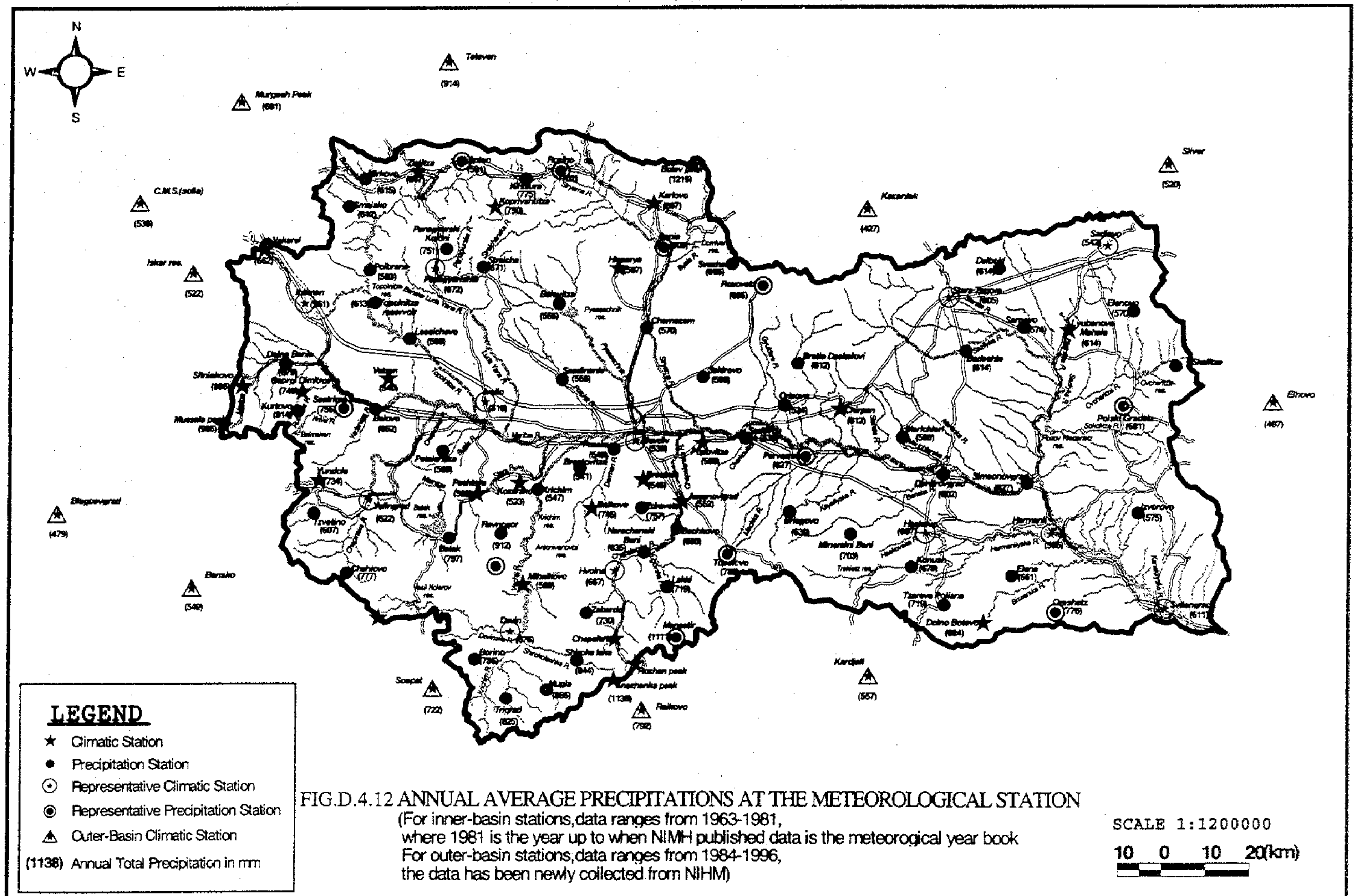


FIG.D.4.12 ANNUAL AVERAGE PRECIPITATIONS AT THE METEOROLOGICAL STATION
(For inner-basin stations,data ranges from 1963-1981,
where 1981 is the year up to when NIMH published data is the meteorogical year book
For outer-basin stations,data ranges from 1984-1996,
the data has been newly collected from NIHM)

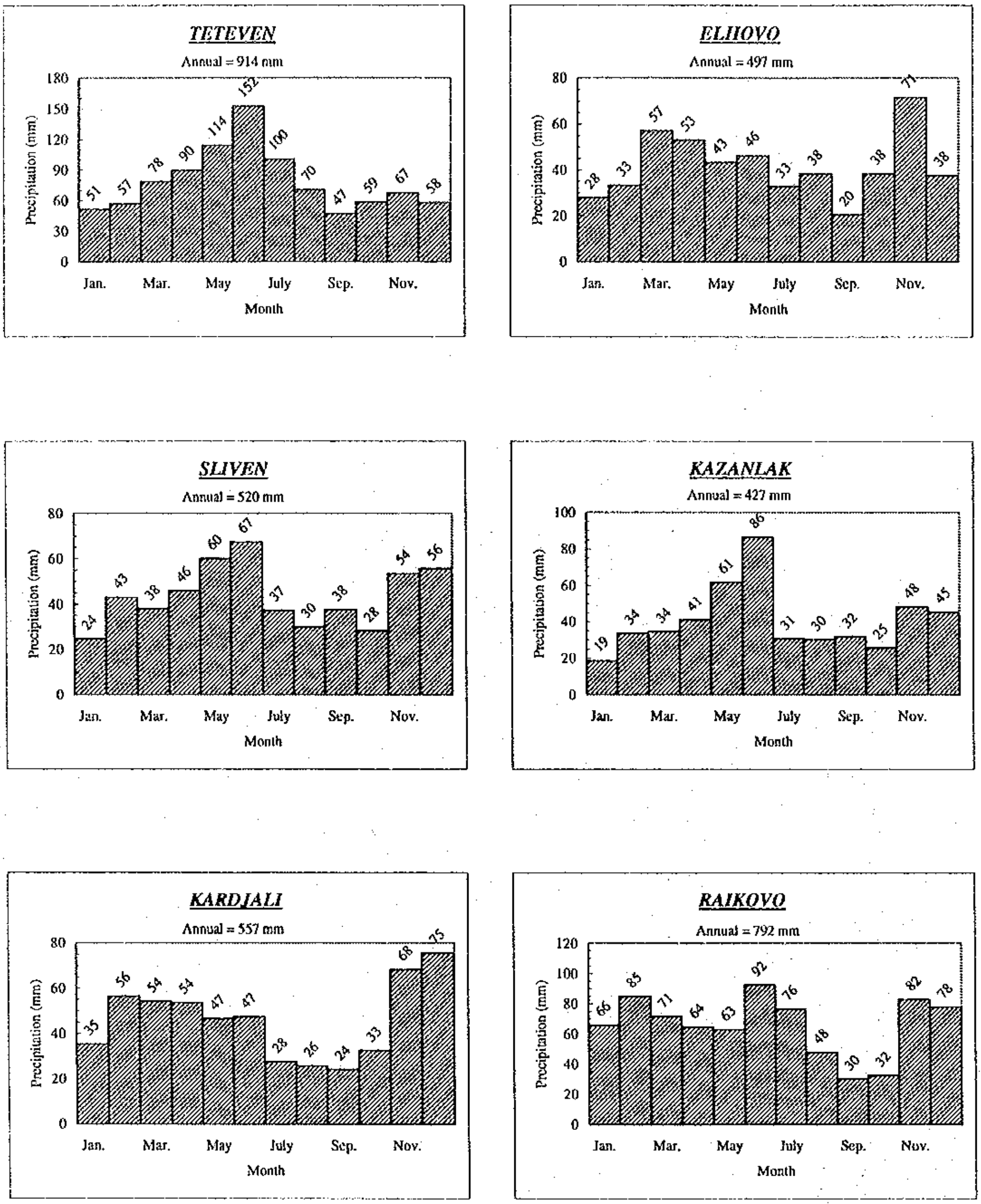


FIG. D.4.13 MONTHLY AVERAGE OUTER-BASIN PRECIPITATIONS (1984-1996) (1/2)

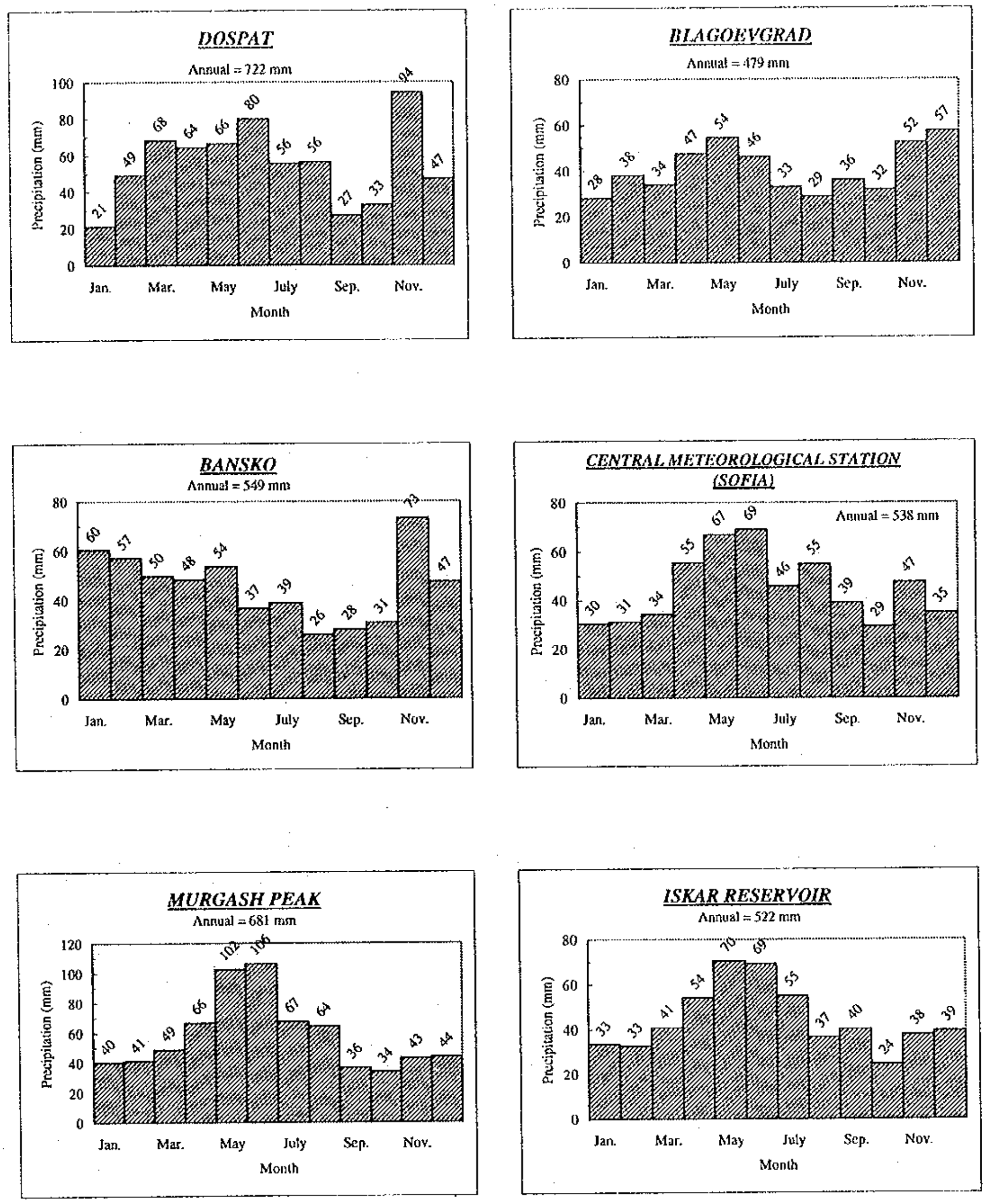


FIG. D.4.13 MONTHLY AVERAGE OUTER-BASIN PRECIPITATIONS (1984-1996) (2/2)

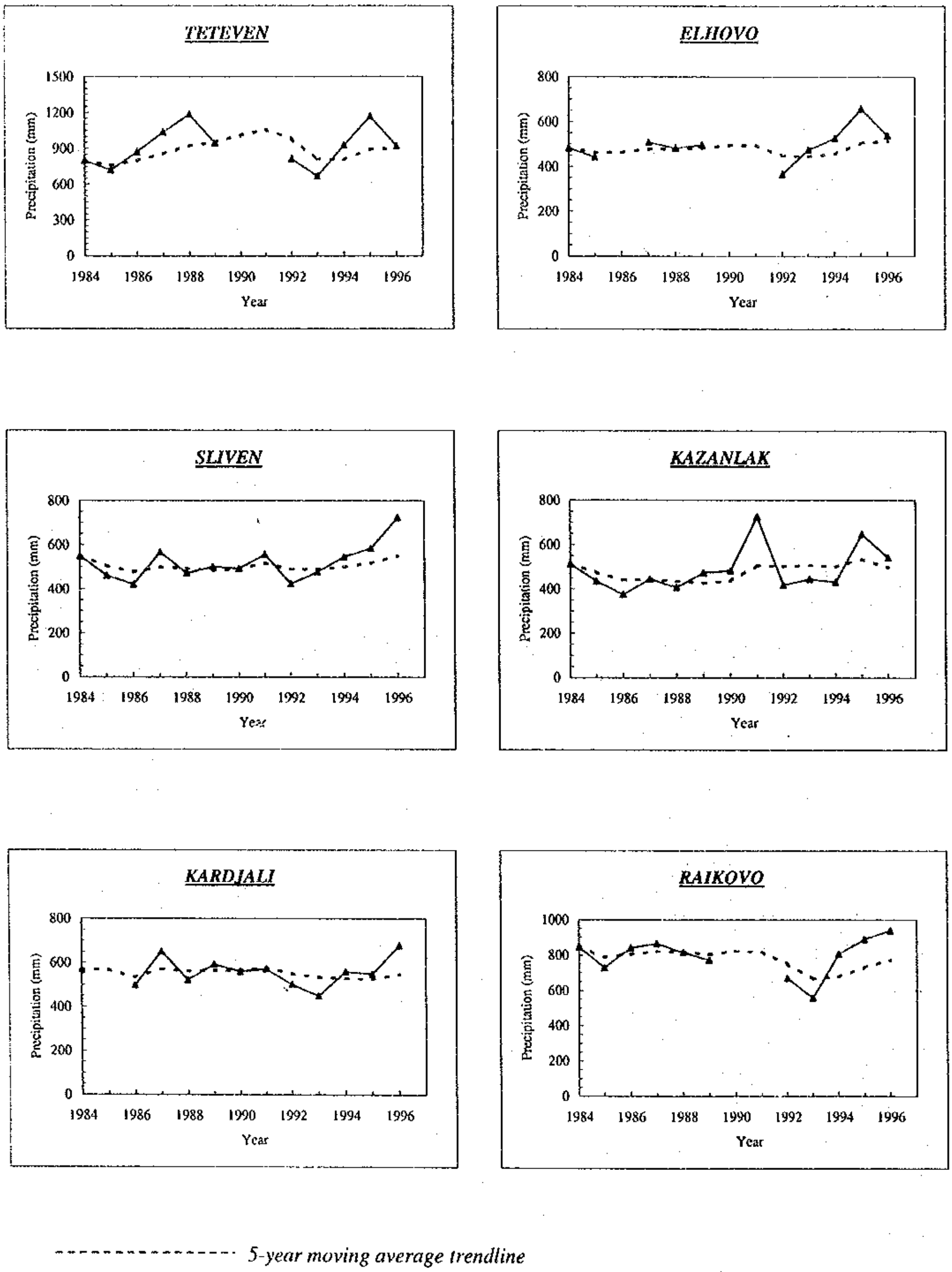


FIG. D.4.14 YEARLY OUTER-BASIN PRECIPITATIONS (1984 - 1996) (1/2)

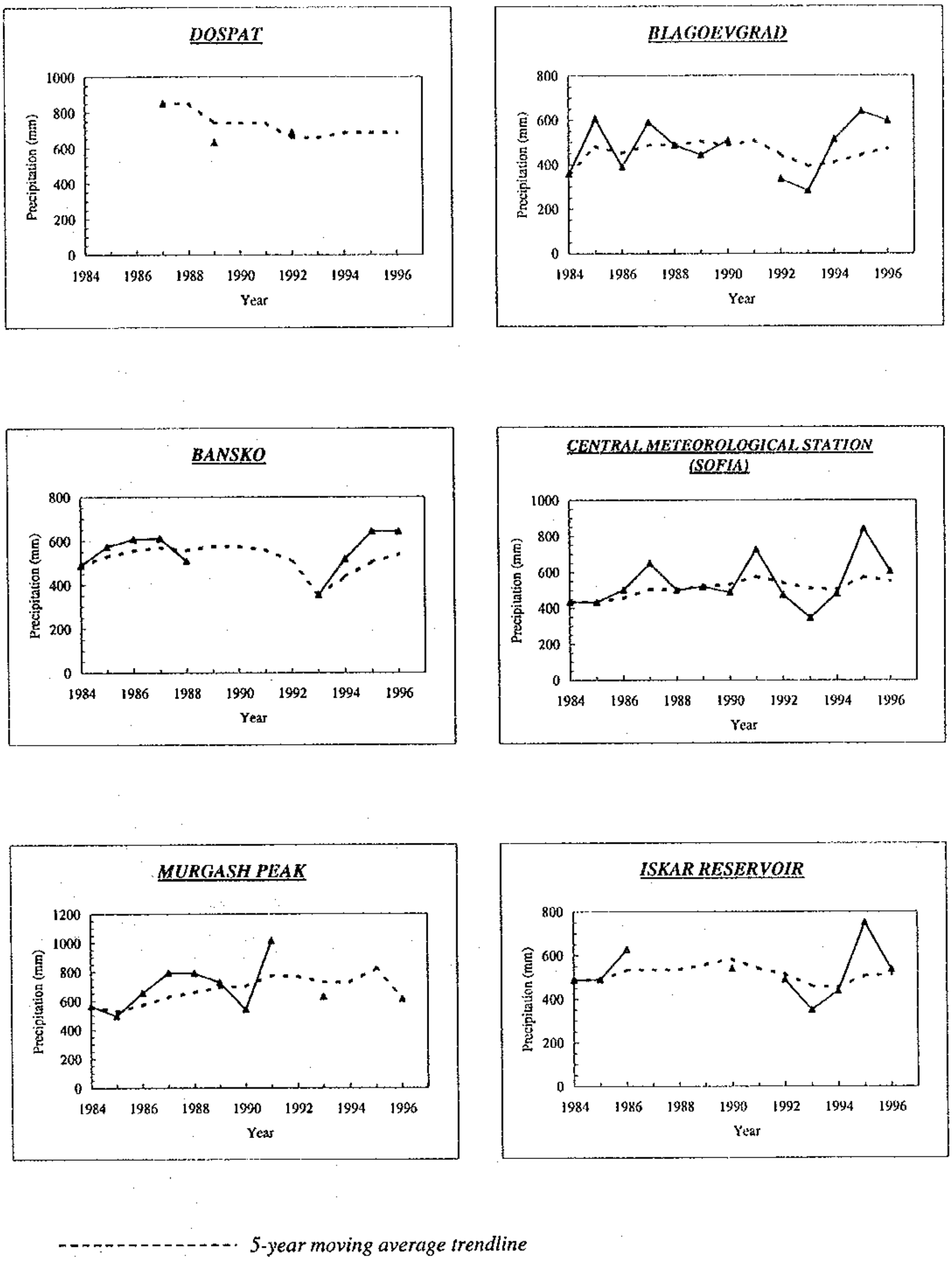


FIG. D.4.14 YEARLY OUTER-BASIN PRECIPITATIONS (1984 - 1996) (2/2)

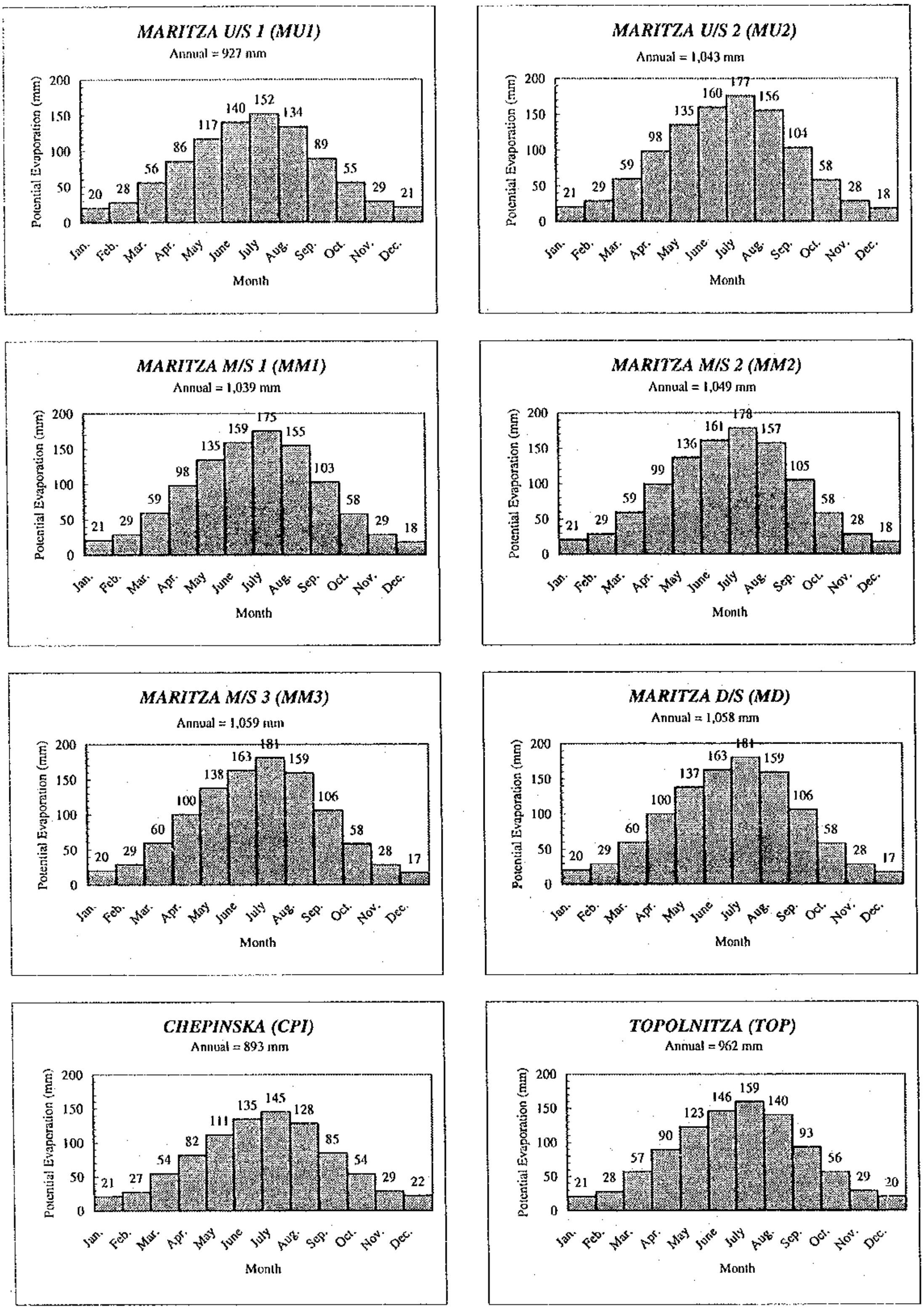


FIG. D.4.15 POTENTIAL EVAPORATIONS OF MAJOR BASINS (1963-1995) (1/2)

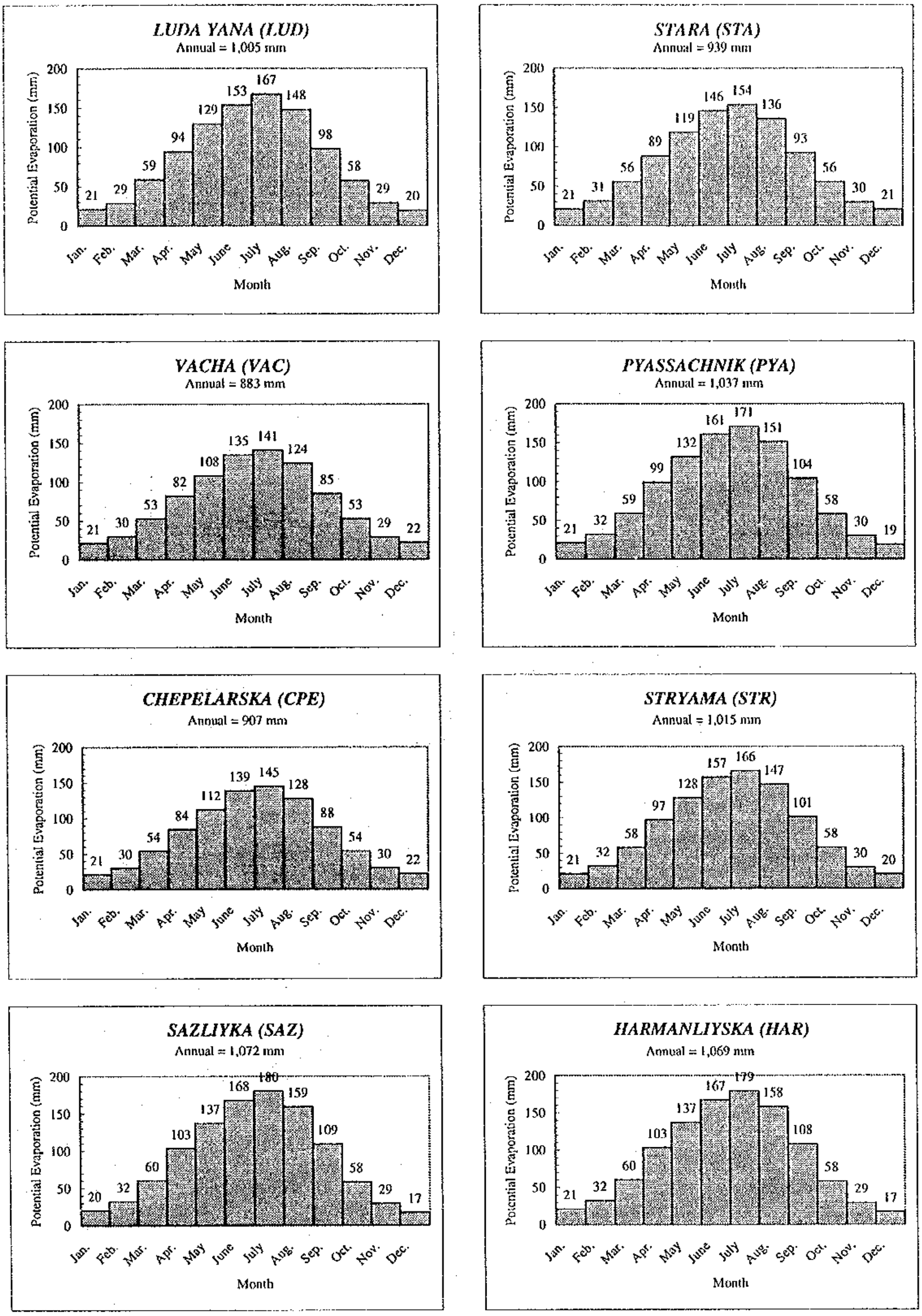
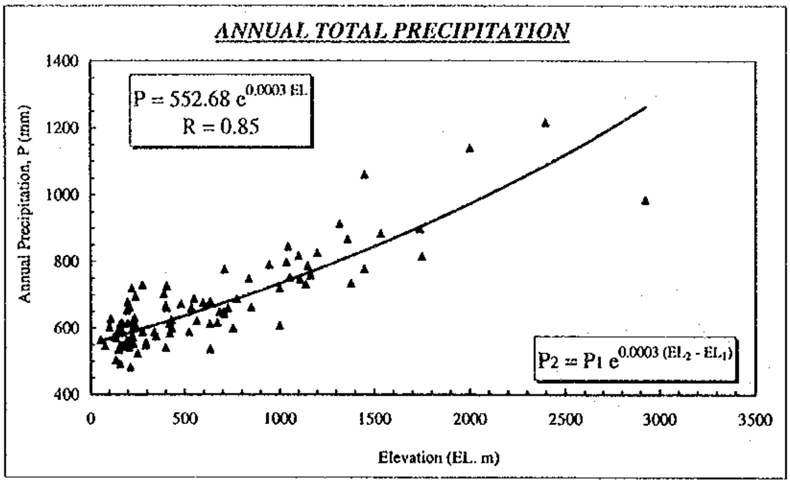
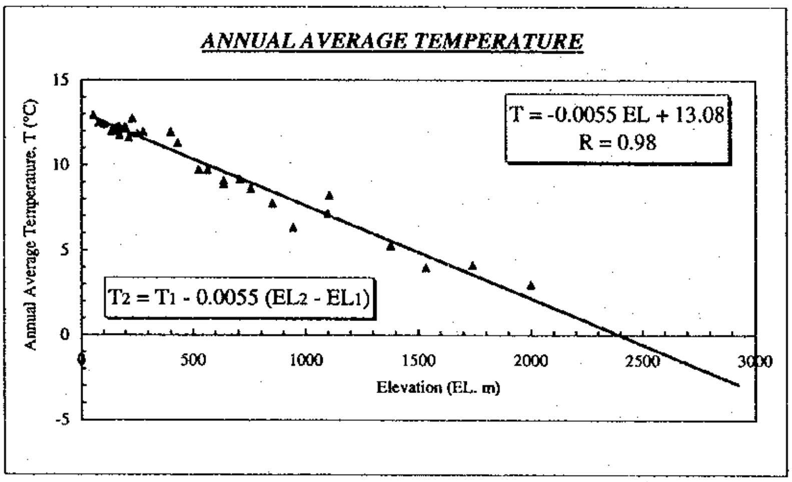


FIG. D.4.15 POTENTIAL EVAPORATIONS OF MAJOR BASINS (1963-1995) (2/2)





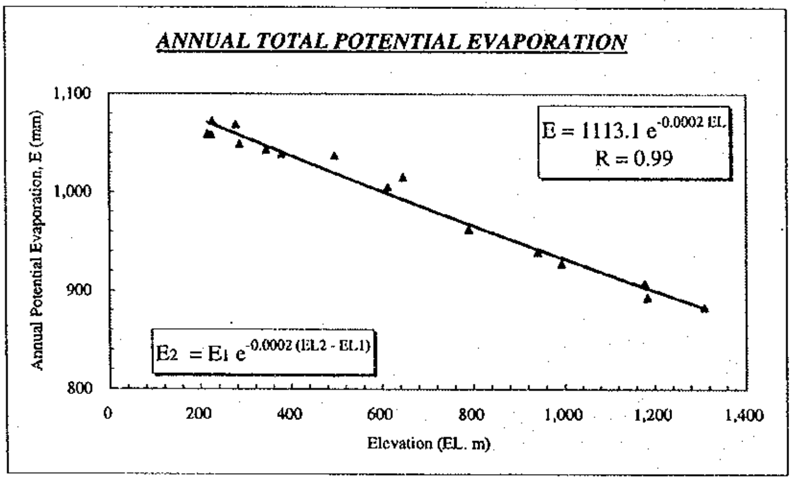


FIG. D.4.16 ELEVATION-METEOROLOGICAL PARAMETER RELATIONS

(data ranges from 1963-1995 and 1963-1981, depending upon availability)

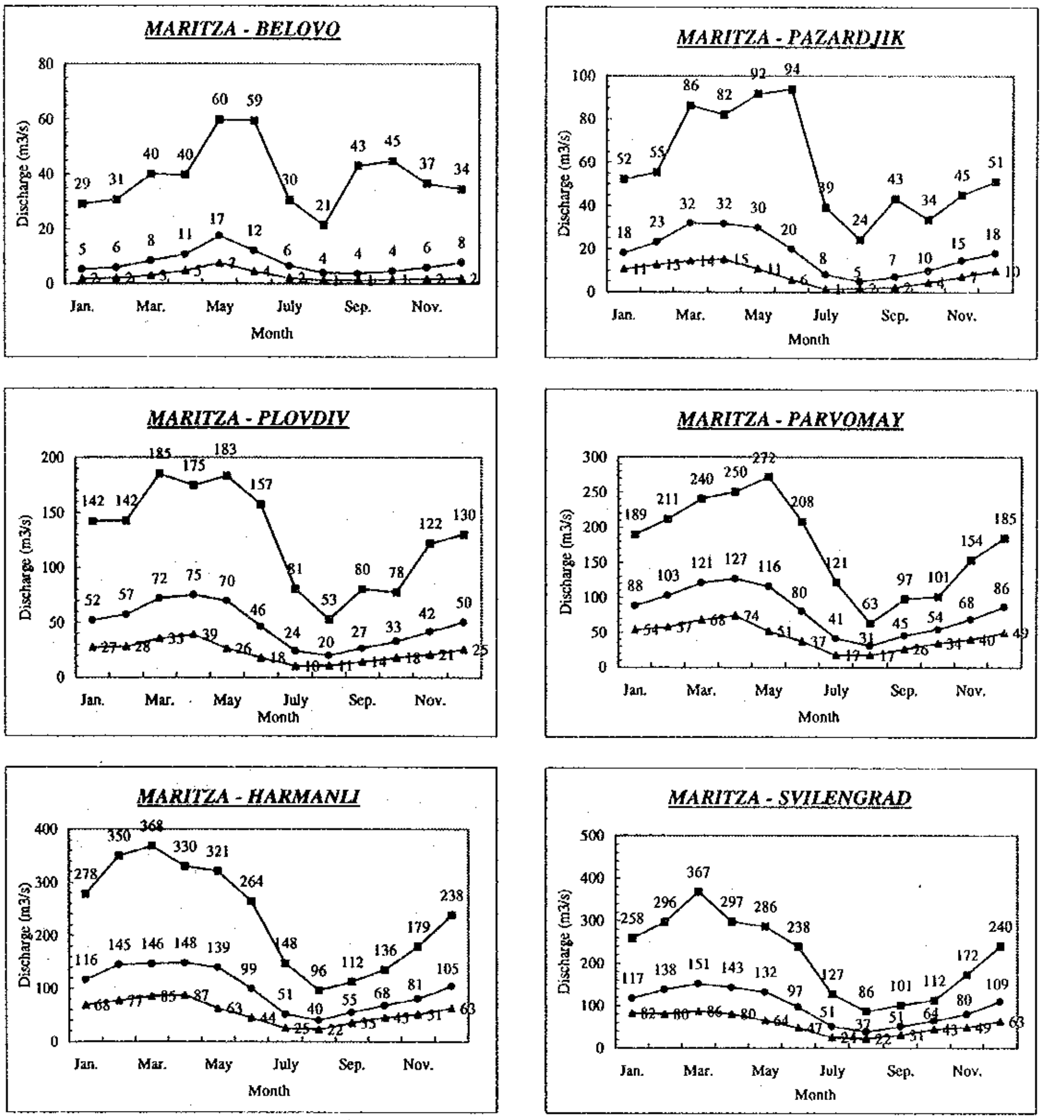


FIG. D.5.1 MINIMUM, AVERAGE AND MAXIMUM DISCHARGES (1946-1995) (1/2)

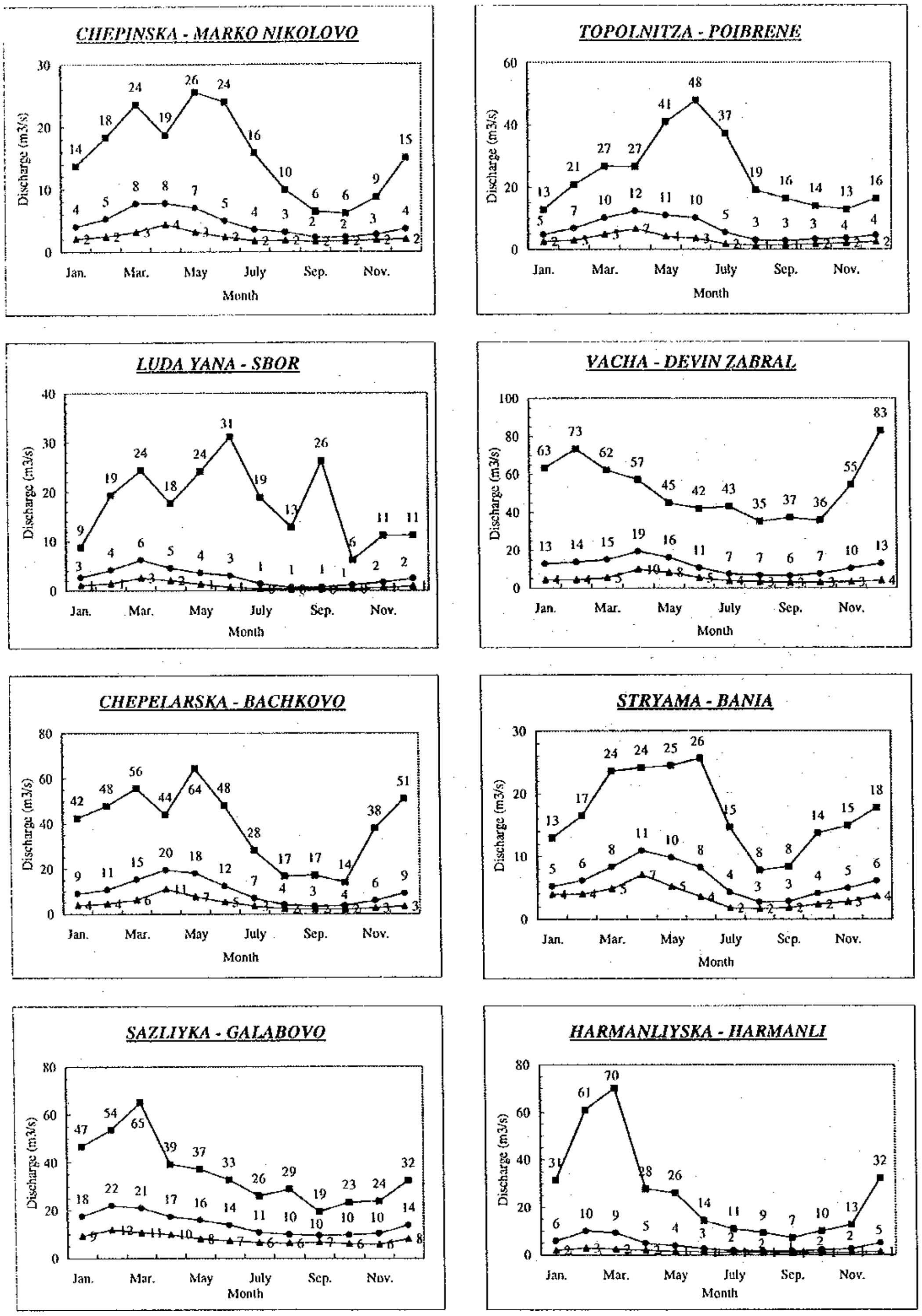


FIG. D.5.1 MINIMUM, AVERAGE AND MAXIMUM DISCHARGES (1946-1995) (2/2)

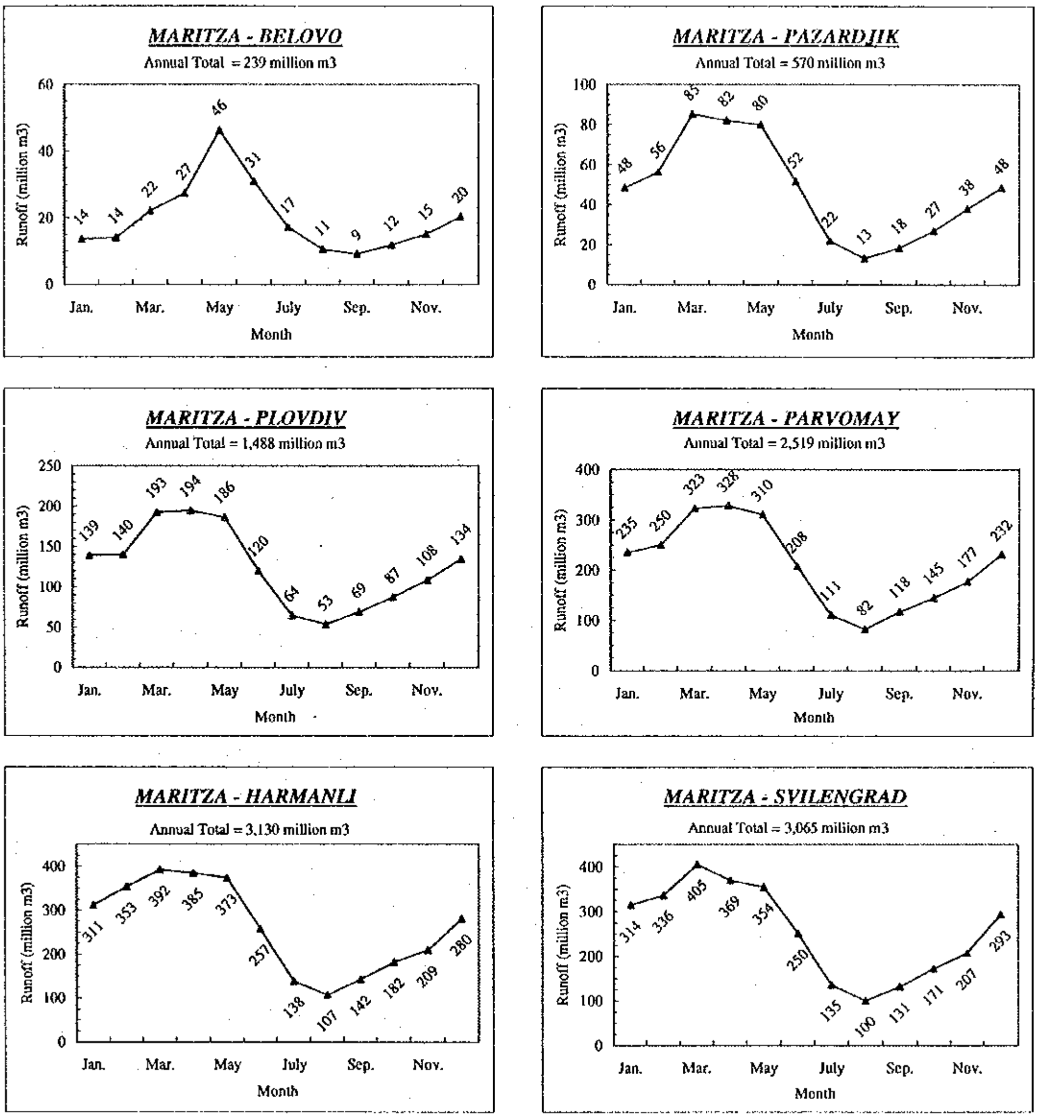


FIG. D.5.2 MONTHLY AVERAGE RUNOFF (1946 - 1995) (1/2)

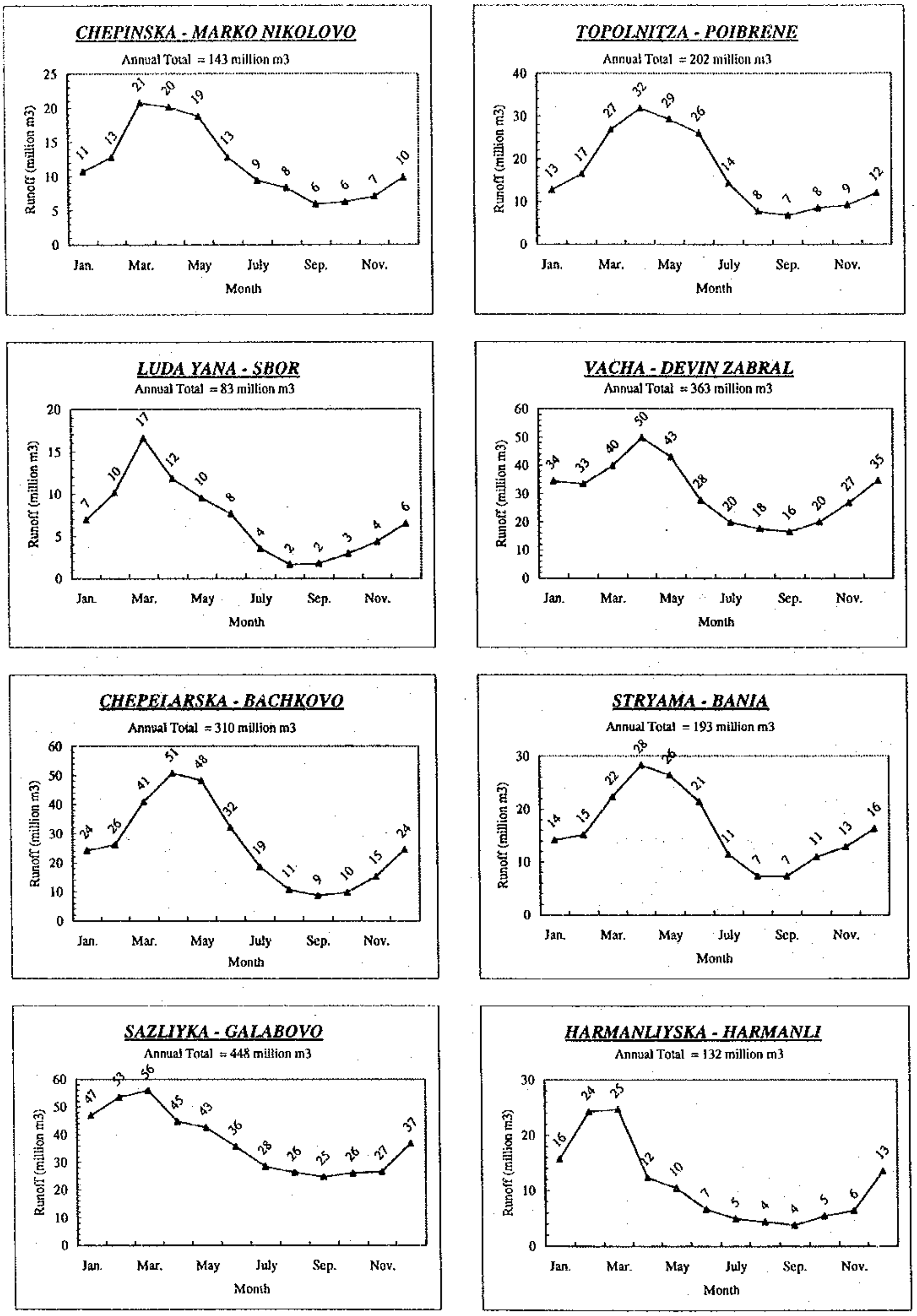
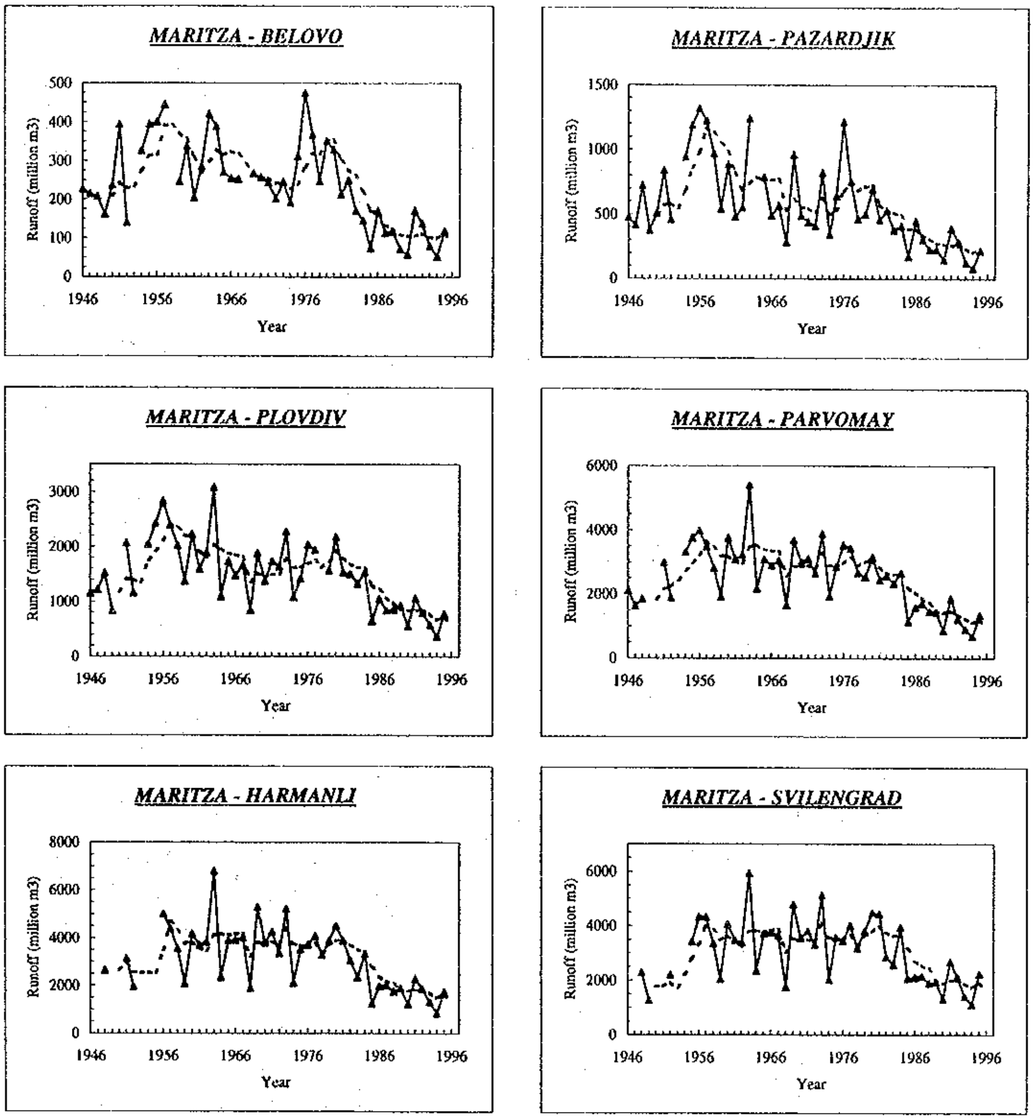


FIG. D.5.2 MONTHLY AVERAGE RUNOFF (1946 - 1995) (2/2)



5-year moving average trendline

FIG. D.5.3 YEARLY VARIATION IN ANNUAL RUNOFF (1946 - 1995) (1/2)

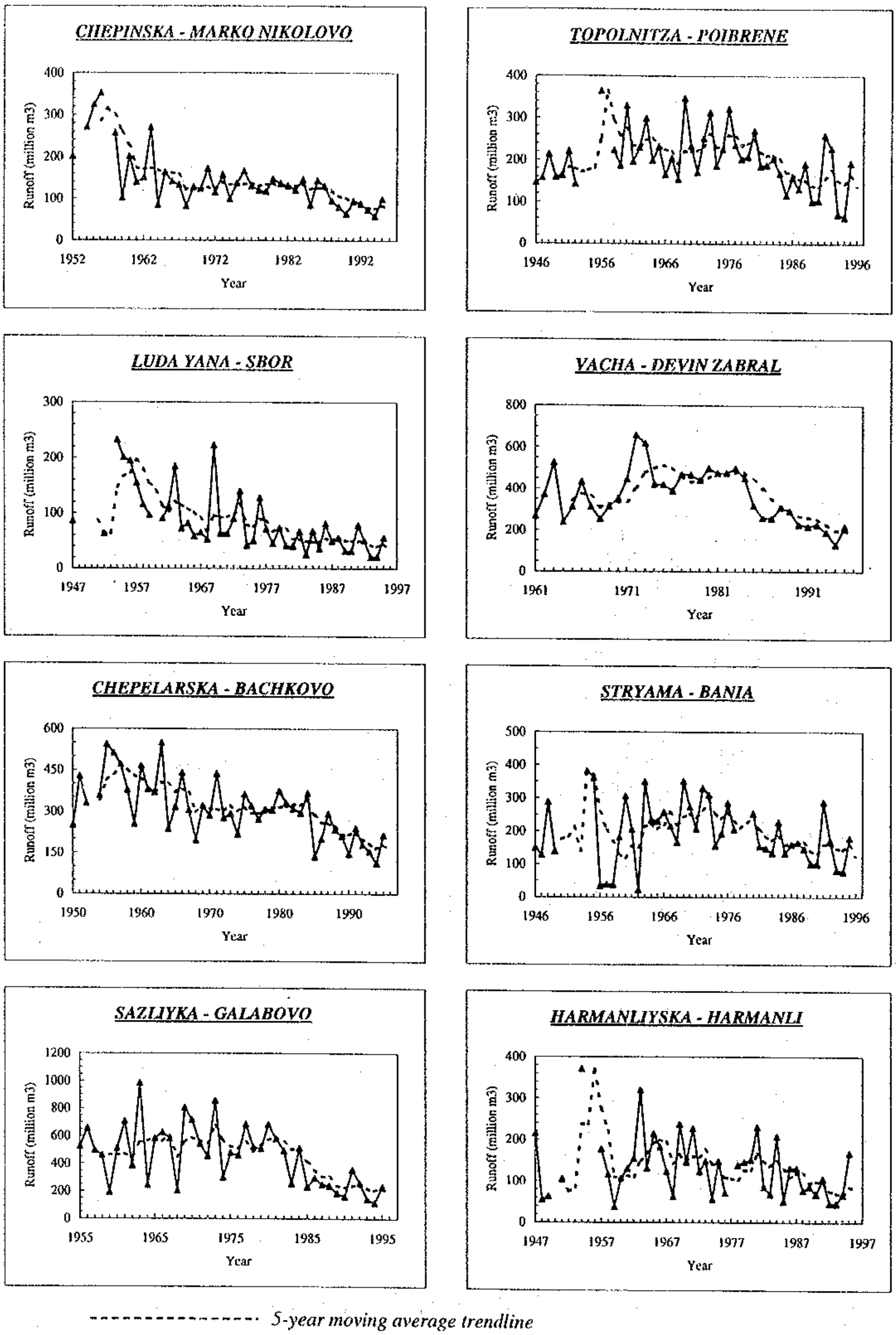
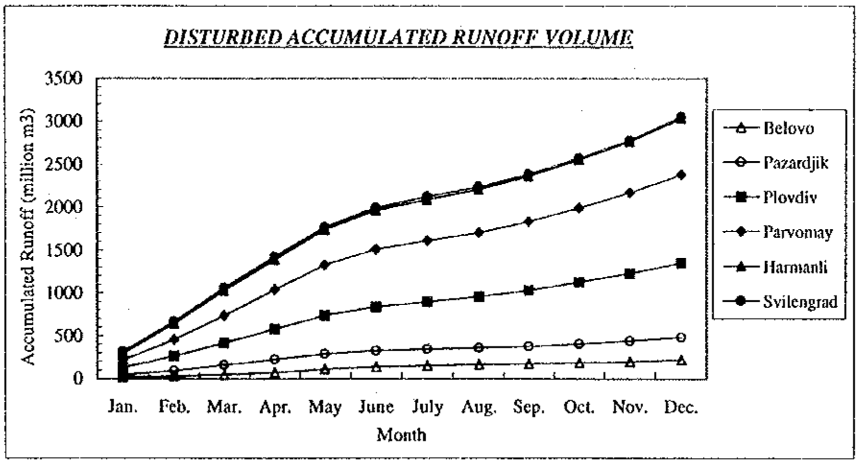
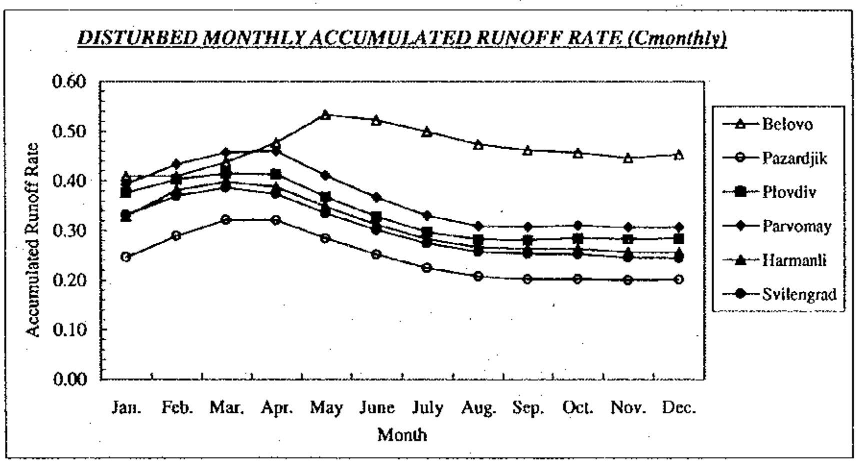


FIG. D.5.3 YEARLY VARIATION IN ANNUAL RUNOFF (1946 - 1995) (2/2)





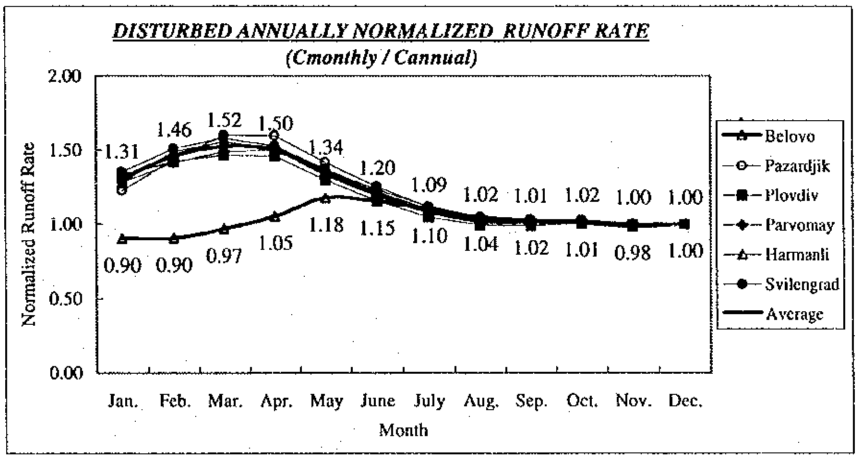
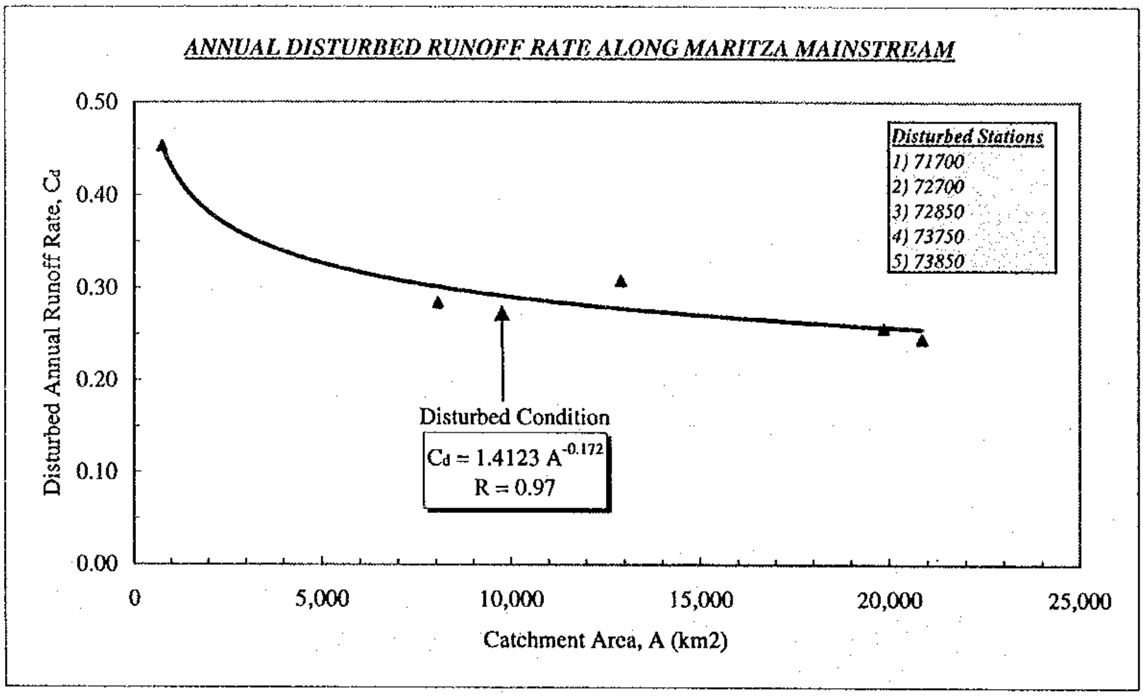
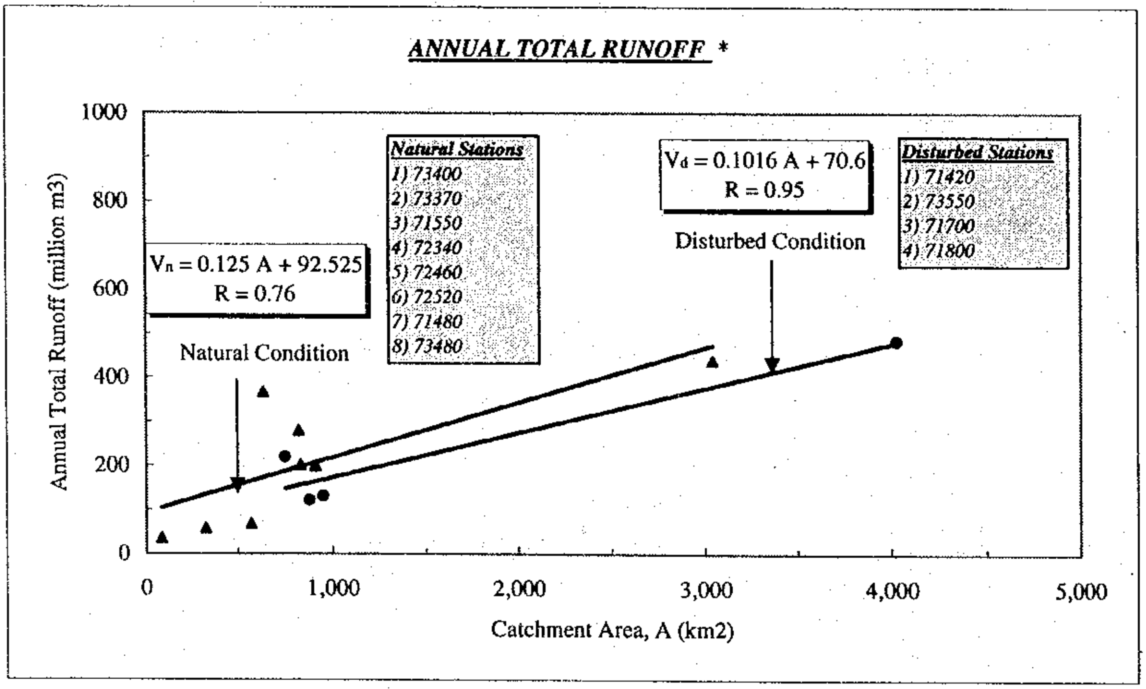


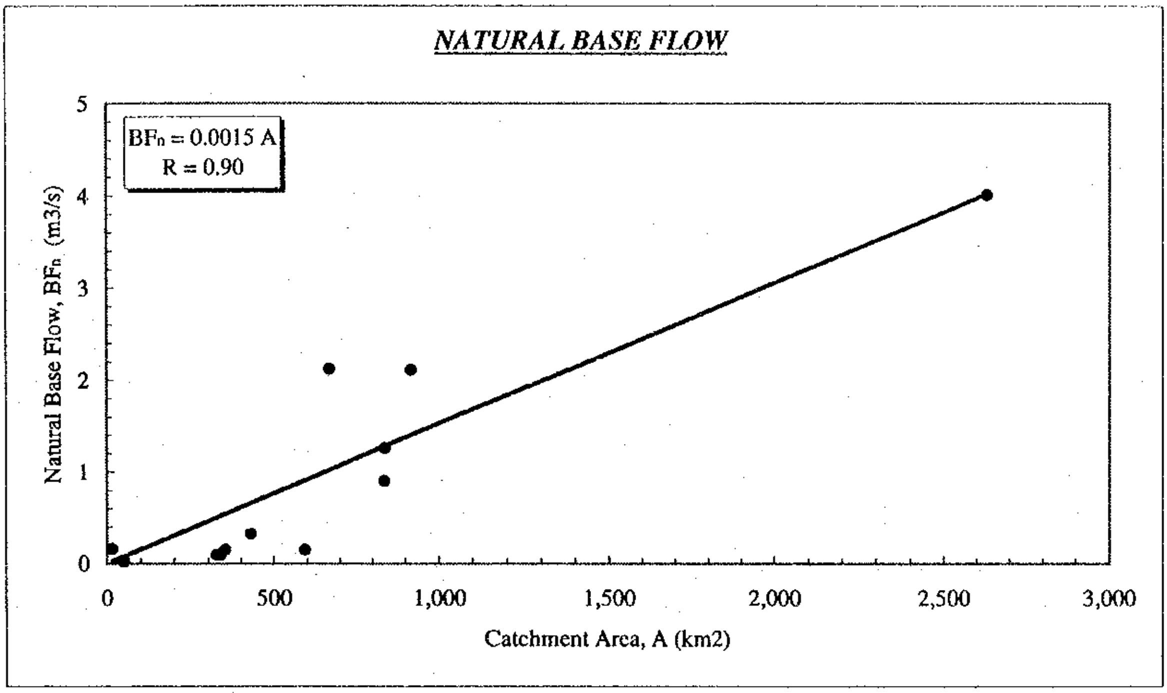
FIG. D.5.4 MASS CURVES OF DISTURBED RUNOFF RATES (1963 - 1995)





* : *Disturbed hydrometric stations with large catchment sizes have not been included as they provide no clear comparison between natural and disturbed flow.*

FIG. D.5.5 NATURAL AND DISTURBED ANNUAL RUNOFFS (1963 - 1995)



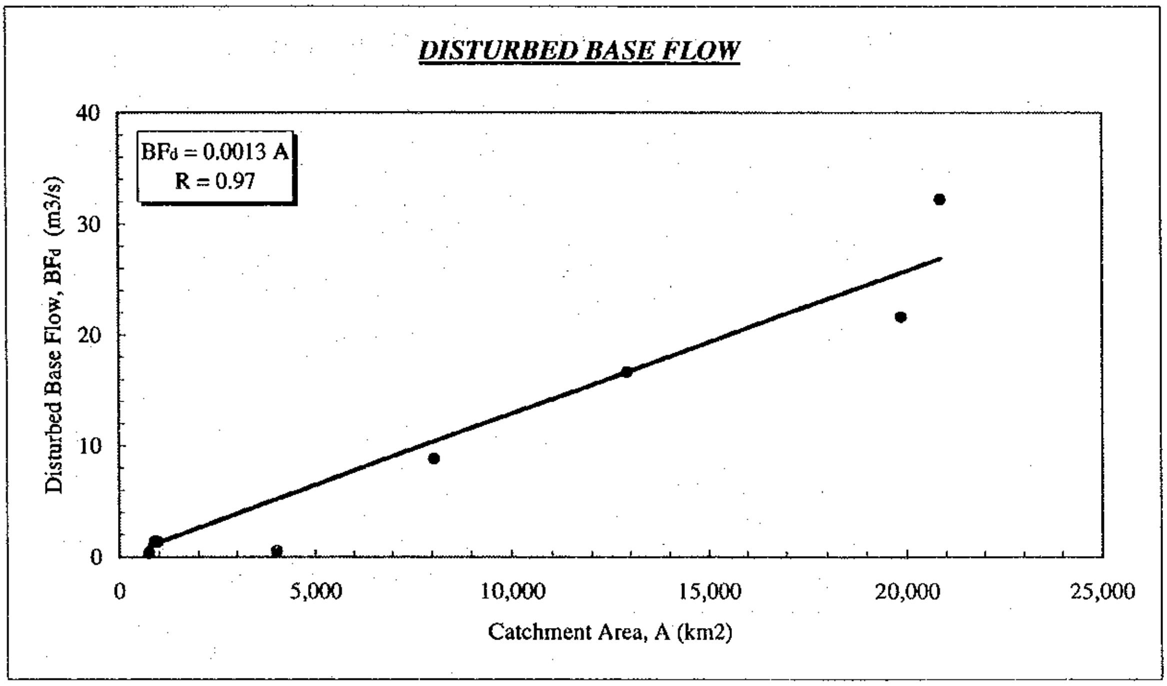


FIG.D.5.6 NATURAL AND DISTURBED BASE FLOWS (1995)

LANDUSE AREA OF CATCHMENTS ALONG MARITZA MAINSTREAM STATIONS
(FROM CORINE LAND COVER MAP USING GIS)

Landuse / Station	Landuse Area (km2)					
	Belovo 71700	Pazardjik 71800	Plovdiv 72700	Parvomay 72850	Harmanli 73750	Svilengrad 73850
Forest	417	2,140	3,940	5,560	6,603	6,824
Grassland	75	434	775	1,300	1,867	1,964
Fruit Tree	13	86	235	423	669	707
Non-Irrigated Land	152	913	1,906	3,600	6,668	7,132
Irrigated Land	8	120	535	927	2,148	2,209
Water Body	5	38	54	84	131	138
Urban Area	23	128	300	515	898	936
Bare Land	59	168	331	509	880	950
Total	752	4,027	8,076	12,918	19,864	20,860

ANNUAL TOTAL RUNOFF RATE AS A FUNCTION OF LANDUSE

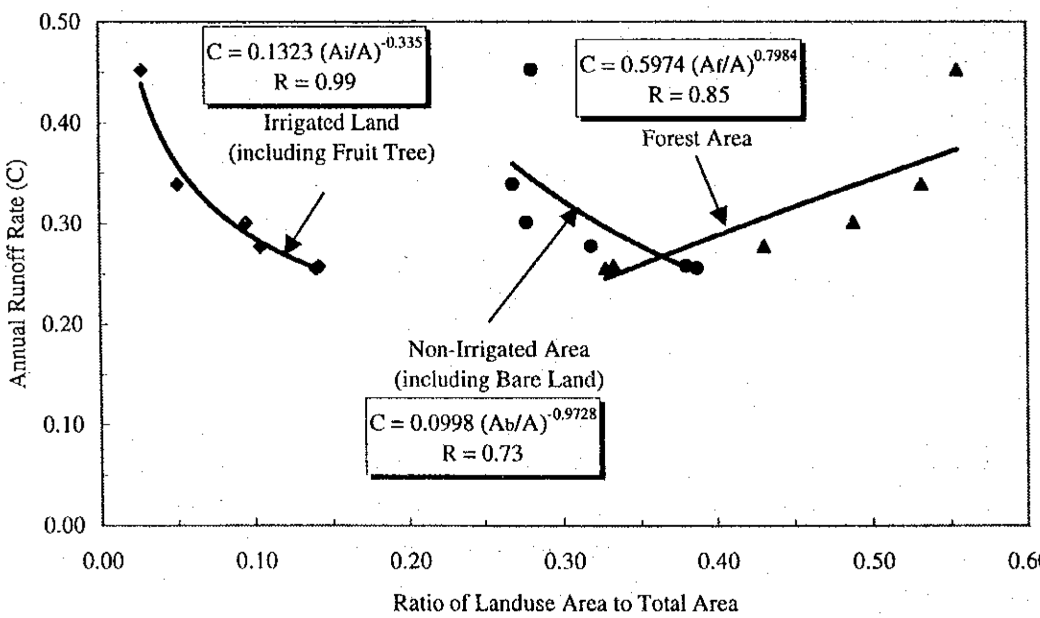


FIG. D.5.7 DISTURBED ANNUAL RUNOFF RATE - LANDUSE RELATIONS

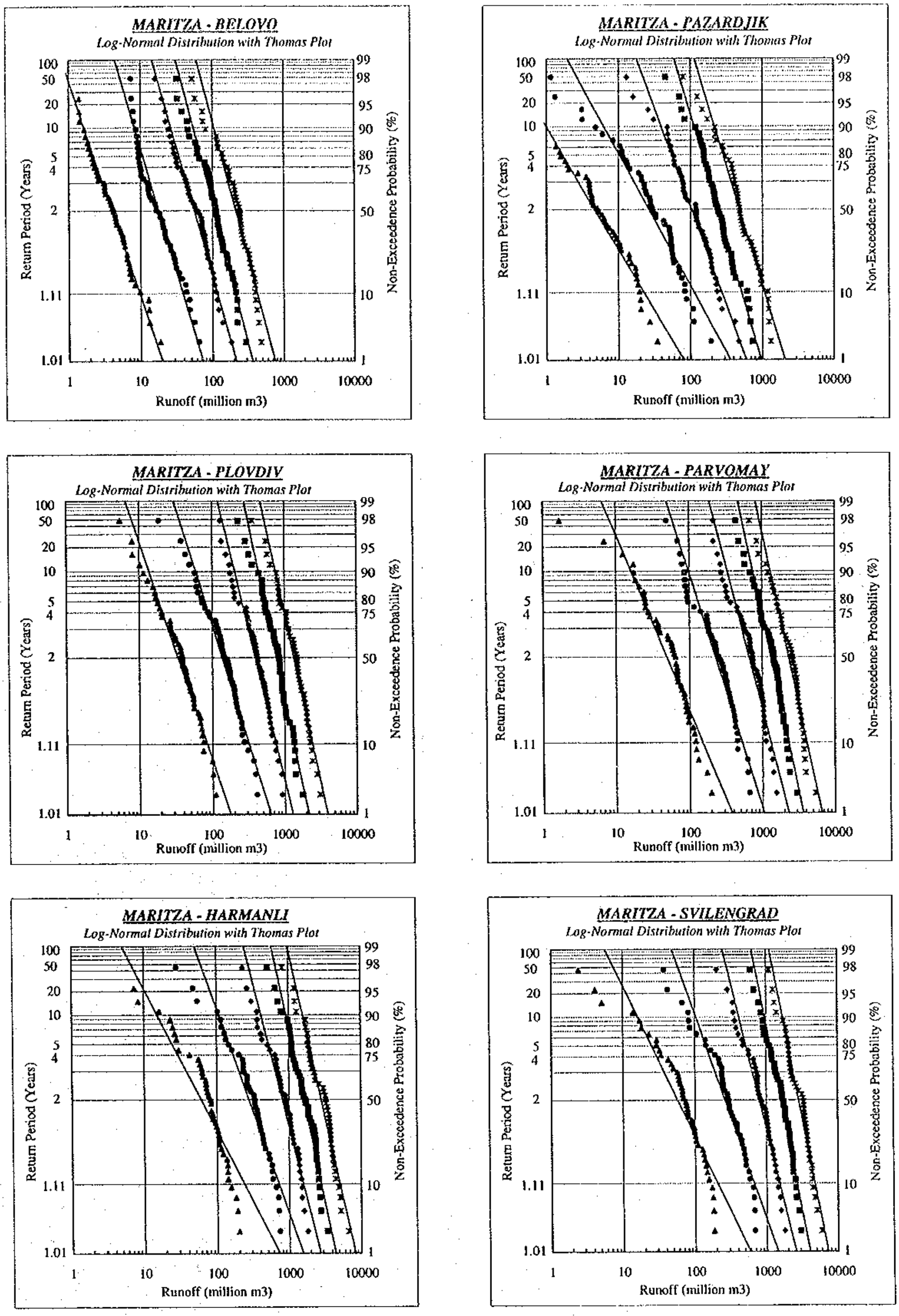
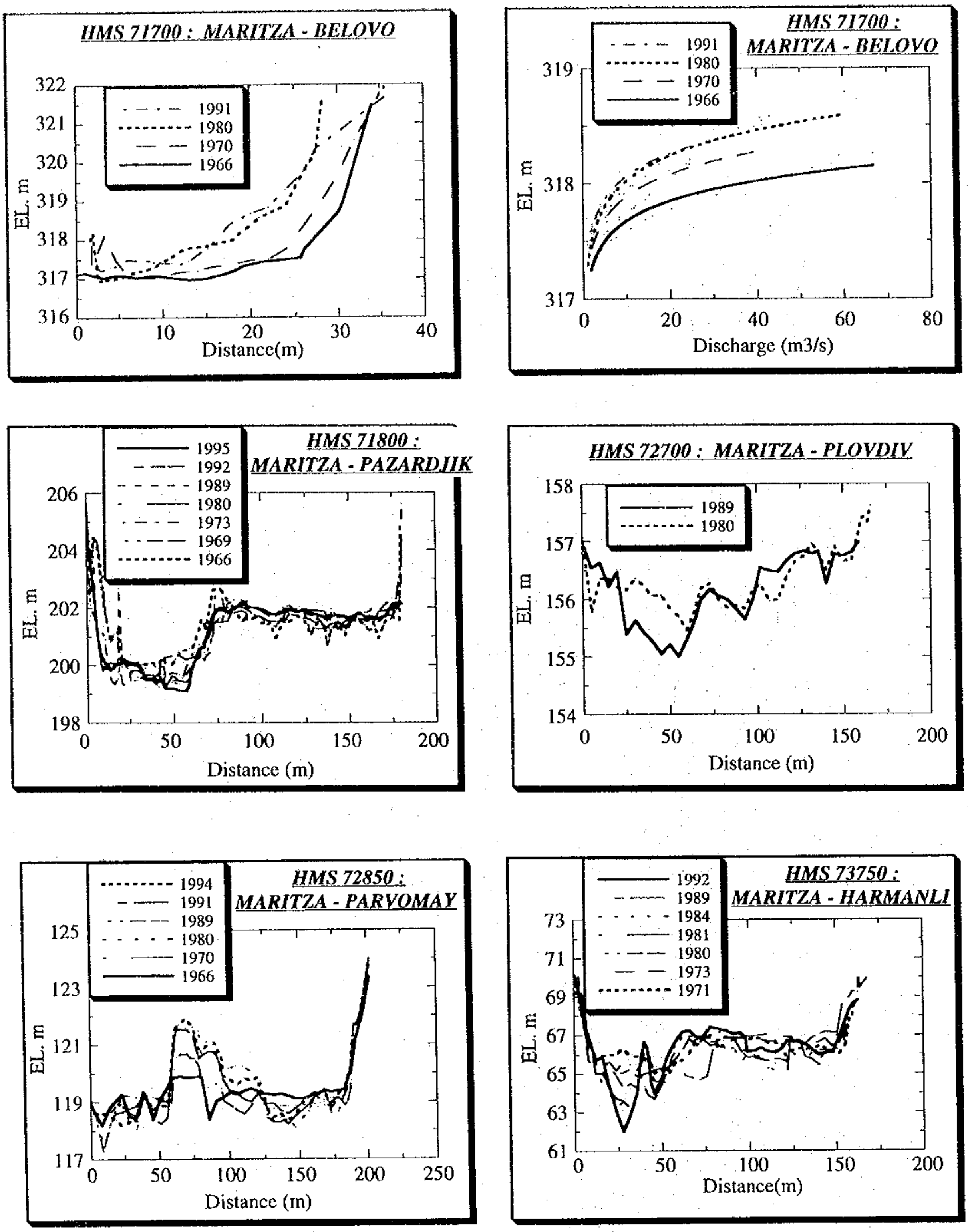


FIG. D.5.8 PROBABLE MINIMUM 1, 3, 6, 9 AND 12-MONTH RUNOFFS (1946-1995)



Note: *The rating curves have been replotted after estimating measured values from NIMH graph sheets. Actual NIMH rating curves are hand fitted, more detailed (sometimes different curves according to stage) and looped in general. For simplicity, the rating curves have been replotted using single valued power type equations since the objective of the rating curves here are only to see the trend.*

FIG. D.5.9 HISTORICAL CROSS-SECTIONS AND RATING CURVES (1/3)

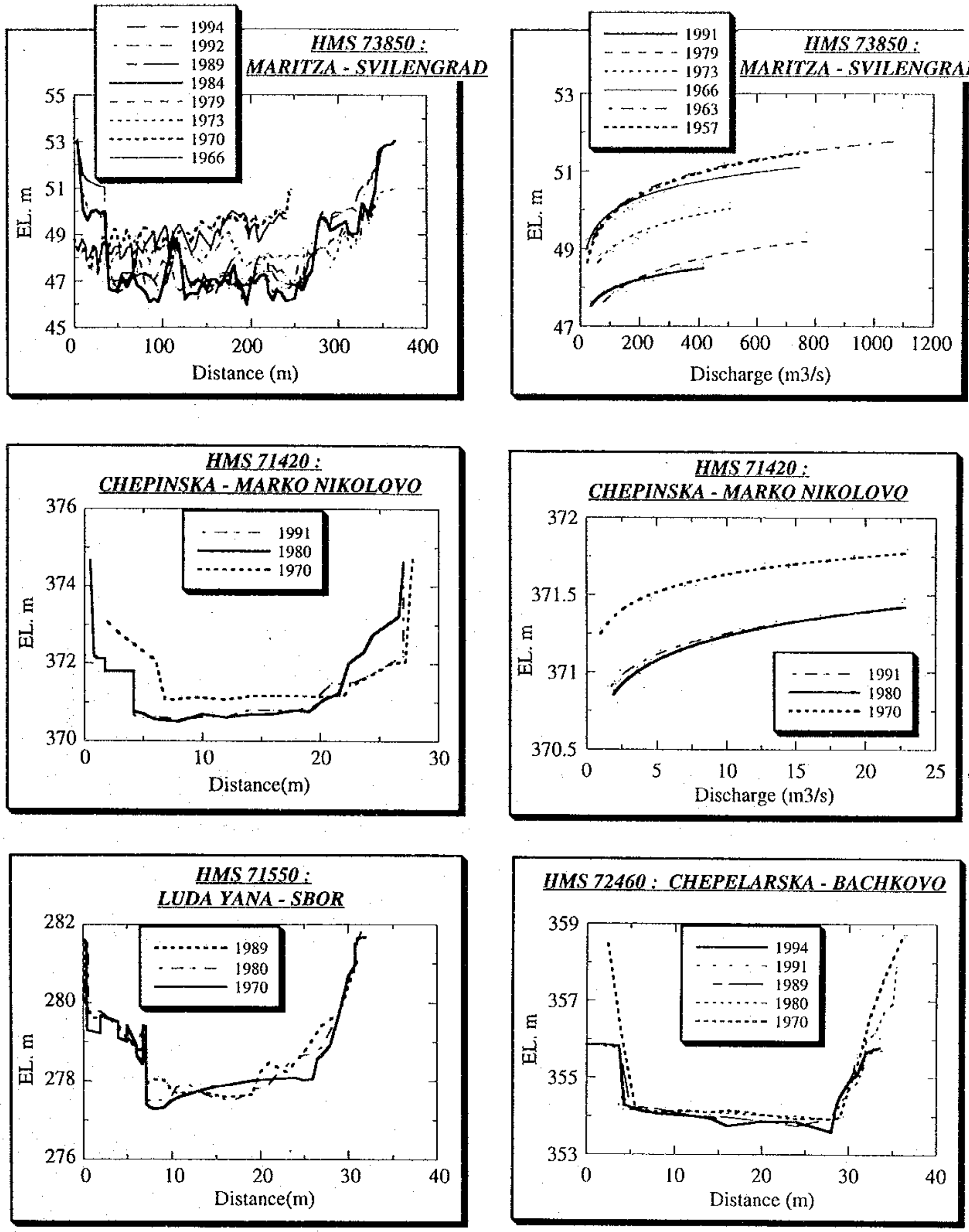


FIG. D.5.9 HISTORICAL CROSS-SECTIONS AND RATING CURVES (2/3)

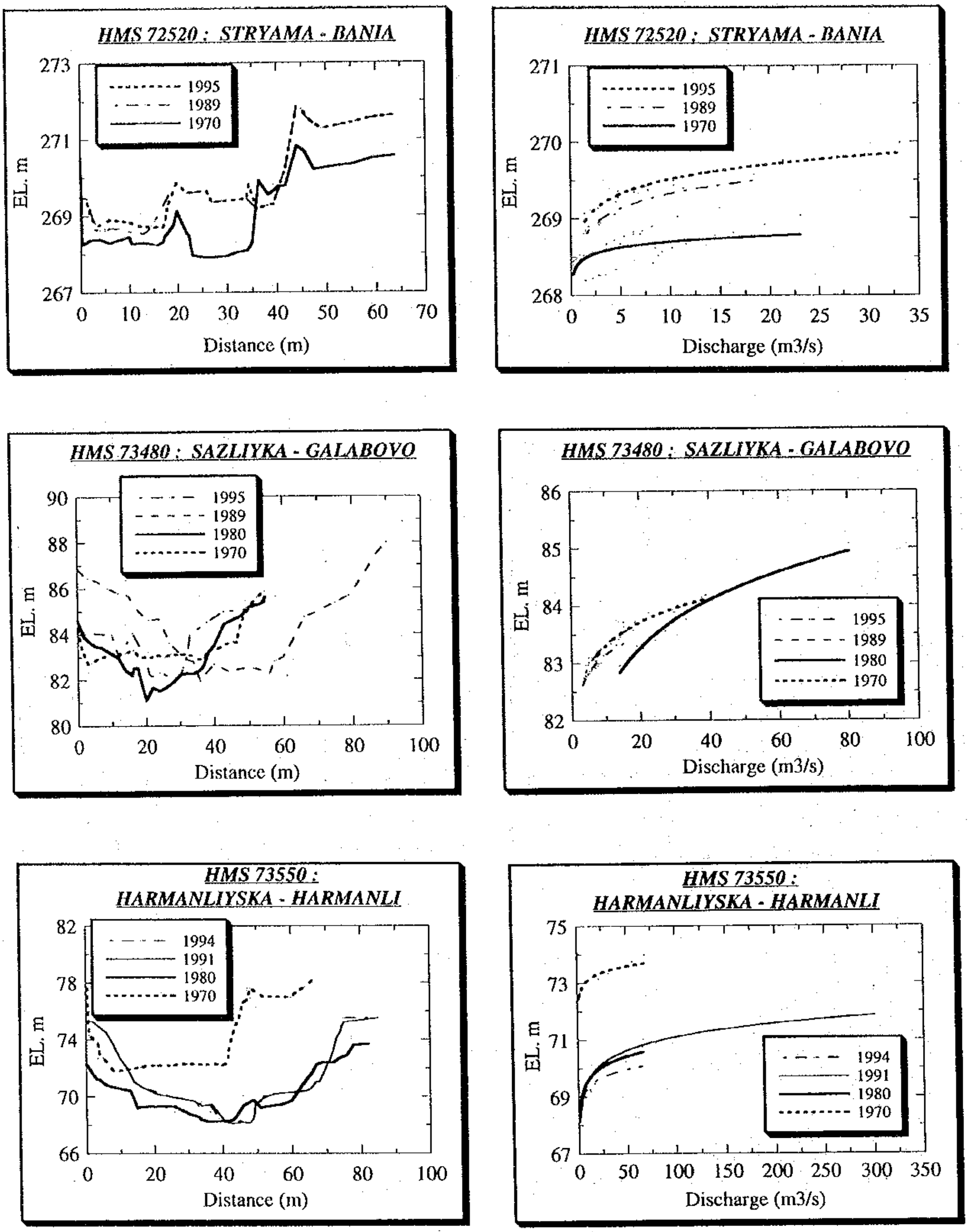


FIG. D.5.9 HISTORICAL CROSS-SECTIONS AND RATING CURVES (3/3)

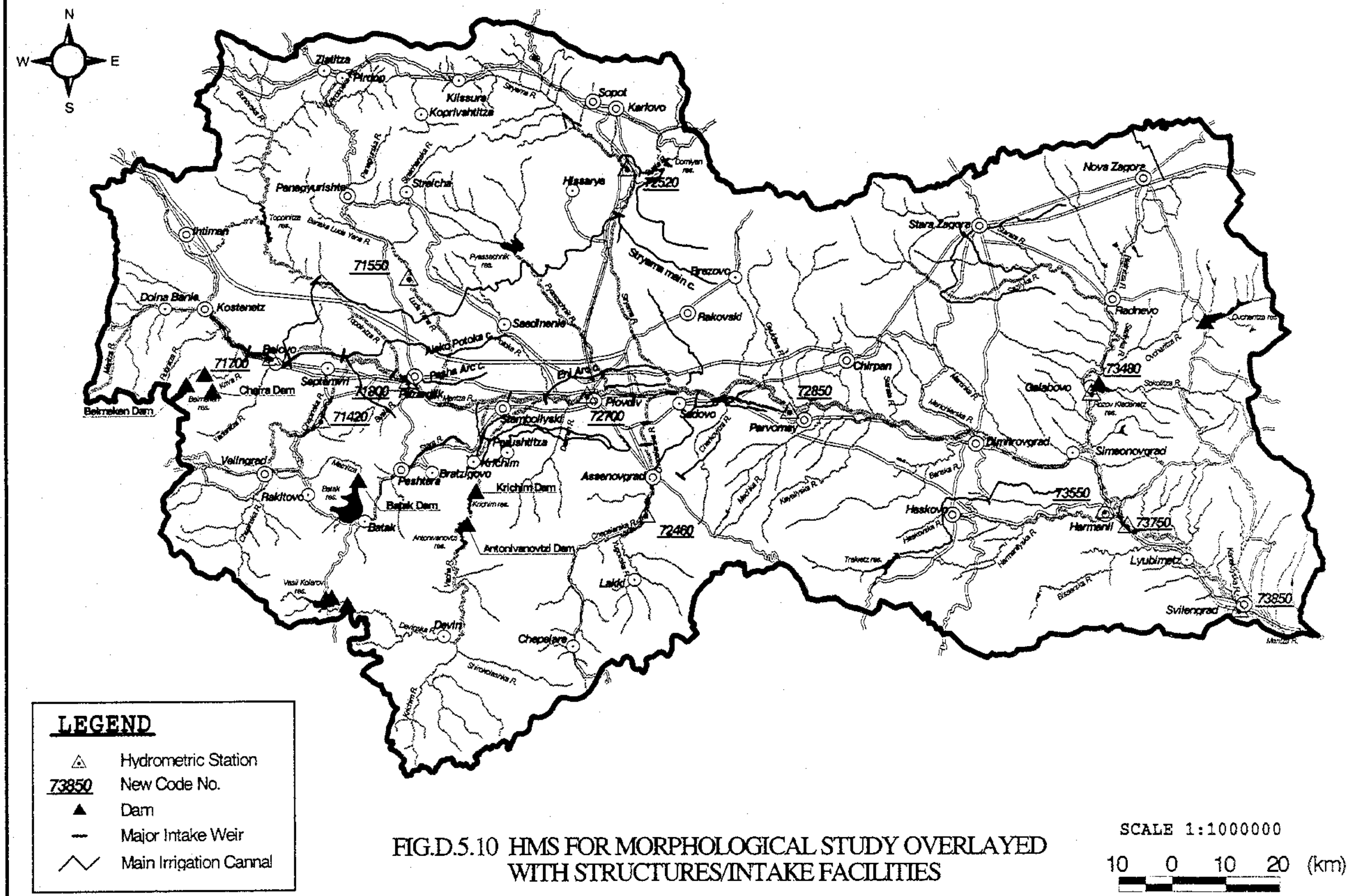


FIG.D.5.10 HMS FOR MORPHOLOGICAL STUDY OVERLAYED WITH STRUCTURES/INTAKE FACILITIES

SUPPORTING REPORT E

WATER RESOURCES

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SUPPORTING REPORT E WATER RESOURCES

Water resources of the Maritza River Basin have been extensively used. Surface water is mainly used for irrigation and hydropower. Groundwater is mainly used for domestic water supply and industry. Surface water resources in the basin are very much disturbed by numerous man-made structures including dams and intakes as well as by inner-basin water transfer and inter-basin water transfer. Groundwater is also disturbed by numerous groundwater wells.

This report mainly describes the conditions of surface water resources in terms of water use, water demand, water resources potential and water balance. Based on these analyses, management plan for water resources was formulated, which is also presented in this report.

1. Water Use Systems

Irrigation systems, hydropower systems, domestic water supply systems, industries are the major users of water in the Maritza River Basin. Other users are animal breeding and fish breeding.

1.1 Irrigation Systems

(1) Irrigation Systems with Area

There are wide irrigation areas in the Maritza River Basin. Before 1989, these irrigation systems in the basin were composed of the state irrigation systems of the Irrigation Systems Ltd. and the cooperative irrigation systems of former state cooperatives. After 1989, these irrigation systems have become the state irrigation systems of Irrigation Systems Ltd. and the irrigation systems of private cooperatives. As the private cooperatives are being formulated after collapsing of former state cooperatives due to on-going agrarian reform, their real situation is still not clear.

There are 16 state irrigation systems with estimated total area of 255,900 ha in the Maritza River Basin (refer to Fig. E.1.1 and Table E.1.1). The major irrigation systems are Topolnitza, Aleko Pazardjik, Stara Zagora, Trakietz and Krichim Cheshnigrovo ISs. 6 branch offices of the Irrigation Systems Ltd. composed of Pazardjik, Plovdiv, Stara Zagora and Haskovo and others manage the state irrigation systems in the basin as shown in Fig. E.1.2.

Actual utilization rate of state irrigation systems in the present is estimated to be only 16.4 % and that of the cooperative irrigation systems is probably smaller than this percentage.

(2) Water Sources of Irrigation

Major water resource of the irrigation systems is surface water supplied from major irrigation reservoirs of Topolnitza, Pyassachnik and Trakietz Reservoirs, about 680 numbers of medium and small size reservoirs/ponds, river intake weirs and major hydropower/multipurpose reservoirs of Belmeken, Batak and Krichim Reservoirs in the Basin. Main water sources of Stara Zagora IS and Nova Zagora IS the transferred water from Koprinka and Jrevchevo Reservoirs in the Tundza River Basin.

Major reservoirs and intakes related to the irrigation systems are shown in Fig. E.1.1 and listed in Table E.1.2. Fig. E.1.3 shows the medium and small size of reservoirs/ponds in the basin.

1.2 Hydropower

(1) Electric Power Generation Systems

Electric power generation composed of thermal power, hydropower and nuclear power generation is conducted by the Nasionalna Electricheska Kompania AD (NEK). Dams and

Cascades Enterprise controls hydropower/multipurpose reservoirs and relating hydraulic facilities, which is a subordinated agency of NEK.

There are three major hydropower systems in the Maritza River Basin as shown in Fig. E.1.1. They are Belmeken-Sestrimo-Chaira Scheme, Batak Cascade Scheme and Dospat-Vacha Cascade Scheme. Thermal power systems in the basin are the Maritza East I,II,III and Maritza III.

Total power generation of Bulgaria in 1995 was 42,003 GWh (100 %), out of which 17,261 GWh (41.1 %) from Kozloduy Nuclear Power Plant, 17,675 GWh (42.1 %) from thermal power plants, 2,507 GWh (6.0 %) from hydropower plants and 4,561 GWh (10.8 %) from other producers. Among the thermal power generation, 12,783 GWh (72.3 %) from Maritza River Basin. Among the hydropower generation, 1,372 GWh (54.7 %) was generated from the Maritza River Basin.

(2) Water Sources of the Hydropower Systems

The major water sources of the hydropower systems in the Maritza River Basin are the hydropower/multipurpose reservoirs such as Belmeken, Batak, Antonivanovtzi and Krichim. Inner-water transfer has been conducted from the hydropower stations to irrigation systems. Inter-basin water transfer has been conducted from Struma and Mesta River Basins to Maritza River Basin. On the other hand, water has been sent to Iskar River Basin from the Belmeken Scheme to supplement domestic water for Sofia City. Table E.1.3 to Table E.1.5 shows the water sources and major facilities of the hydropower systems.

1.3 Domestic and Industrial Water Supply

There are 7 water supply and sewerage companies (VIKs) of the MoRDPW and 5 VIKs of the municipalities in the Maritza River Basin. They are Sofia, Plovdiv, Pazardjik, Smolian, Peshtera, Batak, Velingrad, Haskovo, Stara Zagora and Sliven VIKs. Almost all the population in the Maritza River Basin is served by public water supply. Sewerage treatment is also conducted by VIKs. About 95 (%) of domestic water comes from groundwater and about 5 (%) of it comes from surface water.

There are about 530 industries in the Maritza River Basin composed of food processing (24 % of number), machinery (20 % of number), chemical (8 % of number), pulp and paper (2 % of number) and others. About half of the industries have their own water source of groundwater and about half of them use municipal water supply, so industries depend mainly on groundwater. Some industries such as Agrobiohim in Stara Zagora receive surface water from irrigation systems.

1.4 Others Water Use

Animal breeding:

Based on NIS's data, there are about 156000 cattle, 660000 sheep, 422000 pigs and 2763000 fowls in the Maritza River Basin in 1994. Among them breeding farms have about 36000 (23 %) cattle, 46000 (7 %) sheep, 286000 (68 %) pigs and 442000 (16 %) fowls and rests of them are bred by private farmers.

Fish breeding:

Fish breeding is conducted by using ponds and reservoirs in the Maritza River Basin. Along the main stream of the Maritza River, especially around Pazardjik and Plovdiv, there are fish breeding ponds and they depend on surface water supplied through irrigation canals.

2. Hydraulic Facilities and Necessity of Post-Environmental Assessment

2.1 Major Reservoirs

Table E.2.1 shows major reservoirs in the Maritza River Basin. Fig. E.2.1 shows a hydraulic characteristic of the major reservoirs in the basin. It seems that storage of Topolnitza, Pyassachnik, Trakietz and Batak Reservoirs are not utilized effectively. Hence, it might necessary to study on the improvement of operation of the reservoirs to utilize their storage more effectively. Furthermore, based on the detailed water balance data, we could find that the outflow from some reservoirs to the downstream river reach of dams is very small and it might give negative impacts to the environment. Therefore, it is recommendable to assess the environmental impacts by the existing dams to attain sustainable water use considering balance with environment.

2.2 Major Intakes Weirs

Irrigation Intakes:

In relation to irrigation systems, there are six intakes along the Maritza main stream. They are composed of two gated weirs (Pasha Arc and Zlokuchene Intakes), two river closing dikes made by concrete blocks or rocks (including one temporary dike), and two temporary intakes made by wood and others (refer to Table E.1.2). Among the closing dikes, the dike at the inlet of Eni Arc Canal is a closing overflow dike on the Maritza River made by concrete blocks. The intake in the upstream of Dimitrovgrad (Yabaikovo Intake) is a temporary dike for closing river by rocks between spring and autumn.

In the Topolitza River, there are one gated intake weir (Lissichevo Intake), one overflow weir (Gelemena Intake) and two closing earth dikes at the junction with the Aleko Potoka Canal and at the junction at Topolnitza River during spring and autumn. There is a gated weir of Krichim Intake in the Vacha River. At the beginning of Stryama main canal in the Stryama River, there is a temporary intake.

Water is very much taken by these intakes and closing dikes. Very small quantity of water is released to the downstream reaches between spring and autumn.

Hydropower Intakes:

In relation to the Belmeken-Sestrimo-Chaira and Batak Hydropower Systems, there are complicated water collecting systems composed of intakes and feeder canals to collect water from Maritza River Basin as well as from neighboring river basins of Struma and Mesta.

JICA Study Team conducted site investigation for one of the major water collecting systems of the Belmeken Scheme called Granchar Feeder Canal in the Rila National Park in the end of October 1998. The feeder canal is composed of conduit and tunnel with intakes at the galley streams. The intakes stop stream flow and take almost all the water to the feeder canal. According to MoEW, almost all the water is taken to the feeder canal and there is no water in the downstream galley especially between spring and beginning of autumn.

<u>Necessity for Post-evaluation of Environmental Impacts:</u>
These intake activities by irrigation and hydropower systems might be the reason to meet the requirements for mass production before 1989 and this might have caused adverse impacts to the environment. Therefore, it is highly recommendable to conduct post-evaluation of the environmental impacts by these existing facilities to achieve future sustainable water use by the irrigation and hydropower systems.

3. Water Demand

3.1 Irrigation

Irrigation water demand in the Maritza River Basin was estimated for Year 1994 (4-year drought) and Year 1995 (recent average hydrological year) based on FAO's method. Cropping pattern with its area was estimated based on the data of Year 1996 and is shown in Table E.3.1). Major crops in the state irrigation systems are maize, tobacco, sugar beet, lucerne, vegetable, fruit trees, rice and others.

Water is used for irrigation during April to September. Annual water demand by the state irrigation systems in the basin was estimated to be 260 (mil. m^3) in 1995 and 295 (mil. m^3) in 1994 (refer to Table E.3.2). On the contrary, actual supplied water to the state irrigation systems during 1992 to 1996 was almost 7 to 10 times larger than the estimated demand. Therefore, irrigation water supply was conducted with almost same level before 1989, when the irrigation systems were fully utilized.

3.2 Hydropower

In the hydropower systems, water is sent to hydropower stations (HPPs) for power generation. In the Maritza River Basin, following HPPs are existing;

1) Belmeken-Sestrimo-Chaira Hydropower Scheme
   - Belmeken HPP, Sestrimo HPP, Chaira PSPP and Momina Klisura HPP
   - After Momina Klisura HPP, water is sent to Pyassachnik Reservoir for Toplnitza ISs etc.

2) Batak Cascade Scheme
   - Batak HPP, Peshtera HPP and Aleko HPP
   - After Aleko HPP, water is sent to Aleko Pazardjik IS.

3) Dospat-Vacha Cascade Scheme
   - Teshel HPP, Devin HPP, Antonivanovtzi HPP/PSPP, Krichim HPP, Vacha I HPP and Vacha II HPP
   - After Krichim water is sent to Krichim Cheshnigrovo IS.

4) Others
   - Topolnitza HPP at the Topolnitza Dam
   - Stara Zagora HPP at end of the inter-basin water transfer from Koprinka Reservoir in the Tundza River Basin

Total water used by the hydropower systems (outflow from Belmeken, Batak and Krichim Reservoirs) was 737 (mil. m^3) in 1995 and 550 (mil. m^3) in 1994.

3.3 Domestic and Industrial Water Supply and Others

Annual domestic water demand in the Maritza River Basin was estimated to be 153 (mil. m^3). On the other hand, actual supplied water was 199 (mil. m^3) including loss.

Annual industrial water demand in the Maritza River Basin was 310 (mil. m^3). 20 biggest industries use about 90 (%) of industrial water. Among the 20 industries, 6 food processing factories, 3 machinery factories, 2 chemical factories and 3 pulp and paper factories are included (refer to Table E.3.3).

As the other water demand, annual water demand of animal breeding was about 24.8 (mil. m^3) in 1994 (refer to Table E.3.4).

3.4 Total Water Demand

Table E.3.5 shows summary of estimated basin wise annual water demand as well as actual supplied water in the Maritza River Basin by irrigation, hydropower, domestic water supply, industries, animal breeding in Year 1995 and Year 1994.

Net water demand excluding hydropower in Year 1994 and Year 1995 was estimated to be 841 (mil. m3) and 800 (mil. m3) respectively. However, actual supplied net water volume in Year 1994 and Year 1995 were estimated to be 2376 (mil. m3) and 3082 (mil. m3), which were much bigger than the real water demand. Therefore, water use is necessary to be conducted in more efficient way.

4. Water Resources Potential

4.1 Surface Water Resources

(1) Natural Potential of Surface Water

Natural potential of surface water resources was estimated for Year 1995 and Year 1994. The estimation was based on the basin mean monthly rainfall and runoff rate in the basin.

Table E.4.1 and Fig. E.4.1 shows estimated natural potential of surface water in Year 1994 and Year 1995. Natural potential of surface water resources at Junction 1 (most downstream of the Maritza River) was estimated to be 3537 (mil. m^3) in Year 1994 and 4294 (mil. m^3) in Year 1995.

Fig. E.4.2 shows natural potential of surface water of 4-year drought and 10-year drought, which are estimated, based on probable basin mean annual rainfall with same monthly pattern of Year 1994. The natural potential of 4-year drought is almost same as that of Year 1994. The natural potential of 10-year drought is about 90 (%) of the potential of 4-year drought.

(2) Disturbed Potential of Surface Water

Fig. E.4.3 shows the amount of inter-basin water transfer. Amount of the inflow volume to the Maritza River Basin by inter-basin water transfer between Year 1987 and Year 1996 is 234 mil.m3 (Year 1994) to 433 mil. m3 (Year 1996) including 250 mil. m3 (Year 1995). Outflow volume to Iskar River Basin from Belmeken Scheme (from Grancha Canal in Mesta River Basin) between Year 1987 and Year 1996 is min. 44 mil. m3 (Year 1990) to max. 111 mil. m3 (Year 1991) including 64 mil. m3 (Year 1994) and 106 mil. m3 (Year 1995).

Disturbed potential of surface water in Year 1994 and Year 1995 was estimated taking into account the outflow from major reservoirs into river basins and inter-basin water transfer as shown in Table E.4.2 and Fig. E.4.4. Disturbed potential of surface water resources at Junction 1 was estimated to be 3584 (mil. m^3) in Year 1994 and 4411 (mil. m^3) in Year 1995, which are almost same amount of the natural potential of surface water resources in terms of annual amount as well as seasonal amount. Therefore reservoir operation would be necessary to be revised for more effective utilization.

(3) Total Potential of Water Resources

Total potential of water resources composed of surface water and groundwater was estimated for Year 1994 and Year 1995 at junction points in the Maritza River Basin. In terms of groundwater, recharge potential to the groundwater was estimated from precipitation (refer to Table E.4.3).

Total potential of water resources at Junction 1 was estimated to be 4834 (mil. m^3) in Year 1994 and 5986 (mil. m^3) in Year 1995. Among the total potential, natural potential of surface water of Year 1994 and Year 1995 was estimated to be 33 (%) and 31 (%) respectively and groundwater recharge potential was estimated to be 12 (%).

5. Water Balance

5.1 Surface Water Balance

Fig. E.5.1 shows actual water balance of surface water in Year 1995 and Year 1994 at junction points in the Maritza River Basin, which are based on the estimated disturbed potential and observed discharge volume. Present actual utilization rate of surface water is 49 (%) at Junction 1 to 75 (%) at Junction 6 in Year 1995 (average year) and 69 (%) at Junction 1 to 85 (%) at Junction 6 in Year 1994 (4-year drought). These utilization rates are very high, so the surface water is too much used actually.

If water is utilized efficiently, water utilization rate becomes less than 10 (%) to 11 (%) and it will create large possibility for another utilization for human activity as well as for enhancement of natural environment (refer to Fig. E.5.2).

5.2 Total Water Balance

Utilization rate of total potential of water resources including is as follows;

Utilization rate at Junction 1:

			Year 1994	Year 1995
1)	Total utilization rate			
	-	Total water resources potential	4834 (mil. m^3)	5986 (mil. m^3)
	-	Estimated net water supply	2375 (mil. m^3)	3082 (mil. m^3)
	-	Utilization rate	49 (%)	51 (%)
2)	Utilization rate of surface water			
	-	Surface water resources potential	3537 (mil. m^3)	4294 (mil. m^3)
	-	Estimated net water supply	1869 (mil. m^3)	2576 (mil. m^3)
	-	Utilization rate	53 (%)	60 (%)
3)	Utilization rate of groundwater recharge			
	-	Groundwater recharge potential	1298 (mil. m^3)	1692 (mil. m^3)
	-	Estimated net water supply	506 (mil. m^3)	506 (mil. m^3)
	-	Utilization rate	39 (%)	30 (%)

Total water resources in the Maritza River basin is too much utilized. As the groundwater level is almost stable with dropping water level in limited places, groundwater utilization can be said almost in sustainable level in the present. Therefore, management of surface water resources as well as groundwater is very important for sustainable development in the basin.

6. Water Resources Management

Based on the analysis described above, concept of water resources management was formulated.

6.1 Existing Management for the Maritza River Basin

Management relating to water and environment in the Maritza River Basin has been conducted as follows;

- Control of water resources composed of surface water and groundwater
- Control of water quality composed of surface water and groundwater
- Conservation of natural environment
- Forest management
- Erosion control and soil conservation
- Disaster prevention for floods and debris

Related agencies for the above activities are NIMH of Bulgarian Academy of Science, MoEW, MoH, MoAFAR, Academy of Agriculture and Civil Defense of Council of Ministers (refer to Table E.6.1). Various activities have been conducted separately without integrated management from river basin point of view.

In relation to the above management, following monitoring activities have been conducted (refer to Table E.6.2).

- Climate including precipitation
- Surface water quantity and quality
- Groundwater level and quality
- Soil property, contamination and erosion
- Forest

- Natural environment

Problems of the monitoring activities are as follows;

1) Lack of clear demarcation among the monitoring activities for surface water quality, groundwater quality and forest
2) Insufficient surface water quantity and quality monitoring stations especially along tributaries
3) Data quality of national monitoring network for groundwater
4) Insufficient monitoring for water usage
5) Distributed monitoring data in several relating agencies and inconvenient system for data utilization
6) Lack of observation with regular basis especially for surface water quality

6.2 Assessment of Water Resources

Assessment of water resources was conducted from following two aspects.

- Future water demand and water balance
- Classification of river basins in terms of water resources

6.2.1 Future Water Demand and Water Balance

(1) Future water demand

In relation to the future socio-economy in the Maritza River Basin by Year 2015, following items will affect water resources and water use in the basin very much.

- Future utilization rate of the state irrigation systems will be about 50 (%).
- Future GDP of the industrial sector will be about 4 times of its present GDP.

- Population in the Maritza River Basin will be 1.10 times of present population.

Based on the above assumptions, future water demand in the Maritza River Basin by Year 2015 was estimated as shown in Table E.6.3. Future net water demand will be 2.3 to 2.4 times bigger than the present net water demand. However, comparing the present net water supply, future net water demand will be much smaller than the present net water supply volume. Therefore, management of water use will be also important, so that not to supply water excessively as well as to reduce water loss.

(2) Future water balance

Based on the estimated water demand by Year 2015, future water balance was estimated to be as follows (refer to Fig. E.6.1 as well);

Utilization rate at Junction 1:

	4-year drought (Year 1994 level)	Average year (Year 1995 level)
Total utilization rate		
- Total water resources potential	4834 (mil. m^3)	5986 (mil. m^3)
- Estimated net water demand	2011 (mil. m^3)	1872 (mil. m^3)
- Utilization rate	42 (%)	31 (%)
Utilization rate of surface water		
- Surface water resources potential	3537 (mil. m^3)	4294 (mil. m^3)
- Estimated net water demand	1515 (mil. m^3)	1377 (mil. m^3)
- Utilization rate	43 (%)	32 (%)
Utilization rate of groundwater recharge		
- Groundwater recharge potential	1298 (mil. m^3)	1692 (mil. m^3)
- Estimated net water demand	495 (mil. m^3)	495 (mil. m^3)
- Utilization rate	38 (%)	38 (%)

If water supply will be conducted efficiently future utilization rate will be more sound than the present condition. Therefore, control of water use and potential of surface water as well as groundwater resources will be also very important in the present and in the future.

6.3 Scenarios for Water Resources Management

6.3.1 Zoning for Water Resources Management

In order to formulate water resources management plan, zoning in the Maritza River Basin from the water resources point of view was conducted. The zones are as follows (refer to Fig. E.6.2):

(1) Zone of Category I: Special Basins for Controlling Water Resources Potential

Basins included in this zone are important basins for surface water potential in the Maritza River Basin, which have rich forest area of water resources and major structures for controlling water resources potential such as reservoirs. The river basins of this zone are VAC, CPI, STA, CPE, TOP, MU1 and MD.

(2) Zone of Category II: Basins for Controlling Water Resources Potential and Water Demand

Basins included in this zone have moderate surface water potential as well as moderate surface water demand. The river basins of this zone are MM2 and MM3.

(3) Zone of Category III: Special Basins for Controlling Water Demand

Basins included in this zone are the water consuming basins. The river basins of this zone are as MU2, MM1, LUD, PYA, STR, SAZ and HAR.

6.3.2 Scenarios for Water Resources Management

Based on the above zoning, scenarios for water resources management were formulated as follows;

(1) Scenario 1: Conservation and Enhancement of Water Resources Potential

It is necessary to conserve and enhance water resources potential of the river basins which belong to Category I. This is mainly composed of forest conservation and reforestation including agro-forest and fruit trees.

(2) Scenario 2: Efficient Usage of Water

Efficient usage of water for irrigation, hydropower, domestic water supply and industrial water supply is necessary, so that to stop excessive water use as well as to reduce water loss.

Control of water usage by the proposed river basin management authority is necessary to be conducted based on the evaluation of appropriate water demand and its supply schedule which will be requested by the water user. The proposed river basin managing authority is also necessary to supervise the water usage. In addition to this, water user shall report water use amount accurately and periodically to the river basin authority.

(3) Scenario 3: Effective Control of Water Resources Potential

In order to increase usable water resources potential in dry season, operation of reservoirs is necessary to be updated. Furthermore, inner-basin and inter-basin water transfer is also necessary to be updated, so that to transfer necessary and sufficient water considering balance of natural environment.

The proposed river basin management authority is necessary to supervise reservoir operation as well as inter-basin water transfer. The water user such as Irrigation Systems Ltd. and Dams and Cascades Enterprise should also report their reservoir operation and inter-basin transfer volume accurately and periodically to the river basin management authority.

6.3.3 Scenarios for Soil Protection

Zoning of soil erosion was conducted based on the following information.

- Land cover map derived from CORINE Database
- Slope analysis conducted by the study team
- Erosion potential area derived from geological hazards map of Bulgaria
- Soil map of Bulgaria (scale 1: 400,000)

Fig. E.6.3 shows a result of analysis for erosion potential. Areas of grassland or non-irrigated agricultural land or bare land with slope > 3 deg. overlap erosion potential area in general. Based on the analysis, areas to be made attention for soil erosion were identified as Area 1 to Area 5. In these areas, contour fallow or reforestation including agro-forest and fruit trees would necessary to be considered for protecting soil. As this analysis is only based on the maps, field survey will be necessary to specify problematic areas of soil erosion in detail.

6.4 Countermeasures for Water Resources Management

Based on the scenarios, following activities will be necessary for river basin management of the Maritza River Basin (refer to Table E.6.4);

- Strengthening of monitoring system
- Conservation of forest area for water resources

- Control of water usage
- Control of optimum operation of hydraulic structures
- Setting up river basin authority
- Cost recovery for management
- Relating study for the management

Relating to the above activities, countermeasures for the water resources management proposed in this study are as follows;

- Strengthening of monitoring systems
- Conservation and increase forest area for water resources
- Relating study for water resources management

6.4.1 Strengthening of Monitoring Systems

Strengthening of monitoring systems for meteo-hydrology, water usage and artificial control of water resources will be necessary.

(1) Strengthening of Meteo-hydrological Monitoring Network

Fig. E.6.4 and Fig. E.6.5 shows proposed minimum meteo-hydrological stations for water resources management for the Maritza River Basin. The proposed stations are as follows;

1) Meteorological stations

- Existing automatic climatic stations:	at 7 locations
- Upgrading existing climatic stations from manual to automatic type:	at 8 locations
- Upgrading existing precipitation stations from manual to automatic type:	at 10 locations
- Installing new evaporation stations:	at 5 locations

2) Hydrological stations

- Existing telemetric hydrometric station:	at 1 location
- Existing automatic hydrometric stations:	at 6 locations
- Upgrading existing hydrometric stations from manual to automatic type:	at 6 locations
- Installing new hydrometric stations:	at 13 locations

(2) Strengthening of Monitoring Network for Water Usage and Artificial Control of Water Resources

In order to monitor water usage and artificial control of surface water resources by hydraulic structures, basic monitoring networks are necessary to be established for river basin management (refer to Fig. E.6.6). These gauging stations are to be installed by the water user. Water user is necessary to monitor the intake water, inner-basin transferred water and inter-basin transferred water volume and to submit report to the river basin authority accurately and periodically.

1) Monitoring for water usage by irrigation

- Automatic water level/discharge gauge at intake weirs:	10 locations
- Automatic water level/discharge gauge at irrigation canals:	11 locations

2) Monitoring for water usage for hydropower

- Automatic discharge meter at hydropower stations:	6 locations

3) Monitoring artificial control of surface water resources

- Automatic water level/discharge gauge at reservoirs:	8 locations
- Automatic water level/discharge gauge at inter-basin water transfer points:	8 locations

4) Monitoring of water usage volume for domestic water supply

In order to monitor the intake water volume for domestic water supply, it is necessary to increase number of water meter at the water intake points including groundwater wells. Water meters are to be increased by the VIKs.

5) Monitoring of water usage volume for industries

Monitoring of water usage volume for industries is necessary to be conducted by installing water meter at the groundwater pumping wells etc. Installation of water meters shall be done by industries. Industries shall monitor intake water volume and report to the river basin authority. The river basin authority shall check the water usage volume periodically by sampling survey.

6.4.2 Conservation of Forest Area for Water Resources

Conservation of forest area, especially for Zone I is proposed as shown in Fig. E.6.7. River basins with high priority for forest conservation or reforestation are VAC, CPI, STA, CPE, TOP, MU1. Priority basin for forest conservation with reforestation including agro-forest and fruit trees is MD.

6.4.3 Relating Study for Water Resources Management

In relation to the water resources management of the Maritza River Basin, following studies are necessary to be conducted from now on.

(1) Water Resources Management Study in Bulgaria

This study aims to formulate a basic policy for management of water resources in Bulgaria. By this study, global condition of water resources potential, present and future water demand and water balance will be studied. Furthermore, necessary and sufficient inner-basin and inter-basin transfer of water will be updated. Relating to the Maritza River Basin, Struma, Mesta, Iskar and Tundza River Basins are necessary to be studied together.

(2) Agricultural Development Study in the Maritza River Basin

This study aims to formulate a new strategy for recovery and sustainable development of agriculture in the Maritza River Basin, which will satisfy social and economic sustainability of agriculture as well as balance with water resources and environment. The study will formulate a master plan, which includes a concept of reforming farmers and cooperatives, improvement of farming practice, improvement marketing systems and extention service such as guidance and information service to the farmers and cooperatives. The plan will also includes infrastracture facility plan as well as financial plan with cost recovery.

(3) Water Balance of Hydropower Systems

Operation of reservoirs and hydropower systems in the Maritza River Basin is necessary to be updated based on the estimated present and future water demand of irrigation, hydropower, domestic water supply and industrial water supply.

(4) Rehabilitation of Water Supply Systems

Rehabilitation of water supply systems in the Maritza River Basin including tariff system is necessary to be studied.

(5) Post-Environmental Evaluation of the Existing Major Hydraulic Facilities

This study aims to evaluate the environmental impacts by the existing major hydraulic facilities such as dams and intakes. This study will recommend necessary actions for recovering or improving the environment condition in relation to the facilities, which have adverse impacts on the environment.

6.5 Project Cost

Items of the project cost for water resources management is only the monitoring networks for meteorology and hydrology. Other monitoring networks shall be installed by water users, because monitoring and reporting water usage volume and water controlled volume are considered to be one of the duties of the water users for using water in the basin. Cost for the meteo-hydrological monitoring networks are roughly estimated as follows;

1).	Meteorological stations:	
-	Upgrading existing climatic stations from manual to automatic type:	8 locations
-	Upgrading existing precipitation stations from manual to automatic type:	10 locations
-	Installing new evaporation stations:	5 locations
	Sub-total of cost:	US$ 130,000
2).	Meteorological stations:	
-	Upgrading existing hydrometric stations from manual to automatic type:	6 locations
-	Installing new hydrometric stations:	13 locations
	Sub-total of cost:	US$ 230,000
	Total (1. + 2.)	US$ 360,000

6.6 Proposed Staged Program

Staged program of the proposed river basin management is proposed for following stages.

- Preparation stage: Year 1999 – 2000
- Short term stage: Year 2001 – 2005
- Medium term stage: Year 2006 – 2010
- Long term stage: Year 2011 - 2015

The proposed staged program is shown in Table E.6.5.