3.4

WATER QUALITY MANAGEMENT PLAN

3.4 Water Quality Management Plan

Improvement of water quality management is discussed in this section, mainly focused on surface water quality. The water quality management plan is composed of strengthening of monitoring system, reduction of pollution load, and necessary investigations.

Fig 3.4.1 explained schematically the basic procedure of a water quality management plan. The integrated water quality management plan is developed through several steps from the awareness for the necessity of the management.

The water quality management plan was formulated as following steps:

- Assessment of existing water quality management system
- Scenarios for water quality management
- Countermeasures
- Water quality monitoring tools and equipment plan
- Cost
- Investigation
- Proposed stage program

3.4.1 Assessment of Existing Water Quality Management System

Existing water quality management system is assessed in this section. The problems of the existing management system are explained:

(1) Monitoring System

NIMH and NCESD measure surface water quality. However, the sampling was not regularly taken, and data was not summarized. In addition, no data is exchanged between the institutes even though many of their stations are very close. In term of the location of

the monitoring station, some place such as Pazardjik do not have monitoring station after effluent of town sewerage. Or even though there is a station after effluent of town sewerage in Plovdiv, no measurement took place after 1993.

The problems of the monitoring station are summarized below:

- Irregular frequency of data collection
- No data exchange between the institutes
- Insufficient summarization of data collected
- Inappropriate location of monitoring stations

NCESD updated monitoring system in January 1998. Some stations were added and deleted (Fig. 2.6.1). The sampling parameter and its frequency are planned very detail. However, it is better to make simple system at first. After having appropriate amount of data, sampling parameter and frequency can be separated detail.
Some of the new stations are added in up stream of river. In this moment, these stations are not necessary even though sampling is twice a year. These stations should be added after well performance of monitoring in mid and down stream.

(2) Control of Domestic Wastewater

There are only five WWTPs in the Maritza River basin. First, additional WWTPs are definitely needed to control domestic wastewater. Among 5 WWTPs, only Plovdiv is operated properly to the secondary treatment. However, including Plovdiv, all WWTPs are necessary to be rehabilitated or strengthening maintenance.

Also the sewer pipe should be rehabilitated. The connection of pipes is not fixed, especially bending point. Therefore, wastewater leaks and groundwater flows into the sewer pipe. It makes groundwater pollution and ineffective WWTP work regarding the pollution reduction.

In other aspect, the direct impact of domestic pollution to river is not investigated. The effluent quality to river should be measured.

The problems are summarized below:

- Shortage of WWTPs
- Need of rehabilitation and lack of maintenance for WWTPs
- Pipe connection
- No measurement of sewer effluent quality

(3) Control of Industrial Effluent

Industrial effluent is controlled by MoEW. However, MoEW does not measure its quality. Industry declares the effluent quality individually. The declaration could be incorrectly reported. Industries emitting over the effluent quality regulation are imposed fine. However, the fine is relatively low amount.

The problems are summarized below:

- Incorrect declaration of effluent quality by industry
- Low amount of fine over the regulated effluent level

(4) Mining

There are over 100 active and closed mines, and their relating facilities in the study area. The pollution from mining industry is significantly dangerous. However, the management such as water use, effluent quality, treatment of mining waste and wastewater, and monitoring system, etc. is not investigated.

(5) Solid Waste

Illegal solid waste dumping is found many places in the Maritza River basin. It is because insufficient public (municipal) service. One of the organized solid wastes dumping sites is located in Plovdiv. The site is well constructed. However, the treatment plan for leachate is not established.

The problems are summarized below:

- Unorganized solid waste dumping
- No fixed plan for leachate

3.4.2 Scenarios for Water Quality Management

Water quality management is planned with three scenarios:

- Scenario 1: Reduction of pollution load
- Scenario 2: Strengthening of monitoring system
- Scenario 3: Investigations

In this section, Scenario 1 is discussed. Scenario 2 is discussed in the part of the sub-section 3.4.3. Scenario 3 is discussed in the sub-section 3.4.7.

The characteristic of pollution is mentioned in section 2.6. The pollution is emitted largely from limited catchment and big towns. Therefore, the reduction from big towns is significant effect to the study area. The approach of pollution reduction is proceeded:

- Select priority regions by high loading and deteriorated water quality regions
- Review pollution load from major towns in each region
- Select priority towns and its priority order
- Make draft alternatives for reduction of pollution
- Evaluate the water quality improvement of the alternatives by water quality model

- Select the optimum plan for water quality improvement

(1) Selection of Priority Regions

From Fig 2.6.2 and Fig 2.6.8, water quality relates to pollution load significantly. The regions can be grouped with a few catchments. Four regions shown in Fig 3.4.2 are proposed:

- Up stream, Maritza - MU2, STA, MM1, CPE-1
- Mid-stream, Maritza – MM2, MM3
- Down stream, Maritza – HAR
- Sazliyka - SAZ

Fig 3.4.3 shows the pollution load in regions. Eighty percent of pollution is loaded from these four regions. It means four regions are defined as main polluter in the study area.

(2) Selection of Priority Towns and Priority Order

Priority towns are selected with three steps:

- Review and select priority towns from prioritized four regions (Fig 3.4.4)
- Consider towns chosen by the National Plan of the Ministry of Construction in 1989 (Fig 3.4.5)
- Select an important spot such as tourism area and mining activity area

The first priority is to reduce the pollution from the most effected town. Fig 3.4.4 shows the pollution load from 19 major towns in 4 priority regions. A few major towns are loaded 66 – 90% in each priority regions. Therefore, the pollution reduction from these major towns makes it strong impact to water quality.

These 19 major towns are considered to be the priority towns. In addition, 13 towns and 2 districts are added from the non-prioritized region (Table 3.4.1). The added towns are the selected towns by the National Plan (Fig 3.4.5).

Some towns need severe consideration to environment such as tourist and mining activity area. Even though they may not load a large amount of pollution, these towns should be included for the priority towns. Four towns are selected from an important spot.

The selected priority towns should reduce the pollution load by implementation or rehabilitation of facilities by the year of 2015. It is proposed to separate 3 stages with 3 type of priority order. The execution period and priority order is as follows:

- 1st priority order – project execution in the year of 2001 to 2005
- 2nd priority order – project execution in the year of 2006 to 2010
- 3rd priority order – project execution in the year of 2011 to 2015

The priority order for four prioritized regions and the important spots is determined with the present total pollution load and the future potential domestic load, shown in Table 3.4.2. Towns with pollution of the present load over 3000 kg BOD/d and the future load over 2000 kg BOD/d are chosen as 1st priority. The selected 7 towns are:

- Pazardjik
- Plovdiv
- Assenovgrad
- Dimitrovgrad
- Haskovo
- Stara Zagora
- Velingrad

In the priority region, the selected 1st priority towns are similar to that of the National Plan.

However, Peshtera city that was once selected among the 1st priority towns in the National Plan in 1989 is not selected as 1st priority, but 3rd priority because of the estimated values of pollution load in 1992 and in2015.

All towns in the non-prioritized region are considered as the third order because of relatively low load and much less impact to the Maritza River and the Basin.

(3) Alternative for BOD and TN Reduction

The target level of water quality, regarding BOD and NH4, is to meet the class II of the Regulation No 7. To achieve this goal, the three reduction alternatives are made, shown in Table 3.4.3.

Alt. 1 is to reduce more domestic pollution load than industry and livestock pollution. Alt. 3 is the opposite concept of reduction plan. It is reduced more industrial and livestock load than domestic load. The reduction concept between Alt. 1 and Alt. 3 is Alt. 2.

Both the basic alternatives and the impact of only domestic reduction are simulated (Table 3.10.3). The result is applied to the selection of the alternative.

3.4.3 Countermeasures

Countermeasures for improvement of water quality management are composed of structural plan and non-structural plan. Structural plan is pollution reduction by WWTP. Non-structural plan is strengthening of monitoring system, regulation and investigation.

(1) Pollution Reduction

The reduction alternative is determined with evaluation of Table 3.10.6 and Table 3.10.7. Alt. 3_3 and Alt. 4_3 meet the target of the class II of BOD. For NH4, Alt. 4_3 is the best

quality among the Alternatives. However, it does not meet the class II in upstream and mid-stream of Maritza in some area, and Sazliyka. Alt. 3_3 is the same as Alt. 4_3 except no nitrification at WWTP in Stara Zagora and Haskovo. The difference of the result is the category of Harmanliyska is down to the class III. The reduction of TN is more efficiency from industry and livestock. Therefore, Alt. 3_3 should be executed for the pollution reduction as follows:

BOD reduction

Domestic load reduction by WWTP

- 1st priority town 90% (primary and secondary treatment)
- 2nd priority town 30% (primary treatment)
- 3rd priority town 30% (primary treatment)

Industrial load reduction by regulation

- Top 1-10 90%
- Top 11-20 30%

  (equivalent to 80% reduction of industrial load)

Livestock load reduction by regulation

- farm 30%
- household 30%

  Currently most animals are raised and kept in low number in small farmers. They are regarded as non-point pollution source. As for reduction of pollution load from household livestock, it is recommended to apply dry cleaning method instead of wet cleaning for household livestock and to use sludge for agriculture after dried. This recycle is simple and inexpensive method for small number of livestock.

TN reduction

Industrial load reduction by regulation

- Top 2 fertilizer industries 90%
  (equivalent to 79% reduction of industrial load)

(2) Strengthening of Monitoring System

Monitoring of water quality:

Strengthening of monitoring system is necessary for the water quality management. At first the measurement organizations should be combined. Only one organization is enough to measure water quality.

Then the importance of the monitoring stations is evaluated from river basin management aspects. Impacts by WWTP or major polluters such as industries including mines are considered to be monitored individually and periodically. The stations are classified principal and the auxiliary. The stations are shown in Fig 3.4.6 and summarized below:

Principal Station	–	6 stations in Maritza River
		6 stations in the tributaries
Auxiliary Station	–	7 stations in Maritza River
		24 stations in the tributaries

Water quality is necessary to grasp the impact of town pollution. New station is added in one place as the principal station on the Maritza River: after Luda Yana where existing sewer in Pazardjik and effluent of future WWTP are discharged. Four new stations are added on tributaries as auxiliary station. Tributary of Topolnitza and Blatnitza where effluent from WWTP flows out. And one station is added in mid stream of Luda Yana for tracing the heavy metal pollution. Fourth station is in Batak reservoir, the largest reservoir in the study area. The study proposes frequency and parameter of sampling. Some are overlapped the existing system. The system is summarized:

The frequency of sampling should be:

Principal station – strictly once in a month

Auxiliary station – strictly once in two months (monthly sampling is recommendable)

The measurement parameters are:

General parameter: air temp, water temp, pH, DO, BOD, SS, NH4, NO2, NO3, PO4, SO4, H2S, coliform

Heavy metal: Cu, Zn, Pb, Ni, Fe, Cr, Mn, Mg, Cd, As, Hg

The parameter and sampling frequency of heavy metals are to be modified considering the result.

Biological measurement:

In order to characterize and to support the assessment with the physical/chemical parameters, a biological parameter (Biotic Index) has been shown. To identify ecological "hot spots" these measurements have to be extended. Just nowadays the bacteriological load, as a thread to the health to the population, is measured in the Sazliyka Region. Microbiological parameters should be used at least for all other organic polluted rivers, so at least also for Maritza and Harmanlyiska Rivers.

Industrial effluent:

For industrial effluent, each industry should have obligation to declare the effluent quality correctly. In addition, REIs are necessary to conduct effluent quality survey of industry occasionally. The strict observation is needed and recommendable to start from top 20 industries, then the others. With the observation, the effluent regulation should be reviewed. It is recommended that the effluent quality be the same as effluent level of WWTP.

Livestock:

Each farm should declare the effluent quality. And REIs conduct effluent quality survey occasionally. The strict observation is necessary.

For household animal, it is recommended for REIs to inspect cleaning methods and to change wet cleaning method to dry cleaning method. In addition, REIs had better to instruct the application of manure dried up for agriculture.

3.4.4 Water Quality Monitoring Tools and Equipment Plan

Equipment of water quality measurement is prepared and organized. There is no need for additional apparatus for the proposed sampling parameters.

HD (hydrodynamic) and WQ (water quality) models are well developed in this project. This is a powerful tool for water quality management. The model can verify the pollution impact to the rivers.

3.4.5 Costs of the Countermeasures

For structure cost, it is mentioned in Section 3.8. For non-structure, only software is needed.

3.4.6 Rough Cost Estimation for Industrial Wastewater Treatment

Rough cost estimation for the top 20 industrial wastewater treatment is conducted. Location of the top 20 industries is shown in Fig. 3.4.7.

Rough cost for industrial LWWTP or rehabilitation of existing LWWTP is estimated with following assumption:

- Treated water quality from industry is as the one from municipal WWTP meeting the class III of Regulation of No. 7.
- Land is available for LWWTP.
- If industrial wastewater is necessary for municipal WWTP in terms of carbon source or others, the cost is not estimated. However, cost is estimated if the rehabilitation of pipe is needed.
- The cost is estimated the combined WWTP from several industrial wastewater if it is cheaper.

With the above assumption, the cost for top 20 industries is estimated.

Top 1-5	USD 36.5 mil
Top 5-10	USD 5.8 mil
Top 11-20	USD 13.3 mil
Total	USD 55.5 mil

3.4.7 Investigations

The reduction of pollution and strengthening of monitoring stations are mentioned previous section. Still data is not enough to execute the integrated water quality management. Some investigations are needed such as sewer system and its effluent, industrial effluent, mining waste and its wastewater, and solid waste. Then the implementation of improvement and management are planned.

The detail investigations are discussed as follows:

(1) Sewer System and Its Effluent

Sewer network in each town and the pipe connection should be investigated. Then effluent concentration to river should be measured. It is the direct impact of domestic load.

(2) Industrial Effluent

It is mentioned in the section 3.4.3.

(3) Mining Waste and Its Wastewater

The investigation should be carried out for water use, effluent quality, treatment of mining waste and wastewater, monitoring system, and duration of activity.

(4) Solid Waste

The capacity (duration), treatment of leachate, and monitoring system should be investigated.

(5) Study on Groundwater Management for Controlling Quantity and Quality of Groundwater

Groundwater potential, abstraction and usage and quality will be assessed. A master plan for groundwater management will be formulated.

3.4.8 Proposed Stage Program

Proposed programs are proceeded four stages:

1)	Preparation stage	Year	1999 - 2000
2)	Short term stage		2001 - 2005
3)	Mid term stage		2006 - 2010
4)	Long term stage		2011 - 2015

The detail is shown in Table 3.4.4.

3.4.9 Improvement of Water Quality by WWTP in Pazardjik, Dimitrovgrad, and Stara Zagora

Three towns are selected for feasibility study. The detail is mentioned in Section 3.14. One of the river basin management is to implementation of WWTP. This section describes the impact of WWTP to the priority region and the whole basin.

Pazardjik, Dimitrovgrad, and Stara Zagora are chosen for the feasibility study (F/S). Alt 1_1D shown Table 3.10.3 is simulated, and the result is shown in Fig. 3.10.4. Alt. 1_1 is to reduce domestic pollution from 1st priority towns (Velingrad, Pazardjik, Plovdiv, Assenovgrad, Dimitrovgrad, Stara Zagora, and Haskovo). The pollution reduction from four towns other than three F/S towns does not change water quality in F/S towns. Therefore, the improvement of water quality by WWTP in F/S towns can be evaluated by the result of Alt. 1_1. The impact right after the down stream is summarized with WWTP (Alt. 1_1) and without WWTP (Alt. 0_3):

Town	Priority Region*1	without WWTP	with WWTP	Domestic Load in year 2015*2 (kgBOD/d)	% of Domestic Load reduction by WWTP*3
		mgBOD/L			
Pazardjik	Up Stream, Maritza	12	6	17,900	29
Dimitrovgrad	Mid Stream, Maritza	3	2	9,400	32
Stara Zagora	Sazliyka	61	40	13,100	61

note: *1: see Fig. 3.4.2

*2: pollution load in priority region

*3: reduction rate per priority region based on the load in year 2015

Pazardjik

Improvement of water quality in Pazardjik is clearly significant. Maritza after Luda Yana is BOD of 12 mg/L when WWTP is not exist. However, with treatment by WWTP, water quality improves BOD of 6 mg/L. In addition, this significant impact is identified in Stamboliyski and just before Plovdiv. BOD becomes class I.

Dimitrovgrad

Water quality is slightly improved. In Dimitrovgrad, discharge in river is a large. So WWTP dose not help to improve it a lot. However, 32% of domestic pollution in the priority region of Maritza mid stream is reduced. And improvement of water quality in downstream of Maritza is necessary to reduce pollution form the high loading towns such as Stara Zagora, Haskovo, and Dimitrovgrad. Therefore, WWTP in Dimitrovgrad is important for Maritza River basin management.

Stara Zagora

WWTP in Stara Zagora improves water quality in Sazliyka significantly. The discharge is lower. Therefore, the impact is obvious. And reduction of domestic pollution in the region is as much as 61%. This WWTP has a important environmental impact to the region.

TABLE 3.4.1 SELECTION OF PRIORITY TOWNS AND PRIORITY ORDER

Region			Catchment	Town	Population in 1992	Population in 2015	Town Load in 1992 (kgBOD/d)				Domestic Pollution Load in 2015 (kgBOD/d)	Priority Order*1		
							Domestic Wastewater			Total Poll Load in Town				
							Sewered		Non-Sewered	Total		1st	2nd	3rd
							Non-treated water	Treated water						
Prioritized Region	Maritza	Up stream	MU2-2	Pazardjik	90286	108343	3933		109	4042	6658	5851	X	
			MM1-9	Plovdiv	344336	378770	16734	15061	465	2136	5127	3887	X	
			CPE-1	Assenovgrad	52360	57596	2027			2827	3248	13110	X	
			MM1-12	Stambolliyski	13155	14471	426		71	497	2297	781		X
			MM1-2	Kaloyanovo - Village	2812	3374	38			38	38	182		X
			STA	Peshtera	18900	20790	510	459	128	179	271	617		X
			STA	Batak	4468	4915	96		36	133	145	285		X
			STA	Bratzigovo	5022	5524	54		54	108	115	298		X
		Mid-stream	MM3-9	Dimitrovgrad	50977	61172	2753			2753	4581	3303	X	
			MM2-15	Sadovo*2	2647	2912	143			143	9759	157		X
			MM2-13	Parvomay	16690	18359	542		90	632	1403	991		X
			MM2-1	Chirpan	19694	23633	957		27	984	1312	1276		X
			MM3-1	Simeonovgrad	8265	9918	268		45	312	1434	536		X
		Down stream	HAR-2	Haskovo	80959	89055	4153		55	4208	4298	4809	X	
			HAR-1	Harmanli	21559	26949	931		58	990	1098	1455		X
	Sazliyka		SAZ-7	Stara Zagora	149666	164833	7435		162	7597	19322	8890	X	
			SAZ-6	Radnevo	14203	17044	499		268	767	2643	920		X
			SAZ-4	Gabrovo	9473	11368	450		15	465	4581	614		X
			SAZ-6	Nova Zagora	26658	29324	1324	1192	29	161	163	272		X
Non-Prioritized Region			CPE-2	Lakki	3437	3781	149		9	158	158	204		X
			CPE-3	Chepelare	6085	6694	66		66	131	131	361		X
			LUD-3	Strelcha	5063	5569	96		44	140	140	301		X
			MU1-3	Belovo	5016	5518	190		20	210	627	298		X
			MU1-8 /MU1-10	Kostenetz /Dolna Banya	15667	19584	731		29	760	760	1058		X
			STR-3	Sopot/Karlovo	39065	42972	2110			2110	2724	2320		X
			TOP-2	Ihitman	12860	14146	694	625		69	69	76		X
			VAC-1	Perushtitza	5535	6089	90		52	142	142	329		X
			VAC-1	Kritchin	8875	9763	216		66	282	285	527		X
			VAC-3	Borino - Village	2884	3172			39	39	39	171		X
			VAC-4	Devin	6141	6755	116		54	170	170	365		X
				20 Packed Wastewater										X
				4 Module wastewater treatment facilities										X
	Important Spot*3		CPI-3 /CPI-2	Velingrad /Rakitovo*4	58672	64539	2840		82	2922	3479	3485	X	
			STR-1	Hissarya	8959	9855	339	305	36	70	88	197		X
			LUD-2	Panagjurishte	20944	23038	894		59	953	1112	1244		X
			TOP-3	Pirdop/Zlatiza	14008	15409	756			756	756	832		X
Other Region					601993	635970	0	0	7712	10487	26278	10653	-	-	-
Maritza River Basin					1747334	1921000	53360	17640	9880	48374	105451	52610	-	-	-

*1: Priority Order 1st - Implementation or rehabilitation will be performed in the year of 2000 to 2005
Priority Order 2nd - Implementation or rehabilitation will be performed in the year of 2006 to 2010
Priority Order 3rd - Implementation or rehabilitation will be performed in the year of 2011 to 2015

*2: Polluiton reduction is focused on industrial load.

*3:Towns represent important spot such as tourism area (Velingrad, Hissarya) and significant influence by mining industry (Panagyurishte, Pirdop/Zlatitza)

*4: Pollution loads represent winter season. In summar, the load becomes a double of winter.

TABLE 3.4.2 SELECTION OF PRIORITY ORDER

Domestic Load in 2015 (kg/d)	Total Load Pollution Load in 1992 (kg/d) 0-1000	1000-3000	over 3000
0-600	Kaloyanovo Batak Bratzigovo Nova Zagora	Simionovgrad	Sadovo
600-1200	Peshtera	Stamboliski Radnevo Parvomay	Galabovo
over 1200		Chirpan Harmanli	Pazardjik Plovdiv Assenovgrad Dimitrovgrad Haskovo Stara Zagora

: 1st Priority

: 2nd Priority

: 3rd Priority

TABLE 3.4.3 BASIC ALTERNATIVES FOR POLLUTION REDUCTION

(unit:%)

	BOD									TN
	Domestic				Industry			Livestock		
	Priority Order			Other	Most Loaded Industry			Farm	Other	2 Fertilizer Industries
	1st	2nd	3rd		1 - 10	11 - 20	other			
Alt 1	90	90	90	0	30	0	0	0	0	0
Alt 2	90	90	30	0	30*	30	0	30	0	90
Alt 3	90	30	30	0	90	30	0	30	30	90

TABLE 3.4.2 SELECTION OF PRIORITY ORDER

Domestic Load in 2015 (kg/d)	Total Load Pollution Load in 1992 (kg/d) 0-1000	1000-3000	over 3000
0-600	Kaloyanovo Batak Bratzigovo Nova Zagora	Simionovgrad	Sadovo
600-1200	Peshtera	Stamboliski Radnevo Parvomay	Galabovo
over 1200		Chirpan Harmanli	Pazardjik Plovdiv Assenovgrad Dimitrovgrad Haskovo Stara Zagora

: 1st Priority

: 2nd Priority

: 3rd Priority

TABLE 3.4.3 BASIC ALTERNATIVES FOR POLLUTION REDUCTION

(unit:%)

	BOD									TN
	Domestic				Industry			Livestock		
	Priority Order			Other	Most Loaded Industry					2 Fertilizer Industries
	1st	2nd	3rd		1 - 10	11 - 20	other	Farm	Other	
Alt 1	90	90	90	0	30	0	0	0	0	0
Alt 2	90	90	30	0	30*	30	0	30	0	90
Alt 3	90	30	30	0	90	30	0	30	30	90

TABLE 3.4.4 PROPOSED STAGE PROGRAM OF WATER QUALITY MANAGEMENT

Item				Preparation Year 1999-2000	Short Term Year 2001-2005	Mid Term Year 2006-2010	Long Term Year 2011-2015	After Year 2015
Pollution Rduction	BOD	Domestic	1st priority town					
			2nd priority town					
			3rd priority town					
			Other					
		Industry	Top 1-10					
			Top 11-20					
			Other					
		Livestock	Farm					
			Household					
	TN	2 Fertilizer Industries						
		Other						
Strengthening of Monitoring System								
Investigation / Study		Sewer system and effluent						
		Industrial effluent						
		Mining waste and wastewater						
		Solid waste						
		Groundwater management						
		Implementation of improvement and management based on above investigation						

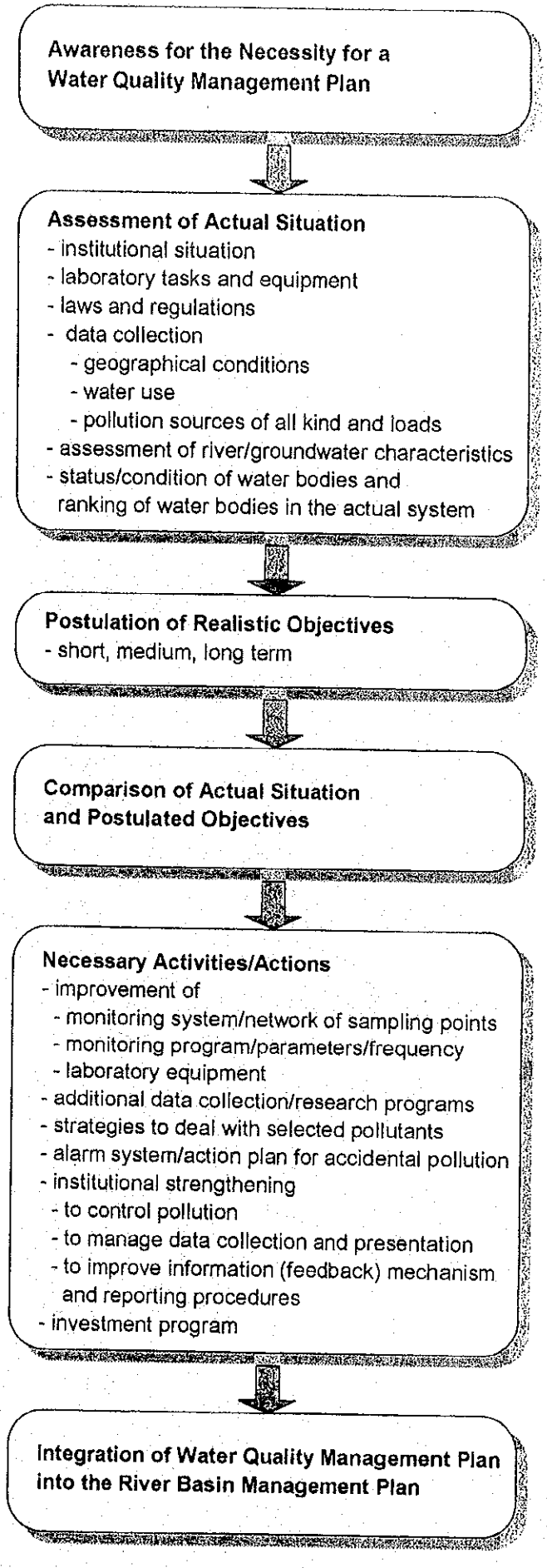


FIG. 3.4.1

BASIC PROCEDURE OF WATER QUALITY MANAGEMENT PLAN

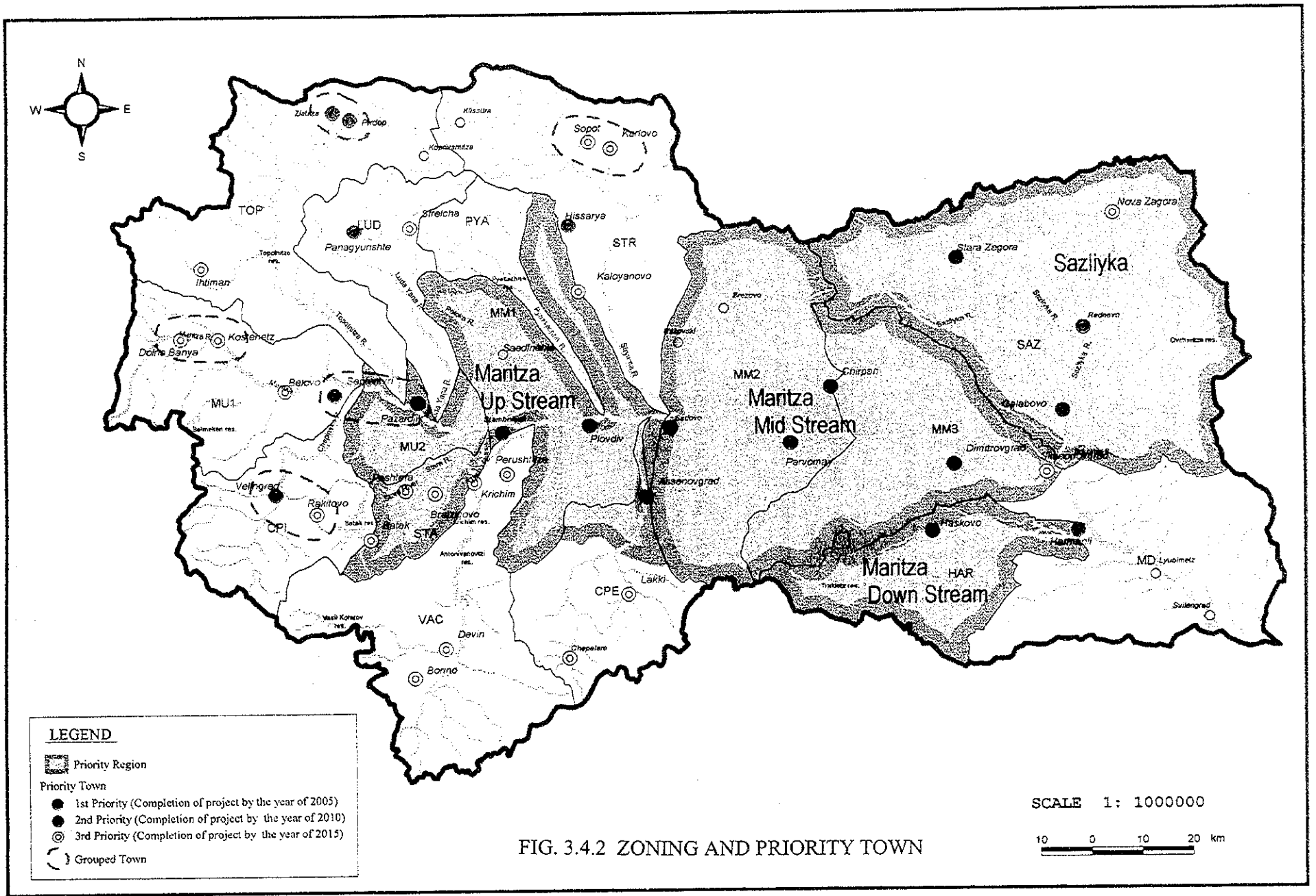


FIG. 3.4.2 ZONING AND PRIORITY TOWN

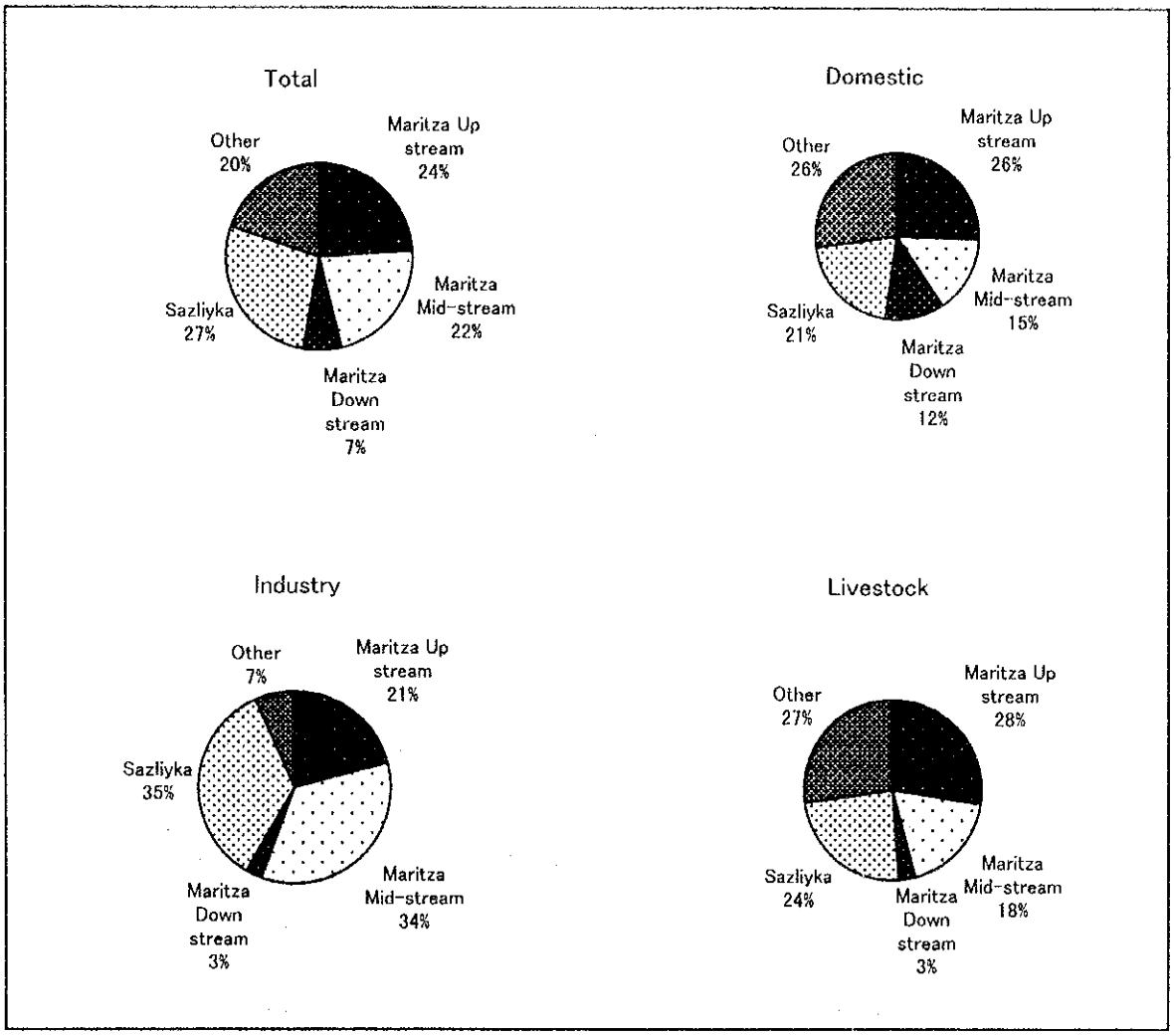


FIG.3.4.3 POLLUTION LOAD FROM PRIORITY REGIONS

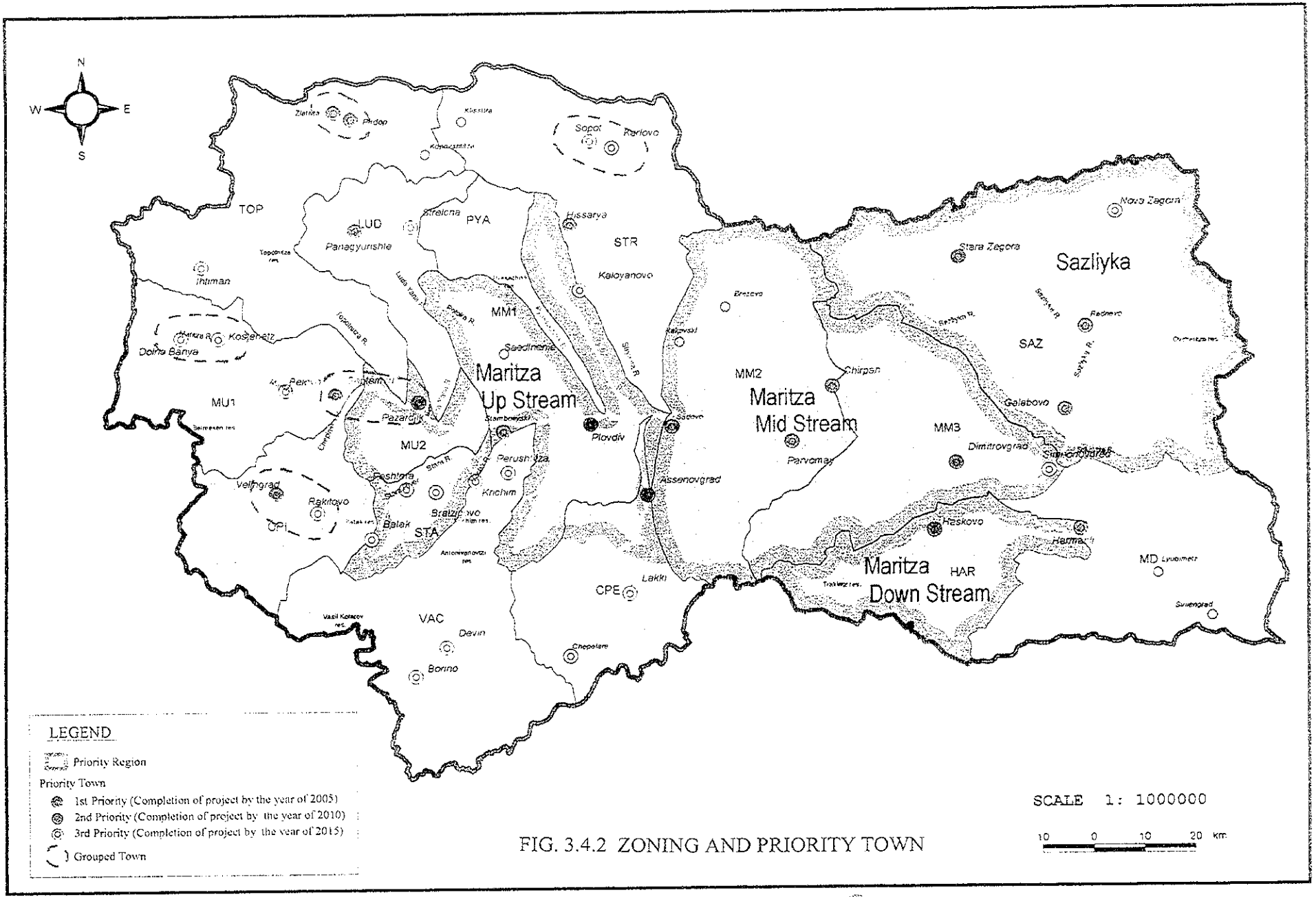


FIG. 3.4.2 ZONING AND PRIORITY TOWN

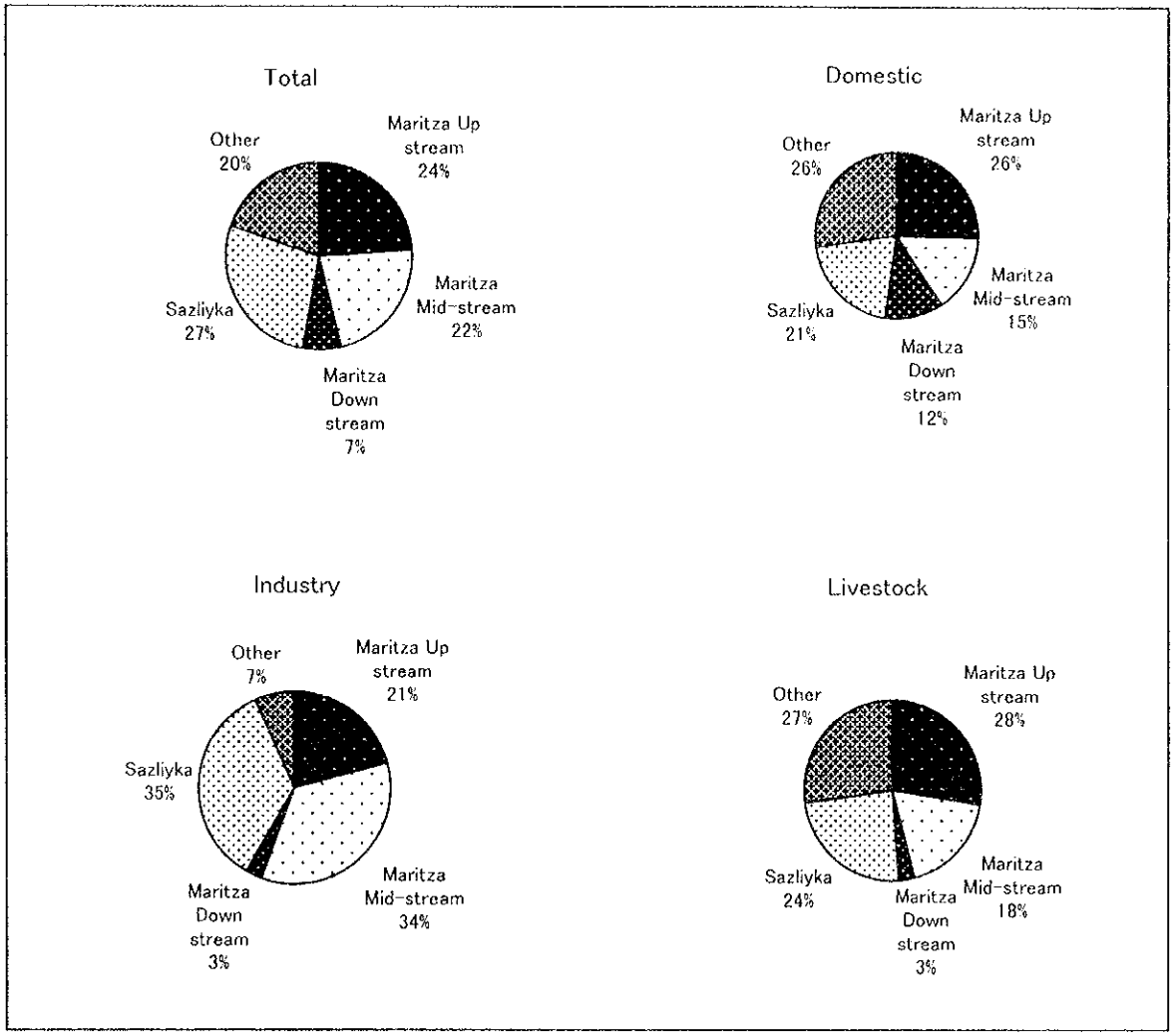


FIG.3.4.3 POLLUTION LOAD FROM PRIORITY REGIONS

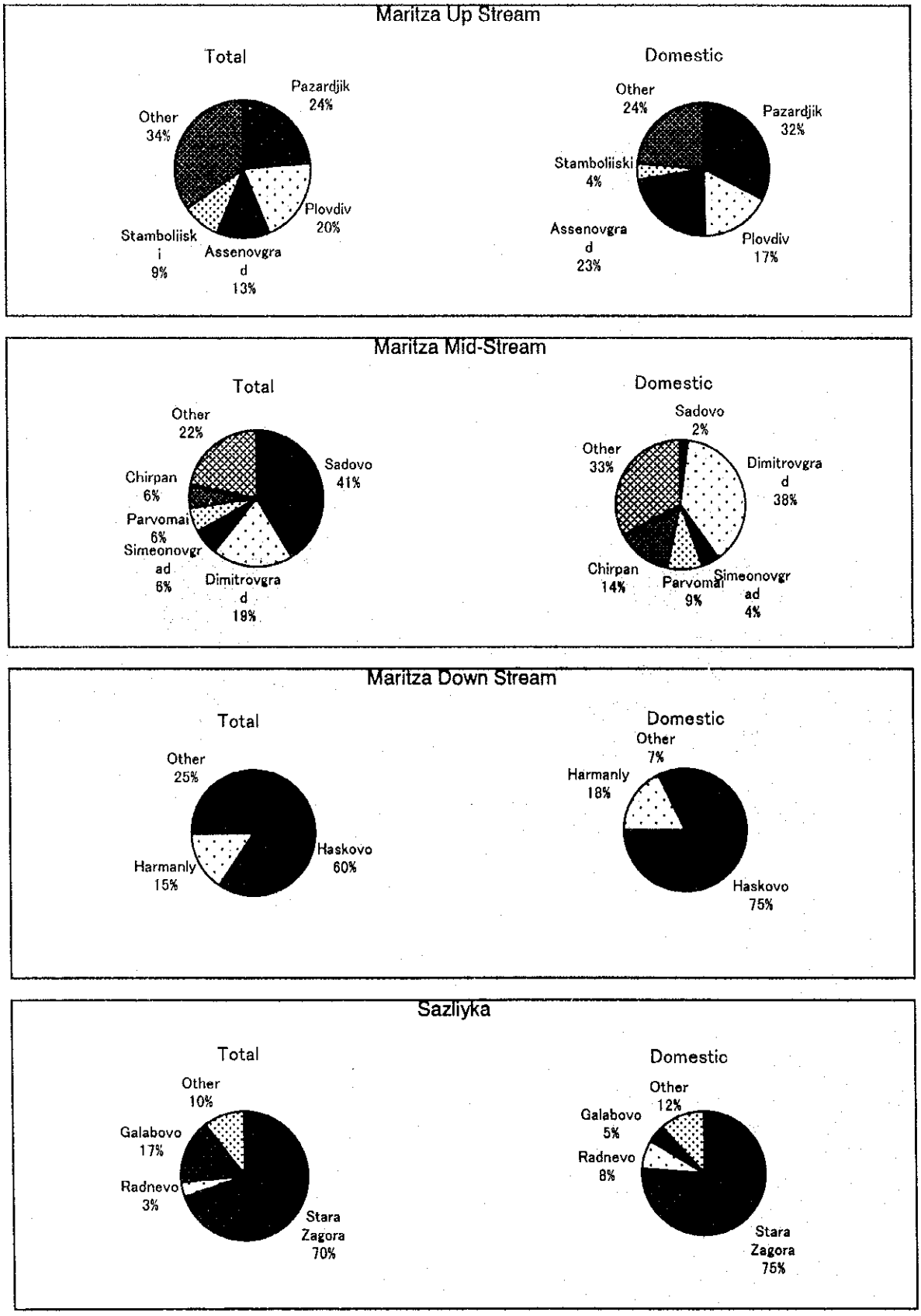
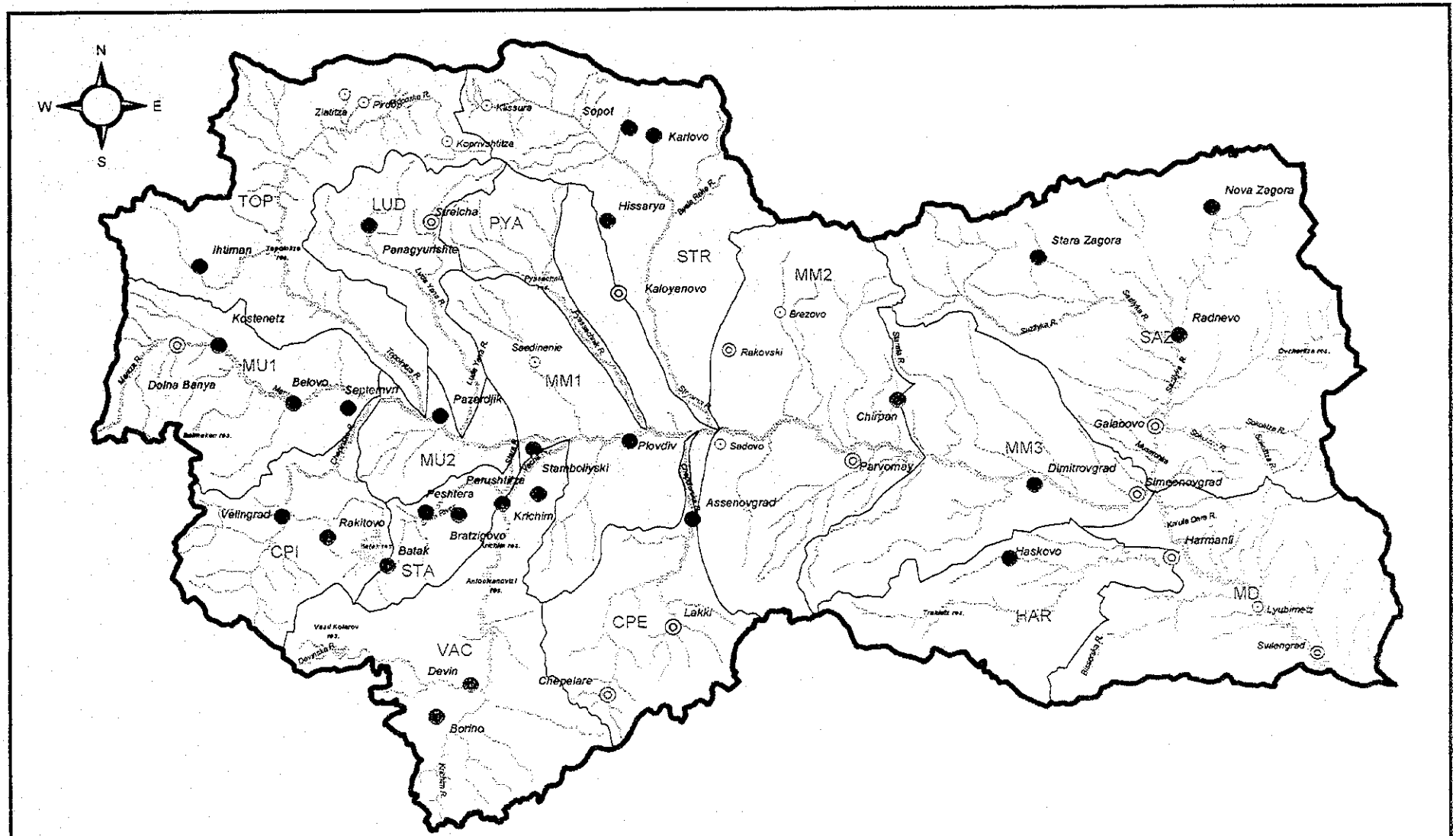


FIG.3.4.4 POLLUTION LOAD FROM MAJOR TOWNS IN PRIORITY REGIONS



LEGEND

Priority Town

- 1st Priority (Completion of project by 1995)
- 2nd Priority (Completion of project by 2000)
- 3rd Priority (Completion of project by 2010)

FIG.3.4.5 NEW OR EXTENDED TREATMENT WORKS OF NATIONAL PLAN IN 1989

SCALE 1: 1000000

10 0 10 20 (km)

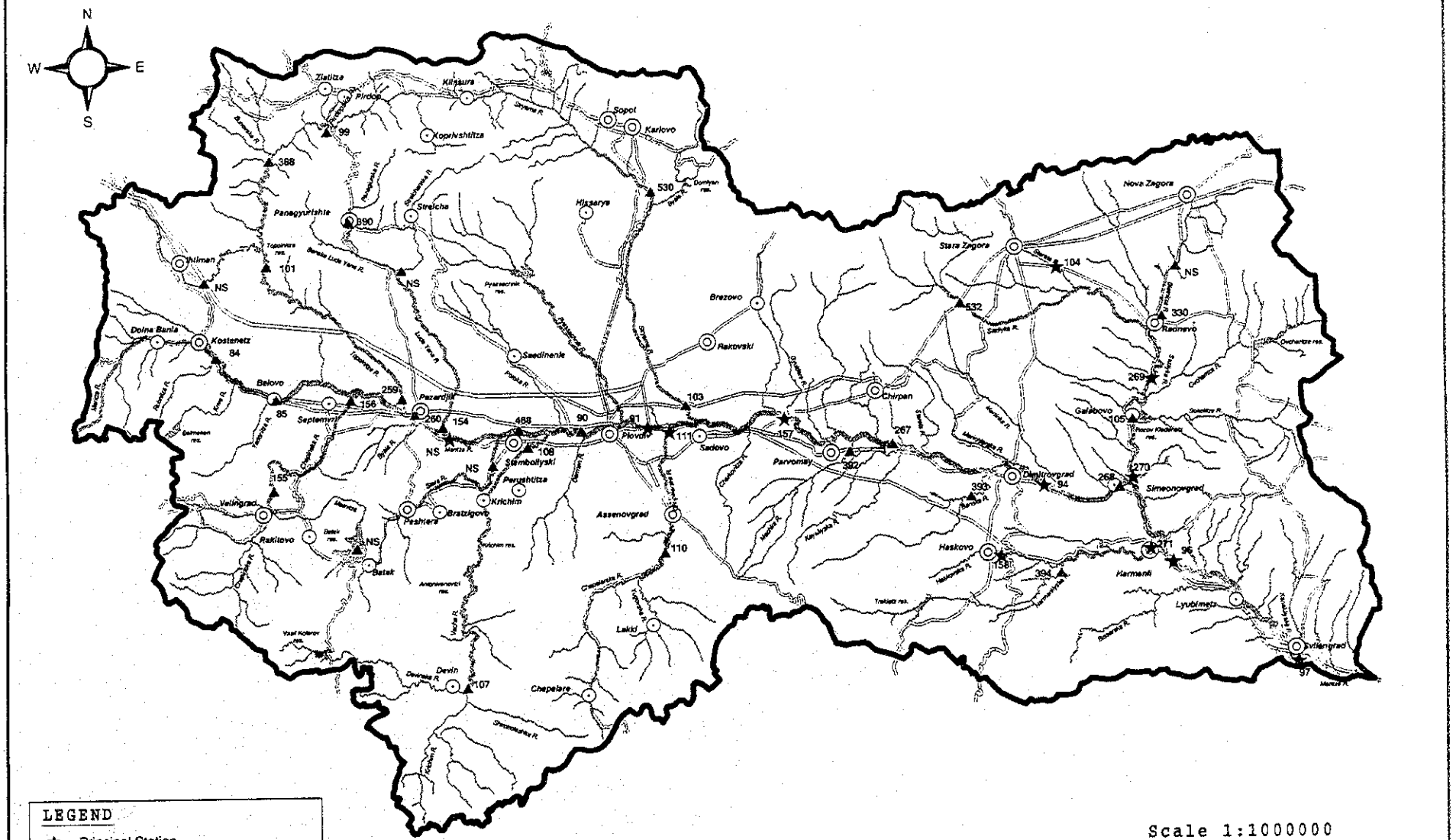


FIG.3.4.6 PROPOSED MONITORING SYSTEM

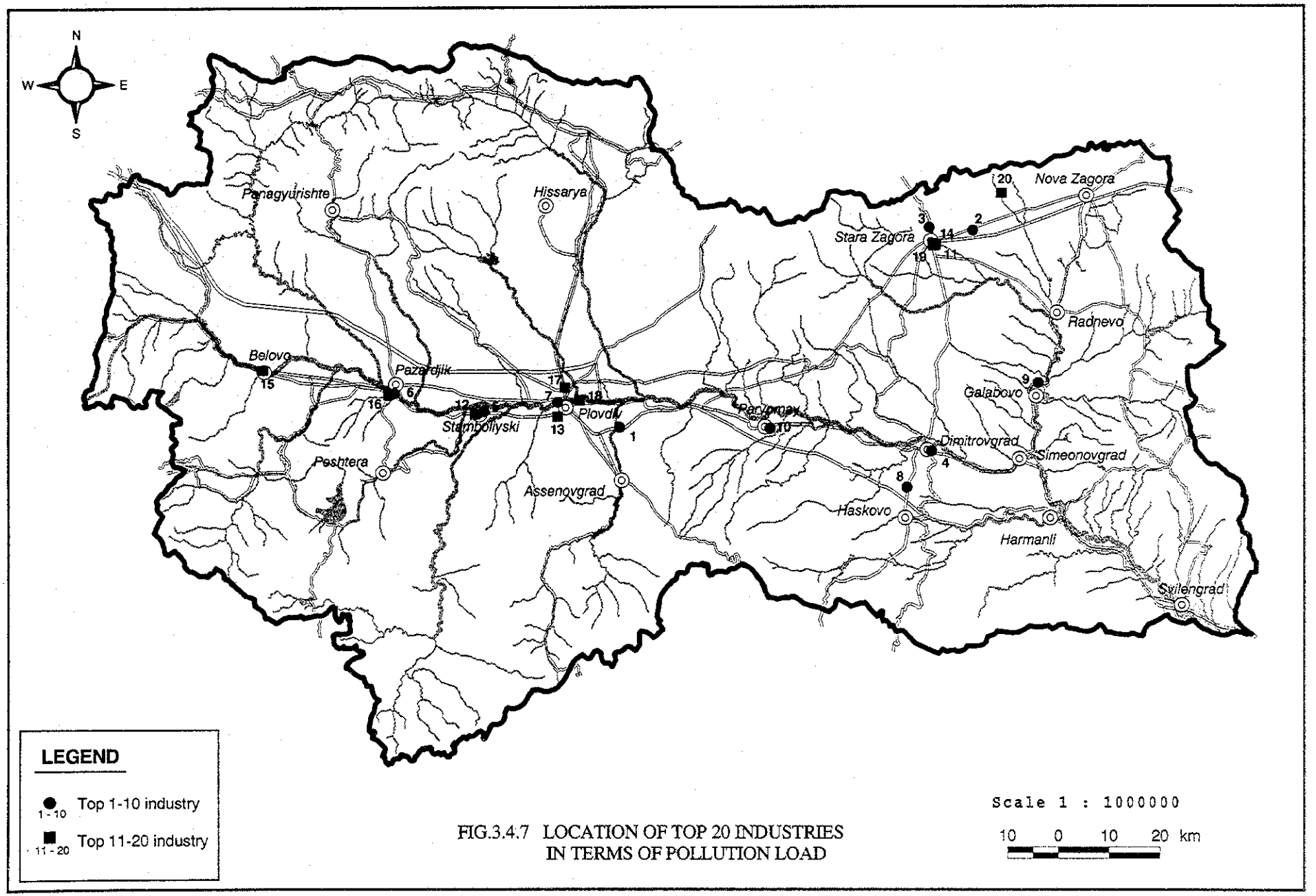


FIG.3.4.7 LOCATION OF TOP 20 INDUSTRIES IN TERMS OF POLLUTION LOAD

3.5

RIVER BASIN MANAGEMENT PLAN

3.5 River Basin Management Plan

The river basin management plan is necessary to be an integrated management plan composed of water resources management, water quality management, natural environment management, land use management, protection of soil erosion and disaster prevention for floods and debris. Among them, priority was given to the water quality management and water resources management in this study. In this sub-section, water resources management plan is mainly discussed.

In order to conserve water resources potential and conduct efficient water use without excessive water supply, strengthening of monitoring networks, conservation and enhancement of areas with higher water resources potential, studies for improvement of water use as well as artificial control of water resources were proposed in this study.

3.5.1 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 3.5.1). 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 3.5.2).

- 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

3.5.2 Future Water Demand and Water Balance

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 3.5.3 and summarized below.

Estimated Future Water Demand by Year 2015

Item	Water demand	
	Year 1994 level (mil. m^3)	Year 1995 level (mil. m^3)
1. Total water volume		
1) Gross volume	2561	2609
2) Net volume	2010	1872
2. Surface water volume		
1) Gross volume	2066	2114
2) Net volume	1515	1377
3. Groundwater volume		
1) Gross volume	495	495
2) Net volume	495	495

Notes: 1) Gross volume includes water for hydropower.
2) Net volume does not include water for hydropower.

Based on the estimated water demand by Year 2015, if efficient water use will be conducted, future water balance will be as follows (refer to Fig. 3.5.1 as well);

Possible Future Water Utilization Rates at Jct.1 (at Svilengrad)

Water resources potential	Year 1994 (%)	Year 1995 (%)
Natural surface water potential	43	32
Groundwater recharge potential	38	38
Total potential	42	31

Notes: 1) Net water demand is applied for above calculation.

If water supply will be conducted efficiently future utilization rate will be more sound than the present condition.

3.5.3 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. 3.5.2):

(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.

3.5.4 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 organization 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 management organization.

(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 organization 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 organization.

3.5.5 Countermeasures for Water Resources Management

Based on the scenarios, following activities will be necessary for river basin management of the Maritza River Basin;

- 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

(1) Strengthening of Monitoring Systems

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

1) Strengthening of Meteo-hydrological Monitoring Network

Fig. 3.5.3 and Fig. 3.5.4 shows proposed minimum meteo-hydrological stations for water resources management for the Maritza River Basin. The proposed stations are as follows;

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

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 reservoirs, basic monitoring networks are necessary to be established for river basin management (refer to Fig. 3.5.5). 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.

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

Monitoring for water usage for hydropower:

Automatic discharge meter at hydropower stations: 6 locations

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

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.

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.

(2) Conservation and Increase Forest Area for Water Resources

Conservation and increase of forest area, especially for Zone of category I is proposed as shown in Fig. 3.5.6. 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.

(3) Relating Development Study for Water Resources Management

In relation to the water resources management of the Maritza River Basin, following development 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 of marketing systems and extension service such as guidance and information service to the farmers and cooperatives. The plan will also includes infrastructure 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) Environmental Post-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.

3.5.6 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. 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

3.5.7 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 3.5.4.

3.5.8 Conclusion and Recommendation

Conclusions and recommendations relating to river basin management especially for water resources in the Maritza River Basin are as follows;

(1) Surface water in the Maritza River Basin is used extensively with very high utilization rates without so much consideration about the real water demand as well as balance between environment. Groundwater in the Maritza River Basin is also used extensively within a sustainable level, although there are rather big water supply loss. Therefore, it is recommendable to conduct efficient water use, so that not use water excessively.

(2) Forest area is a very important area of natural water resources. Therefore, it is recommendable to conserve the basins with wide forest area (especially Zone I) including reforestation.

(3) Water resources potential in the basin are very much disturbed by numerous hydraulic facilities as well as inner-basin and inter-basin water transfer, but these facilities do not contribute for increasing annual and seasonal water resources potential effectively. Therefore, it is recommendable to update the operation of the existing hydraulic facilities to increase water resources potential effectively considering environment.

(4) Some of the hydraulic facilities seem to make adverse impact to the surrounding natural environment. Therefore, it is recommendable to assess environmental impact of these existing facilities to attain sustainable water use and control.

(5) In relation to the control of water use as well as water resources potential, strengthening of monitoring systems for meteo-hydrology, water usage and artificial control of water is recommendable.

(6) In relation to the water resources management plan for the Maritza River Basin, relating studies such as "Water Resources Management Study in Bulgaria", "Agricultural Development Study in the Maritza River Basin", "Water Balance of Hydropower Systems" and "Rehabilitation of Water Supply Systems" and "Post-Evaluation of the Existing Major Hydraulic Facilities" were proposed.

TABLE 3.5.1 EXISTING ACTIVITIES RELATING TO RIVER BASIN MANAGEMENT

Activity	Responsible agents
A. Control of Water Resources	
1) Meteo-hydrological and hydraulic observation	1) NIMH
2) Monitoring of groundwater	1) NIMH 2) Depart. "Protection and use of groundwater" of MoEW
3) Control of water use permit for surface water	1) Depart. "Protection and use of surface water" of MoEW
4) Control of water use permit for groundwater	1) Depart. "Protection and use of groundwater" of MoEW
5) Control of operation of major reservoirs	1) Depart. "Protection and use of surface water" of MoEW
6) Monitoring of floods	1) Civil Defense of Council of Ministers
7) Evacuation of people from floods	1) Civil Defense of Council of Ministers
8) Structural countermeasures for floods (river improvement)	1) Local commission for natural disasters and calamities
B. Control of Water Quality	
1) Monitoring of surface water quality	1) REIs with NCESD of MoEW 2) NIMH
2) Monitoring of groundwater quality	1) REIs with NCESD of MoEW 2) Depart. "Protection and use of groundwater" of MoEW 3) NIMH 4) Hygiene Epidemiology Inspection of MoH
3) Monitoring and regulation of industrial wastewater	1) REIs of MoEW
4) Collection and treatment of domestic wastewater including some industrial wastewater	1) VIKs
5) Monitoring of hazardous chemical and waste	1) Civil Defense of Council of Ministers
6) Evacuation of people from accidental pollution	1) Civil Defense of Council of Ministers with local committee for hazards
C. Conservation of Natural Environment	
1) Monitoring	1) Depart. "National nature protection service" of MoEW
2) Conservation of natural park, natural monument and biodiversity	- ditto -
D. Forest Management	
1) Monitoring	1) National Forestry Board of MoAFAR
2) Conservation, reforestation and control for production	- ditto -
E. Erosion Control and Soil Conservation	
1) Monitoring of erosion	1) National Forestry Board of MoAFAR 2) Civil Defense of Council of Ministers
2) Monitoring of soil erosion	1) Soil institute "Pushkarov" of Academy of Agriculture
3) Countermeasures for erosion	1) National Forestry Board of MoAFAR 2) Local committee for hazards
4) Guidance against soil erosion	1) Depart. "National Soil Service" of MoAFAR

TABLE 3.5.2 EXISTING MONITORING NETWORKS IN THE MARITZA RIVER BASIN

Observation item / Agency/Institute		Climate/ rainfall	Surface-water		Ground-water		Soil	Forest	Nature (bio-diversity, scenery)	Remarks
			Water level/ discharge	Quality	Water level/ discharge	Quality				
1	**Bulgarian Academy of Science**									
1-1	National Institute of Meteorology and Hydrology (NIMH)	X	X	X	X	X				National monitoring network
2	**Ministry of Environment and Waters**									
2-1	National Center of Environment and Sustainable Development (NCESD)		X (partly started in 1997)	X		X	X			National monitoring network
2-2	National Nature Protection Service								X	National monitoring network
2-3	Depart. "Protection and use of groundwater"				X	X				Supplemental monitoring system started since 1993/1994
4	**Ministry of Agriculture, Forests and Agrarian Reform**									
4-1	National Forestry Board						X	X	X	National monitoring network
4-2	Irrigation Systems Ltd.	X (rainfall only)	X		X					Monitoring network for irrigation systems including irrigation reservoirs
5	**Academy of Agriculture**									
5-1	Soil Institute "Pushkarov"						X			Supplemental monitoring system
6	**Ministry of Energy**									
6-1	Dam and Cascade Enterprise	X	X							Monitoring network for hydropower systems including multi-purpose reservoirs
7	**Ministry of Health**									
7	Hygiene Epidemiology Inspection					X				Monitoring for drinking water sources

TABLE 3.5.3 SUMMARY OF WATER DEMAND WITH WATER SOURCES

1 Water Demand in Average Year (as a level of Year 1995)

1-1 Amount (Unit: 1000 m3/Year)

No.	Water Demand	Year 2015 (Case 1)		
		Surface water	Groundwater	Total
1	Irrigation water demand (IR)	1,041,426		1,041,426
1)	State irrigation	867,855		867,855
2)	Cooperative irrigation	173,571		173,571
2	Hydropower	0		0
1)	Demand (HD)	736,706		736,706
2)	Outflow	-736,706		-736,706
3	Domestic water supply (DW	9,346	177,567	186,913
4	Industrial water supply (IW)	325,097	294,135	619,232
5	Animal breeding (AW)	1,242	23,607	24,849
	Total Demand (TD)	2,113,817	495,310	2,609,127
	Percentage	81.0%	19.0%	100%
	Net Demand (ND)	1,377,111	495,310	1,872,421
	Percentage	73.5%	26.5%	100%

2 Water Demand in 4-Year Drought (as a level of Year 1994)

2-1 Amount (Unit: 1000 m3/Year)

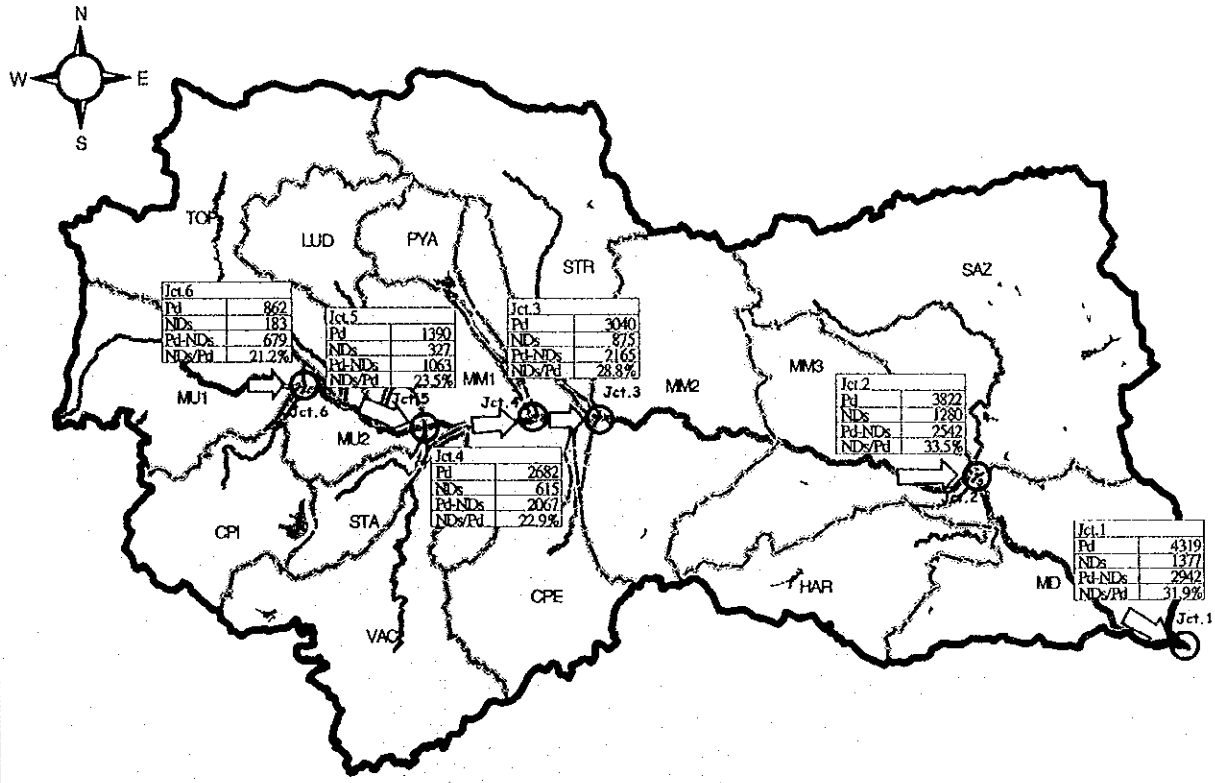
No.	Water Demand	Year 2015 (Case 1)		
		Surface water	Groundwater	Total
1	Irrigation water demand	1,179,590		1,179,590
1)	State irrigation	982,992		982,992
2)	Cooperative irrigation	196,598		196,598
2	Hydropower	0		0
1)	Demand	550,496		550,496
2)	Outflow	-550,496		-550,496
2	Domestic water supply	9,346	177,567	186,913
3	Industrial water supply	325,097	294,135	619,232
4	Animal breeding	1,242	23,607	24,849
	Total Demand (TD)	2,065,771	495,310	2,561,081
	Percentage	80.7%	19.3%	100%
	Net Demand (ND)	1,515,275	495,310	2,010,585
	Percentage	75.4%	24.6%	100%

Case 1 in 2015: Utilization rate of state irrigation systems is 50 (%).
Proportions of surface water and groundwater were set as follows;

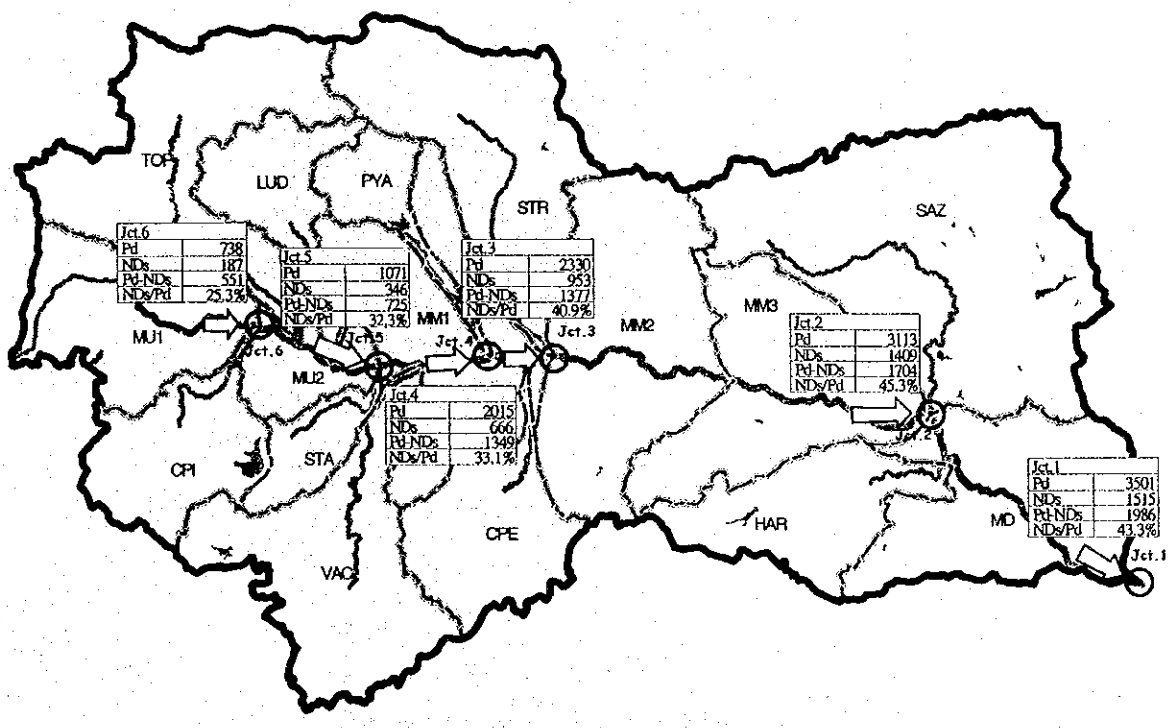
State irrigation : Almost all (about 100 %) is supplied by surface water.
Cooperative irrigation : - ditto -
Domestic water supply : 5 (%) from surface water and 95 (%) from groundwater.
Industrial water supply : 5 (%) from surface water and 95 (%) from groundwater in the present
Increased water demand is supplied by surface water.
Animal breeding : 5 (%) from surface water and 95 (%) from groundwater.

TABLE 3.5.4 PROPOSED STAGED PROGRAM OF RIVER BASIN MANAGEMENT

No.	Item	Preparation Year 1999 - 2000	Short term Year 2001 - 2005	Medium term Year 2006 - 2010	Long term Year 2011 - 2015	After Year 2016
1.	**Strengthening of monitoring systems**					
1-1	Meteo-hydrology					
1-2	Water intake for irrigation					
1-3	Water intake for hydropower					
1-4	Artificial control of surface water resources					
1-5	Water intake for domestic water supply					
1-6	Water intake for industry		Top 50 factories	Top 51-100	Other factories	(Continue)
2.	**Conservation and increase forest area for water resources**		Investigation	Priority basins	Other basins	(Continue)
3.	**Relating studies**					
3-1	Water resources management study in Bulgaria					
3-2	Agricultural development study in the Maritza River Basin		1st priority groups	2nd priority groups	3rd priority groups	
	Implementation of aguricultural development (for reference)			1st priority groups	2nd priority groups	3rd priority groups
3-3	Water balance of hydropower systems					
	Operation of hydropower systems based on the water balance study (for reference)					
3-4	Rehabilitation of water supply systems					
	Implementation of rehabilitation of water supply systems (for reference)					



ANNUAL BALANCE IN AVERAGE YEAR (LEVEL OF YEAR 1995)

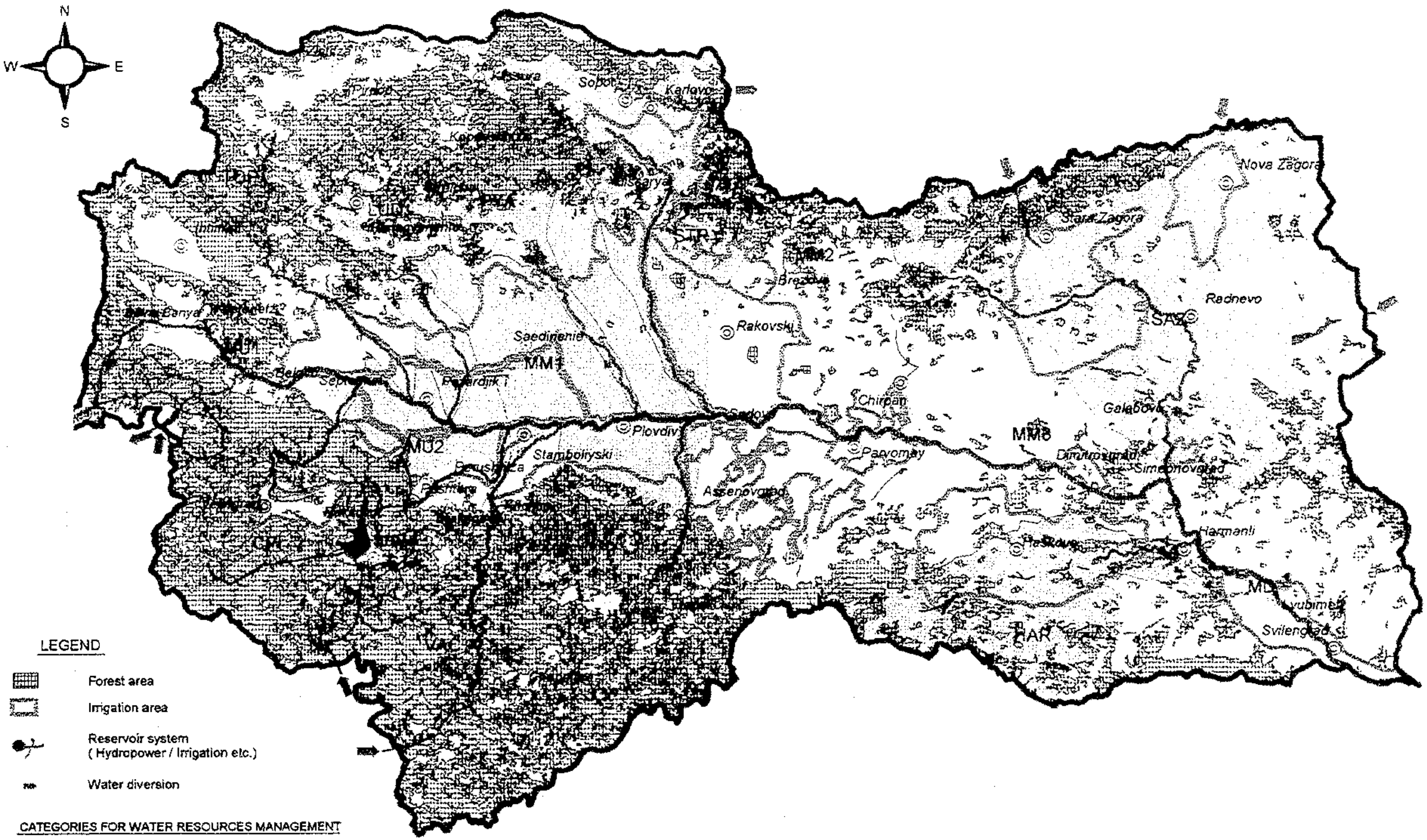


ANNUAL BALANCE IN 4-YEAR DROUGHT (LEVEL OF YEAR 1994)

Pd : Surface water potential with major dams (mil.m³/year)
NDs : Net water demand composed of irrigation ,domestic WS,industrial WS and animal breeding (mil.m³/year)
NDs/Pd : water utilization rate (%)

Note
CASE1 : Utilization rate of the state irrigation system with about 50 (%)

FIG.3.5.1 POSSIBLE SURFACE WATER BALANCE IN 2015 (CASE1) BASED ON THE ESTIMATED WATER DEMAND



CATEGORIES FOR WATER RESOURCES MANAGEMENT

Category	Basins	Points for Manegement
Category I	Special basins for controlling water resources potential	1). Conservation of areas with water resources potential (forest) 2).Supplemental reforestation (MU1,CPI,VAC,CPE,TOP) 3).Positive reforestation (MD) 4). Optimum operation of reservoir systems 5). Optimum diversion of water
Category II	Basins for controlling water resources potential and demand	1). Conservation of areas with water resources potential 2). Optimum operation of reservoir systems and water supply systems
Category III	Basins for controlling water demand	1). Optimisation of demand 2). Optimum water supply for demand

FIG.3.5.2

ZONING WATER RESOURCES MANAGEMENT

SCALE 1:1000000

10 0 10 20 (km)

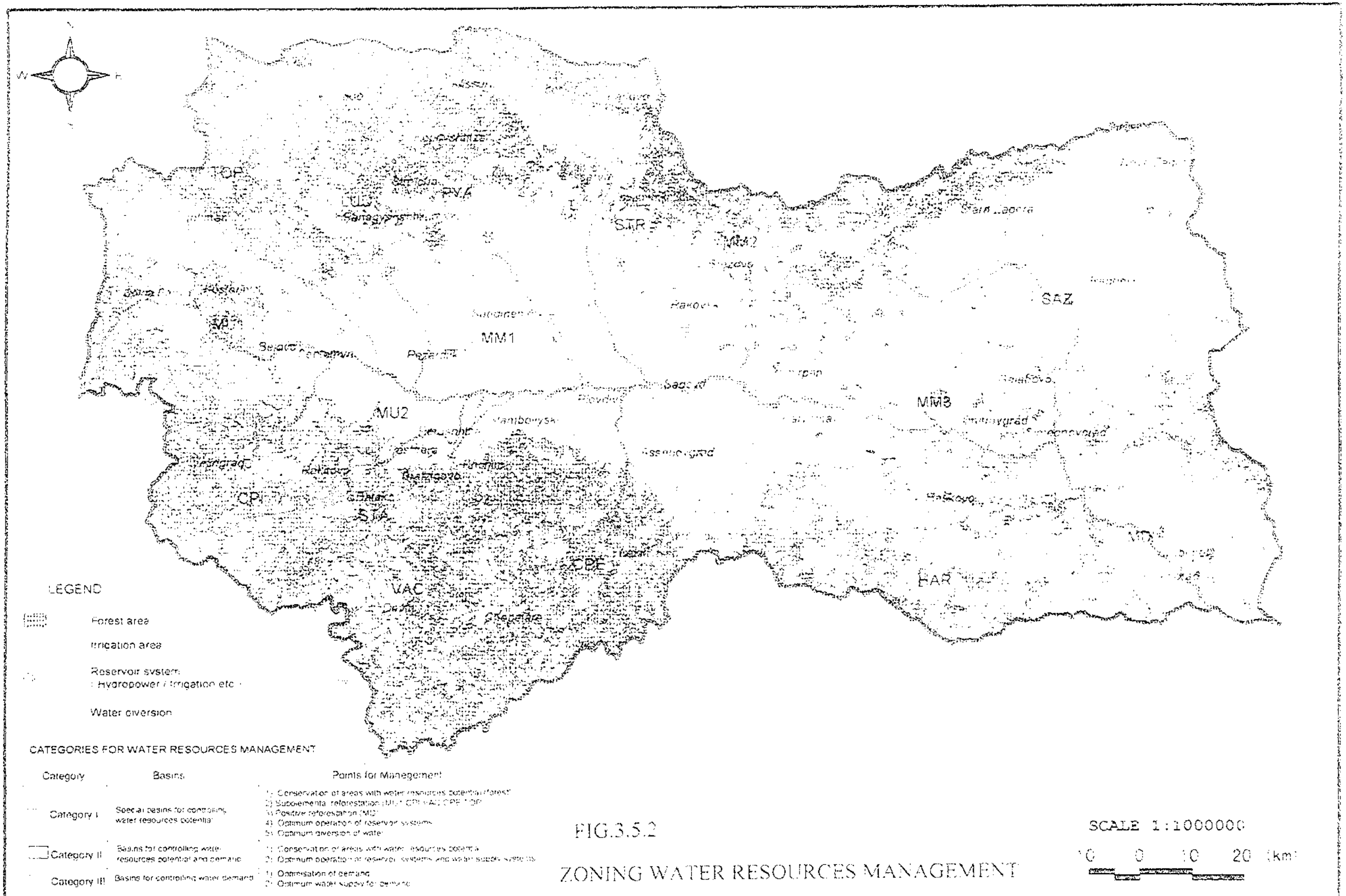


FIG.3.5.2

ZONING WATER RESOURCES MANAGEMENT

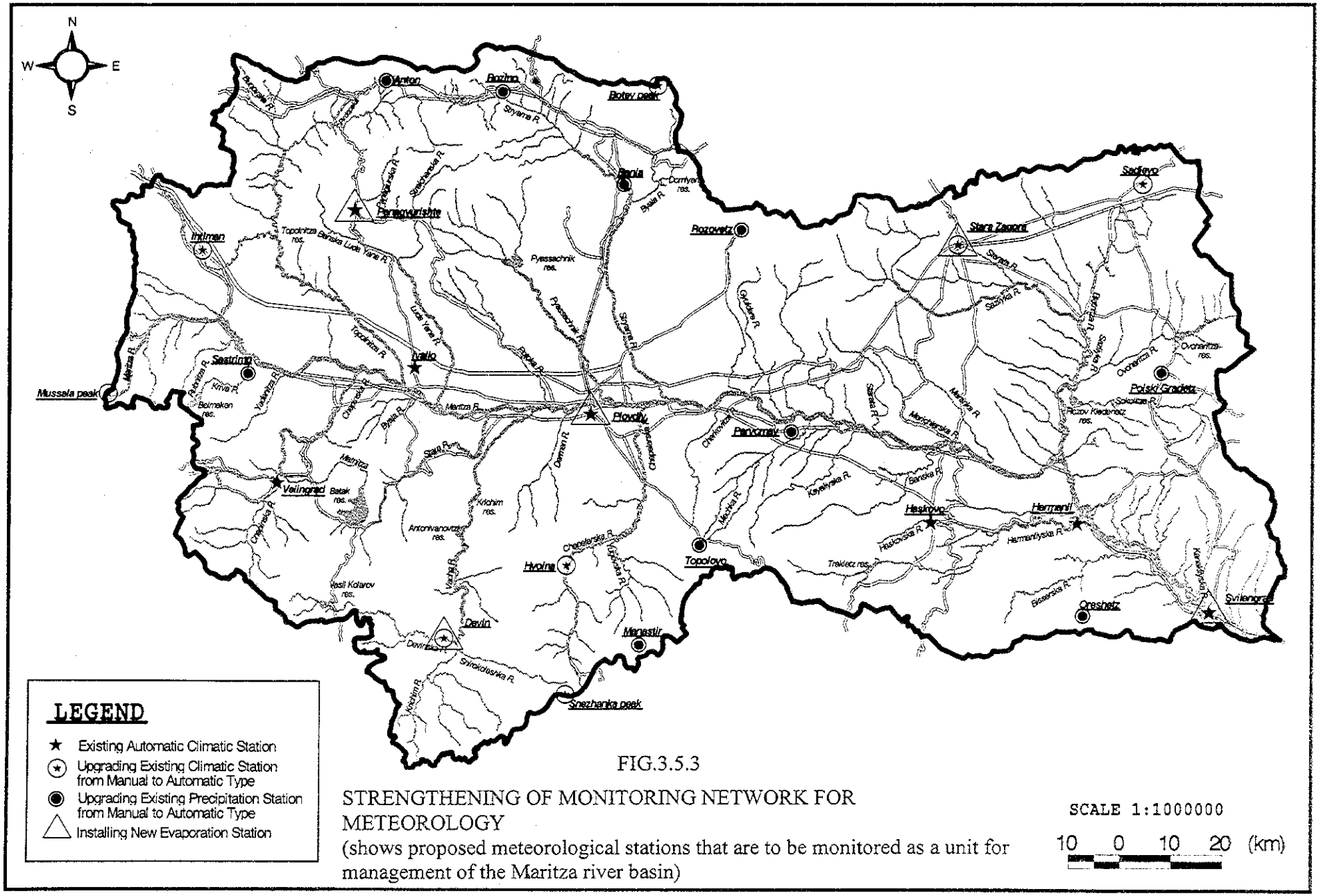


FIG.3.5.3

STRENGTHENING OF MONITORING NETWORK FOR METEOROLOGY

(shows proposed meteorological stations that are to be monitored as a unit for management of the Maritza river basin)

LEGEND

- ★ Existing Automatic Climatic Station
- Upgrading Existing Climatic Station from Manual to Automatic Type
- ◎ Upgrading Existing Precipitation Station from Manual to Automatic Type
- Installing New Evaporation Station

FIG.3.5.5

STRENGTHENING OF MONITORING NETWORK FOR METEOROLOGY

(Shows proposed meteorological stations that are to be monitored as a part of management of the Maritza river basin)

SCALE 1:1000000

10 0 10 20 Km

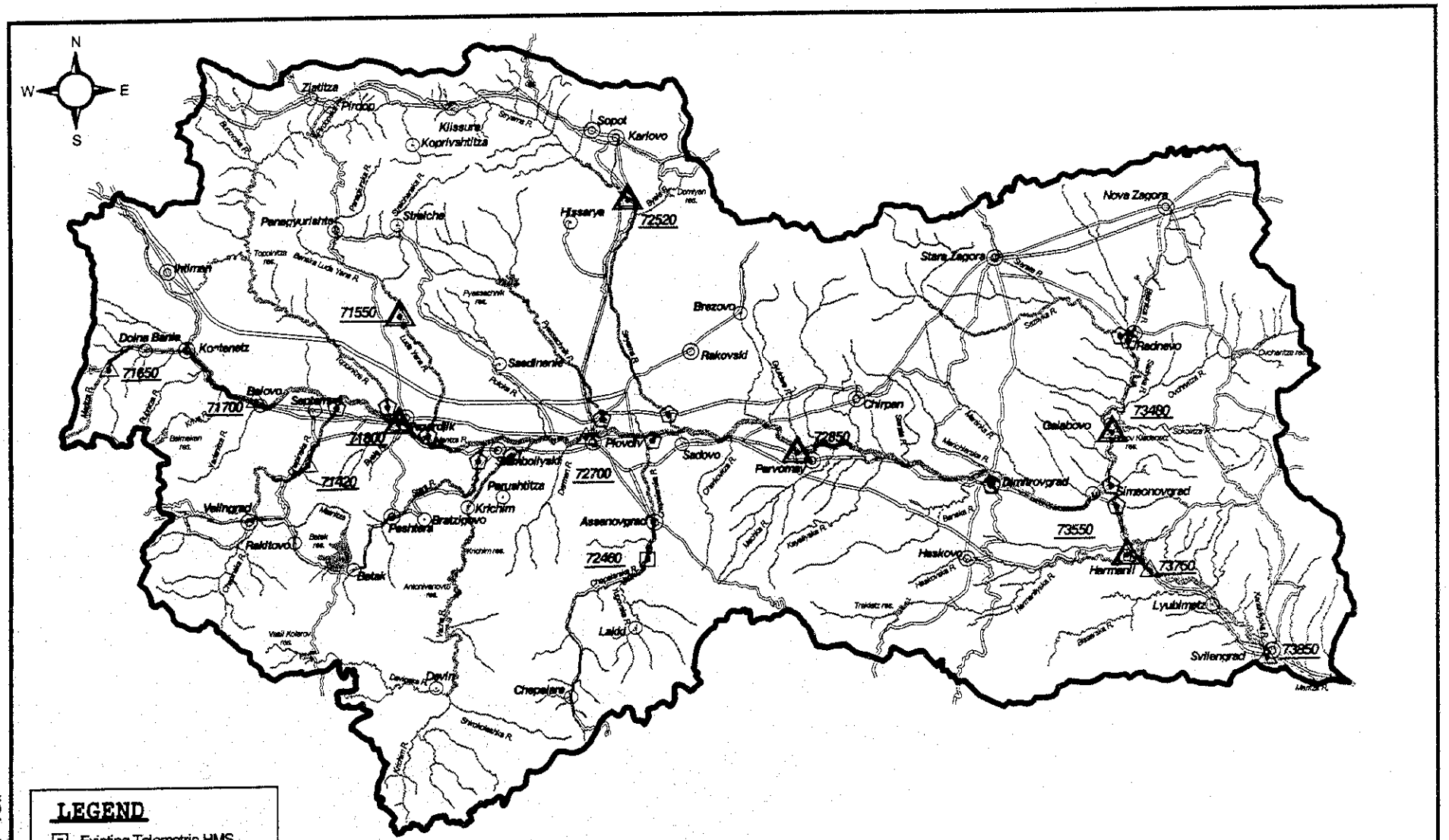
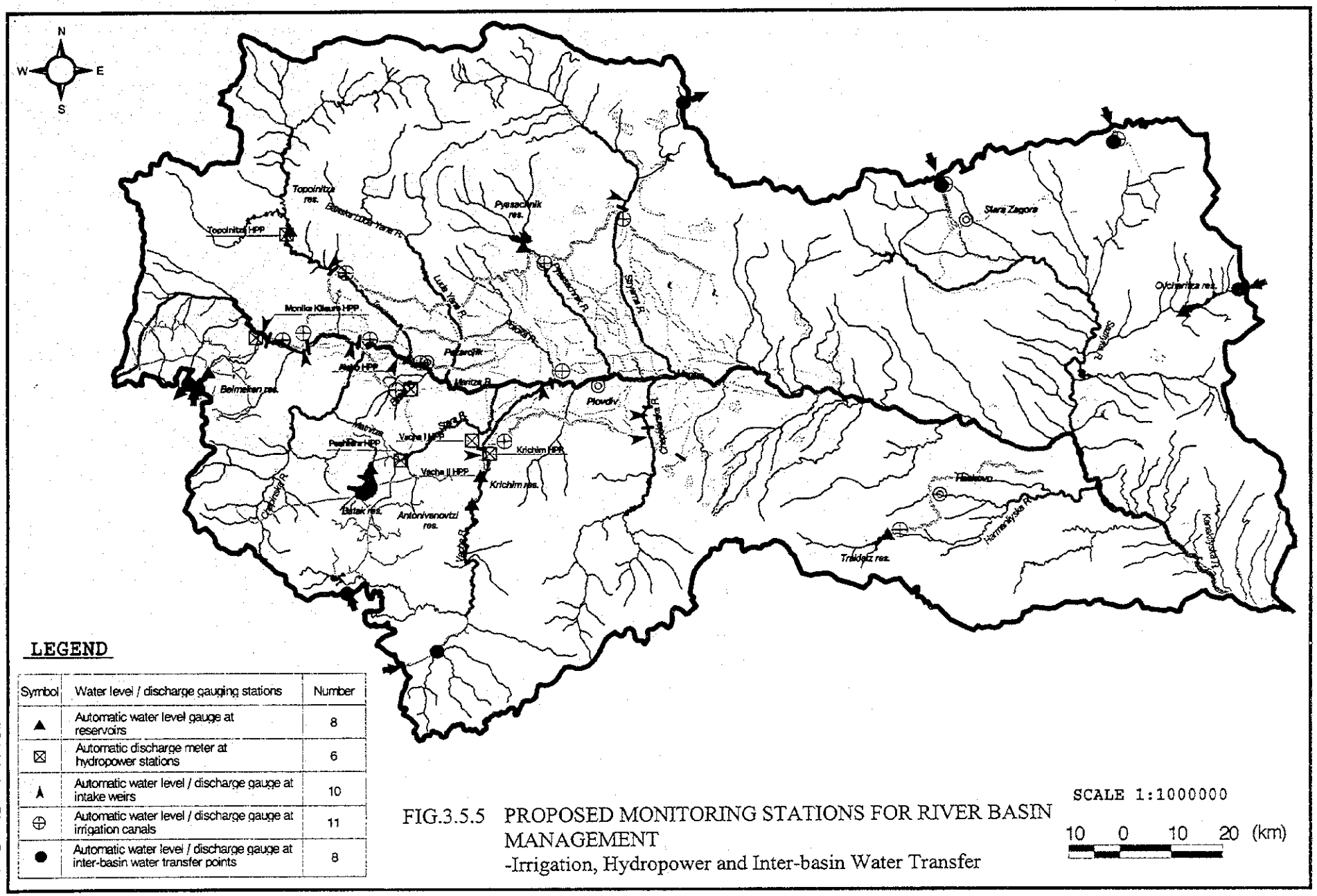


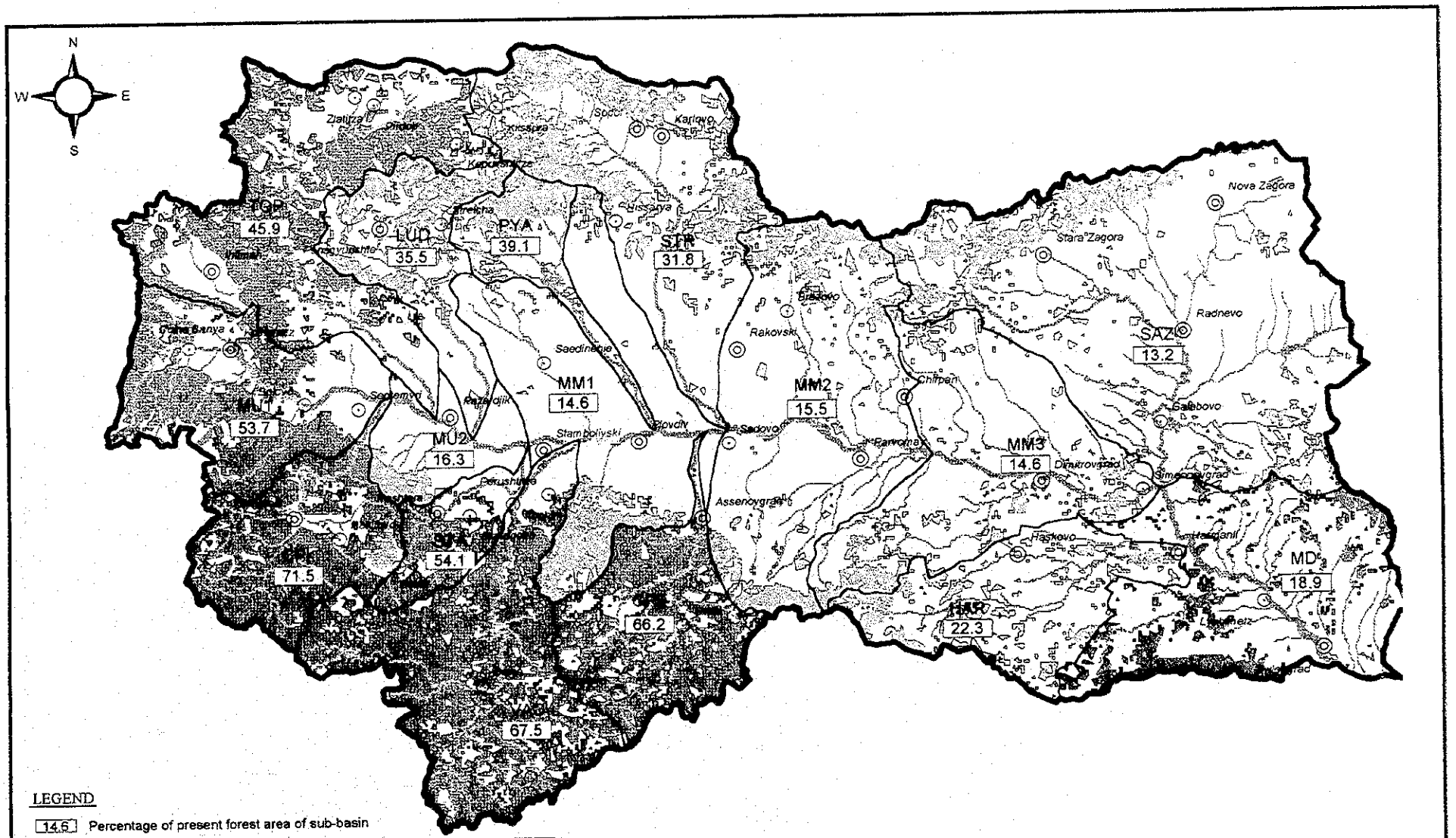
FIG.3.5.4 STRENGTHENING OF MONITORING NETWORK FOR HYDROLOGY
(shows proposed hydrometric stations that are to be monitored as a unit for management of the Maritza river basin)



Symbol	Water level / discharge gauging stations	Number
▲	Automatic water level gauge at reservoirs	8
⊠	Automatic discharge meter at hydropower stations	6
⅄	Automatic water level / discharge gauge at intake weirs	10
⊕	Automatic water level / discharge gauge at irrigation canals	11
●	Automatic water level / discharge gauge at inter-basin water transfer points	8

FIG.3.5.5 PROPOSED MONITORING STATIONS FOR RIVER BASIN MANAGEMENT
-Irrigation, Hydropower and Inter-basin Water Transfer

SCALE 1:1000000
10 0 10 20 (km)



LEGEND

14.6 Percentage of present forest area of sub-basin

Class	Priority for Forest Conservation/Reforestation for water resources
Class 1	1). High priority of forest conservation 2). Supplemental reforestation for water resources
Class 2	1). Medium priority of forest conservation and reforestation for water resources
Class 3	1). High priority of forest conservation and reforestation (including agro-forestry and fruit trees) for water resources

FIG.3.5.6 AREAS FOR FOREST CONSERVATION AND REFORESTATION FOR WATER RESOURCES

SCALE 1:1000000

10 0 10 20 (km)

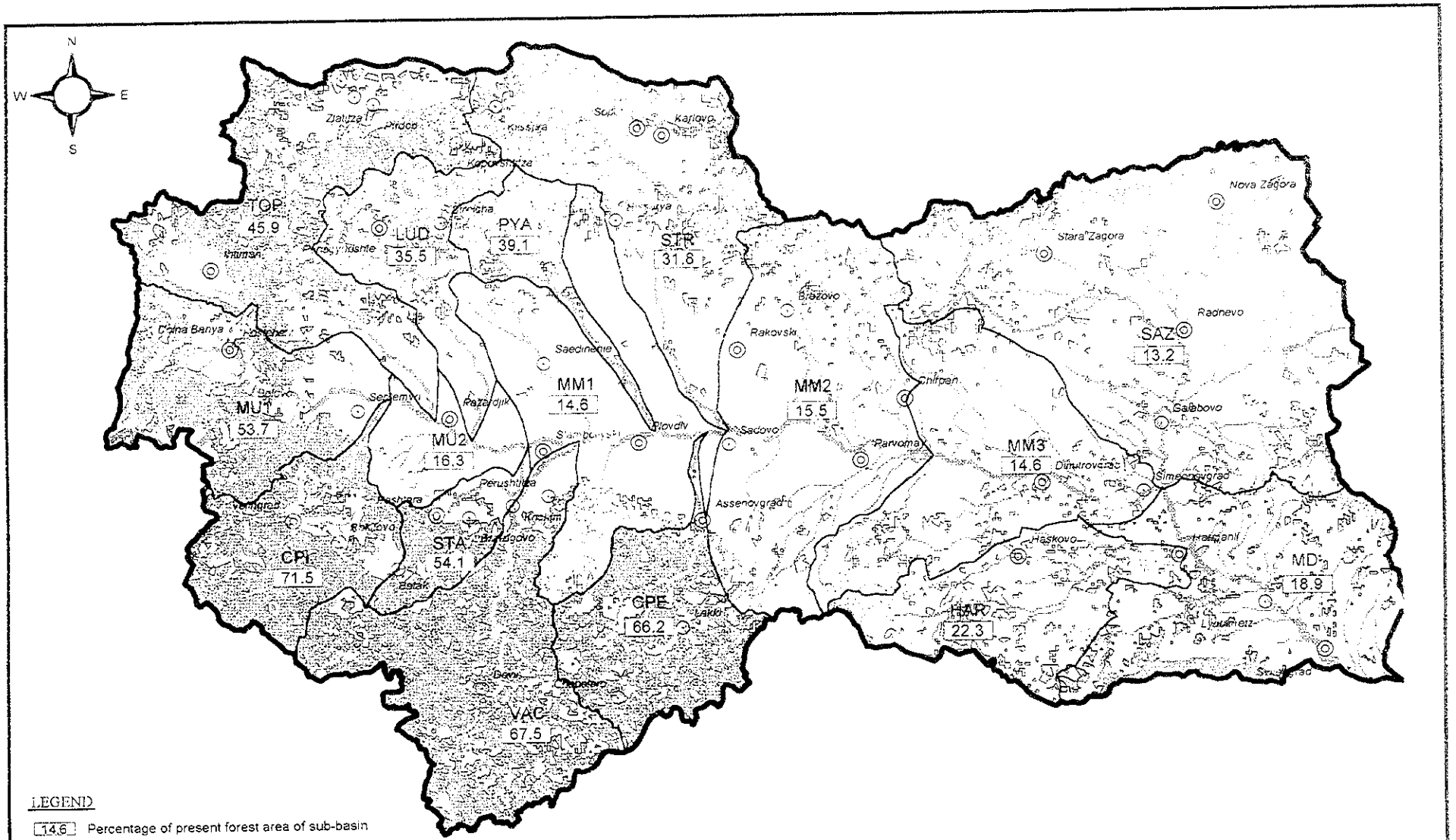


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FIG.3.5.6 AREAS FOR FOREST CONSERVATION AND REFORESTATION FOR WATER RESOURCES

SCALE 1:1000000

10 0 10 20 (km)

3.6

STRUCTURAL AND NON STRUCTURAL MEASURES