad** (Left bank Sewage System)		
Name of the receiving water :	Danube River		
River km of the effluent discharge :	1255		
Critical Emissions	Discharge	(m3/y)	31,142,000
	BOD5	(t/y)	6,285
	Tot N	(tN/y)	988
	Tot P	(tP/y)	298
	Susp. Solids	(t/y)	5,205
Seasonal Variations :	The CDF-critical dilution factor (Q_{95} : Q_{effl}), is rather high (i.e. 850-900) accounting at whole river flow, but in the mixing zone after bank outlet of sewage, CDF is around 150-200. The emission affects water quality but doesn't change it dramatically.		
Immediate Causes of Emissions	There is no WWTP. Actually, there are two larger and several smaller outlets, which are planned to be connected to the 10 km long main collector.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial City. The lack of money for investment.		
Receiving Waters	Direct outflow in the Danube River (left bank).		
Nearby Downstream Uses	Several withdrawals (wells) of bank filtrate for Water Treatment Plant (total capacity ~ 150000 m^3/d) supplying the largest part of City Area are all located along the riverbank downstream of existing sewage outlets. Planned outlet will be move downstream. Also, there is a large recreation area downstream of sewage outlet.		
Transboundary Implications	There are no direct transboundary implications but rather indirect ones.		
Rank	**High**		

Name of the Hot Spot:	**City of Nis**
Name of the receiving water :	Nisava River (right tributary of South Morava River)
River km of the effluent discharge :	9 (upstream of the mouth in South Morava River)
Critical Emissions	Discharge (m3/y) 28,335,000 BOD5 (t/y) 5,891 Tot N (tN/y) 826 Tot P (tP/y) 289 Susp. Solids (t/y) 4,959
Seasonal Variations :	The CDF-critical dilution factor (Q_{95} : Q_{effl}), is extremly low (i.e. 3-5). The emission affects water quality dramatically. Anoxic and anaerobic conditions in river are frequently observed. During low flow season fish kills are observed. Strong influence on water quality of South Morava River.
Immediate Causes of Emissions	There is no WWTP. Actually, there are two large outlets. It is planned to connect its to the main collector.
Root Causes of Water Quality Problems	The emission of pollution from a large industrial City. The lack of money for investment.
Receiving Waters	Direct outflow to Nisava River.
Nearby Downstream Uses	Several withdrawals of water for irrigation. Also, there is a large potential recreation area 20 km downstream of sewage outlet.
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.
Rank	**High**

Name of the Hot Spot:	**City of Pristina**		
Name of the receiving water :	Sitnica River		
River km of the effluent discharge :	1165		
Critical Emissions	Discharge	(m3/y)	16,500,000
	BOD5	(t/y)	3,959
	Tot N	(tN/y)	570
	Tot P	(tP/y)	148
	Susp. Solids	(t/y)	3,207
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extremely low (i.e. 1.5-2.5). The pollution emission has a detrimental effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are regularly observed during the largest part of the year. There is also a strong influence on water quality of Ibar River.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there is one large outlet ending at location of planned WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a large Metropolitan area located on the riverbank. The lack of money for investment.		
Receiving Waters	Direct outflow in the Pristevka stream, tributary of small Sitnica River (Watershed of Velika Morava).		
Nearby Downstream Uses	There are not nearby downstream users as the water quality is out of any class. The water would be potentially use for irrigation and for industrial water supply. There is the strong influence on water supply of settlements in Sitnica and Ibar River valleys.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Zrenjanin**		
Name of the receiving water :	Bega River		
River km of the effluent discharge :	25		
Critical Emissions	Discharge	(m3/y)	15,750,000
	BOD5	(t/y)	4,161
	Tot N	(tN/y)	975
	Tot P	(tP/y)	226
	Susp. Solids	(t/y)	3,905
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extremely low (i.e. 3-5). The pollution emission has a detrimental effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are regularly observed during the large part of the year. There is also the influence on water quality of Tisa River (10 km long river section upstream of the mouth in Danube River.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there are several outlets, which are planned to be connected to the main collector.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment. There is also strong influence of polluters from Romania. (i.e. Temisoara, Industry, several livestocks, etc.)		
Receiving Waters	Direct outflows in the Bega River, tributary of Tisa River.		
Nearby Downstream Uses	There are several nearby downstream users; Fish ponds, irrigation, and industry. The use of water is limited on the periods of higher flows as the water quality during low flow periods is out of any class. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Bega River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**Vrbas – Kula Regional System**		
Name of the receiving water :	DTD Canal		
River km of the effluent discharge :	40		
Critical Emissions	Discharge	(m3/y)	9,450,000
	BOD5	(t/y)	3,592
	Tot N	(tN/y)	547
	Tot P	(tP/y)	151
	Susp. Solids	(t/y)	3,022
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extremely low (i.e. 2-3). The pollution emission, particularly during the full production of food processing industry, has a detrimental effect on water quality as well as on the ecosystem of DTD Canal. Anoxic and anaerobic conditions along the downstream section of Canal are regularly observed. During the full production of seasonal industry the fish kills are observed. There is also the influence on water quality of Tisa River as DTD Canal empties in Tisa River near Becej Gate.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there are several outlets, which will be connected to the Regional Sewage System.		
Root Causes of Water Quality Problems	The emission of pollution from two industrial (large food processing industry) towns located on the Canal bank. The lack of money for investment.		
Receiving Waters	Direct outflows in the DTD Canal, about 40 km upstream from the mouth with Tisa River.		
Nearby Downstream Uses	There are several nearby downstream users, i.e. fishponds, irrigation, industry. The use of water is limited on the periods of higher flows as the water quality during low flow periods is out of any class. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Bega River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Leskovac**		
Name of the receiving water :	Ju`na (South) Morava River		
River km of the effluent discharge :	128		
Critical Emissions	Discharge	(m3/y)	12,600,000
	BOD5	(t/y)	3,193
	Tot N	(tN/y)	295
	Tot P	(tP/y)	132
	Susp. Solids	(t/y)	2,903
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is low (i.e. 12-15). The pollution emission has an extremely adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are occasionally observed. There is also the influence on water quality of Velika Morava River.		
Immediate Causes of Emissions	There is no Municipal WWTP. The existing outlet on the Veternica River (tributary of South Morava River) bank will be moved (10 km long collector) downstream to the location planned for WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment.		
Receiving Waters	As it is planned, the effluent will be discharged to the Ju`na (South) Morava River, tributary of Velika Morava River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited on the periods of higher flows as the water quality during low flow periods is bad. There is a need of several downstream users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of J. Morava River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Krusevac**		
Name of the receiving water :	Zapadna (West) Morava River		
River km of the effluent discharge :	17		
Critical Emissions	Discharge	(m3/y)	10,100,000
	BOD5	(t/y)	3,088
	Tot N	(tN/y)	333
	Tot P	(tP/y)	179
	Susp. Solids	(t/y)	2,689
Seasonal Variations	The CDF-critical dilution factor (Q_{95} : Q_{effl}) is rather low (i.e. 35-45). The pollution emission has an adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are observed during the low flow periods. There is also the influence on water quality of Velika Morava River.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there is the outlet and structure for pumping station at the location of planned WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment.		
Receiving Waters	Direct outflow to the Zapadna (West) Morava River, tributary of Velika Morava River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited. There is a need of several downstream users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Z. Morava River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Cacak**		
Name of the receiving water :	Zapadna (West) Morava River		
River km of the effluent discharge :	168		
Critical Emissions	Discharge	(m3/y)	10,930,000
	BOD5	(t/y)	2,740
	Tot N	(tN/y)	410
	Tot P	(tP/y)	139
	Susp. Solids	(t/y)	2,350
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is rather low (i.e. 15-20). The pollution emission has an adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are observed during the low flow periods. There is also the influence on water quality of Velika Morava River.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there are two outlets, which are planned to be connected to the main collector.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment.		
Receiving Waters	Direct outflows in the Zapadna (West) Morava River, tributary of Velika Morava River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited. There is a need of several downstream users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Z. Morava River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Sabac**		
Name of the receiving water :	Sava River		
River km of the effluent discharge:	101		
Critical Emissions	Discharge	(m3/y)	8,500,000
	BOD5	(t/y)	2,124
	Tot N	(tN/y)	287
	Tot P	(tP/y)	113
	Susp. Solids	(t/y)	1,805
Seasonal Variations :	The CDF-critical dilution factor (Q_{95}: Q_{effl}), is rather high (i.e. 100-120) accounting at whole river flow but in the mixing zone after bank outlet of sewage, CDF is around 20-30. The emission affects water quality but doesn't change it dramatically even in the mixing zone.		
Immediate Causes of Emissions	There is no WWTP. Actually, there are several outlets, which are planned to be connected in one.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment.		
Receiving Waters	Direct outflow in the Sava River (right bank).		
Nearby Downstream Uses	Several withdrawals (wells) of bank filtrate for several smaller towns as well as dozens withdrawals (wells) for two Belgrade Water Treatment Plant (total capacity ~ 450000 m^3/d are all located along the Sava riverbanks downstream of planned sewage outlet. Also, there is a large recreation area downstream of planned sewage outlet.		
Transboundary Implications	There is no direct transboundary implications but indirect ones.		
Rank	**High**		

Name of the Hot Spot:	**City of Vranje**		
Name of the receiving water :	Ju`na (South) Morava River		
River km of the effluent discharge :	221		
Critical Emissions	Discharge	(m3/y)	9,450,000
	BOD5	(t/y)	2,059
	Tot N	(tN/y)	286
	Tot P	(tP/y)	92
	Susp. Solids	(t/y)	1,782
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extremely low (i.e. 2-3). The pollution emission has an extremely adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are frequently observed. There is also the influence on water quality of Velika Morava River.		
Immediate Causes of Emissions	There is no Municipal WWTP. Existing outlet in small Vranjska stream (tributary of South Morava River) will be moved (7 km long main collector) downstream to the location planned for WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The lack of money for investment.		
Receiving Waters	The direct outflow in the Ju`na (South) Morava River, tributary of Velika Morava River.		
Nearby Downstream Uses	There are several nearby downstream users; water supply (bank filtrate), irrigation, industry. The use of water is limited, as the water quality during low flow periods is bad. There is a need of several downstream users to increase use of water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of J. Morava River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Valjevo**		
Name of the receiving water :	Kolubara River		
River km of the effluent discharge :	77		
Critical Emissions	Discharge	(m3/y)	8,750,000
	BOD5	(t/y)	1,883
	Tot N	(tN/y)	293
	Tot P	(tP/y)	122
	Susp. Solids	(t/y)	1,498
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extremely low (i.e. 2.5-3). The pollution emission has an extremely adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are frequently observed.		
Immediate Causes of Emissions	There is no Municipal WWTP. The WWTP is under construction. About 80% of civil works are finished. The lack of money to finish the work.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the top of watershed.		
Receiving Waters	The direct outflow in the Kolubara River, tributary of Sava River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited on the periods of higher flows as the water quality during low flow periods is bad. There is a need of several downstream users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Kolubara River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Subotica**		
Name of the receiving water :	Lakes ; Palic and Ludos		
River km of the effluent discharge :			
Critical Emissions	Discharge	(m3/y)	17,350,000
	BOD5	(t/y)	4,161
	Tot N	(tN/y)	696
	Tot P	(tP/y)	187
	Susp. Solids	(t/y)	4,267
Seasonal Variations	The variation of pollution emission depends on seasonal industry (food processing).		
Immediate Causes of Emissions	The overloading of existing WWTP (110,000 p.e., activated sludge process) which was built in 1975. Lack of capacity (for additional 90,000 p.e.) of existing Municipal WWTP as well as the lack of facilities for nutrients removal. The need for the Renovation of existing WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the top of watershed. The lack of money for the investment.		
Receiving Waters	The effluent from WWTP discharges to facultative lagoons than to Palic Lake. Overflow discharges to Keres creek (enters from Hungary), the tributary of Ludos Lake, which is the famous wild bird reserve (Ramsar Site).		
Nearby Downstream Uses	Palic Lake is the large recreational area. The water is used for recreation. Ludos Lake is the famous wild bird reserve (Ramsar Site). Overflow from Ludos Lake is used for supply of a large fish pond.		
Transboundary Implications	There are not direct transboundary implications.		
Rank	**High**		

Name of the Hot Spot:	**City of Uzice**		
Name of the receiving water :	Djetinja River		
River km of the effluent discharge :	32		
Critical Emissions	Discharge	(m3/y)	7,300,000
	BOD5	(t/y)	1,643
	Tot N	(tN/y)	222
	Tot P	(tP/y)	62
	Susp. Solids	(t/y)	1,164
Seasonal Variations	The CDF-critical dilution factor (Q_{95} : Q_{effl}) is rather low (i.e. 5-6). The pollution emission has an adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are observed during the low flow periods.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there are several outlets, which are planned to be connected on the 8 km long collector.		
Root Causes of Water Quality Problems	The emission of pollution from a large industrial town located on the riverbank. The Lack of money for investment.		
Receiving Waters	Direct outflows in the Djetinja River, tributary of Zapadna (West) Morava.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited. There is a need of several downstream users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Djetinja and Zapadna Morava River.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones because of large emission of pollution.		
Rank	**High**		

Name of the Hot Spot:	**City of Zajecar**		
Name of the receiving water :	Timok River		
River km of the effluent discharge :	67		
Critical Emissions	Discharge	(m3/y)	5,633,000
	BOD5	(t/y)	1,461
	Tot N	(tN/y)	205
	Tot P	(tP/y)	55
	Susp. Solids	(t/y)	1,121
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is rather low (i.e. 5-6). The pollution emission has an adverse effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are observed during the low flow periods.		
Immediate Causes of Emissions	There is no Municipal WWTP. Actually, there is outlet, which will be moved to the location of planned WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a medium size industrial town located on the riverbank. The Lack of money for investment.		
Receiving Waters	Direct outflows in the Timok River, direct tributary of Danube.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited. There is a need of several downstream smeller users to use water (i.e. bank filtrate) for water supply. The water would be potentially use for recreation as there is a large recreational area in riparian zone of Timok River.		
Transboundary Implications	There are direct transboundary implications as the Timok River makes the State Border (19 km long) with Bulgaria.		
Rank	**High**		

Name of the Hot Spot:	**City of Bor**		
Name of the receiving water :	Borska stream (tributary of Timok River)		
River km of the effluent discharge :	27		
Critical Emissions	Discharge	(m3/y)	5,494,000
	BOD5	(t/y)	1,398
	Tot N	(tN/y)	145
	Tot P	(tP/y)	43
	Susp. Solids	(t/y)	1,095
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is extreely low (i.e. 2-3). The pollution emission has a detrimental effect on water quality as well as on the ecosystem. Anoxic and anaerobic conditions in river are observed during the largest part of the year, particularly during low flow periods.		
Immediate Causes of Emissions	There is no Municipal WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a medium size industrial town located on the riverbank. The Lack of money for investment.		
Receiving Waters	Direct outflows in the Borska stream, the tributary of Timok River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry. The use of water is limited as its water quality is out of any class. The water would be potentially use for recreation as there is a large recreational area in riparian zone.		
Transboundary Implications	There are direct transboundary implications as the Borska stream is the left tributary of the Timok River which makes the State Border (19 km long) with Bulgaria.		
Rank	**High**		

Name of the Hot Spot:	**City of Senta**		
Name of the receiving water :	Tisa River		
River km of the effluent discharge :	121		
Critical Emissions	Discharge	(m3/y)	3,690,000
	BOD5	(t/y)	1,402
	Tot N	(tN/y)	238
	Tot P	(tP/y)	55
	Susp. Solids	(t/y)	1,138
Seasonal Variations	The CDF-critical dilution factor (Q_{95}: Q_{effl}) is 800-1000. The pollution emission has an adverse effect on the Tisa River water quality as well as on the aquatic ecosystem.		
Immediate Causes of Emissions	There is no Municipal WWTP. The WWTP is under construction. About 75% of civil works are finished.		
Root Causes of Water Quality Problems	The emission of pollution from upper part of watershed. The emission of pollution from the industrial (food processing industry) town located on the bank of the river. The lack of money for Investment.		
Receiving Waters	The direct outflow in Tisa River.		
Nearby Downstream Uses	There are several nearby downstream users; irrigation, industry, recreation. The use of water is limited as the water quality during low flow periods is out of class. It is used for recreation, supply fishponds, irrigation.		
Transboundary Implications	There are not direct transboundary implications but rather indirect ones.		
Rank	**High**		

Name of the Hot Spot:	**Rozaje Town**		
Name of the receiving water :	Ibar River		
River km of the effluent discharge :	251		
Critical Emissions	Discharge	(m3/y)	1,575,000
	BOD5	(t/y)	394
	Tot N	(tN/y)	38
	Tot P	(tP/y)	12
	Susp. Solids	(t/y)	302
Seasonal Variations :	The CDF-critical dilution factor (Q_{95}: Q_{effl}), is rather low (i.e. 20-30). The pollution emission affects water quality as well as aquatic ecosystem.		
Immediate Causes of Emissions	There is no WWTP.		
Root Causes of Water Quality Problems	The emission of pollution from a small growing town located in Montenegro just on the top of Ibar River watershed. The lack of money for investment.		
Receiving Waters	Direct outflow to Ibar River.		
Nearby Downstream Uses	The use of bank filtrate for water supply of several smaller settlements. Several withdrawals of water for irrigation. The multipurpose reservoir "Gazivode" assigned for irrigation and industrial water supply. It is also planned for water supply of City of Pristina.		
Transboundary Implications	There is no direct transboundary implications.		
Rank	**High** (water resource protection)		

Name of the Hot Spot:	**Blace Town**		
Name of the receiving water :	Blatasnica Stream (tributary of Rasina River)		
River km of the effluent discharge :	28		
Critical Emissions	Discharge	(m3/y)	1,250,000
	BOD5	(t/y)	329
	Tot N	(tN/y)	48
	Tot P	(tP/y)	15
	Susp. Solids	(t/y)	211
Seasonal Variations :	The CDF-critical dilution factor (Q_{95}: Q_{effl}), is extremely low (i.e. 1-2). The emission affects water quality as well as aquatic ecosystem.		
Immediate Causes of Emissions	The overloading of existing WWTP (5,000 p.e., activated sludge process) which was built in 1981. Lack of capacity (for additional 15,000 p.e.) of existing WWTP as well as the lack of facilities for nutrients removal. The need for the Renovation of existing WWTP.		
Root Causes of Water Quality Problems	The growing emission of pollution from a several small towns located on the top of river watershed. The lack of money for investment.		
Receiving Waters	Direct outflow to the river which flows to the reservoir “Celije” assigned for water supply of City of Krusevac.		
Nearby Downstream Uses	The regional water supply. Several withdrawals of water for irrigation.		
Transboundary Implications	There are no direct transboundary implications.		
Rank	**High** (drinking water resource protection)		

Name of the Hot Spot:	**Mojkovac Town**		
Name of the receiving water :	Tara River		
River km of the effluent discharge :	96		
Critical Emissions	Discharge	(m3/y)	630,000
	BOD5	(t/y)	131
	Tot N	(tN/y)	19
	Tot P	(tP/y)	5
	Susp. Solids	(t/y)	118
Seasonal Variations :	The CDF-critical dilution factor (Q_{95}: Q_{effl}), is 300-320. The emission affects water quality as well as aquatic ecosystem, which is the reserve of nature.		
Immediate Causes of Emissions	The Direct discharge of wastewater as there is no WWTP.		
Root Causes of Water Quality Problems	The growing emission of pollution from a small growing town located in Montenegro on the top of river watershed. The lack of money for investment.		
Receiving Waters	Direct outflow to the Tara River whose Canyon is under protection as the UNESCO Heritage.		
Nearby Downstream Uses	Especial protected mountainous ecosystem.		
Transboundary Implications	There are no direct transboundary implications.		
Rank	**High** (protection of Word Heritage)		

Name of the Hot Spot:	**Kolasin Town**		
Name of the receiving water :	Tara River		
River km of the effluent discharge :	126		
Critical Emissions	Discharge	(m3/y)	956,000
	BOD5	(t/y)	195
	Tot N	(tN/y)	35
	Tot P	(tP/y)	7
	Susp. Solids	(t/y)	145
Seasonal Variations :	The CDF-critical dilution factor (Q_{95} : Q_{effl}), is 200-220). The emission affects water quality as well as aquatic ecosystem, which is the reserve of nature.		
Immediate Causes of Emissions	The Direct discharge of wastewater as there is no WWTP.		
Root Causes of Water Quality Problems	The growing emission of pollution from a small growing town located in Montenegro on the top of river watershed. The lack of money for investment.		
Receiving Waters	Direct outflow to the Tara River whose Canyon is under protection as the UNESCO Heritage.		
Nearby Downstream Uses	Especial protected mountainous ecosystem.		
Transboundary Implications	There are no direct transboundary implications.		
Rank	**High** (protection of Word Heritage)		

Part D

Water Environmental Engineering

1. Summary

1.1. National Targets and Instruments for Water Pollution Reduction

Following the disintegration of former Socialist Federal Republic of Yugoslavia (SFRY), the Government of the Federal Republic of Yugoslavia (FRY), having considered the state of environmental protection under newly created conditions, adopted the Resolution on the **Environment Protection Policy**, setting also the national objectives in the field of water protection as follows:

- Creation of a basis for the development of a humane society in the Federal Republic of Yugoslavia which will carry on developing on a lasting basis in conformity with nature, bearing in mind the right of the future generations to satisfy their needs on the same or a higher level;
- Creation of conditions for the preservation and rational use of natural resources and prevention of their degradation, prevention of uncontrolled pollution and further degradation of the environment, and elimination of the consequences of earlier pollution and degradation of the environment;
- Management of the environment in a manner conducive to the protection and improvement of human health;
- Development of an integral system of protection and improvement of the environment and quality of life, improvement of the existing system of protection of the environment and provision of an institutional frame for effective operation of that system;
- Creation of conditions for the interests arising from the concept of sustainable development and protection and improvement of the environment, to be analysed and taken into account when making plans for the development of settlements and use of land;
- Gradual enforcement of the “polluter pays” principle on the basis of regulations applicable to the country as a whole;
- Creation of conditions for the development of pollution control methods suited to the peculiarities of our country and its attained level of development;
- Preservation of a “satisfactory” ecological balance in our country and taking part in the protection of the biosphere;
- Prevention of the import and transfer of hazardous matters and “dirty” technologies.

Several laws and regulations affecting the environmental protection were enacted (or incorporated in the legal framework) on the basis of the mentioned Resolution, including:

- Law on the Fundaments on Environmental Protection (Federal Government Gazette, no. 24/98)
- Law on the Water Regime (Federal Government Gazette, no. 59/98)
- Law on the Environment Protection (Government of Serbia Gazette, no. 61/91),
- Law on the Environment (Government of Montenegro Gazette, no. 12/96),
- Law on Waters (Government of Serbia Gazette, no. 46/91, 53/93, 48/94, 54/96),
- Law on Waters (Government of Montenegro Gazette, no. 6/95)

which also deal, to some extent, with the protection of waters.

The implementation of the newly enacted Federal Law on the Basic Principles of Environmental Protection (enacted in May 1998) will be particularly defined through regulations that should set the procedures to be followed in the event of accidents and for the prevention thereof, regulations relating to the waste handling and disposal and regulations relating to the criteria for ecological spatial zoning.

Moreover, the measures to be applied are also required by the conventions and international agreements to which the FRY has acceded or is in the process of doing so.

Following the environmental protection objectives laid down in the mentioned Resolution, a lot of work has been done on the republican level in planning and designing of the policy and measures in water management, including also the protection of water resources.

The adopted *Water Management Plan of the Republic of Serbia* covers all aspects of the regulation, utilization and protection of waters in Serbia. The preparation of the same document for Republic of Montenegro was started in 1997 and is to be finished up to the end of 1998.

The both documents determine the objectives and principles of regulating the regime, utilisation and protection of waters.

The *main National objectives in the field of water protection* wanted to be achieved through the implementation of water resources management in FRY as well as in the Danube watershed are as follows:

- Preparation and implementation of a plan for the maintenance and development of the water regime and improvement of all forms of rational and integral utilisation of waters, by improving all components of the water regime (distribution according to space and time, quantity and quality), in the scope of an integral and unified system of utilisation and protection of and against waters,
- Determination of available water resources in watersheds and conditions for integral, complex, uniform and rational water management, taking into account the land contour limitations and preventing these options from being menaced by partial interests and/or single purpose solutions,
- Definition of the water management development and capabilities of water management as an inciting or limiting factor in the scope of other components of the Republic's development, with a view to making it possible for the water management sector to keep abreast with economic, social and urban infrastructure development,
- Integral, complex, rational and uniform use of water resources in all spheres, both for household water supply and satisfaction of the needs of other water users, and determination of the optimal configuration and parameters of the future systems for integral utilisation, regulation and protection of waters in given localities and territories,
- Seeing to the protection and improvement of the quality of water up to the level of trouble-free use for specified purposes, as well as the protection of the environment in general and the improvement of the quality of life, all in the complex of integral utilisation and protection of and against waters,
- Directing scientific, research, study and monitoring activities, as well as engineering and construction work in the field of water management for the sake of a rational progress of the society as a whole.
- Fostering co-operation and responsibility sharing for environmental protection among managers, planners, policy makers and users of water within the catchment area; the polluter-pays principle should be promoted.
- Promoting of co-operation between countries bordering the same transboundary watercourses and international lakes.

The *Instruments for the reduction of water pollution* in use (or will be used) in the field of water protection in the FRY are as follows:

- Regulatory (laws, decrees, rules, instructions and directives setting the legal frame for the enforcement of the adopted water protection policy and achievement of the national objectives set),
- Economic instruments (determined by law or applied in the economy) for stimulating investment in water pollution control (i.e. the full developing and implementing of "polluter pay" principles, decreasing taxes and fees for equipment using in water and environment protection, free import of equipment using in water and environment protection without any custom fees, etc.)
- Technical and technological (legal norms in the technical and technological sphere setting the proper methods of preparatory, design and construction works, etc., strongly following the environmental protection requirements),
- Institutional (i.e. developing of institutional infrastructure such as relevant governmental and municipal agencies, inspectorates, licensed water quality control laboratories, etc.).

It has to be pointed out that the main improvement in protection of waters is going to be reached by the construction (including the upgrading of sewage systems) of municipal wastewater treatment plants as it is concluded in Part B as well in this report.

1.2 Measures for Reduction of Water Pollution

The Law on Waters in both republics (Serbia and Montenegro) requires the preparation of *Water Pollution Control Master Plan* for each republic individually. These plans will be based on the Water Management Master Plan for given Republic and will define all relevant elements for water protection, the stakeholders and their duties in implementing phase, as well as the deadlines for execution of planned measures.

The following measures are determined separately:

- the prevention or limitation of the emission of hazardous or harmful materials into aquatic ecosystems,
- the prevention of waste and other materials from being stored/dumped at places where they can spoil the quality of waters,
- the treatment of wastewater,
- measures to be applied in the event of accidental pollution,
- Institutional responsible for the implementing of various measures,
- Deadlines for the planned activities
- liabilities and authorisations in connection with the protection of waters.

All the activities will be supported by the Water Management Information System where the ambient water quality data, wastewater discharge data as well as the Cadastre of Polluters, Wastewater Treatment Plants and structures built (or will be built) for the purposes of WPC, etc. will be comprised and update regularly. This Water Management Information System is presumed to be an important tool for an integral, complex and unified water regime and quality management.

The following are some of the important provisions to be incorporated in the Water Pollution Control Master Plans:

- The Sewage systems for wastewater and rainwater have to be built in parallel with the extension of the water supply network;
- Industries discharging wastewater into municipal sewers have to build facilities for the pre-treatment of their wastewater so to remove hazardous and toxic substances up to a level which is not harmful to the health of people working in sewers and does not hinder the operation of central municipal wastewater treatment plants. Its are also obliged to remove materials which cannot be removed by the conventional biological treatment usually practised on the municipal WWTPs ;
- Industrial enterprises causing an unreasonably high pollution have to decrease emission by making of the necessary changes of equipment, raw materials and intermediates, by dislocation of facilities, as well as by improving of the working discipline ;
- For the treatment of effluents (including power station cooling water), it is necessary to use effective (in case of conventional pollutants) and the best (in case of hazardous materials) available wastewater treatment technologies.
- For the municipal wastewater it is necessary, as a rule, to apply the conventional biological treatment (i.e. high or low load activated sludge) aiming to reduce suspended solids, biodegradable organics and microbial emission, but to apply nutrients (N and P) removal where necessary (i.e. in sensitive areas such as reservoirs, protected parts of nature, etc.)
- The municipal wastewater (as well as other wastewater) treatment has to be adjusted to comply with the category set for the given water course or to reach the quality of water required by downstream water users. If necessary, additional measures (e.g., raising the low flow, allocation of the source of pollution, or applying of other technical measures) ought to be implemented for adjusting of the recipient's water regime in order to meet the set standards.
- The discharging of thermally polluted water (e.g. from thermal power stations), is permitted up to the limits established in accordance with receiving capacity of given recipient without posing a threat to the ecosystem, accelerating biodegradation processes in benthos and spoiling the favourable quality-related characteristics of river water for its users.
- Proper control is required for non-point sources of pollution, particularly in the agricultural sector (i.e using of fertilisers and other agrochemicals), urban storm water, forestry (forest roads, felling, fires, pesticides), transport (hydrocarbons, lead), garbage (waste dumps and septic pits) as well as in case of trade in and use of hazardous materials;
- In the case of potential sources of pollution (tanks and other storages of hazardous and harmful materials), apart from applying the necessary safety measures, it is also necessary to monitor and maintain these in good conditions and take the proper action in emergencies.
- In the designing of reservoirs and water storages, provisions should be made for the increasing of low flow (improvement of the water regime) so to provide a proper flow rate and quality of water for downstream users, as well as for the purposes of protecting the water quality and riparian ecosystems.

1.3. Expected Regional and Transboundary Effects of Actual and Planned Measures

Although the current and planned measures set in the national documents are analyzed in the national context, its will also produce a regional and transboudary effect since every ton of pollution reduced is a contribution on the regional base.

By the Implementing of planned measures the FR of Yugoslavia is going to give a substantial contribution in Danube and Black Sea pollution Reduction but also expects the equivalent contribution of upstream Danube Countries.

The following effects are expected to be reached by implementing of measures current and planned measures:

- The significant Pollution Reduction on the National and Regional level
- A general improvement of the quality of natural waters and the state of ecosystems, the aquatic ones in particular
- The Improvement of the quality of waters flowing into the FRY from the countries in its neighborhood and the quality of waters flowing out of the FRY
- Improvement of the quality of the drinking water resources and reduction of the cost of its delivery and treatment
- The Protection of Water and Biological resources so to preserve its for the future generations
- The Improvement of the health and living standards of the population by providing better water for drinking and recreational purposes
- The Creation of the conditions for efficient management of the risk of industrial accidents
- A general improvement of the attitude of citizens and states of the Danube Basin to waters and the environment
- The engagement of research, consulting and industrial capacities as well as creating of new jobs.