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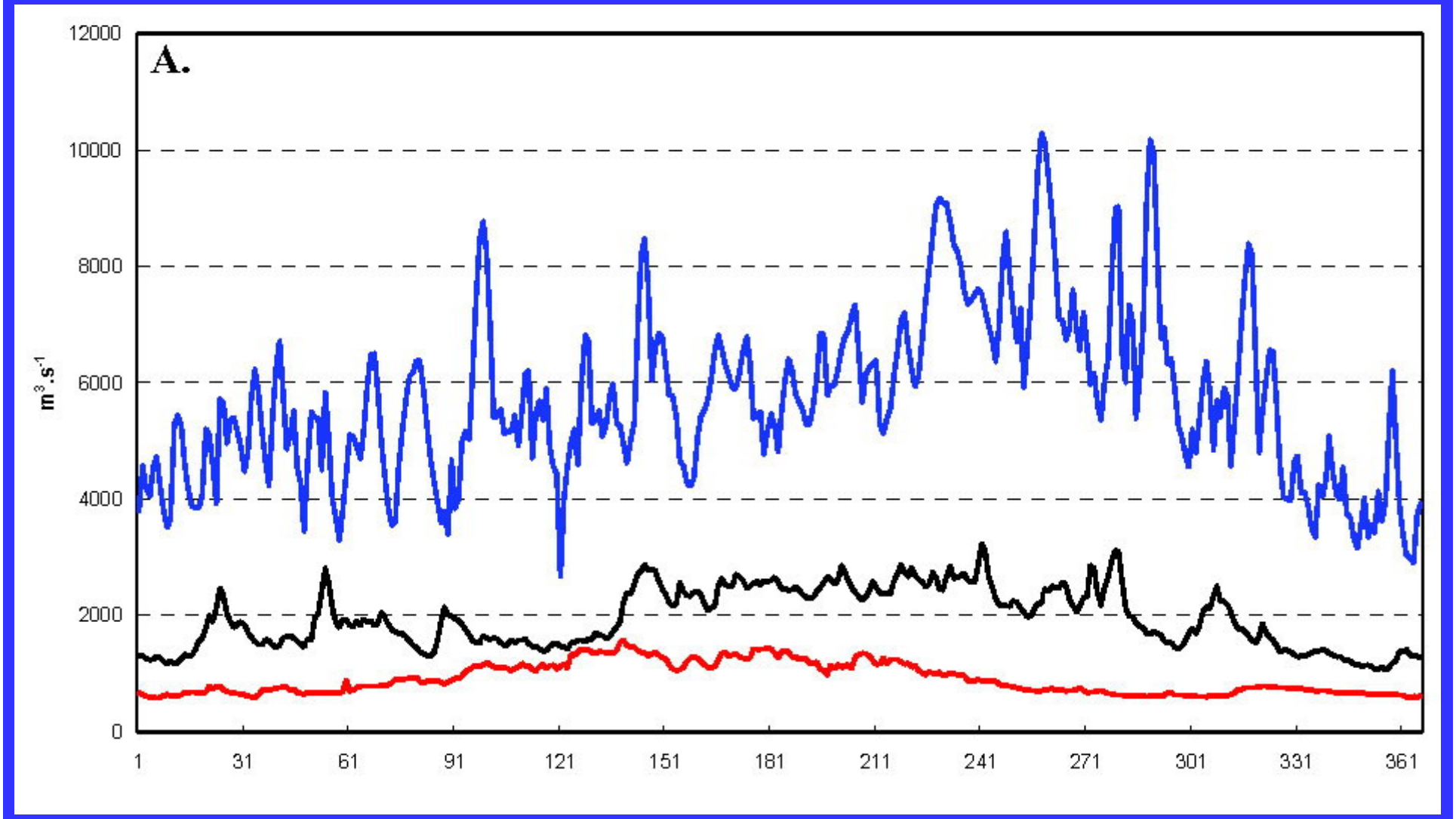
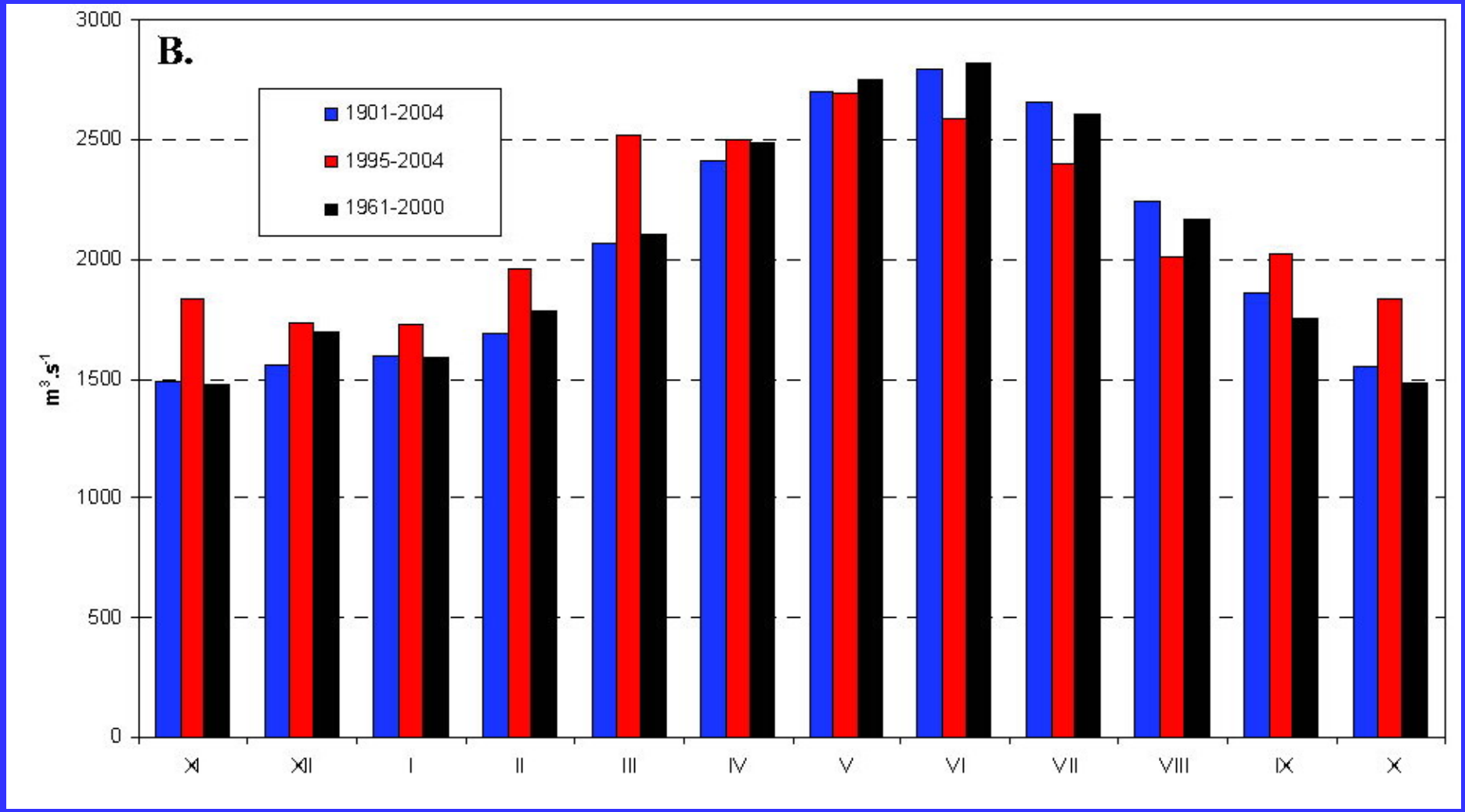
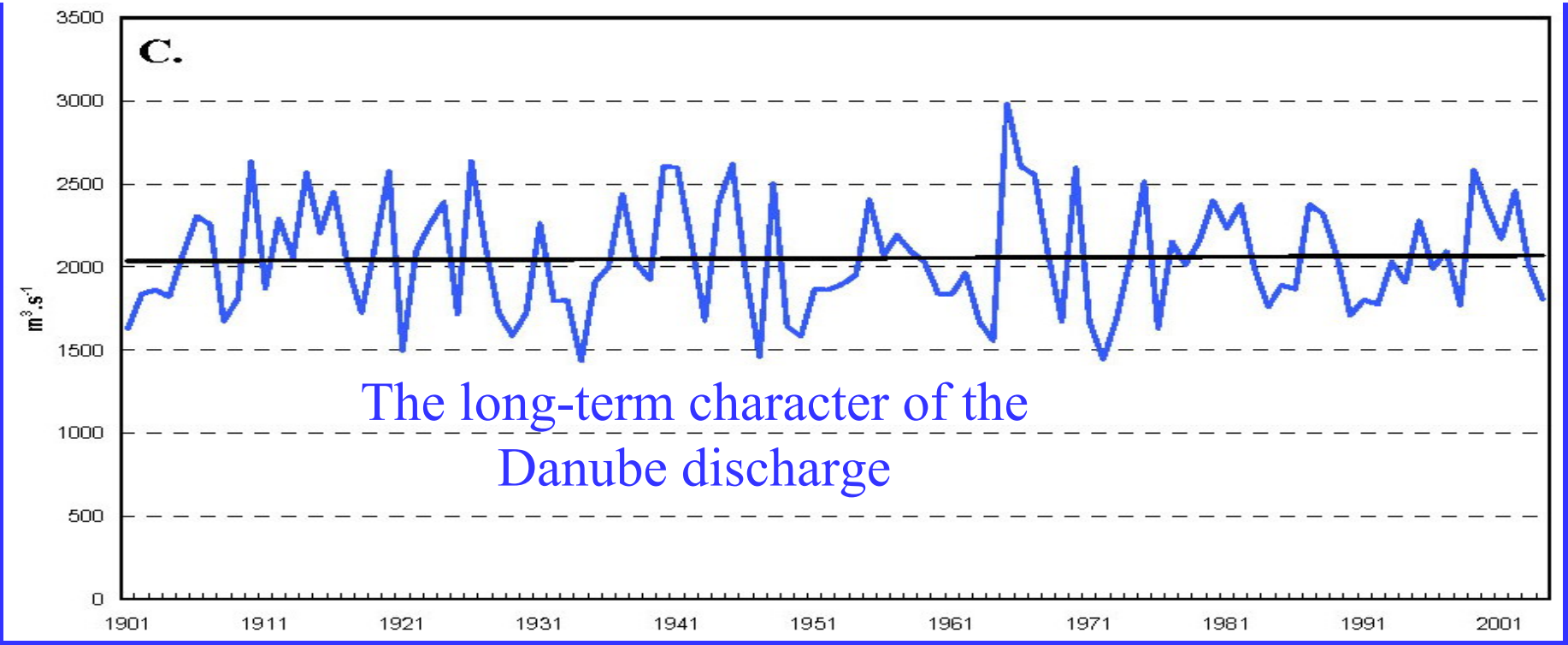
Hydrological and morphological changes in the Danube

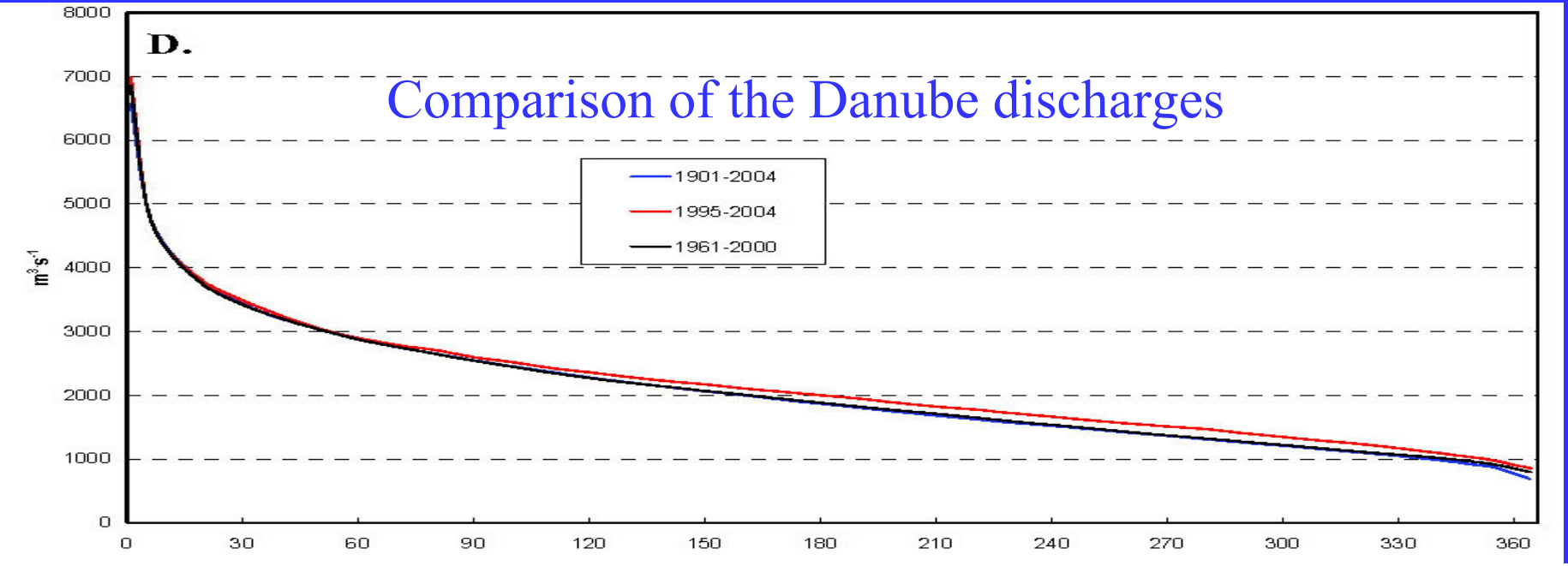
Danube Monitoring Scientific Conference Publication, Slovak Section, chapters:


A.
12000
10000
8000
6000
4000
2000
0
m3.s-1
1
31
61
91
121
151
181
211
241
271
301
331
361

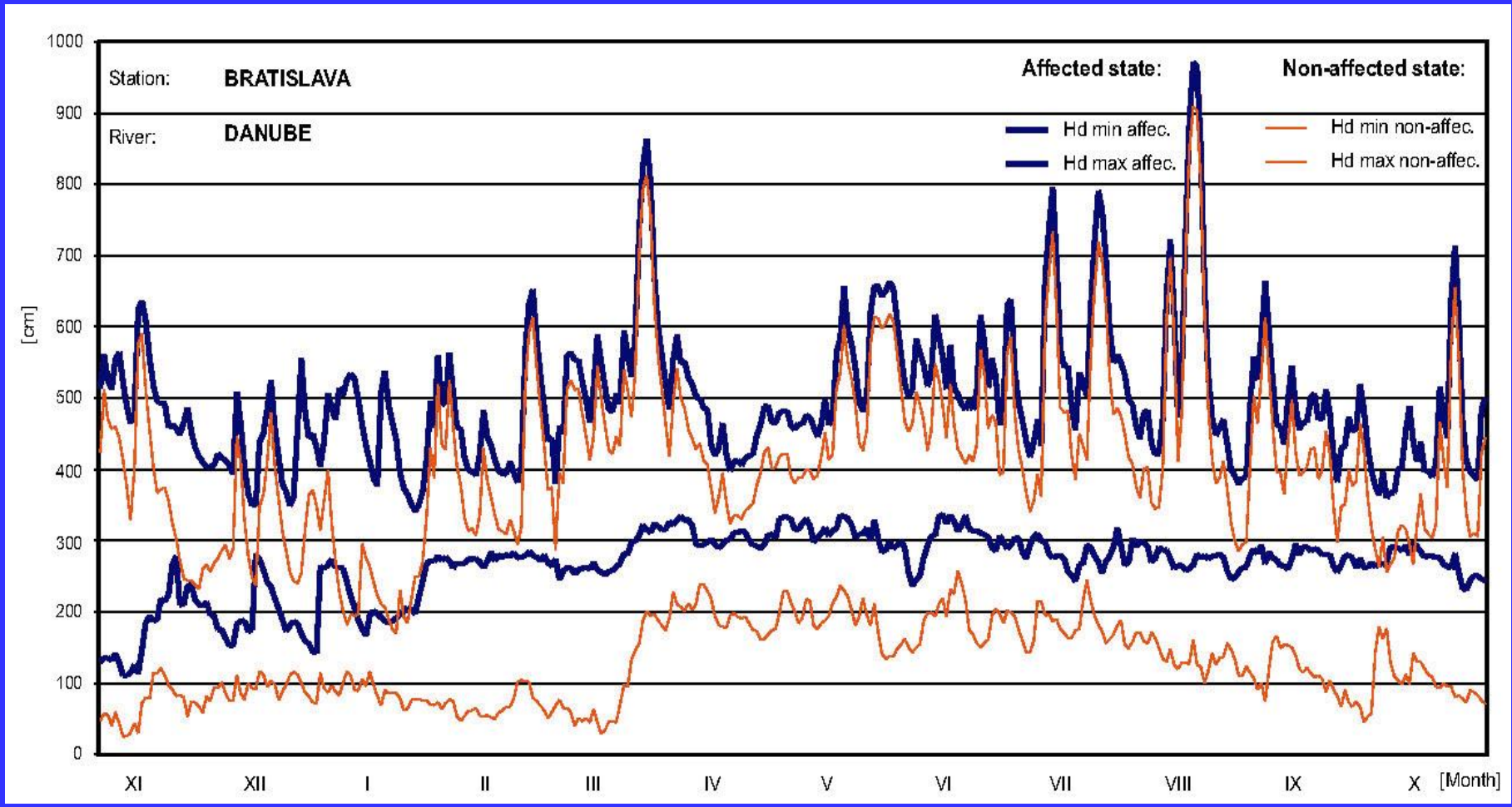

B.
1901-2004
1995-2004
1961-2000
3000
2500
2000
1500
1000
500
0
m3.s-1
XI
XII
I
II
III
IV
V
VI
VII
VIII
IX
X



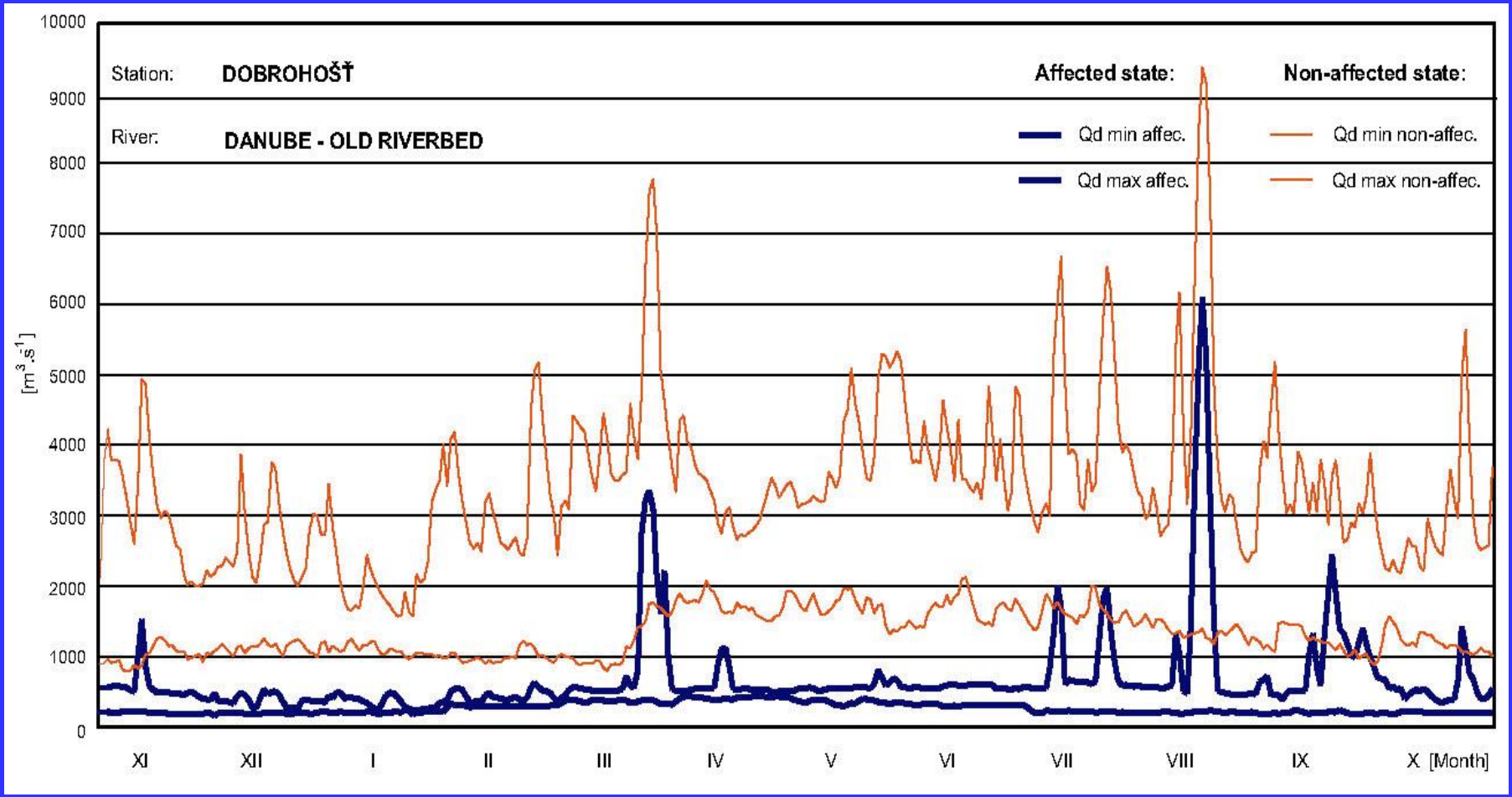
The long-term character of the Danube discharge



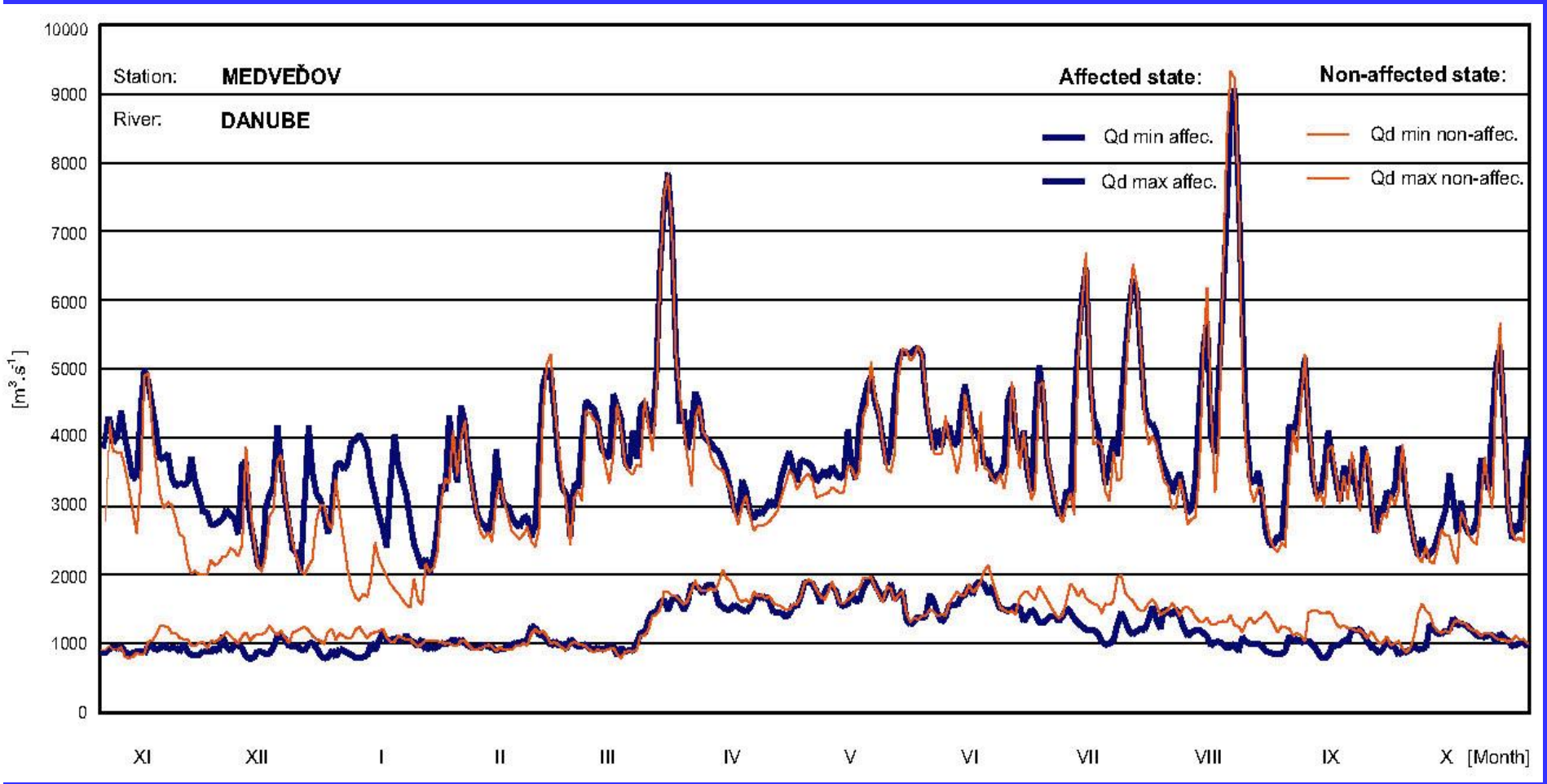
Comparison of the Danube water stages



Comparison of the Danube discharges



Comparison of the Danube discharges

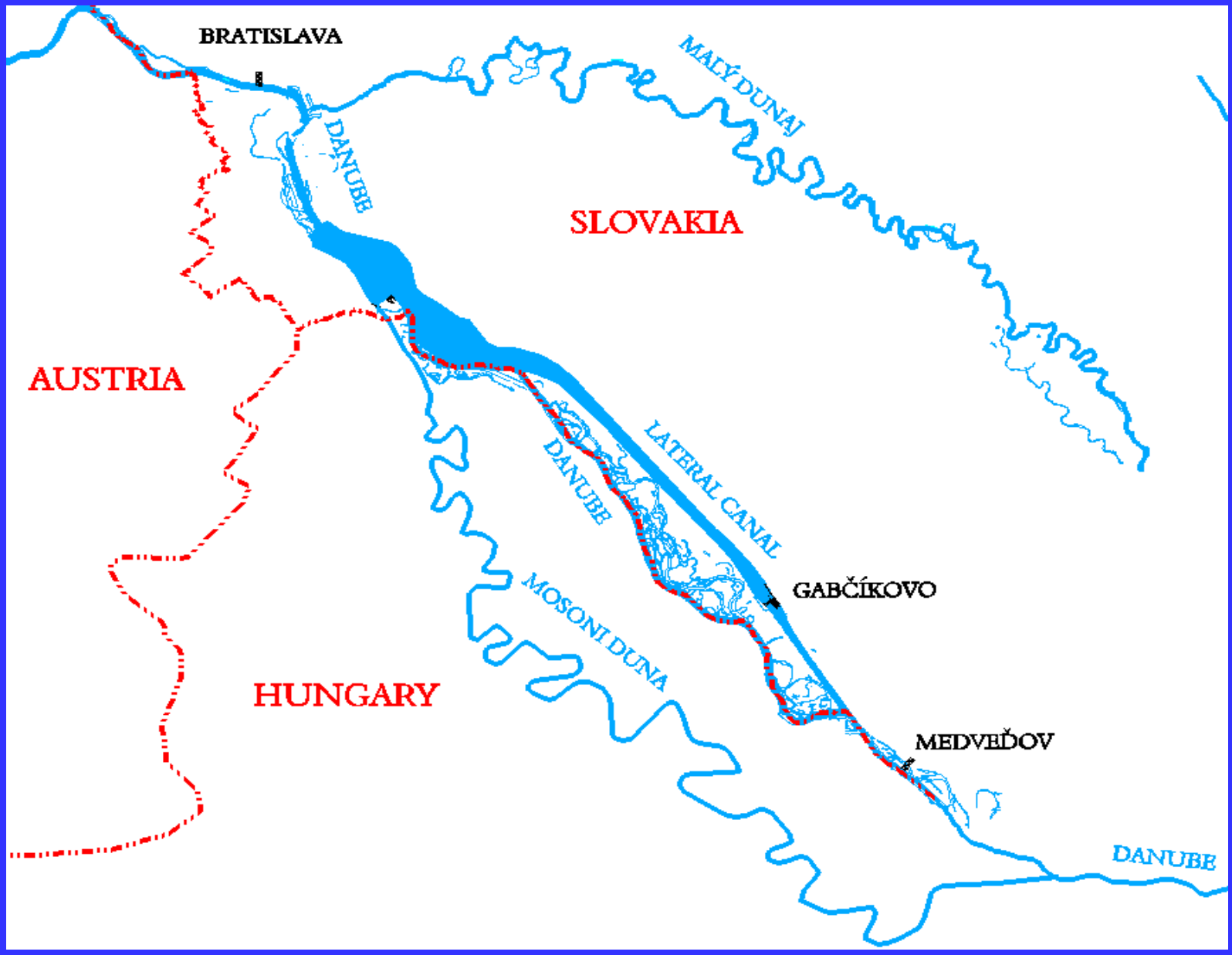


After putting the Project into operation regulation of the Danube discharges became possible. The major part of the non-flood water flow through the bypass canal and agreed part into the Old Danube. This considerably improved the flood control in this Danube stretch.

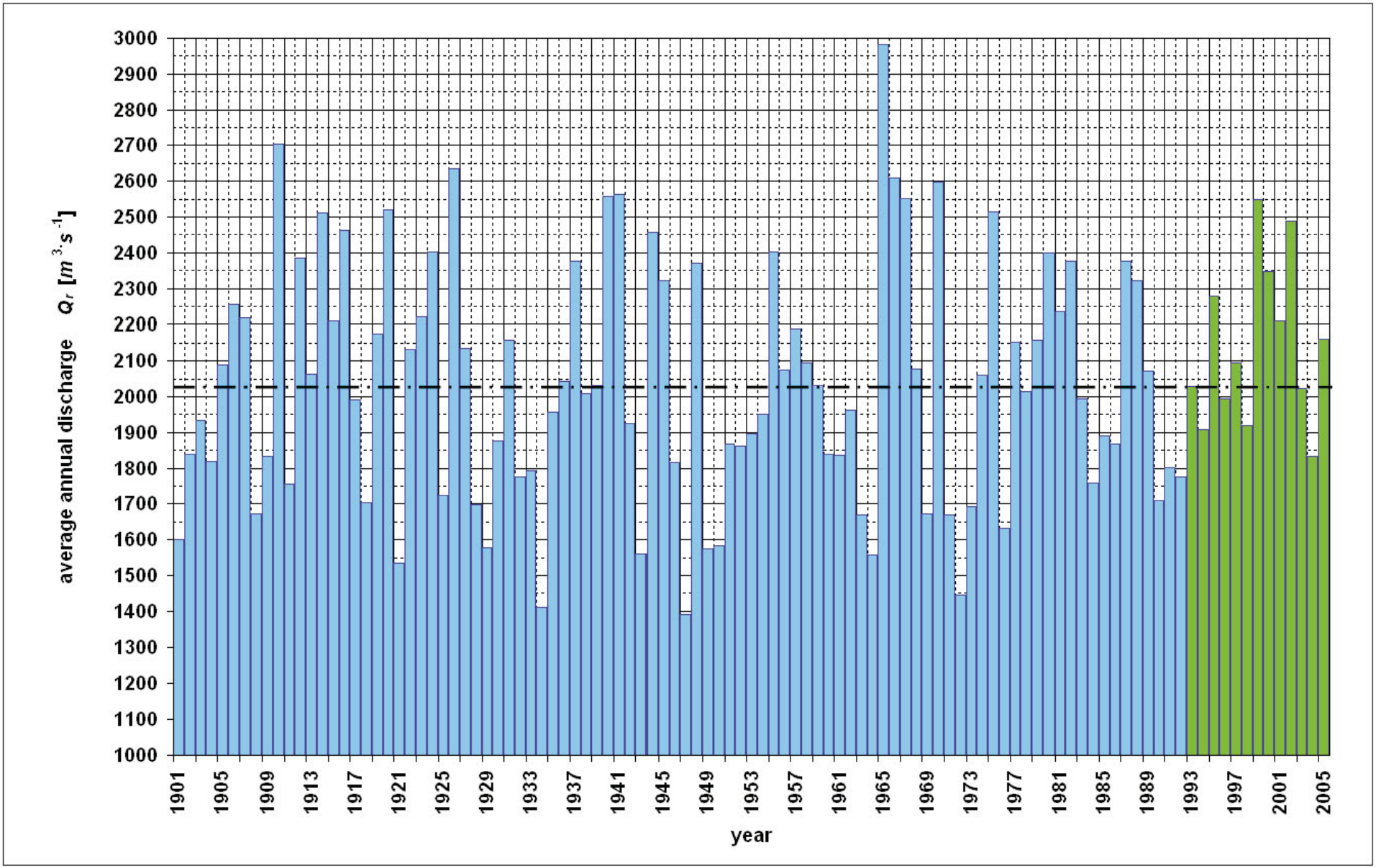
The Danube left side arm system takes water from the bypass canal and the right side arm system from the reservoir at Čunovo and upstream from submerged weir at Dunakiliti.

Upstream from reservoir water level is impounded, during flood discharges slightly lowered. Downstream from Gabčíkovo structures discharge was influenced only insignificantly.

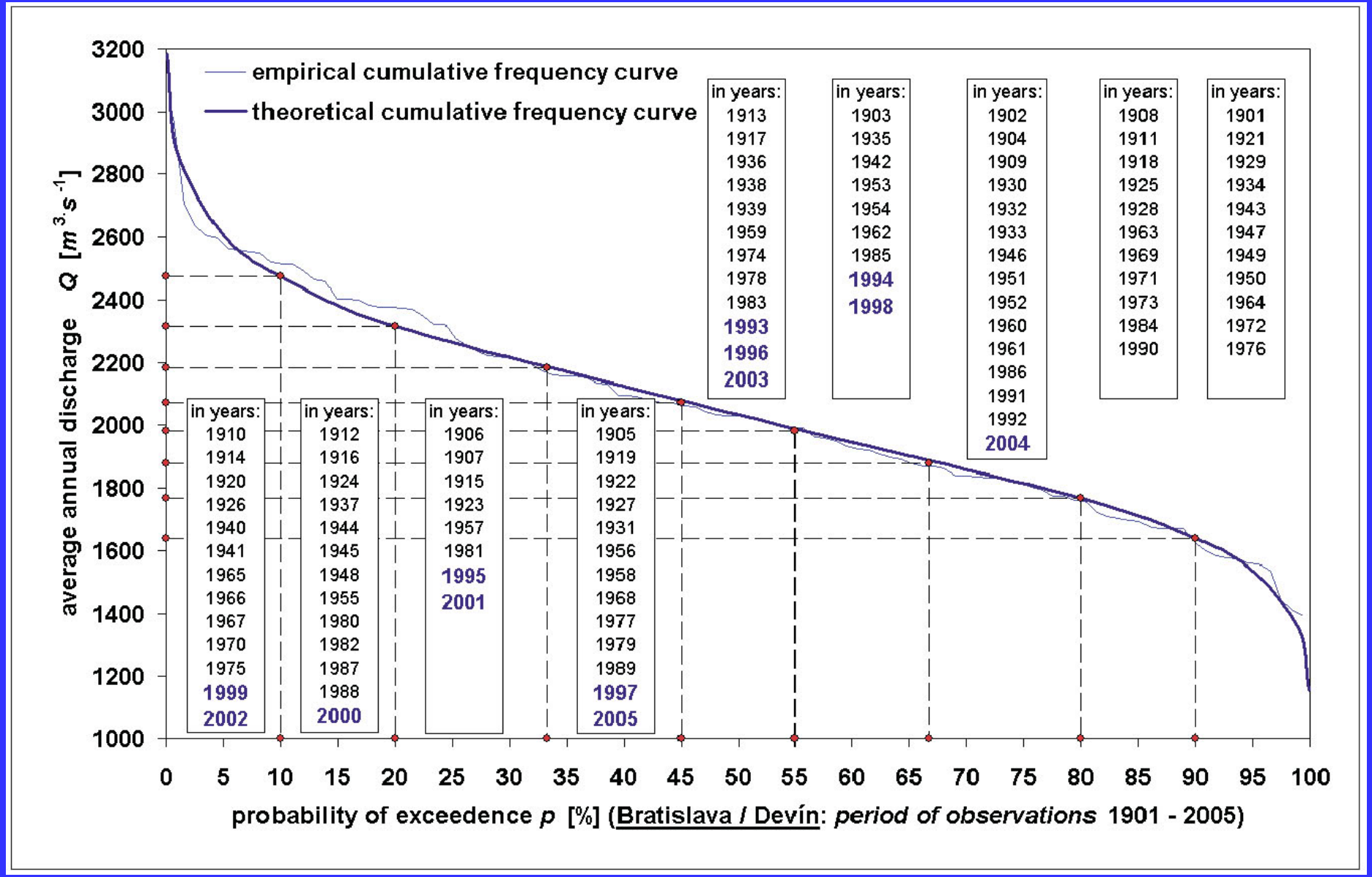
The large „Žitný ostrov“ and Szigetkoz



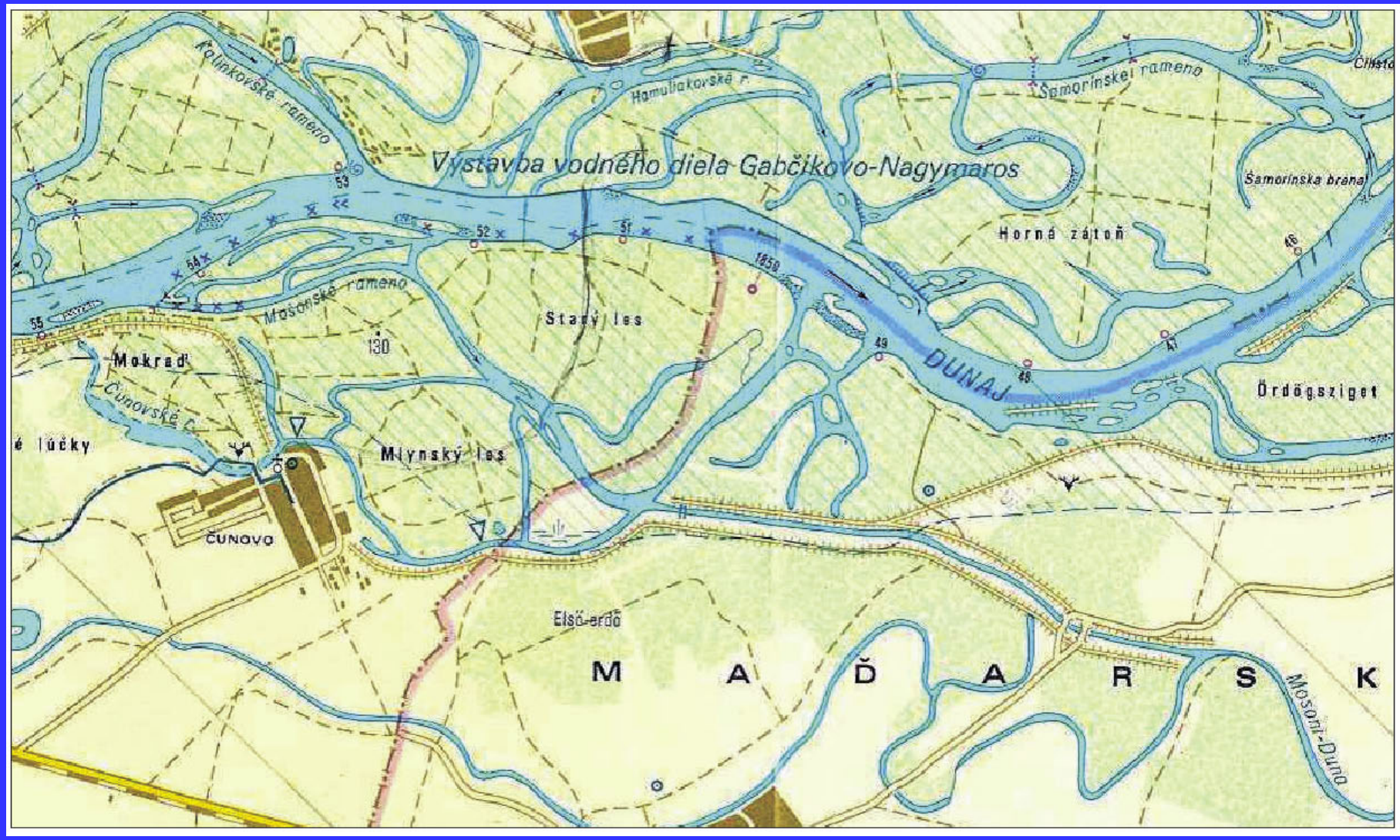
Average annual Danube discharges

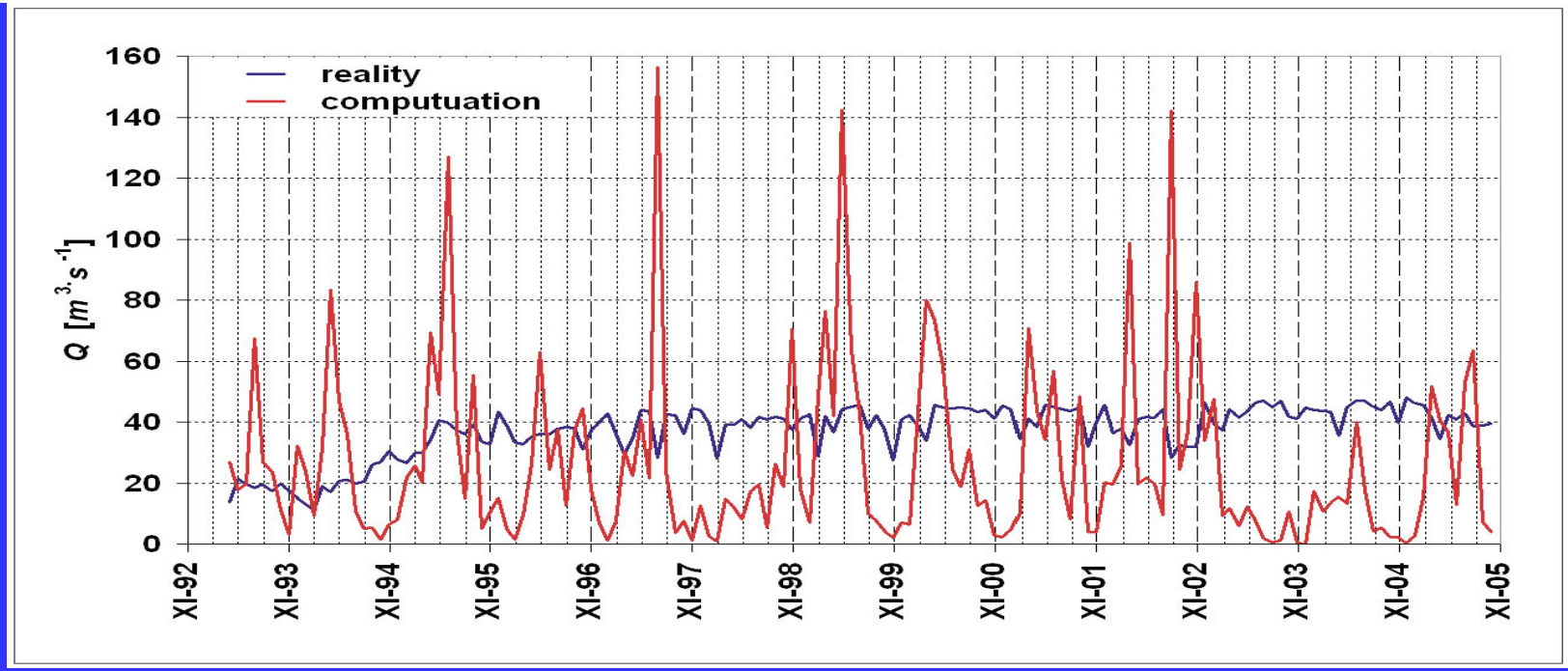


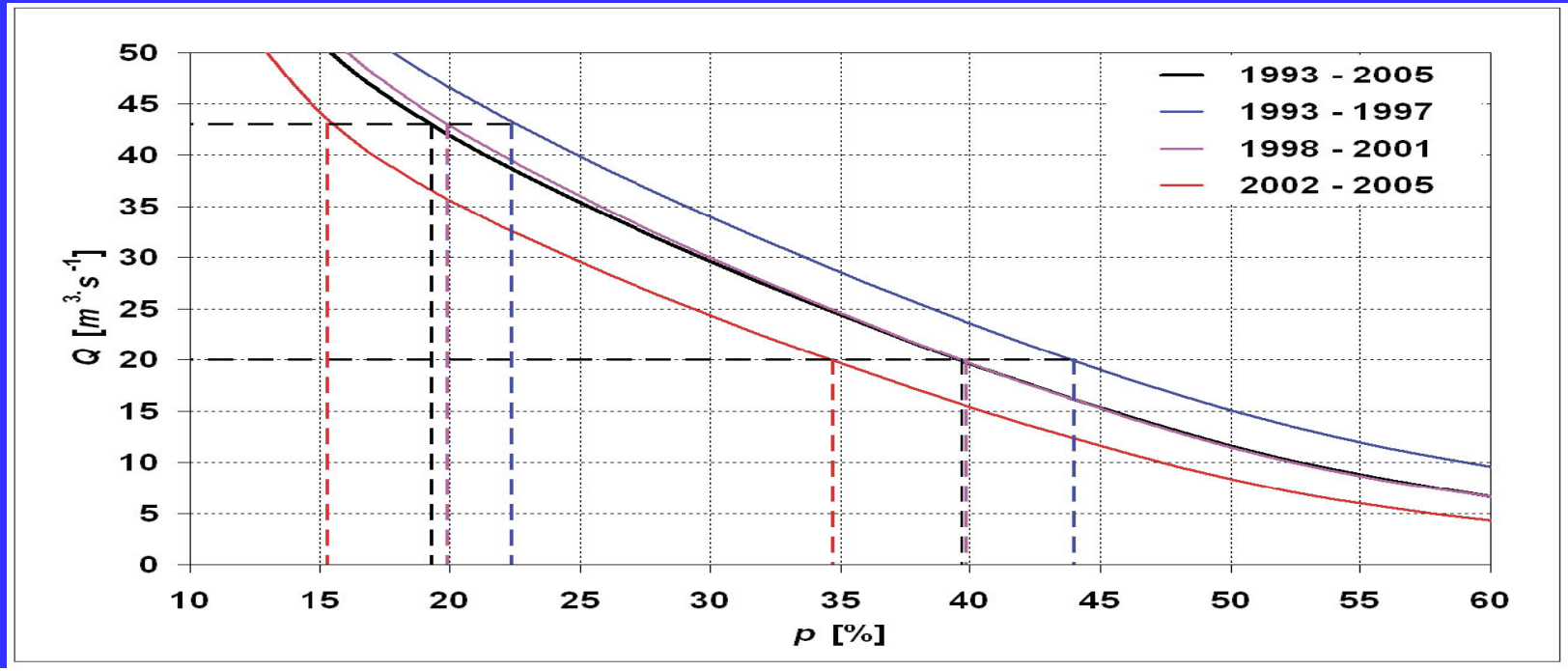
Average annual discharges and probability of its exceeding



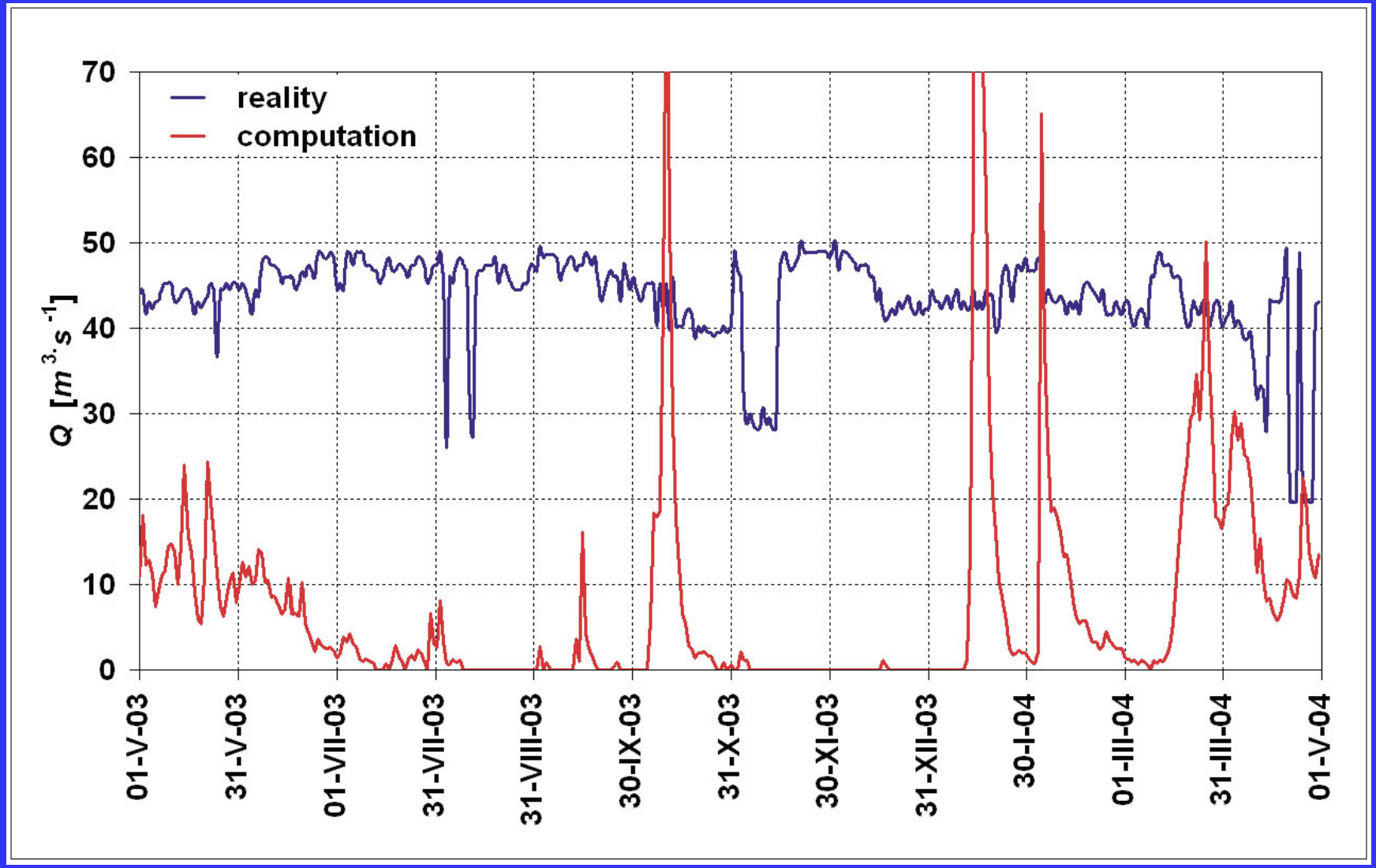
Gabčíkovo area before construction of the Project



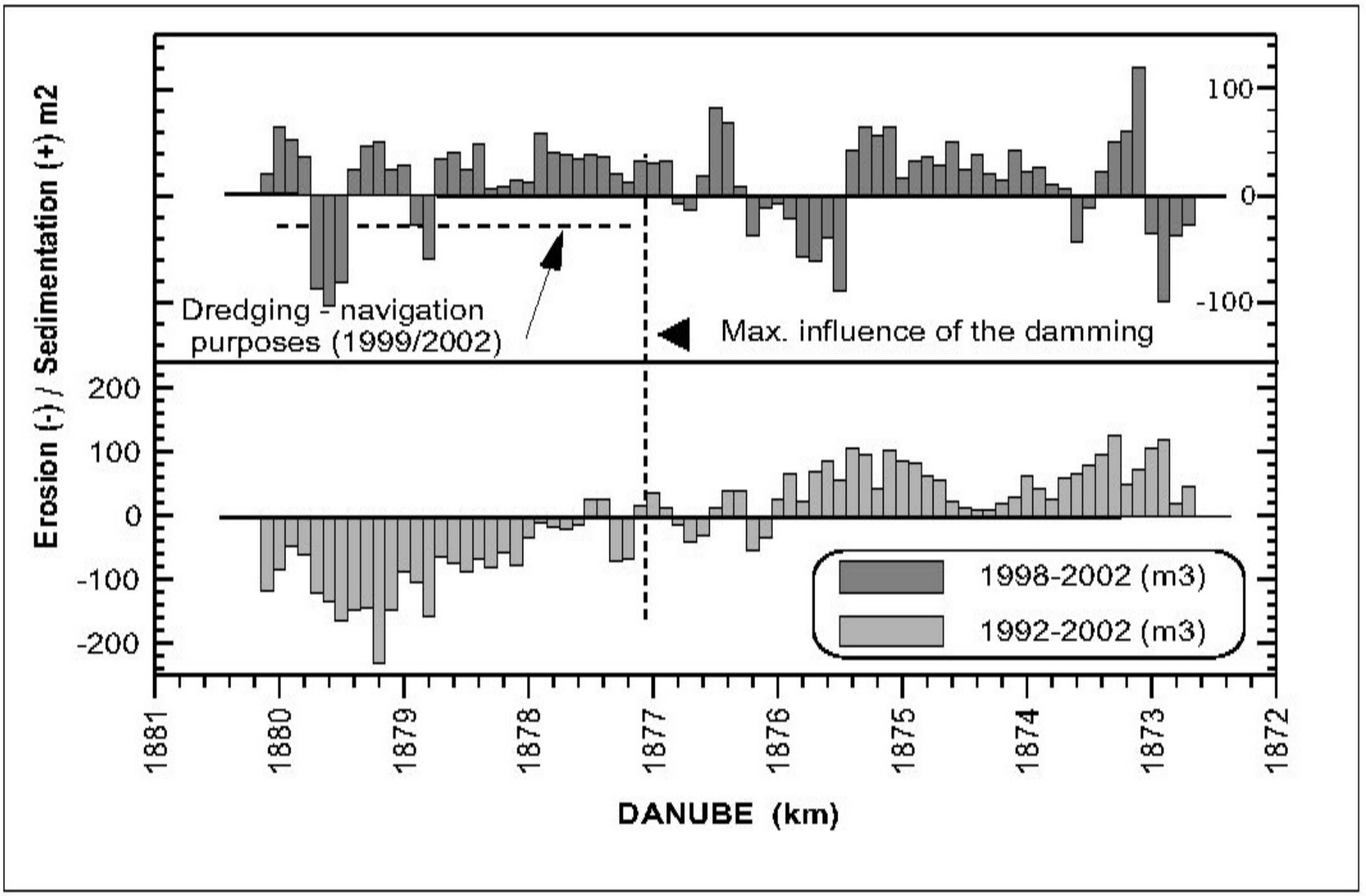

reality
computuation
Q [m3.s-1]
160
140
120
100
80
60
40
20
0
XI-92
XI-93
XI-94
XI-95
XI-96
XI-97
XI-98
XI-99
XI-00
XI-01
XI-02
XI-03
XI-04
XI-05

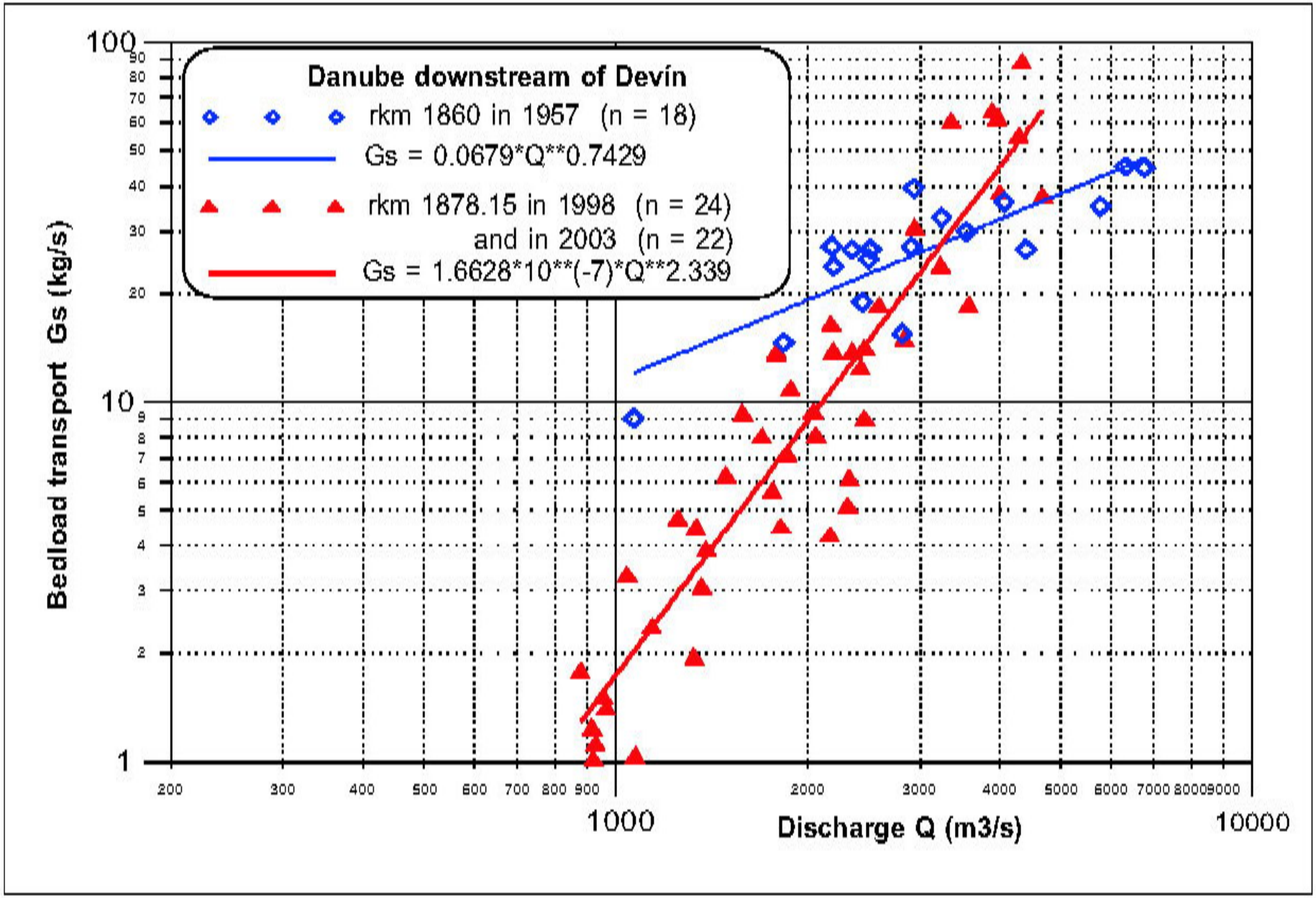

1993 - 2005
1993 - 1997
1998 - 2001
2002 - 2005
Q [m3.s-1]
50
45
40
35
30
25
20
15
10
5
0
10
15
20
25
30
35
40
45
50
55
60
p [%]

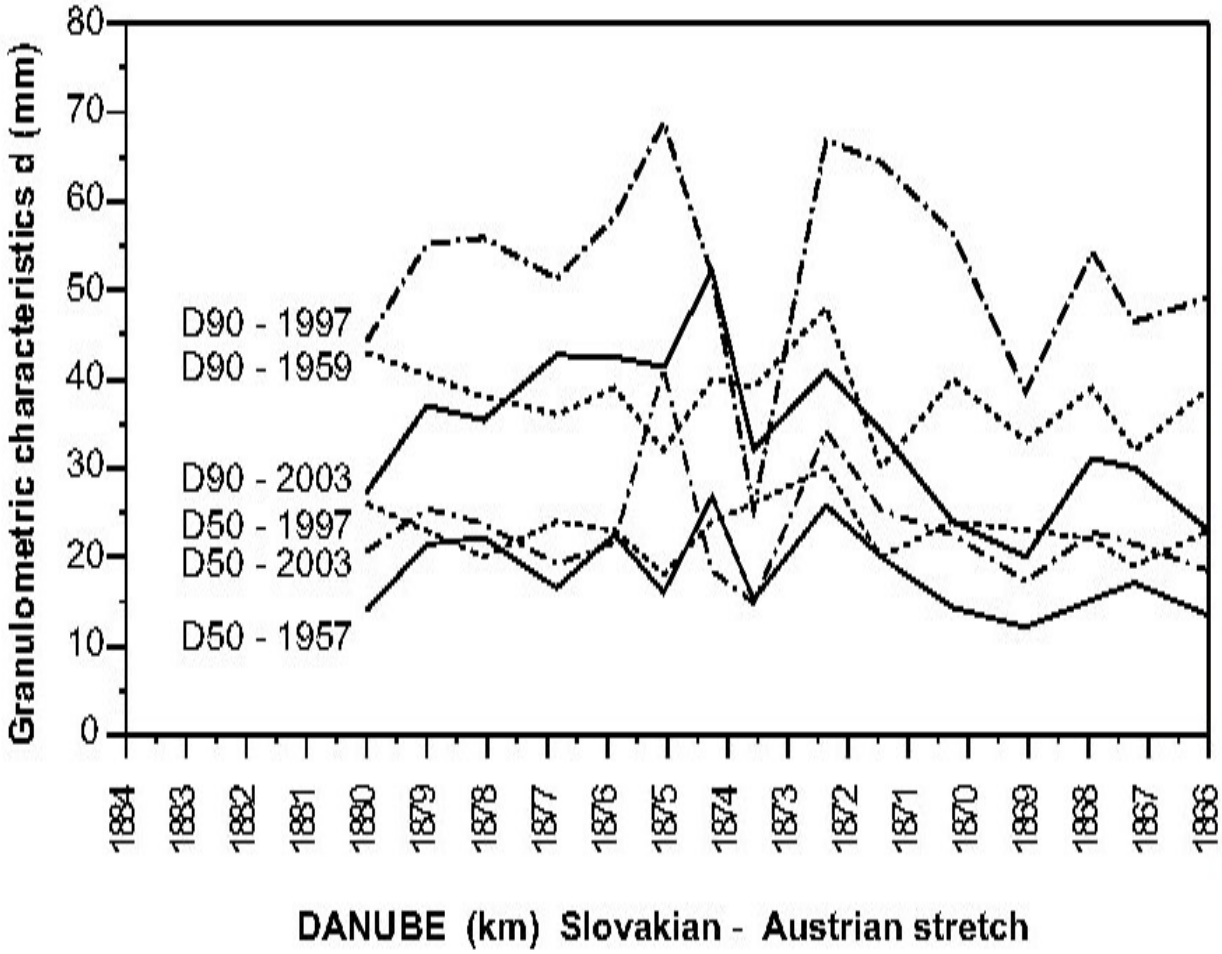
Entrance into the Danube Mosoni arm

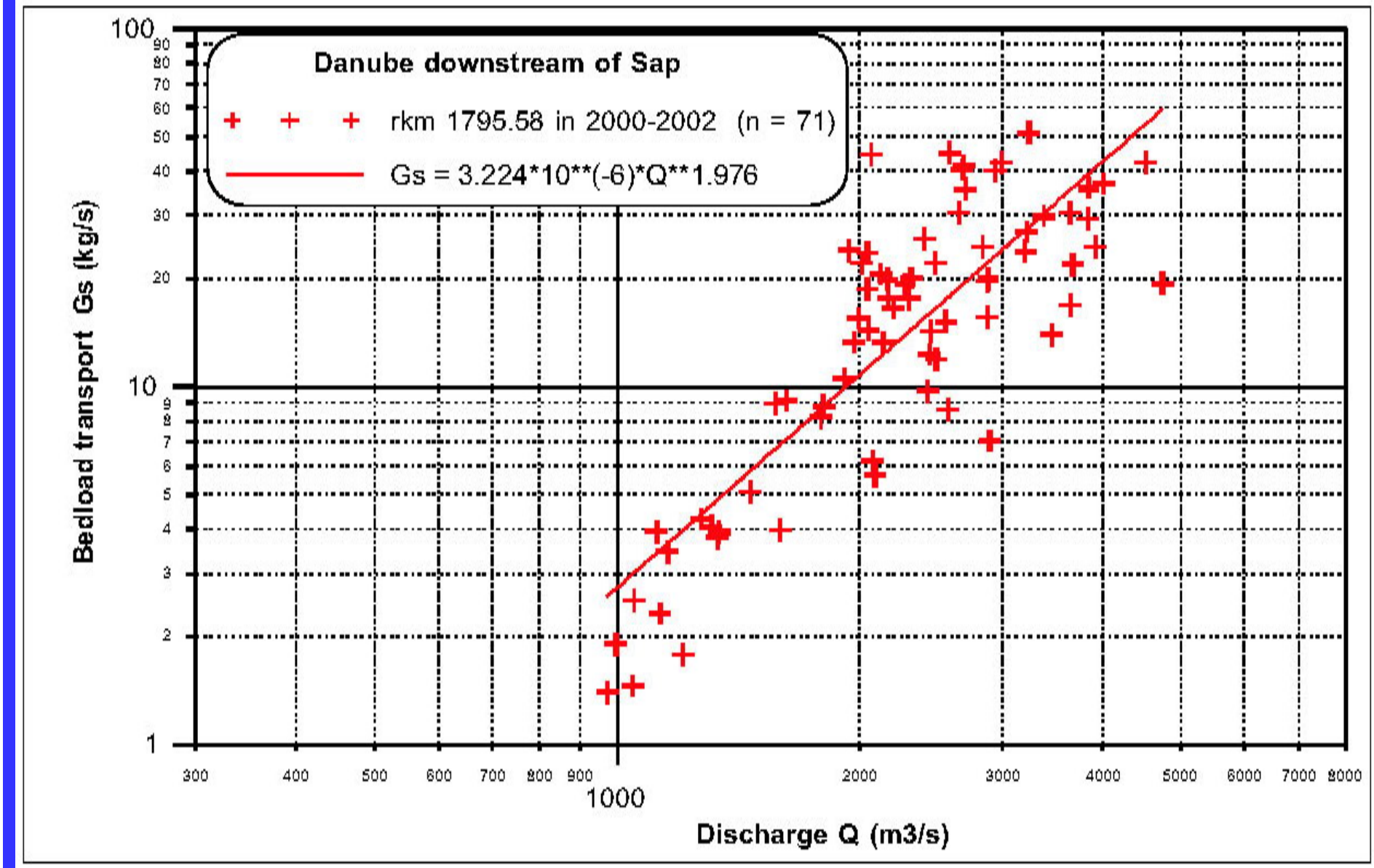

reality
computation
Q [m3.s-1]
70
60
50
40
30
20
10
0
01-V-03
31-V-03
01-VII-03
31-VII-03
31-VIII-03
30-IX-03
31-X-03
30-XI-03
31-XII-03
30-I-04
01-III-04
31-III-04
01-V-04

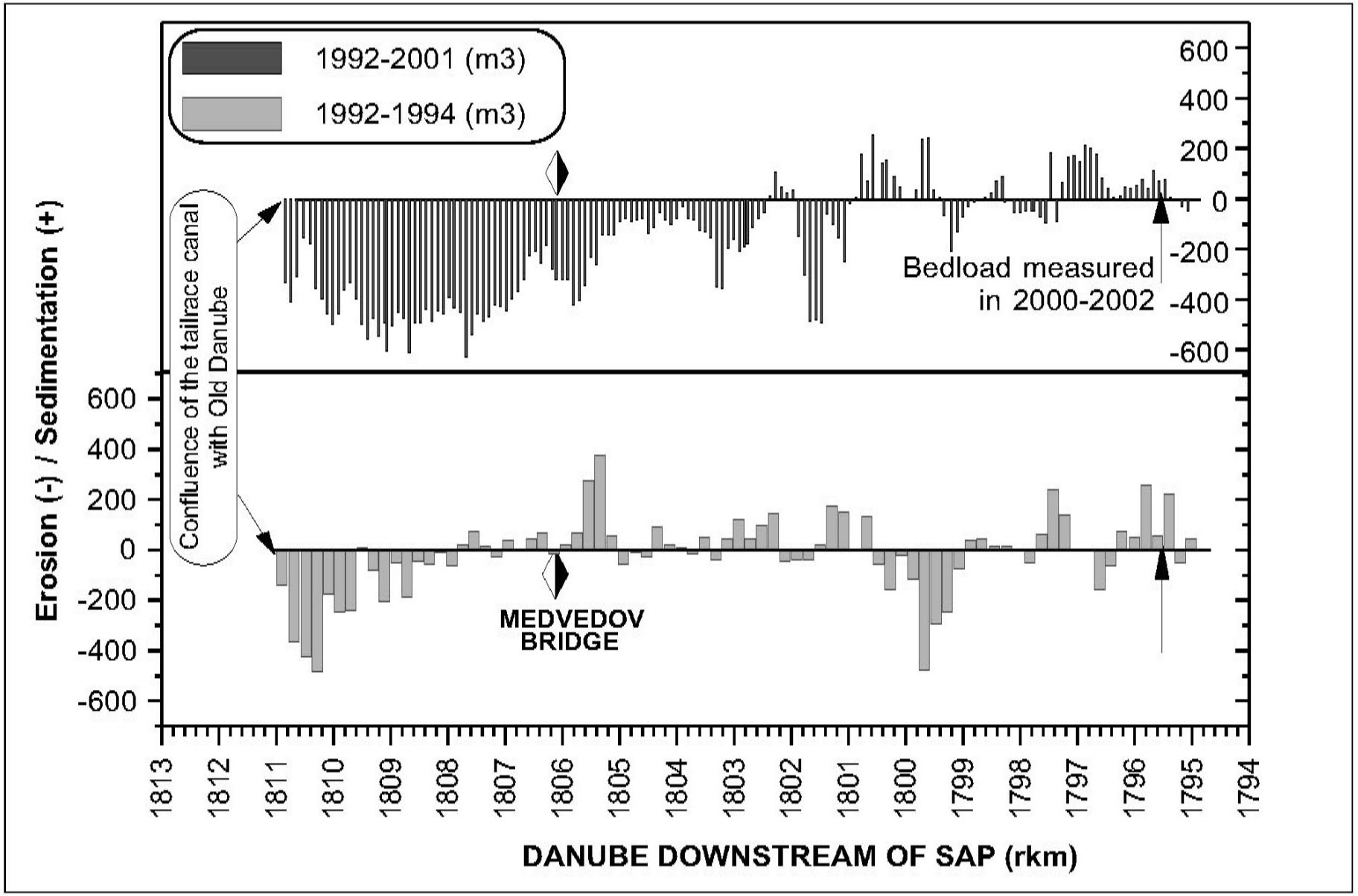
After putting the Gabčíkovo hydraulic structures into operation, the discussions about technical measures for providing the water discharge in the Mosoni have become purposeless. **The Čunovo reservoir guarantees that the necessary water amount will discharge from the Danube into the Mosoni arm at any time. Since putting the Gabčíkovo project into operation, the water discharge into the Mosoni arm has provided adequate ecological and water management conditions, even in the periods of low discharges in the Danube, for example in 2003. In addition, the possibility to reduce discharge in the Mosoni arm by the structures in the Čunovo weir and in the weir on Hungarian territory creates favourable conditions for protection against floods at high water level stages in the Danube. The Hungarian side also uses them effectively, for example as it did during the flood in August 2002.**

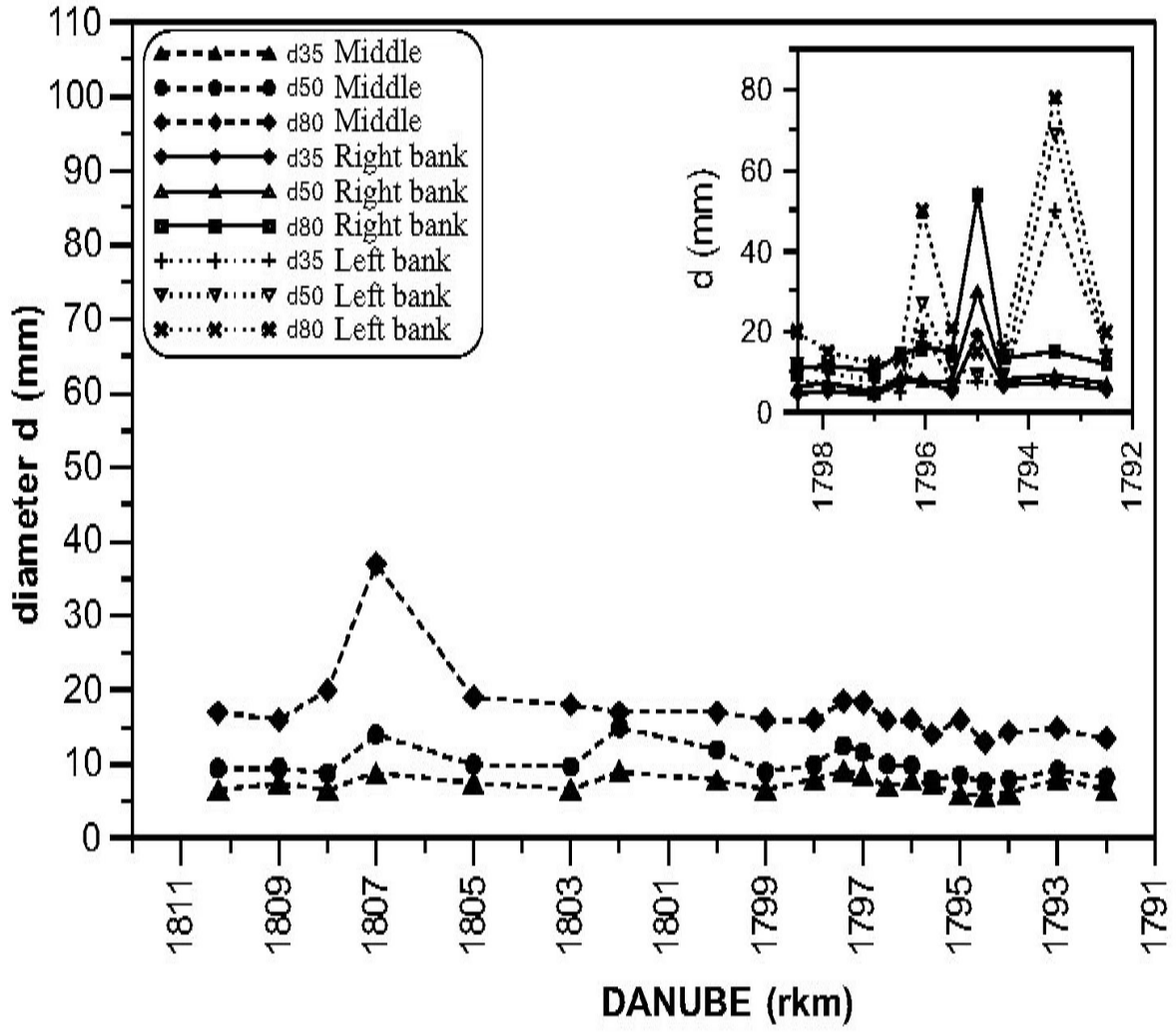

Erosion (-) / Sedimentation (+) m2
100
0
-100
Dredging - navigation purposes (1999/2002)
Max. influence of the damming
200
100
0
-100
-200
1998-2002 (m3)
1992-2002 (m3)
1881
1880
1879
1878
1877
1876
1875
1874
1873
1872
DANUBE (km)

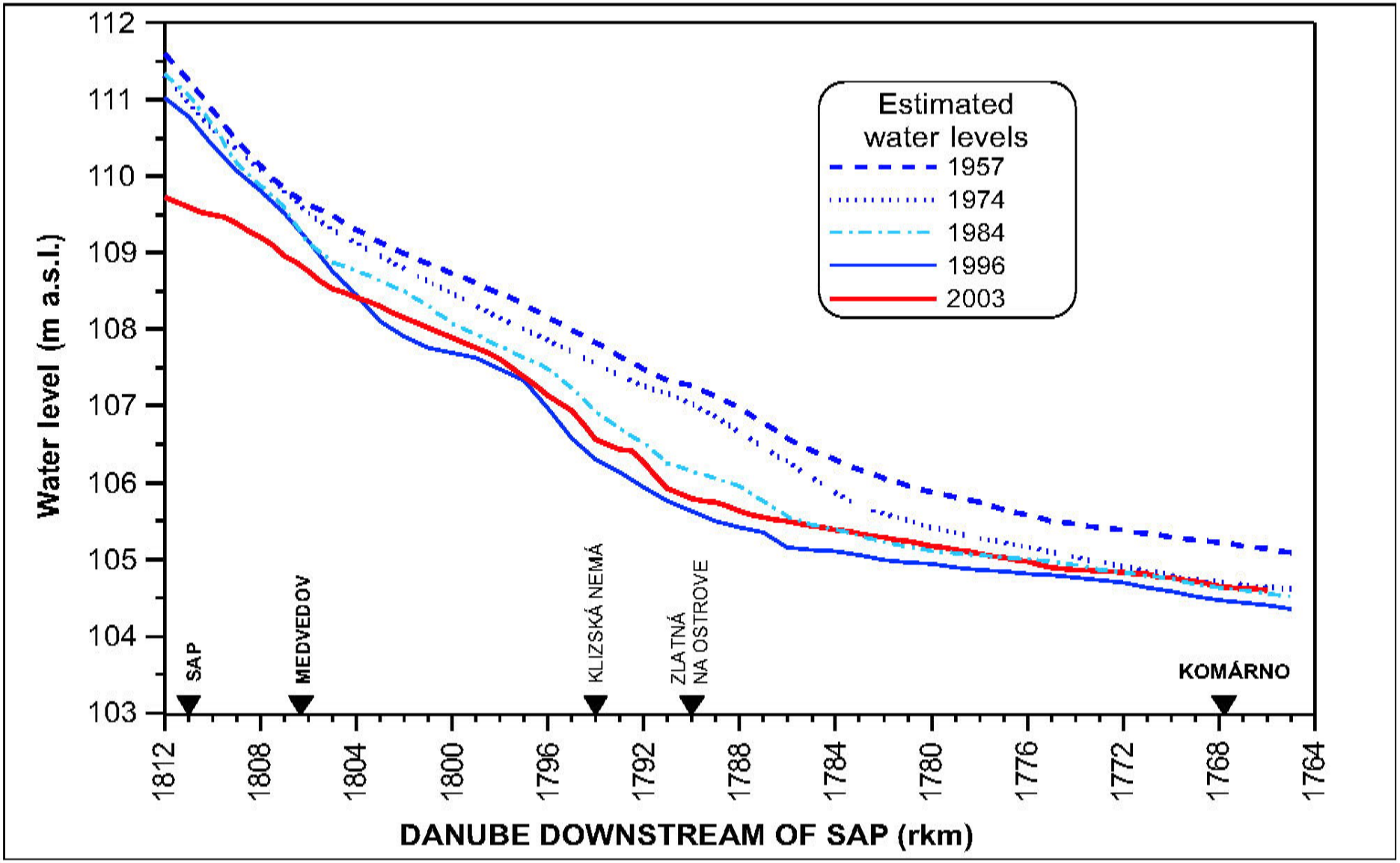

Danube downstream of Devín
rkm 1860 in 1957 (n = 18)
Gs = 0.0679*Q**0.7429
rkm 1878.15 in 1998 (n = 24)
and in 2003 (n = 22)
Gs = 1.6628*10**(-7)*Q**2.339
Bedload transport Gs (kg/s)
Discharge Q (m3/s)
100
10
1
200
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000

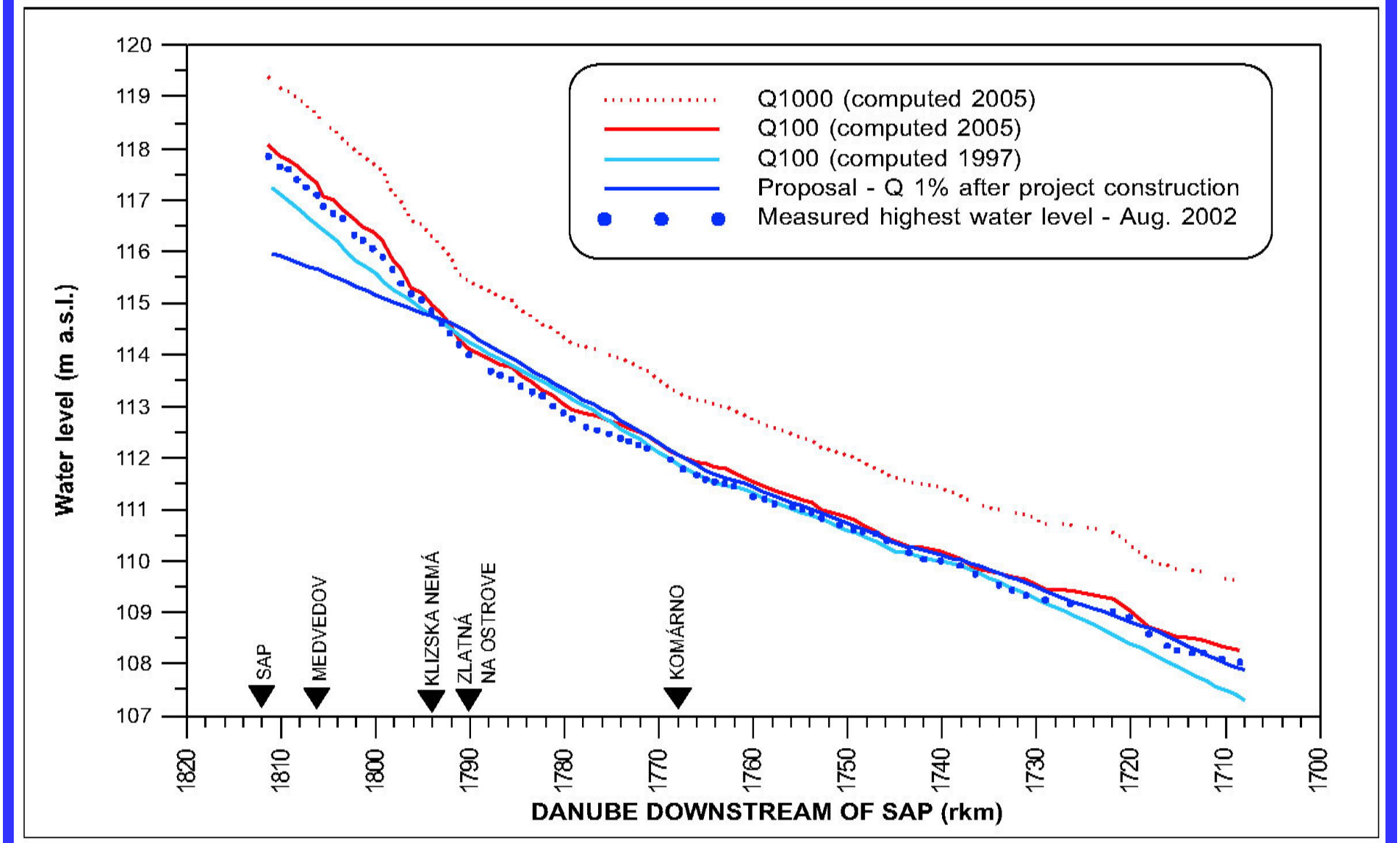

Granulometric characteristics d (mm)
80
70
60
50
40
30
20
10
0
D90 - 1997
D90 - 1959
D90 - 2003
D50 - 1997
D50 - 2003
D50 - 1957
1884
1883
1882
1881
1880
1879
1878
1877
1876
1875
1874
1873
1872
1871
1870
1869
1868
1867
1866
DANUBE (km) Slovakian - Austrian stretch


Danube downstream of Sap
rkm 1795.58 in 2000-2002 (n = 71)
Gs = 3.224*10**(-6)*Q**1.976
Bedload transport Gs (kg/s)
Discharge Q (m3/s)
100
90
80
70
60
50
40
30
20
10
9
8
7
6
5
4
3
2
1
300
400
500
600
700
800
900
1000
2000
3000
4000
5000
6000
7000
8000

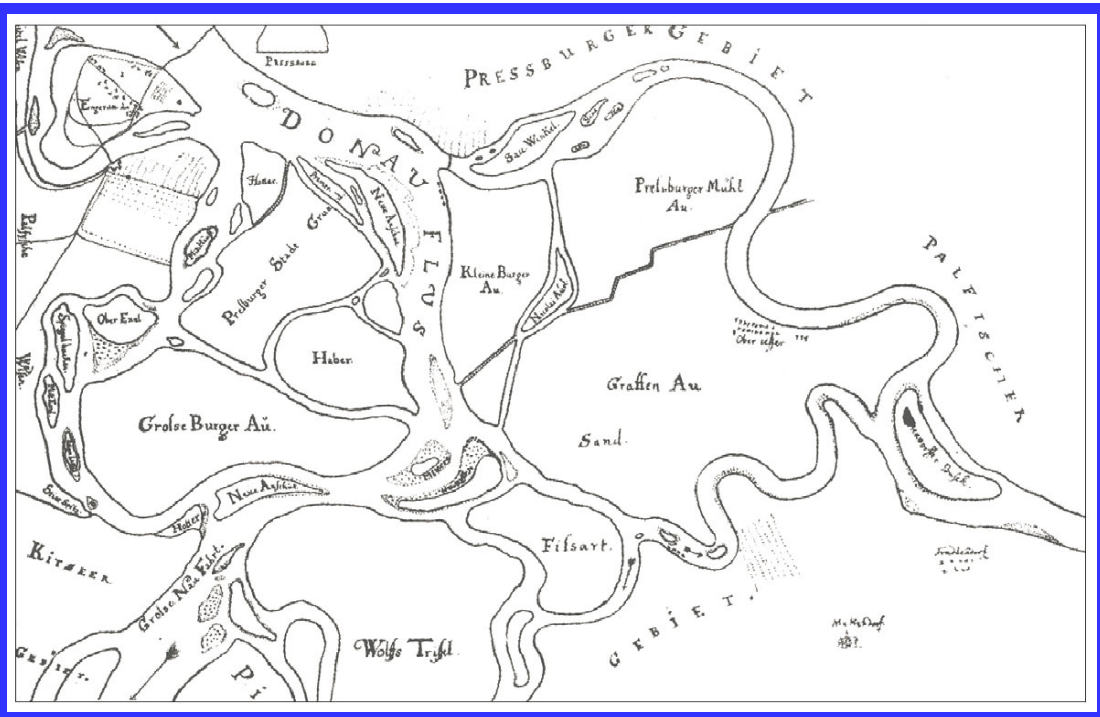

1992-2001 (m3)
1992-1994 (m3)
Confluence of the tailrace canal with Old Danube
Bedload measured in 2000-2002
MEDVEDOV BRIDGE
Erosion (-) / Sedimentation (+)
DANUBE DOWNSTREAM OF SAP (rkm)
600
400
200
0
-200
-400
-600
1813
1812
1811
1810
1809
1808
1807
1806
1805
1804
1803
1802
1801
1800
1799
1798
1797
1796
1795
1794

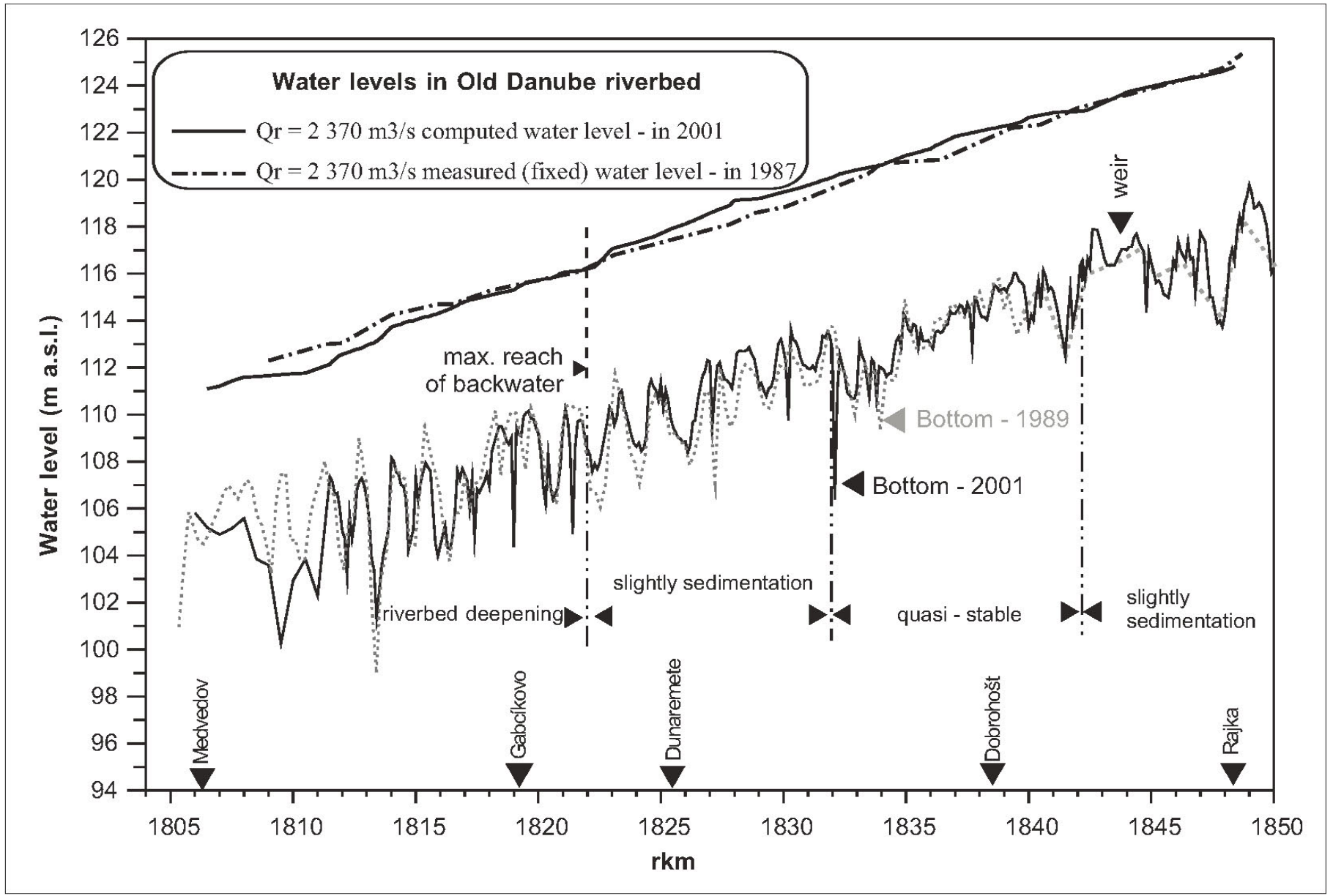

d35 Middle
d50 Middle
d80 Middle
d35 Right bank
d50 Right bank
d80 Right bank
d35 Left bank
d50 Left bank
d80 Left bank
diameter d (mm)
DANUBE (rkm)
d (mm)

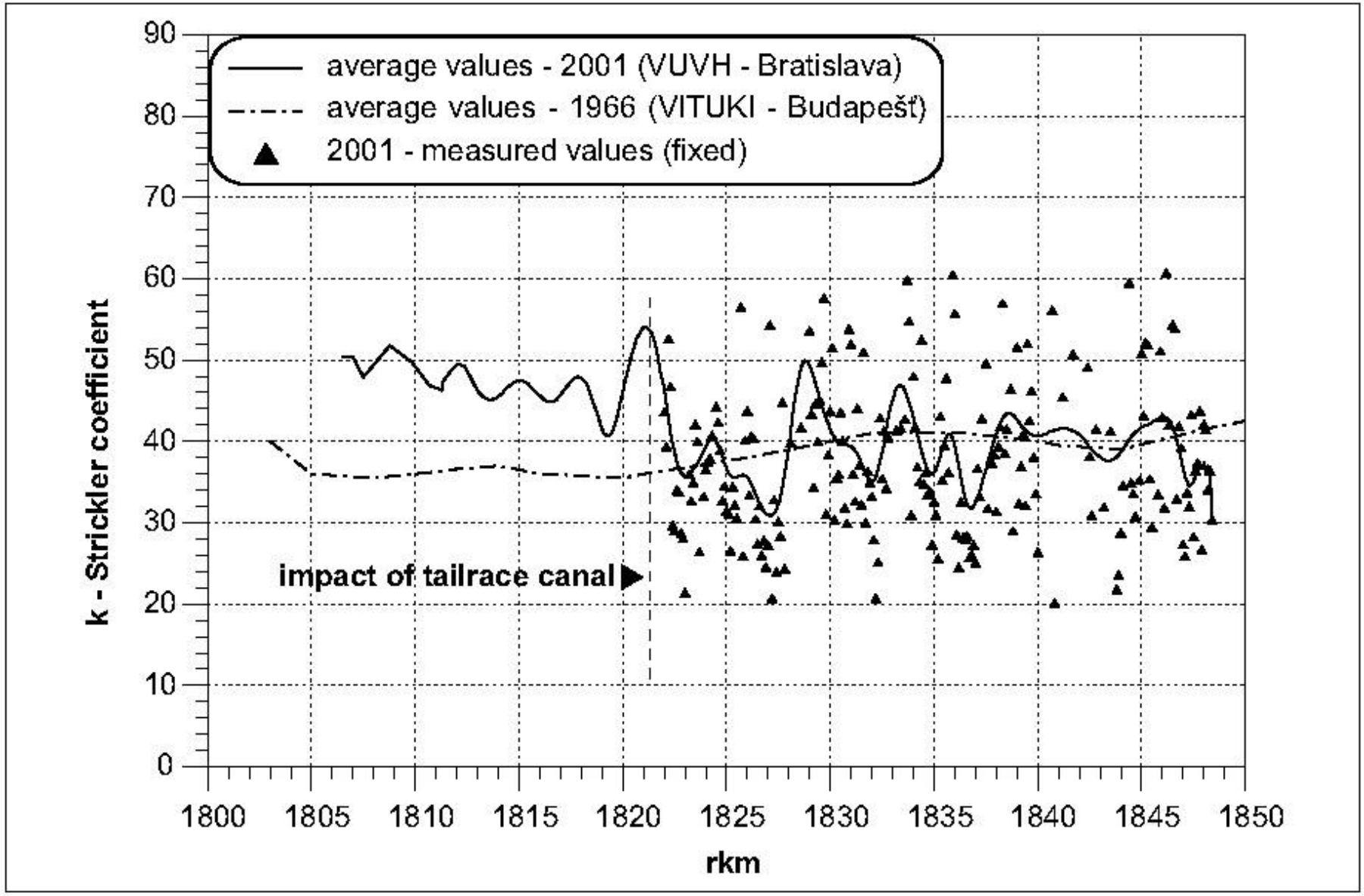

Estimated water levels
1957
1974
1984
1996
2003
Water level (m a.s.l.)
112
111
110
109
108
107
106
105
104
103
SAP
MEDVEDOV
KLIZSKÁ NEMÁ
ZLATNÁ NA OSTROVE
KOMÁRNO
1812
1808
1804
1800
1796
1792
1788
1784
1780
1776
1772
1768
1764
DANUBE DOWNSTREAM OF SAP (rkm)

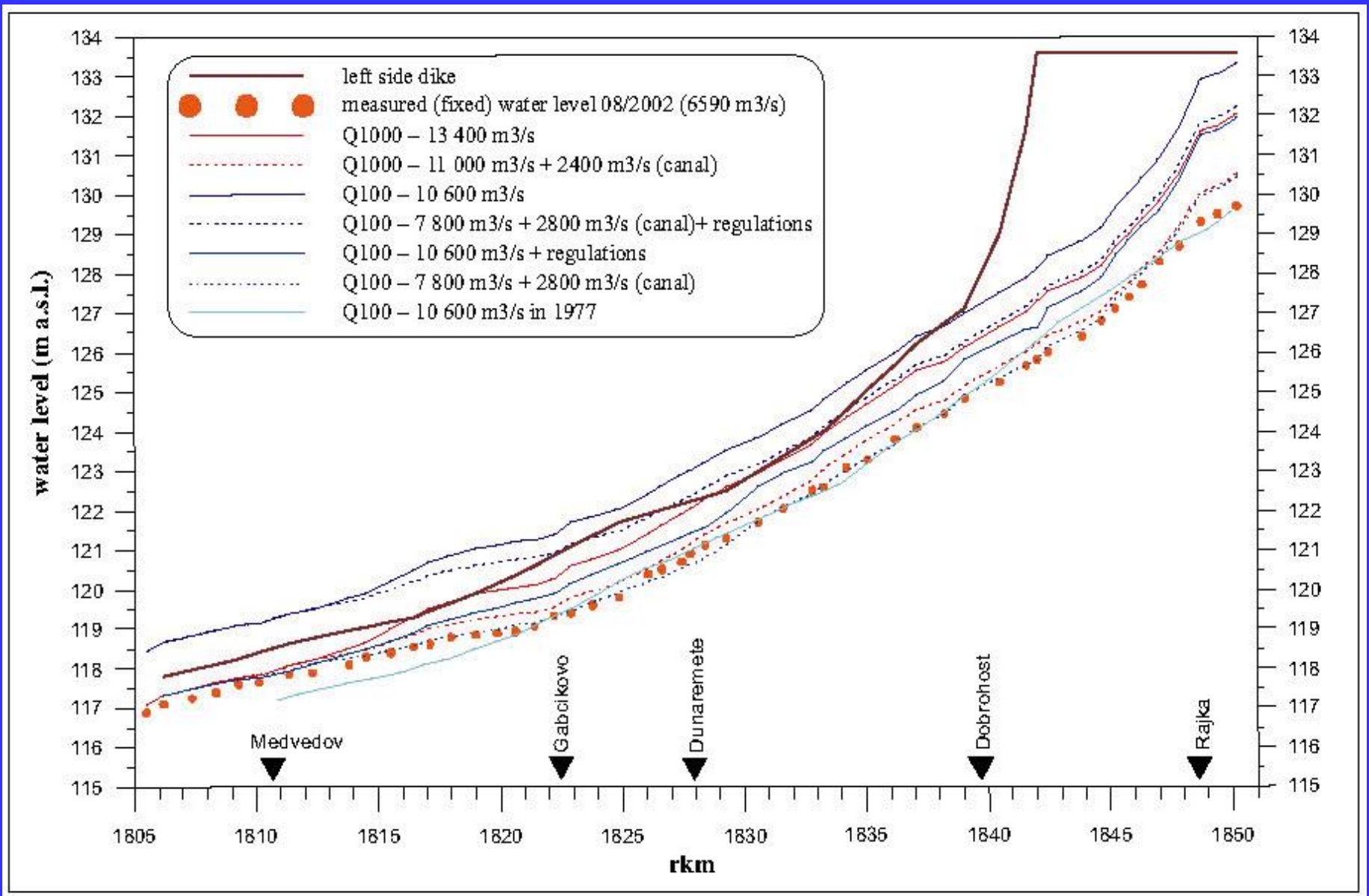

Q1000 (computed 2005)
Q100 (computed 2005)
Q100 (computed 1997)
Proposal - Q 1% after project construction
Measured highest water level - Aug. 2002
Water level (m a.s.l.)
120
119
118
117
116
115
114
113
112
111
110
109
108
107
SAP
MEDVEDOV
KLIZSKA NEMÁ
ZLATNÁ NA OSTROVE
KOMÁRNO
1820
1810
1800
1790
1780
1770
1760
1750
1740
1730
1720
1710
1700
DANUBE DOWNSTREAM OF SAP (rkm)

The data of bedload transport and morphological changes of the Danube riverbed illustrate the dynamics of river processes and changes, which are influenced by the Gabčíkovo hydraulic structures and partly also by not fulfilling the Joint Treaty Project (maintenance of the Old Riverbed, not realised measures downstream of Sap). Their significance lays first of all in their practical application for optimisation of the proposed regulation measures (navigation conditions, flood control, revitalization of the river branches and within-dike zone). Data on changes of river processes in the Danube are also a significant source of information, which represents a basis for a qualified evaluation of the river's present state, as well as for the subsequent decision making process in the frame of preparing water-management plans for the river basin within the implementation of the Water Framework Directive of EU.

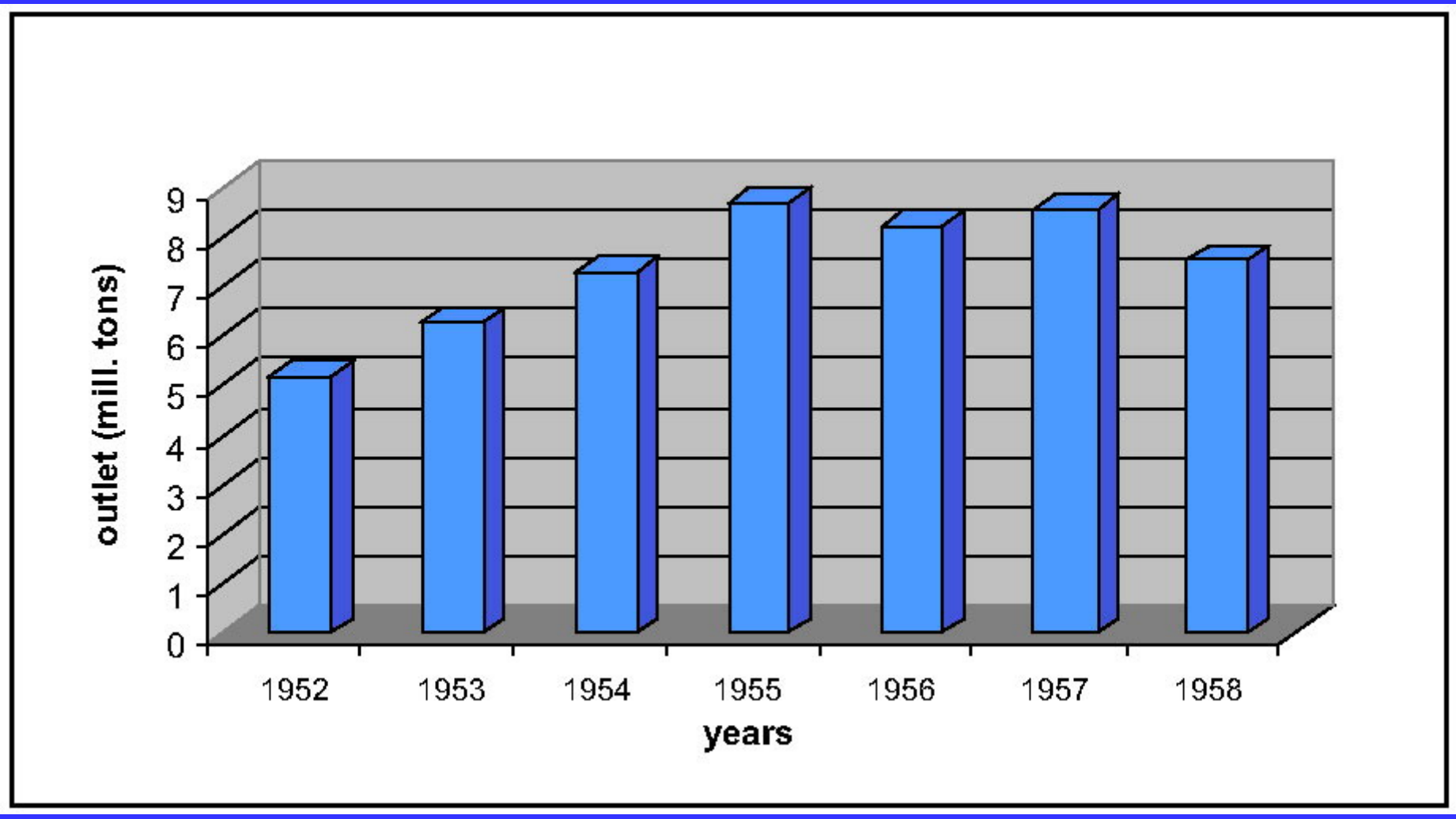

Pressburger Gebiet
Donau Fluss
Prelsburger Mühl Au.
Palfischen
Kleine Burger Au.
Haber.
Graffen Au.
Sand.
Grolse Burger Aü.
Fifsart.
Kitseer
Wolfs Trifel.

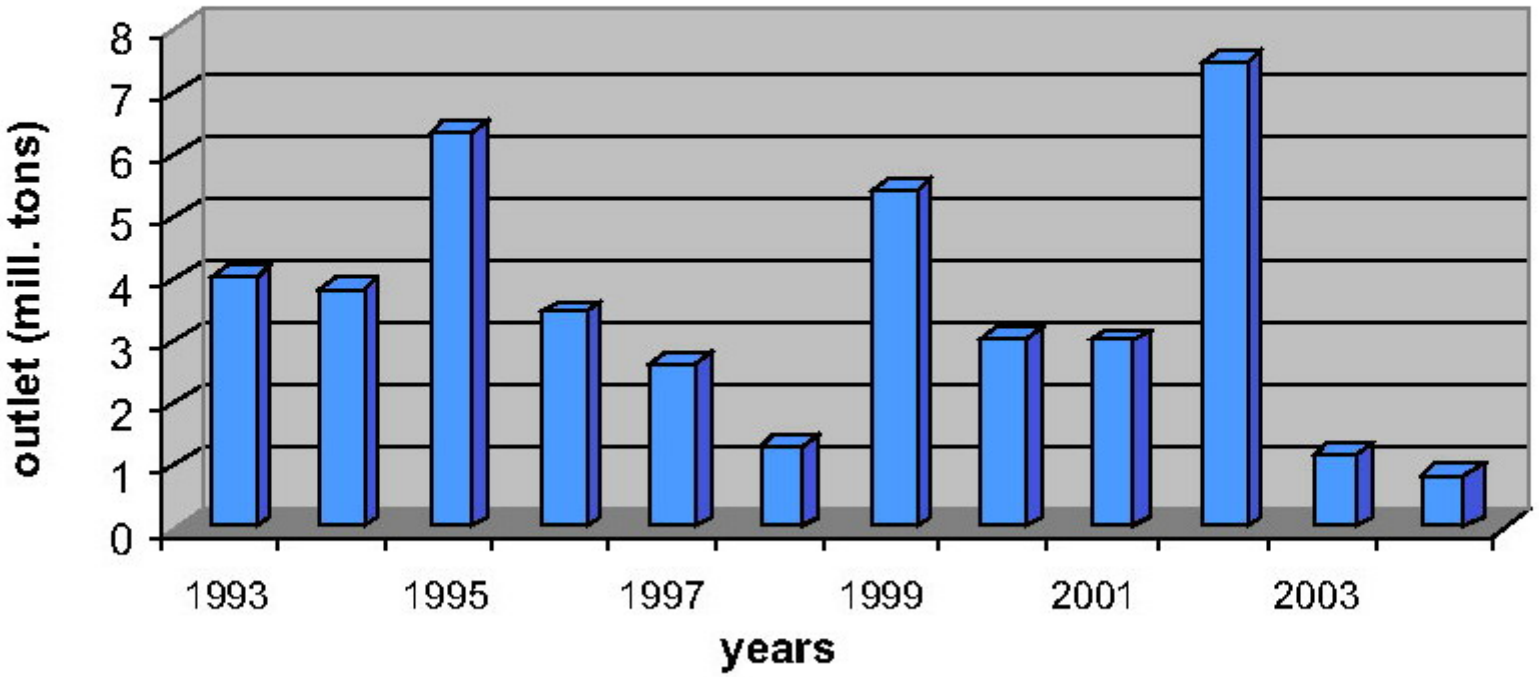

Water levels in Old Danube riverbed
Qr = 2 370 m3/s computed water level - in 2001
Qr = 2 370 m3/s measured (fixed) water level - in 1987
Water level (m a.s.l.)
126
124
122
120
118
116
114
112
110
108
106
104
102
100
98
96
94
max. reach
of backwater
weir
Bottom - 1989
Bottom - 2001
slightly sedimentation
riverbed deepening
quasi - stable
slightly
sedimentation
Medvedov
Gabcikovo
Dunaremete
Dobrohošt
Rajka
1805
1810
1815
1820
1825
1830
1835
1840
1845
1850
rkm


average values - 2001 (VUVH - Bratislava)
average values - 1966 (VITUKI - Budapešť)
2001 - measured values (fixed)
impact of tailrace canal
k - Strickler coefficient
rkm
0
10
20
30
40
50
60
70
80
90
1800
1805
1810
1815
1820
1825
1830
1835
1840
1845
1850

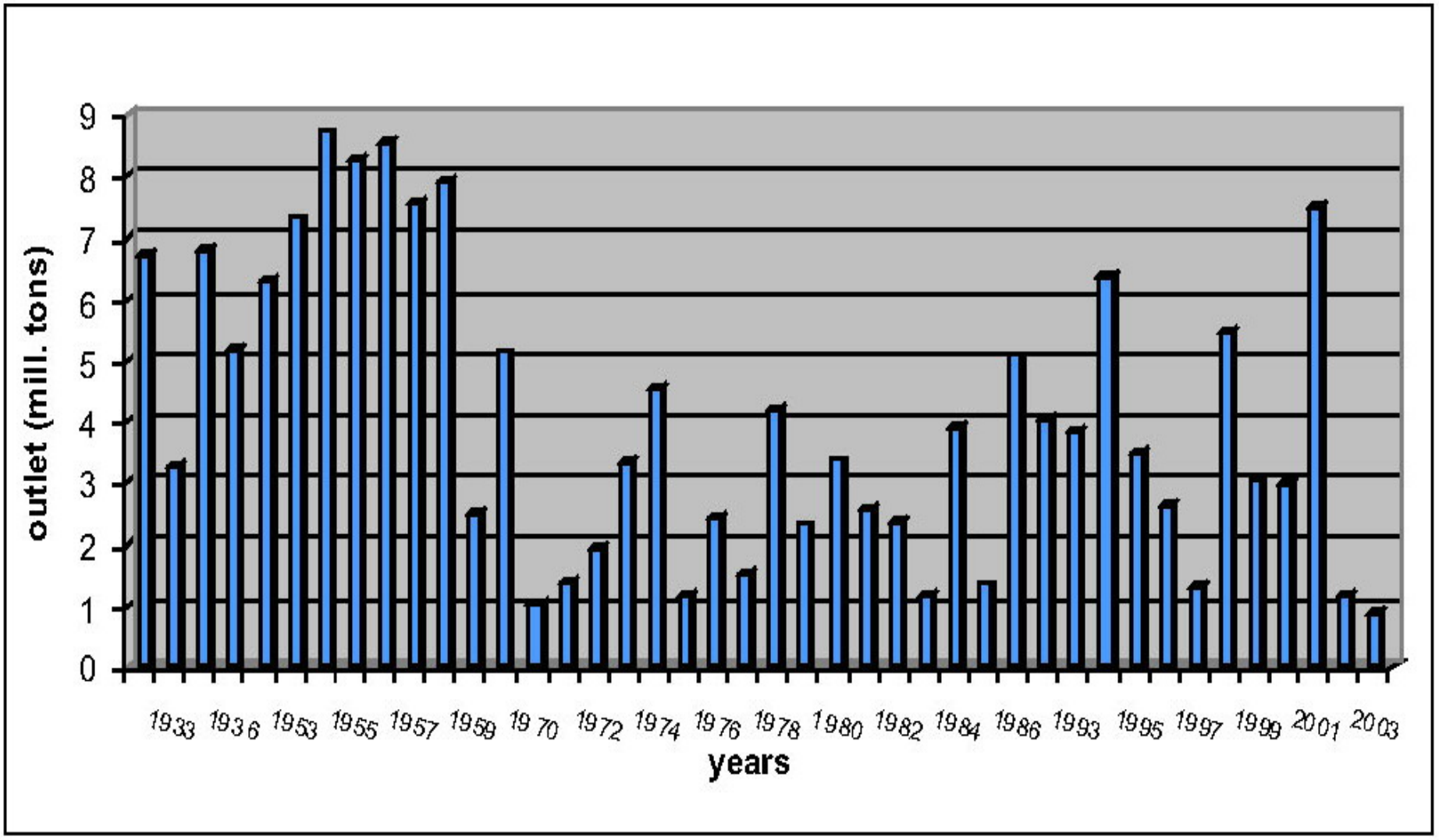

left side dike
measured (fixed) water level 08/2002 (6590 m3/s)
Q1000 – 13 400 m3/s
Q1000 – 11 000 m3/s + 2400 m3/s (canal)
Q100 – 10 600 m3/s
Q100 – 7 800 m3/s + 2800 m3/s (canal)+ regulations
Q100 – 10 600 m3/s + regulations
Q100 – 7 800 m3/s + 2800 m3/s (canal)
Q100 – 10 600 m3/s in 1977
water level (m a.s.l.)
rkm
Medvedov
Gabcikovo
Dunaremete
Dobrohost
Rajka

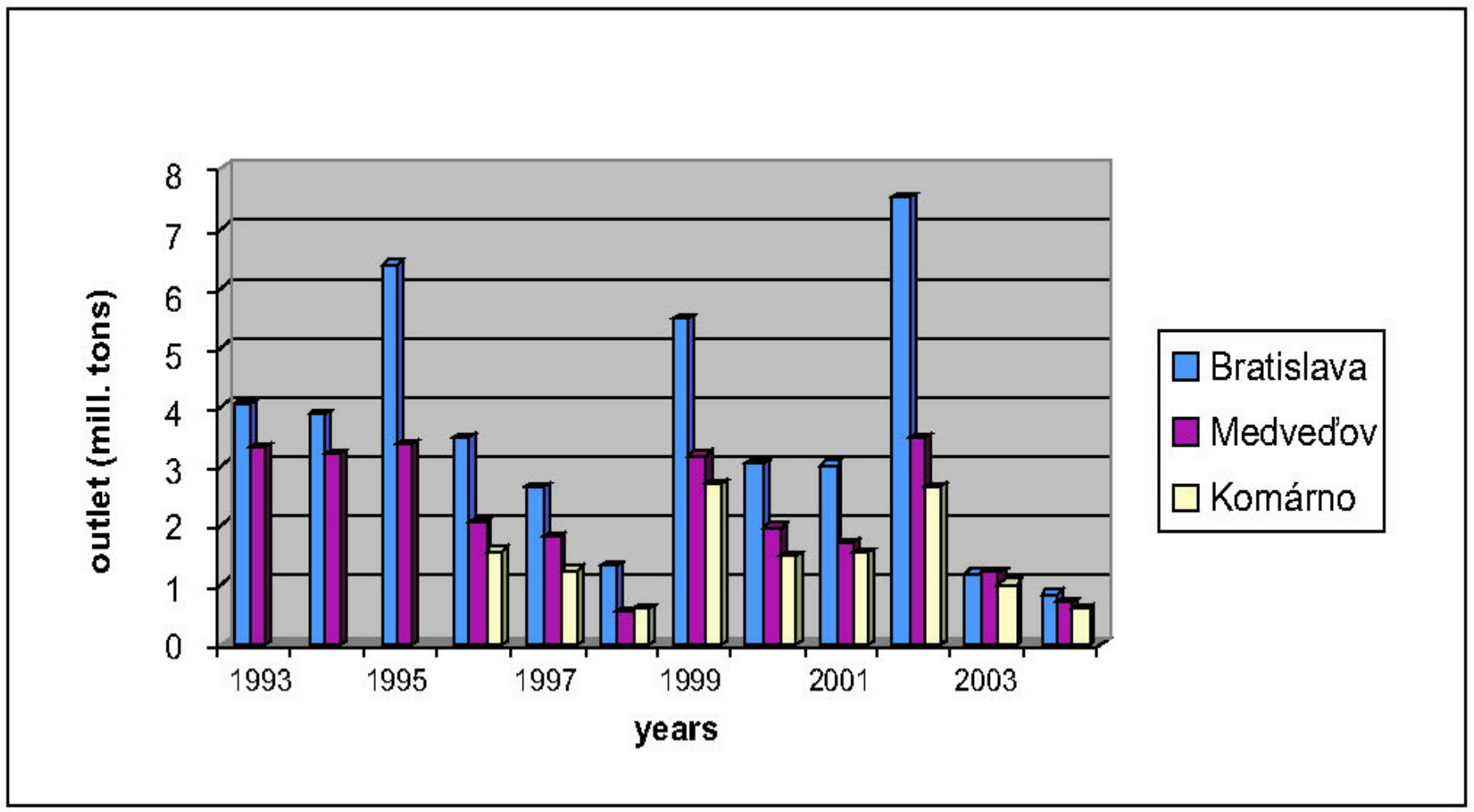
The regulative measures focused on improvement of the discharge capacity of the Old Danube and the floodplain area in the stretch Čunovo – Sap (removal of vegetation from inside of the Old Danube river channel, floodplain maintenance, mowed meadows in the floodplain, adjustment of the river channel capacity, etc.) can provide a good reduction of water level during flood events. The course of water level in the lower part of the arm system and in the area at Sap is influenced by changes of the floodplain area (floodplain shape, vegetation overgrowing, retention, human impacts), hydrological coincidence of flood discharges downstream of the confluence (tailrace canal and the Old Danube) and backwater effect upstream of Medveďov bridge profile. The results indicated that **the most evident increase of flood water level propagates upstream of Medveďov**, thus improvement measures should concentrate not only at the Old Danube floodplain but also at this river section. These questions are solved at present although complexly, in close collaboration with the Hungarian specialists.


outlet (mill. tons)
0
1
2
3
4
5
6
7
8
9
1952
1953
1954
1955
1956
1957
1958
years


outlet (mill. tons)
8
7
6
5
4
3
2
1
0
1993
1995
1997
1999
2001
2003
years

Suspended load transport in the Danube at Bratislava




outlet (mill. tons)
0
1
2
3
4
5
6
7
8
1993
1995
1997
1999
2001
2003
years
Bratislava
Medveďov
Komárno

The conditions for the existence and development of erosion and sedimentation processes, and transport of suspended load and bed load have considerably changed in the Danube downstream from Bratislava in the last half-century. As shown by a series of measurements carried out by the Slovak Hydrometeorological Institute, the transport of suspended load strictly depends on water discharges. Sedimentation of suspended load in the Čunovo reservoir also depends on the discharge. In the years without an occurrence of higher discharges, the sedimentation of suspended load in the Čunovo reservoir is minimal to insignificant because that part of suspended load which could settle (correspondingly to its grain size) in the Čunovo reservoir, had already settled in the backwater stretch of the Freudenau hydraulic structure, and in the Danube and its arms upstream of the granite threshold in the Danube at Bratislava. These data could support the manipulation of discharges, stream velocities, and water levels in the Čunovo reservoir, and the manipulation of discharges in the arm system.