2.5
GROUNDWATER RESOURCES

2.5 Groundwater Resources

2.5.1 Monitoring System for Groundwater in Maritza River Basin

NIMH, NCESD and former CoG of MoEW manage the monitoring systems for groundwater. NIMH started the measurement of groundwater table and water quality from December 1959 for a few wells. NCESD and CoG started also the measurement from 1980 and 1992, respectively. It is reported that NCHE of MoH has also the monitoring system for the groundwater quality.

Monitoring stations of each organization are shown in Fig. 2.5.1 and Fig. 2.5.2. Monitoring system is composed of 327 stations composed of 161 stations of NIMH, 67 of NCESD, and 99 stations of CoG. CoG's monitoring stations are in the regions of Pazardjik, Plovdiv, Karlovo, and Haskovo. No organization has been established to synthesize the data of each organization at present.

Many of the stations of NIMH as well as those of NCESD could not be clarified the geological formation and aquifer type. However, the stations of CoG are well examined and could be realized the geological and hydrogeological conditions as well as aquifer types such as unconfined aquifer, confined aquifer, and fissure aquifer in each station.

2.5.2 Hydrogeological Condition

Unconfined aquifer and locally confined aquifer are distributed in the plain and hilly region. Its aquifer basin has a thickness of over 100 meters in the maximum and mainly consists of gravel, sand with clay.

Karst water is also distributed near Pazardjik, Stamboliyski, Devin, upstream part of Assenovgrad in Rhodopes Massif, and Brezovo to Stara Zagora in the Srednogorie Structural Zone where Precambrian and Cretaceous carbonate rocks are distributed

respectively. Those are considered to be aquifer because of many solution cavities and solution openings.

It is expected the distribution of fissure water because of the distribution of many faults. Some of them are the thermal groundwater. But, fissure water is not thoroughly investigated in the whole Basin.

According to the study report of CoG, average transmissivity of unconfined aquifer is about 1500 $m^3/d/m$ in the left bank and about 3000 $m^3/d/m$ in the right bank side of Pazardjik and Plovdiv. This study suggested also the distribution of thermomineral water in the bed rocks of Proterozoic marbles laid under the basin of unconfined aquifer.

Fig. 2.5.3 shows "Hydrogeological Map", which was compiled from hydrogeological map issued by former Bulgarian Academy of Science in 1967. High productivity of groundwater is expected in the surroundings of from Septemvri to Sadovo along Maritza river, from Harmanli to Lyubimetz along Maritza river, and along Stryama river. Its transmissivity ranges from 500 to 2000, locally to 4000 $m^3/d/m$, and these areas are suitable for big-scaled development. Other plain and hilly regions are expected to develop for local consumption. Groundwater is used as spring for local consumption in mountainous area.

2.5.3 Groundwater Table

The fluctuation of groundwater table in an unconfined aquifer shows the change of water volume stored. Among the 327 observation wells in the Maritza river basin, continuous measurement of groundwater table and water quality analyses have been conducted by NIMH for 16 wells and another 78 wells of them have measured several times in a year.

The data of long-term groundwater table fluctuation show a tendency to lower slightly in 5 areas during these 25 years (Year 1971 – 1995). They are the northern part of the Maritza Main Stream between Plovdiv – Pazardjik (2 wells: –1.50 m to –2.00 m), southern part of

the Maritza Main Stream between Sadovo – Parvomay Region (2 wells: -0.50 m to –3.00 m), near Simeonovgrad (1 well: -1.50 m), near Ihitiman (1 well: -1.50 m) and near Stara Zagora (1 well: -1.50 m).

2.5.4 Groundwater Quality

Data of NIMH:

Water quality data from NIMH are collected 13 wells in this Study. The result is shown as trilinear diagram in the Fig. 2.5.3 and summarized in the following table. Water quality as groundwater, the greater part of observation wells are classified into " Ca (HCO_3) type" representing river water and or unconfined water. Groundwater quality of 1055 well in Galabovo and 1084a well in Pazardjik have the character of " $CaSO_4$ - $CaCl_2$ type" midway between unconfined water and mineralized or karstic water. Groundwater quality of Galabovo may be contaminated from the high contents of sulphates.

Groundwater Quality - data from NIMH

(average value : mg/l)

No.	Well No.	Basin	pH	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	$NH4^+$	Na+ K	Total Fe	Hard-ness
*BSS2823		-		-	250	250	50	no	0.5	150	80	no	-	0.2	12
1	1084a	MU2	7.4	240	201.0	33.9	42.66	0.21	0.06	95.5	32.8	0.29	58.3	0.25	20.7
2	1082g	MM1	7.2	283	84.1	21.6	15.28	0.13	0.05	54.0	17.1	0.13	69.0	0.11	11.5
3	651	MM1	7.9	573	90.4	61.9	9.00	0.05	0.08	136.0	46.4	0.92	46.0	1.88	29.8
4	1052	MM2	7.4	283	93.2	21.9	21.61	0.33	0.11	0.33	16.0	0.33	64.2	0.50	12.9
5	1028	MM2	7.9	482	117.0	22.6	6.91	0.07	0.03	55.5	39.5	0.23	102	0.83	16.8
6	1066	MM3	7.5	328	109.0	35.3	10.98	0.25	0.27	79.7	20.4	0.37	78.3	0.67	15.8
7	1053	MM3	7.5	275	100.0	23.2	6.06	0.15	0.22	74.8	17.3	0.32	50.1	0.47	14.1
8	1059	MD	7.5	244	71.9	31.6	7.72	0.01	0.03	78.3	21.9	0.21	46.7	1.67	16.0
9	1081	LUD	7.2	186	85.4	24.7	10.60	0.58	0.09	52.5	16.0	0.50	41.9	0.36	10.9
10	1068	STR	7.2	135	36.2	15.1	23.41	3.94	0.03	31.3	13.1	1.47	30.0	0.51	7.1
11	1042a	STR	7.3	121	42.8	13.8	8.07	0.06	0.02	21.5	2.0	0.38	50.6	0.25	3.3
12	1061	HAR	7.3	247	124.0	33.3	10.30	0.16	0.31	71.3	20.2	0.83	65.2	0.26	14.3
13	1055	SAZ	7.5	292	299.0	49.2	10.42	0.19	0.05	119.0	42.0	0.37	92.6	1.35	26.4

Data are collected from 1984 to 1996. Data of well 1028,651, 1042a,1059 are collected from 1984 to 1988 or 1989 because of deteriorating equipment.

Type of sources : pipe well, shaft well, spring

* Bulgarian State Standard 2823/83 "Drinking water"

Generally speaking, water quality of raw groundwater is not so good on the basis of NIMH data. Nitrite, ammonia of all samples exceed the Bulgarian State Standard 2823/83 "Drinking water", and many samples exceed the Standard in total Fe and hardness. It is noted that water quality of the station number 1084a near Pazardjik and 1055 near Galabovo are characterized by the high concentration of sulphates comparing with another stations, and 1068 near Karlovo by the high contents of ammonia and nitrite.

Data of Ministry of Health (MoH):

Data of the raw groundwater quality for the domestic water from MoH are summarized in the following table. It is reported that manganese contents deviates the Bulgarian drinking water standard in all regions. The groundwater quality in Pazardjik region is characterized by the high contents of bacterial count, and water quality in Haskovo region is worse than another regions in general.

Groundwater Quality for Domestic Water - data from MOH

(average value : mg/l)

Region	Number of source*	NH_4^+	No_2^-	No_3^-	Fe total	Mn^{2+}	Bacterial count (no./liter)
**BSS2823/83	-	Not be counted	Not be counted	50	0.2	0.1	50
Pazardjik	64	-	-	-	-	0.14	50
Plovdiv	60	0.01	1.5	-	-	0.25	-
Stara Zagora	6	-	-	-	-	0.3	-
Haskovo	66	0.005 - 0.19	0.02 - 0.17	62.3	-	0.29 - 1.13	-
Total	196						

* Type of sources : pipe well, shaft well, spring

** Bulgarian State Standard 2823/83 "Drinking water"

Data of CoG:

General tendency of groundwater quality in Pazardjik, Plovdiv, Karlovo and Haskovo regions is recognized as follows (refer to Table 2.5.1 to 2.5.3).

1) Unconfined Aquifer

① Phosphates (PO_4^{3-}) contamination is found in the tributary area of Topolnitza, Syate, Luda Yana, Potoka, Vacha, Pyassachnik, Guldere, Mechka, and Haskovo river, especially in May and April.

② Nitrate (NO_3^-) contamination is distributed in the catchment area of Mechka river.

③ Haskovo region is characterized by the contamination of Sulphate (SO_4^{2-}) in the left tributary of Haskovo river. 13 wells of 17 monitoring wells are recorded the contamination of Phosphates (PO_4^{3-}), or Nitrate (NO_3^-), or Sulphates (SO_4^{2-}).

④ Unconfined water of these four regions is connected with river water and it may be easy to be polluted by the human activity for production.

2) Neogene Confined Aquifer

Monitoring wells are divided into two categories of Quaternary aquifer and Neogene aquifer. The deference of water quality between the two is slightly distinguished on their chemical contents and an extent of contamination.

Wells of R8, R12, R14 and R16, located in the north of Plovdiv, indicate the excess contents of radium (Ra226) and total beta activity comparing with the BSS2323/83. Uranium ore deposits are distributed in these areas.

2.5.5 Groundwater Resources

Most interesting groundwater resource is the Quaternary unconfined aquifer in the study area. It is distributed mainly in Quaternary deposit along the Maritza river and its tributary in where flood plane is widely distributed.

Karst water distributed in the carbonates rocks and fissure aquifer in the fractured zone are not suitable for the large scale development of urban water supply, industrial and irrigation

supply. A possible development volume of them is small and located in remote area from the big town and beneficiaries.

Karlovo Area

1) Quaternary-Pliocene Unconfined Aquifer

The Quaternary-Pliocene unconfined aquifer is important for the regional economy and it is exploited well. It is reported that the groundwater resource was assessed 1273 l/s. About 1028 l/s of its is utilized during the dry season. Available utilization volume is about 245 l/s or 7.73 x 10^6 m^3 / year.

2) Pliocene Confined Aquifer

The groundwater resource of the Pliocene confine aquifer is divided into two parts and it is estimated on the basis of transmissivity as follows.

Area	Transmissivity	Potential	Potential
Northern part (recharge area)	30 m^3/d/m	60.4 l/s	1.90 x 10^6 m^3 / year
Southern part (drainage area)	60 m^3/d/m	25.3 l/s	0.80 x 10^6 m^3 / year
Total	-	85.7 l/s	2.70 x 10^6 m^3 / year

Northern part of Plovdiv – Pazardjik Region

1) Quaternary Aquifer

Quaternary aquifer of this region is well investigated and it is reported that available utilization volume is estimated about 21.9x10^6 m^3 / year.

2) Pliocene Aquifer

Static reserves of Pliocene aquifer are estimated to be 9.2x10^9 m^3.

Plovdiv – Pazardjik Region

1) Quaternary Aquifer

Groundwater resource potential of Quaternary aquifer is estimated to 5,355 l/s or 168.88 x 10^6 m^3 / year on the basis of the following transmissivity.

- North of Maritza River : 756 m^2/d/m
- South of Maritza river : 1100 m^2/d/m

2) Pliocene Aquifer

Groundwater resource potential of Pliocene aquifer is estimated to be 459 l/s or 14.48 x 10^6 m^3 / year. The area of north of Maritza river is estimated to be 68 l/s or 2.14 x 10^6 m^3 / year and the south of its is 391 l/s or 12.33 x 10^6 m^3 / year. The transmissivity values used for these calculations are 197 m^3/d/m and 225 m^3/d/m respectively.

2.5.6 Geothermal Resources

Data of thermomineral water are collected. It was clarified that the flow rate of thermomineral water is small and its temperature is insufficient for a large development. It is suitable for the development of local use.

2.5.7 Recommendation

Master plan study shall be conducted to formulate the groundwater resources development and the preservation program for groundwater basin. The Study area is divided into 16 drainage areas. The groundwater basin is spread on some drainage areas. The groundwater basin, which is located in and around Pazardjik and Plovdiv, shall be given priority to

formulate the master plan. This groundwater basin is the most important for the human activity from the environmental and economic points of view in the study area and includes MU1, TOP, LUD, CPI, STA, VAC, PYA and MM1 drainage basins.

TABLE 2.5.1 GROUNDWATER QUALITY – UNCONFINED WATER-DATA FROM COG

(unit: mg/l)

Basin	pH	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	$NH4^+$	Na+ K	Total Fe	Hard-ness
* BSS2823/83			250	250	50	no	0.5	150	80	no		0.2	12
MU1	7.0-7.9	51-201	6-49	15-21	1-10	0-0.1	0.1-0.6	7-73	6-16	0-0.27	11-14	<0.1	0.9-4.7
MU2	6.8-8.3	67-387	5-189	4-47	0-90	0-0.07	0.2-1.6	7-154	2-31	0-0.03	13-54	<0.1-0.9	0.8-10.2
MM1	7-8.3		9-273	7-104	1-266	0-2.23	<0.2-2.4	7-206	3-48	0-0.04	9-116	<0.1-2.5	2.4-13.6
MM2	7.2-8.2	188-375	27-346	10-73	5-189	0-0.2	0-1.7	68-184	8-58	0 (0.05)	10-120	<0.1-0.2	4.1-12.8
MM3	7.3-8	338-448	17-276	20-217	5-72	0-0.02	<0.2-1.4	100-182	6-63	0-0.008	29-104	<0.1	6.6-11.8
TOP	7.0-7.8	199-449	6-810	18-71	1-136	0-0.36	0.2-2.4	75-320	16-84	0-0.03	16-77	<0.1-(1.8)	5.0-7.8
LUD	7.0-7.8	239-407	9-111	12-19	13-20	0-0.18	0.4-1.6	80-92	17-26	0-0.03	21-35	<0.1-(0.2)	5.5-6.5
PYA	7.4-8.7	62-206	11-19	9-13	8-20	0-0.07	0.1-1.4	15-48	5-11	0 (0.1)	20-24	<0.1	1.2-3.3
STR	6.4-8.8	33-237	12-62	4-31	0-128	0-0.8	<0.05-1.4	6-60	0-38	0 (0.01)	7-61	<0.1	0.3-4.8
VAC	7.2-7.8	156-436	11-41	5-30	10-105	0-1.03	0.05-1.2	56-114	4-43	0	8-33	<0.1 (0.4)	3.2-9.2
CPE	7.8-7.9	145-171	32-37	5-9	2-3	0	<0.2	48-57	6	0	10-13	<0.1	2.9-3.3
HAR	7.5-8.3	66-485	27-506	5-68	1-59	0-1.36	<0.2-1.8	25-160	4-47	0-0.01	13-220	<0.1 (0.2)	1.6-11.8

Data are collected from 1995 to 1997. Total monitoring well are 99. No numerical analysis

* Standard : Bulgarian State Standard 2823/83 "Drinking water"

TABLE 2.5.2 SEASONAL FLUCTUATION OF GROUNDWATER QUALITY – UNCONFINED WATER

(average value : mg/l)

Basin	Season	No*	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	Na+K
**BSS2823/83				250	250	50	no	0.5	150	80	
MU2	May	6	226	129.3	22.7	16.1	2.7	1.10	89.9	19.5	31.3
	October		207	51.8	16.3	15.1	0.015	0.45	64.8	13.6	22.1
MM1	May	13		94.3	27.4	24.9	0.13	0.71	98.3	24.5	35.0
	October		303	70.0	24.0	18.0	0.09	0.30	84.0	22.4	35.0
MM2	May	9	271	165.4	45.1	84.2	0.03	0.45	125.5	29.8	49.7
	October		265	132.0	36.0	64.0	0.04	0.44	108.0	24.0	46.0
MM3	May	4	405	135.0	67.8	30.1	0	0.88	134.0	31.0	64.2
***	October		390	142.5	51.3	34.4	0.004	0.60	127.9	31.5	60.7
STR	May	11	123	43.0	16.3	14.1	0	0.40	36.6	12.2	17.2
	October		134	40.8	18.4	25.6	0.04	0.37	43.2	13.3	18.2
HAR	May	17	294	112.5	36.3	25.6	0.006	0.95	91.3	20.5	60.8
	October	13	304	119.0	38.0	27.5	0.057	0.55	93.0	20.9	66.4

Data are collected from 1995 to 1997. * : sample number, No numerical analysis

** Bulgarian State Standard 2823/83 "Drinking water"

*** MM3 : Only Haskovo area

TABLE 2.5.3 SEASONAL FLUCTUATION OF GROUNDWATER QUALITY – PLIOCENE CONFINED WATER

(average value : mg/l)

Basin	Season	No*	HCO_3	SO_4^{2-}	Cl^-	NO_3^-	NO_2^-	PO_4^{3-}	Ca^{2+}	Mg^{2+}	Na+K
**BSS2823/83				250	250	50	no	0.5	150	80	
MM1	May	4	187	31.8	16.6	11.8	0.06	0.37	46.8	13.0	20.6
	October		182	40.2	17.5	2.9	0	0.27	40.8	14.0	28.5
MM2	May	9	326	80.7	29.4	31.4	0.08	0.80	101.1	25.9	42.3
	October		345	53.7	21.7	27.1	0	0.20	87.8	23.3	43.4
STR	May	6	154	37.0	17.3	25.4	0.02	0.35	37.9	10.3	32.9
	October	7	156	27.1	14.0	1.7	0.02	0.40	32.8	8.3	31.4

Data are collected from 1995 to 1997. * : sample number, No numerical analysis

** Bulgarian State Standard 2823/83 "Drinking water"

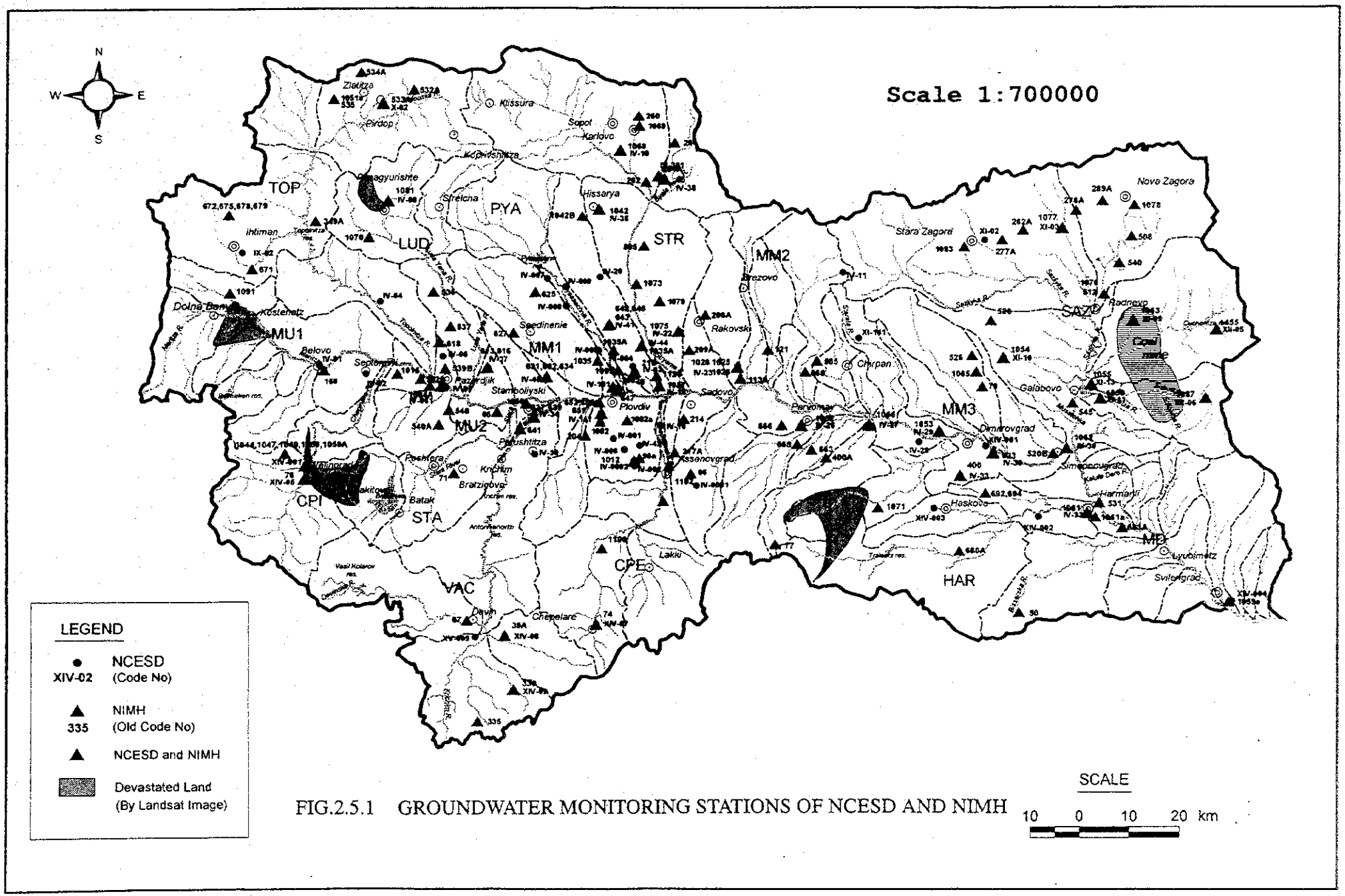


FIG.2.5.1 GROUNDWATER MONITORING STATIONS OF NCESD AND NIMH

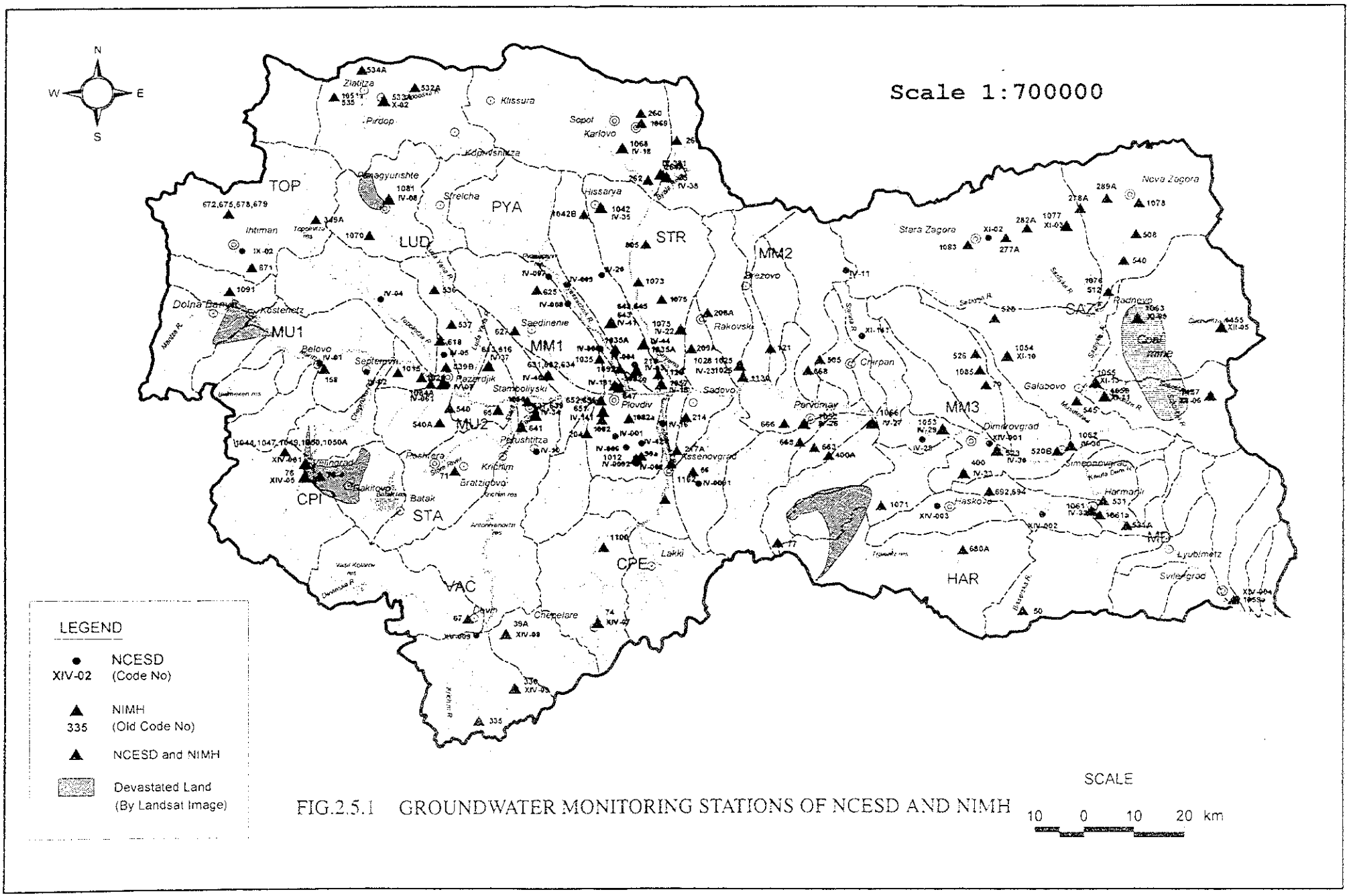


FIG.2.5.1 GROUNDWATER MONITORING STATIONS OF NCESD AND NIMH

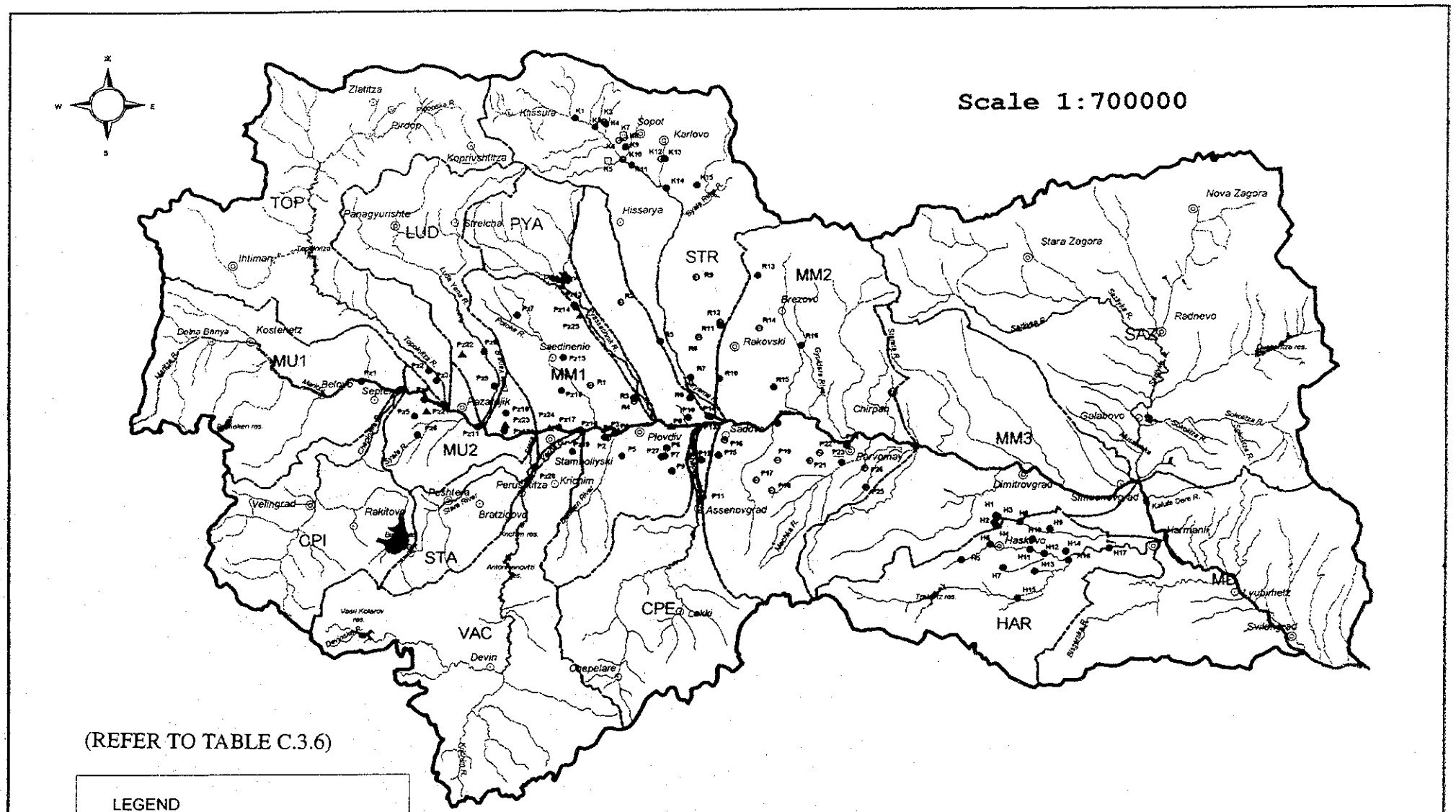
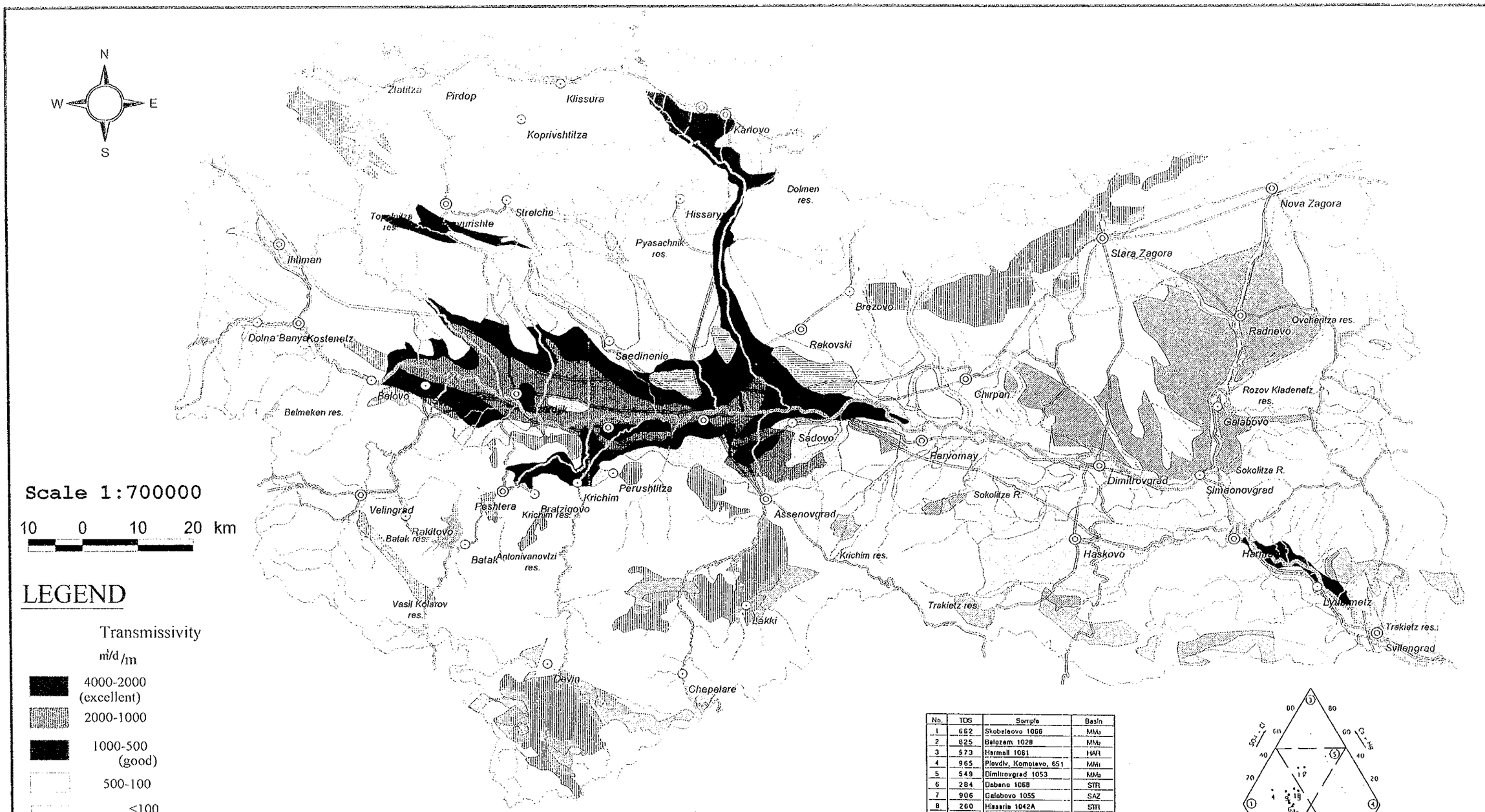


FIG.2.5.2 MONITORING SYSTEM BY MOEW
(FORMER COMMITTEE OF GEOLOGY)



LEGEND

Transmissivity

m²/d /m

- 4000-2000 (excellent)
- 2000-1000
- 1000-500 (good)
- 500-100
- <100 (bad)
- High Mineralized Water
- Groundwater is used as spring water
- Exposure of coal bearing sandstone (possibility of bad water quality)
- Exposure of carbonate rocks (possibility of hard water)

No.	TDS	Sample	Basin
1	662	Skobelsovo 1066	MMa
2	825	Belozem 1028	MMa
3	573	Harmali 1061	HAR
4	965	Plovdiv, Komotevo, 651	MMt
5	549	Dimitrovgrad 1053	MMa
6	284	Debeno 1068	STR
7	906	Galabovo 1055	SAZ
8	260	Hissarlia 1042A	STR
9	503	Obruchishte 1059	MD
10	417	Ponagyurishte 1081	LUD
11	705	Pazardjik 1084a	MMz
12	544	Plovdiv, East, 1082g	MMt
13	569	Parvomai 1052	MMz

Data from NIMH

Groundwater Quality Type
- ① Unconfined aquifer
- ② Confined aquifer
- ③ Mineralized water
  - Volcanic water
  - Karst aquifer
- ④ Sea water, Fossile water
- ⑤ Intermediate water

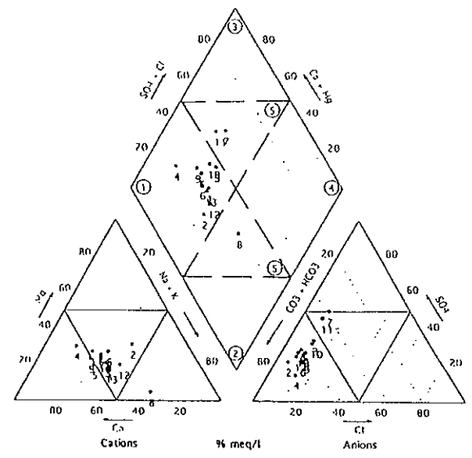


FIG.2.5.3 DISTRIBUTION OF TRANSMISSIVITY

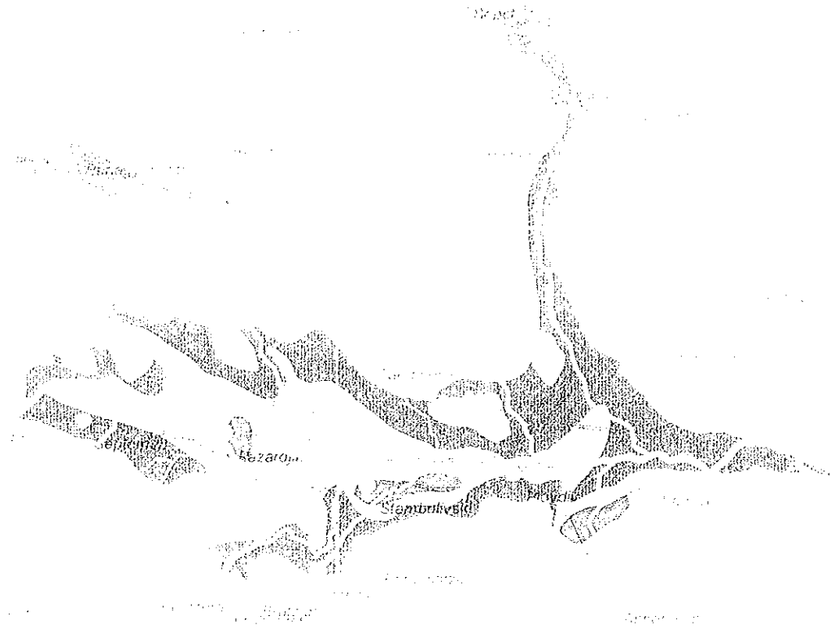


FIG.2.5.3 DISTRIBUTION OF TRANSMISSIVITY

2.6

WATER QUALITY AND POLLUTION SOURCE

2.6 Water Quality and Pollution Source

2.6.1 Surface Water Quality

(1) Monitoring

Monitoring the water quality in the Maritza River Basin started in 1975. Several institutions worked together under the National System for Ecological Monitoring (NASEM) and under the direction of the former Ministry of Environment (MoE) and collected, analyzed and investigated the water quality about surface and groundwater and exchanged the results.

Part of the system have been under:

- Ministry of Environment and Water (MoEW) with the National Center for Environment and Sustainable Development (NCESD), the Regional Inspectorates (REI), and the former Committee of Geology (COG),
- Ministry of Health (MoH) with the Hygiene and Epidemioloy Inspectorates (HEI),
- Bulgarian Academy of Science (BASc) with the National Institute of Meteorology and Hydrology (NIMH).

In 1993, the monitoring system of the NCESD consisted of about 60 observation and sampling points. They were concentrated along the Maritza River and its main tributaries, i.e., Sazliyka, Banska Luda Yana, Topolnitza, Harmanliyska, Chepelarska, and Chepinska.

In 1998, the monitoring system of NCESD was updated by the ordnance (MoEW Ref. No. RD-249), adding 13 new stations and deleting several stations, in order to coordinate with the monitoring networks of HEI and NIMH. In addition, the information procedure has to be established. The monitoring system consists of 40 stations and shown in Fig. 2.6.1.

About surface waters, the most complete data (chemical analysis) exists in the MoEW and has been mainly used in this study regarding the surface water quality.

For the sampling and analyzing, the Regional Inspectorates are responsible. The samples are processed, transported, stored and analyzed in the laboratories of the Regional Inspectorates, according the Bulgarian standards.

In situ are measured: pH, temperature, dissolved oxygen, conductivity. All other parameters is analyzed in the laboratories such as: BOD, COD, oxidizability, TDS and SS, nitrogen as NH_4, NO_2 and NO_3-N, PO_4, Ca, Mg, Cl, S, Fe, Mn, Ni and Zn, other heavy metals, H_2S, cyanide, phenol and oil.
Results of these analysis and data have been collected, and some of the results are regularly published by the NCESD.

(2) Water Quality Based on Chemical Characterization

The quality is evaluated with the Regulation No 7 of Ministry of Health. The regulation has four classes as follows:

- Class I: Usable for drinking water source,
- Class II: Acceptable for recreational use and fish farming,
- Class III: Acceptable for irrigation and industrial use, and
- Beyond Class III: Unsuitable to use for any purpose.

Concentration and load varied seasonally. The pollution load dropped in summer, however, water quality became worse because of the decrease of river discharges and the increase of water use for irrigation.

Figs. 2.6.2, 2.6.3 and 2.6.4 show the seasonal water quality by BOD, NH4 and NO3 in 1994 - 1996. Comparing Figs 2.6.2 and Fig 2.6.8, the water quality of the Maritza River strongly depends on the pollution loads. The Sazliyka and Harmanliyska Rivers have a high loading and seem to be polluted yearly. Also the Banska River is deteriorated yearly.

The seasonal water quality by NH4 shows that all parts of the river are lower water quality than the Class I. The most polluted river reaches are the Sazliyka and Harmanliyska Rivers that are the same as by BOD loads. The water quality of these two rivers is lower than the class III. In the Chepelarska River, the water quality is deteriorated and becomes lower than the class III in summer and fall. The river basin seems to be polluted more by NH4 than by BOD.

The seasonal water quality by NO3 is Class I or Class II except upstream of the Sazliyka River in January through March. It can be concluded that the NO3 loads do not seem to have so significant impact to the Maritza River Basin as BOD and NH4 loads.

(3) Biological Characterization

Surface water can be characterized with either physical/chemical or biological parameters. Both groups of parameters have advantages and disadvantages and should be used to back up each other and to give a comprehensive and detailed characterization of the water quality. Biological methods have advantages, as the effect of pollution can be still seen even after the pollution can not be measured/analyzed anymore. Chemical parameters are needed to characterize and to identify the pollution, also to quantify it. Both methods complement one another.

The Bulgarian regulation N.7 lists under Group E, Biological indexes, several biological parameters, (number 80 to 87):

- Saprobity (as Prantle-Book index, Zelikan- Marvan Rotstain index)
- Macro-zoobenthos species diversity, matching degree, domination degree
- Total number of microorganisms (direct count)
- Total coli titre, Escherichia coli titre and pathogenic microorganisms

The water quality of the Sazliyka and Blatnitza Rivers is characterized since middle of 1997 with microbiological parameters. Measured are: Bacterial count, coliforms, faecal coliforms and pathogens.

Until now only few results exist but the high number of bacteria as bacterial count, coliforms or faecal coliforms show as well as the chemical parameters the high pollution load in the Sazliyka sub catchment.

In the Monitoring of Waters and Bio-monitoring Department of NCESD, the surface water quality is assessed with the help of macroinvertebrates. And a biotic index is formulated. From 1996 to 1998, the water quality of the Maritza River has been studied at more than 70 sites, in interval of about 5 km.

Fig. 2.6.5 shows the result of the biological assessment study on the water quality of the Maritza River conducted by NCESD. The water quality is classified into BI-1, 2, 3, 4, and 5 from Bad, Poor, Doubtful, Fair to good quality. From this assessment total 15 "hot spots" are identified as follows:

- Topolnitza and Pirdopska Rivers, Topolnitza reservoir, because of pollution through the copper plant in Pirdop,
- Maritza River after Dimitrovgrad, pollution through the chemical factory "Neohim",
- Sazliyka River after Stara Zagora, sewerage from the town and the wastewater from "Agrobiohim"
- Maritza River after Belovo, chemical factory
- Banska Luda Yana River, polluted through "Asarel"
- Stara Reka, pollution through "Biovet-Peshtera", veterinary products.
- Chepelare, zinc plant in Plovdiv and pesticide factory "Agria"

- Stara River after Karlovo, wastewater from town.
- Stryama River, organic pollution from pig farm in Manole.
- Maritza River before Popovitsa, alcoholic spirit factory "Crystal"
- Haskovska River, pollution with domestic and industrial wastewater.

2.6.2 Pollution Sources

The pollution sources can be characterized with physical/chemical/biological parameters, it is possible to assess the pollution loads. Pollution sources in the Maritza River Basin are:

- Towns and villages, with or without sewer system, connected to a WWTP or not,
- Industries with or without (pre-) treatment.
- Live stock farms,
- Dumping sites (domestic, industrial or hazardous wastes)
- Mining sites.

In the Study unit loads of BOD, TN, NH4 and NO3 from domestic, livestock farm and land use each pollution source to the Maritza River and its tributaries are estimated and shown in Table 2.6.1.

Fig 2.6.8 shows BOD load by pollution source. SAZ-7 where Stara Zagora is located is found high load in all pollution sources. The pollution source and the loads are summarized in Fig. 2.6.6, Fig 2.6.7 and Fig 2.6.9, and Table 2.6.3, Table 2.6.4, and Table 2.6.5.

Fig 2.6.6 shows domestic load contributes 46% of total pollution regarding BOD. By catchment load, 21% of total pollution comes from SAZ-7 shown in Fig. 2.6.7. 48% of pollution is loaded from 5 sub-catchment. The pollution is not loaded uniformly from the study area. Main towns in the 5 most loaded catchments are Stara Zagora,

Sadovo, Pazardjik, Plovdiv, and Haskovo. The load from 5 towns is 42% of total pollution in the Maritza Basin.

In Fig 2.6.9, pollution load is broken down to each classified source. SAZ-7 is highest load in all classified sources. Tendency of pollution load is that only a few sub-catchments contribute a large part of pollution, especially industry. Top 3 industries control 54% and 88% of BOD and TN load, respectively.

(1) Domestic

In the Maritza River Basin live in total about 1,750,000 people, of which about 68 % live in towns or villages with more than 5000 inhabitants. Domestic loads are classified as follows:

- connect to only sewer system : 37 %
- connect to both sewer and wastewater treatment plant: 21 %
- not connected to sewer system : 42 %

A percentage shown above is based on population in 1992. The detail is shown in Table 2.6.2.

High loading basins are Sazliyka, Harmanliyska, Maritza around Pazardjik, Plovdiv and Dimitrovgrad, up steam of Stryama and Chepinska, and downstream of Chepelarska. All of the high loading basin locate top ranked town such as Plovdiv, Stara Zagora, Haskovo, Pazardjik, Assenovgrad, Dimitrovgrad, Velingrad, and so on.

(2) Industry

Many different industries are located in the Maritza River Basin. They belong to following branches:

- Power generation, chemical industry, food, machinery, mining (ore and coal), pulp and paper, textile, transport, cement industry and others.

From the industries, the top 50 polluters regarding to the BOD and nitrogen have been identified (Table 2.6.3). Regarding BOD, 2 industries ("Kristal 91" and "Agrobiohim") are already providing nearly 50 % of the BOD load, regarding the discharged nitrogen 2 industries ("Agrobiohim" and "SC Neohim") are responsible for more than 85 % of the total nitrogen load. Selecting the "top 20 industries" will cover 86 % of the total BOD load and 94 % of the total nitrogen load. The general statement is that a limited number of polluters is responsible for a high percentage of the load.

(3) Livestock farm

Livestock pollution is distributed over the basin compared with other source. According to the available information, loads/pollution from the farms can be expected mainly along the Maritza, Sazliyka and Harmanliyska and Stryama Rivers. Sazliyka region is the highest loading, 73 % of BOD and 65 % of TN load is from pig and cattle respectively.

The number of the big farms decreased in the last years, but the number of animals in small farms increased. Most animals are raised and kept in low number in small farms, they are regarded as non point pollution source. In 1995 about 79 % of the cattle , 83 % of the cows, 57 % of the pigs and 92% of the sheep were raised in private farms. Regarding cattle, 83 % of the farms are raising only 1 or 2 animals, 16 % 3 - 10 animals and only 0.6 % have more than 10 animals.

(4) Land use pattern

The pollution from land use discharges during rain. The distribution of pollution based on sub-basin is spread whole basin. Among them, Sazliyka is the highest load because of the largest agricultural land use. Pollution effect by fertilizer and pesticide

could not quantified. However, these area largely used for agriculture has high potential of fertilizer and pesticide pollution.

(5) Dumping sites

Dumping sites could be also regarded as point sources, in case the leachate would be collected and discharged untreated or treated. This is not the case in the Maritza river basin.

The thread exists that unorganized dumping sites act as temporary point pollution source. In case, the site is flooded, and the polluted waters are discharged into the rivers. Quality and quantity of such events are unknown.

Wastes in the Maritza River Basin can be classified as:

- domestic, industrial, hazardous wastes.

Records about the wastes regarding: producer, location of storage, characteristics/properties of the waste, physical condition, composition, storage are collected in regional inspectorates and in NCESD since 1992.

(6) Mining

Pollution from mining industries is not quantified. Investigations/data gathering in this project resulted in the identification of 101 mines and deposits, including uranium mines, still under operation or already closed. Fig. 2.6.9 shows the location of the identified and mentioned objects. The high number of objects and the problematic of the possible (heavy metal) pollution from open or closed mine show the complexity of this pollution source and requires further attention.

TABLE 2.6.1 UNIT LOAD

Category of Pollution Source		BOD (kg/d)	TN (kg/d)	NH4 (kg/d)	NO3 (kg/d)	Q (L/d)	Reference
Domestic	***Non-sewered***	***0.0135***	***0.0032***	***0.00119***	***0.0012***		***UNDP report***
	Sewered without treatment	***0.054***	***0.008***	***0.00476***			
	Sewered with Treatment	***0.0054***	***0.0032***	***0.0012***	***0.00168***		***JICA WQ survey 1997***
Livestock	Pig wet cleaning no treatment	0.145	0.038	0.027	0	0.085	TN&NH4: Danish Standard pig, Q: Manole pig farm
	Pig dry cleaning, Liquid manure only	0.07	0.017	0.015	0	0.004	TN, NH4 &Q: Danish Standard pig BOD :UNDP report
	Pig wet cleaning 3 step WWTP	***0.014***	***0.008***	***0.001***	***0.006***	***0.085***	***JICA investigation, Manole pigfarm***
	Pig wet cleaning mechanic WWTP	***0.035***	***0.01***	***0.008***	***0***	***0.085***	***Getimate***
	Cow wet cleaning no treatment	0.682	0.285	0.18	0	0.04	BOD, TN, NH4 & Q:Danish Standard cow
	Cow dry cleaning, liquid manure only	0.06	0.12	0.11	0	0.024	TN: Danish Standard cow BOD: UNDP report
	Cow wet cleaning mechanical WWTP	***0.045***	***0.09***	***0.083***	***0***	***?***	***Getimate***
	Sheep total	0.06	0.027	0.016	0	-	Danish Standard sheep
	Fowl wet cleaning liquid manure	0.006	0.00147	0.001	0	?	Danish Standard chicken
	Fowl wet cleaning mechanical WWTP	***0.003***	***0.0007***	***0.0005***	***0***	***?***	***Getimate***
Landuse	***Bare+urban+water body***	***0***			***0.2***		
	forest+grass	***0***			***0.2***		***Japanese related textbook***
	non-irrigate+irrigate+fruit	***0***			***0.68***		***(Forest+Grass) + 5% of applied fertilizer (3500kgN/km2/yr in 1995)***

: used for estimation of pollution loads

TABLE 2.6.2 CONNECTION RATE OF SEWER SYSTEM BASED ON POPULATION

Main Basin	Sub-Basin	Sewered		Non-Sewered	Total	% of Sewered	% of Treated
		Not Treated	Treated				
CPE	CPE-1	51649	0	16117	67766	76	0
	CPE-2	2713	0	2393	5106	53	0
	CPE-3	1200	0	9035	10235	12	0
Sub-Total		55562	0	27545	83107	67	0
CPI	CPI-1	0	0	0	0	-	-
	CPI-2	2566	0	13501	16067	16	0
	CPI-3	49321	0	17390	66711	74	0
Sub-Total		51887	0	30891	82777	63	0
HAR	HAR-1	17013	0	7854	24867	68	0
	HAR-2	75869	0	21799	97667	78	0
	HAR-3	0	0	8227	8227	0	0
Sub-Total		92881	0	37880	130761	71	0
LUD	LUD-1	0	0	0	0	-	-
	LUD-2	0	16323	15243	31566	52	52
	LUD-3	1748	0	4590	6338	28	0
Sub-Total		1748	0	19833	21581	8	0
MD	MD-1	0	0	1066	1066	0	0
	MD-2	0	0	0	0	-	-
	MD-3	0	0	243	243	0	0
	MD-4	0	0	0	0	-	-
	MD-5	0	0	336	336	0	0
	MD-6	0	0	1018	1018	0	0
	MD-7	0	0	343	343	0	0
	MD-8	7322	0	10079	17401	42	0
	MD-9	0	0	2778	2778	0	0
	MD-10	0	0	0	0	-	-
	MD-11	0	0	137	137	0	0
	MD-12	0	0	858	858	0	0
	MD-13	0	0	1741	1741	0	0
	MD-14	0	0	774	774	0	0
	MD-15	0	0	0	0	-	-
	MD-16	0	0	676	676	0	0
	MD-17	0	0	0	0	-	-
	MD-18	2892	0	7558	10450	28	0
	MD-19	0	0	6636	6636	0	0
	MD-20	0	0	2410	2410	0	0
	MD-21	0	0	837	837	0	0
Sub-Total		10214	0	37491	47705	21	0
MM1	MM1-1	0	0	2088	2088	0	0
	MM1-2	0	0	12740	12740	0	0
	MM1-3	0	0	0	0	-	-
	MM1-4	0	0	4587	4587	0	0
	MM1-5	6709	0	11681	18390	36	0
	MM1-6	0	0	5186	5186	0	0
	MM1-7	0	0	0	0	-	-
	MM1-8	0	0	0	0	-	-
	MM1-9	0	0	63912	63912	0	0
	MM1-10	0	0	4665	4665	0	0
	MM1-11	0	305685	349	306034	100	100
	MM1-12	7786	0	6416	14201	55	0
Sub-Total		14494	305685	111623	431803	74	71
MM2	MM2-1	17483	0	10959	28442	61	0
	MM2-2	0	0	176	176	0	0
	MM2-3	0	0	11697	11697	0	0
	MM2-4	0	0	4599	4599	0	0
	MM2-5	0	0	0	0	-	-
	MM2-6	444	0	10940	11384	4	0
	MM2-7	0	0	0	0	-	-
	MM2-8	0	0	4419	4419	0	0
	MM2-9	15584	0	1969	17553	89	0
	MM2-10	0	0	5633	5633	0	0
	MM2-11	0	0	0	0	-	-
	MM2-12	0	0	7857	7857	0	0
	MM2-13	9905	0	10344	20248	49	0
	MM2-14	0	0	7182	7182	0	0
	MM2-15	2611	0	6983	9594	27	0
	MM2-16	0	0	0	0	-	-
Sub-Total		46027	0	82758	128785	36	0

Main Basin	Sub-Basin	Sewered		Non-Sewered	Total	% of Sewered	% of Treated
		Not Treated	Treated				
MM3	MM3-1	4892	0	3261	8153	60	0
	MM3-2	0	0	1965	1965	0	0
	MM3-3	2567	0	3024	5591	46	0
	MM3-4	0	0	0	0	-	-
	MM3-5	0	0	0	0	-	-
	MM3-6	0	0	1277	1277	0	0
	MM3-7	0	0	132	132	0	0
	MM3-8	0	0	0	0	-	-
	MM3-9	50285	0	2844	53129	95	0
	MM3-10	0	0	9947	9947	0	0
	MM3-11	0	0	4320	4320	0	0
	MM3-12	0	0	568	568	0	0
Sub-Total		57743	0	27339	85082	68	0
MU1	MU1-1	0	0	0	0	-	-
	MU1-2	8005	0	24513	32517	25	0
	MU1-3	3465	0	7802	11267	31	0
	MU1-4	0	0	0	0	-	-
	MU1-5	0	0	0	0	-	-
	MU1-6	0	0	0	0	-	-
	MU1-7	0	0	0	0	-	-
	MU1-8	8397	0	2099	10496	80	0
	MU1-9	0	0	1744	1744	0	0
	MU1-10	4958	0	5292	10250	48	0
Sub-Total		24825	0	41449	66275	37	0
MU2	MU2-1	0	0	0	0	-	-
	MU2-2	71840	0	58754	130594	55	0
	MU2-3	0	0	0	0	-	-
	MU2-4	0	0	1210	1210	0	0
	MU2-5	0	0	0	0	-	-
	MU2-6	0	0	0	0	-	-
Sub-Total		71840	0	59964	131804	55	0
PYA	PYA	0	0	16170	16170	0	0
Sub-Total		0	0	16170	16170	0	0
SAZ	SAZ-1	0	0	0	0	-	-
	SAZ-2	0	0	2630	2630	0	0
	SAZ-3	0	0	1625	1625	0	0
	SAZ-4	8223	0	12033	20256	41	0
	SAZ-5	0	0	0	0	-	-
	SAZ-6	9107	24192	28372	61671	54	39
	SAZ-7	135822	0	48217	184039	74	0
	SAZ-8	0	0	0	0	-	-
Sub-Total		153152	24192	92877	270221	66	9
STA	STA	12075	9322	31223	52620	41	18
Sub-Total		12075	9322	31223	52620	41	18
STR	STR-1	0	6186	21414	27600	22	22
	STR-2	0	0	10327	10327	0	0
	STR-3	38535	0	26471	65005	59	0
Sub-Total		38535	6186	58212	102932	43	6
TOP	TOP-1	0	0	0	0	-	-
	TOP-2	0	12685	8751	21436	59	59
	TOP-3	16783	0	4972	21755	77	0
	TOP-4	0	0	0	0	-	-
Sub-Total		16783	12685	13722	43190	68	29
VAC	VAC-1	5578	0	18438	24016	23	0
	VAC-2	0	0	2917	2917	0	0
	VAC-3	0	0	12529	12529	0	0
	VAC-4	2120	0	3938	6058	35	0
Sub-Total		7698	0	37821	45519	17	0
Total		655464	365071	726798	1747334	58	21

TABLE 2.6.3 TOP 50 INDUSTRIAL LOAD

No	MOE Ref.	Location	Catch	Institution	Business	Tributary	Discharge to	EWWTP	Working days/yr	Quantity (m3/d)	Conc (mg/L)		Load (kg/d)		% of BOD		% of TN	
											BOD5	TN	BOD5	TN	Relative Load	Accum. of Rel. Load	Rel. Load	Rel. Accum. Load
1	55	Katunitza	MM2-15	"Kristal 91"	Food processing	Maritza	Maritza		260	3000	4500	90	9616	192	26.6	27	1.2	1
2	89	Stara Zagora	SAZ-7	"Agrobiohim"	Chemical	Sazliika	Bedetcka	Y	365	69120	105	125	7258	8640	20.1	47	55.3	57
3	3	Stara Zagora	SAZ-7	"Zagorka" Brewery Ltd	Food processing	Sazliika	TS	Y	365	4200	600	20	2520	84	7.0	54	0.5	57
4	29	Dimitrovgrad	MM3-9	SC Neohim	Chemical	Maritza	Maritza	Y	365	45100	38	103	1698	4645	4.7	58	29.7	87
5	19	Stamboliiski	MM1-12	"Vitamina" Ltd.	Food processing	Maritza	Maritza	Y	260	12700	150	2	1357	18	3.8	62	0.1	87
6	1	Pazardjik	MU2-2	"Maritsa" KK Ltd.	Food processing	Maritza	TS	Y	260	15297	120	10	1308	109	3.6	66	0.7	88
7	56	Plovdiv	MM1-9	"Kristal 91" sweet factory	Food processing	Maritza	TS	Y	260	5240	300	20	1120	75	3.1	69	0.5	88
8	1 to 5	WWTP-Haskovo industry	HAR-2	Joint fnd TWWKS	Waste Treatment	Banska r.	Banska r.	Y	365	5375	152	10	817	54	2.3	71	0.3	88
9	14	Galabovo	SAZ-4	TEPS "Maritza East" 1	Electric Power	Sazliika	slag pond	Y	365	49740	15	1.3	746	65	2.1	73	0.4	89
10	6	Parvomai	MM2-13	"Bulkons" Ltd.	Food processing	Maritza	TS	Y	260	6340	150	10	677	45	1.9	75	0.3	89
11	78	Stara Zagora	SAZ-7	Meat Factory Ltd.	Food processing	Sazliika	TS	Y	260	1281	500	50	456	46	1.3	76	0.3	89
12	2	Stamboliiski	MM1-12	"Tzelhart" Ltd.	Pulp and paper	Maritza	Maritza	Y	260	67400	9.2	10	442	480	1.2	78	3.1	92
13	45	Plovdiv	MM1-9	"Plovdivska konserva" dep.1	Food processing	Maritza	TS	Y	260	4000	150	10	427	28	1.2	79	0.2	93
14	77	Stara Zagora	SAZ-7	"Gali Zagoretz" Ltd.	Food processing	Sazliika	TS	Y	260	1167	500	50	416	42	1.2	80	0.3	93
15	35	Belovo	MU1-3	KMH "Belovo" Ltd.	Pulp and paper	Maritza	Maritza	Y	365	16500	25	2	413	33	1.1	81	0.2	93
16	3	Pazardjik	MU2-2	"Trakia papir" Ltd.	Pulp and paper	Maritza	Pismanka	Y	260	10000	50	3.18	356	23	1.0	82	0.1	93
17	108	Plovdiv	MM1-9	"Alen mack" Ltd.	Cosmetics	Maritza	TS		260	2450	200	10	349	17	1.0	83	0.1	93
18	100	Plovdiv	MM1-9	"Pulpudeva" Ltd.	Tannery	Maritza	TS	Y	260	1600	300	20	342	23	0.9	84	0.1	94
19	88	Stara Zagora	SAZ-7	"Biser Oliva" Ltd.	Food processing	Sazliika	TS	Y	260	6000	80	20	342	85	0.9	85	0.5	94
20	2, 5	Oriahovitza	SAZ-7	Stoianovi Brothers Maenad 1901	Wine Production	Sazliika	TS		260	290	1500	56	310	12	0.9	86	0.1	94
21	91	Assenovgrad	CPE-1	"Askon" Ltd.	Food processing	Chepelarska	TS	Y	260	2800	150	10	299	20	0.8	87	0.1	94
22	7	Pazardjik	MU2-2	"Mletchana promislenost" Ltd.	Food processing	Maritza	TS	Y	260	1096	360	40	281	31	0.8	87	0.2	94
23	57	Plovdiv	MM1-9	"Mletchana promislenost" Ltd.	Food processing	Maritza	TS		260	1300	300	30	278	28	0.8	88	0.2	95
24	87	Karlovo	STR-3	"Mesokombinat"	Food processing	Striama	Striama	Y	260	1172	300	50	250	42	0.7	89	0.3	95
25		Velingrad	CPI-1	Milk Industry	Milk Industry	Maritza		Y	260	500	600	70	214	25	0.6	89	0.2	95
26	79	Stara Zagora	SAZ-7	"Serdika" Ltd.	Food processing	Sazliika	TS	Y	260	770	300	40	165	22	0.5	90	0.1	95
27	8	Stara Zagora	SAZ-7	"Petko Enev" [Can Factory]Ltd	Food processing	Sazliika	TS		260	1500	150	10	160	11	0.4	90	0.1	95
28	20	Panagjurishte	LUD-2	"Oborishte" Ltd.	Textile	Luda Iana	TS	Y	260	1800	112.6	10	144	13	0.4	91	0.1	95
29	29	Sopot	STR-2	"VMF Sopot"	Machinery	Manastirska	Manastirska	Y	260	4492	45	2	144	6	0.4	91	0.0	95
30	3	Karlovo	STR-3	"Karlovska Koprina" Ltd.	Textile	Striama	TS	Y	260	2870	70	5	143	10	0.4	92	0.1	95
31	7	Chirpan	MM2-1	"Zagorka Malt Factory"	Food processing	Maritza	Dry Gully	Y	260	1260	150	5	135	4	0.4	92	0.0	96
32	15	Mednikarovo	SAZ-2	TEPS "Maritza East" 3	Electric Power	Sokolitza	Sokolitza	Y	260	28500	6.6	1.65	134	33	0.4	92	0.2	96
33	16	Velingrad	CPI-1	"Kristal" Ltd.	Chemical	Maritza	Tchepinska		60	2487	305	18	125	7	0.3	93	0.0	96
34	27	Tzerovo	TOP-1	"Vitehprom" Ltd.	Wine	Topolnitza	Topolnitza		260	33	5000	50	118	1	0.3	93	0.0	96
35	26	Kalugerovo	TOP-1	"Vitehprom" Ltd.	Wine	Topolnitza	Topolnitza	Y	260	100	1600	10	114	1	0.3	93	0.0	96
36	89	Plovdiv	MM1-9	"KCM" Ltd.	Lead, cooper	Chepelarska	Chepelarska	Y	365	32400	3.5	3	113	97	0.3	94	0.6	96
37	47	Plovdiv	MM1-9	"Plovdivska konserva" dep.3	Food processing	Maritza	TS	Y	260	714	200	10	102	5	0.3	94	0.0	96
38	13	Chirpan	MM2-1	"Vinprom Tchirpan" Ltd	Food processing	Maritza	TS	Y	160	700	300	10	92	3	0.3	94	0.0	96
39		Brezovo	CPE-1	"Vinprom" Ltd	Food processing	Maritza	non existing		60	100	5000	20	82	0	0.2	94	0.0	96
40	14	Ljubimetz	MD-18	BK "Sakar" ltd	Wine	Maritza	TS		60	100	5000	25	82	0	0.2	95	0.0	96
41	16	Velingrad	CPI-1	"Kristal" Ltd.	Chemical	Maritza	Tchepinska		200	2487	60	3.6	82	5	0.2	95	0.0	97
42	58	Pestera	STA	"Biovet" Ltd.	Pharmaceutical	Stara Reka	Stara Reka	Y	365	5338	15	0.13	80	1	0.2	95	0.0	97
43	6	Haskovo	HAR-2	Manuella	Textile	Harmanliiska	TS	Y	260	2160	50	0.16	77	0	0.2	95	0.0	97
44	25	Dimitrovgrad	MM3-9	TEPS: Maritsa 3	Power Plant	Maritza	Maritza	Y	365	5000	15	1.65	75	8	0.2	95	0.1	97
45		Velingrad	CPI-1	Mototecnika	car repair & cleaning	Maritza	TS	Y	260	993.6	100	6	71	4	0.2	96	0.0	97
46	46	Plovdiv	MM1-9	"Plovdivska konserva" dep.2	Food processing	Maritza	TS	Y	260	443	200	10	63	3	0.2	96	0.0	97
47	110	Plovdiv	MM1-9	"Rodina" Ltd.	Paper	Maritza	TS	Y	260	1260	70	5	63	4	0.2	96	0.0	97
48	70	Parvomai	MM2-13	"Mletchna promishlenost" (dairy)	Food processing	Maritza	TS	Y	260	237	360	40	61	7	0.2	96	0.0	97
49	6	Pazardjik	MU2-2	"M&M - 90" Ltd.	Food processing	Maritza	TS	Y	260	693	120	25	59	12	0.2	96	0.1	97
50	86	Bania	STR-3	"Vinzavod Bania" Ltd.	Food processing	Striama	TS	Y	260	270	300	10	58	2	0.2	96	0.0	97
		Other (186 industries)											1272	504	3.5	100	3.2	100
		Total											36104	15628	100	100	100	100

TABLE 2.6.4 POLLUTION LOAD OF LIVESTOCK

(unit: kg/d)

Main Catch	Sub-Catch	Pig		Cattle		Fowl		Total	
		BOD	TN	BOD	TN	BOD	TN	BOD	TN
CPE	CPE-1	58	17	57	113	83	20	198	150
	CPE-2	37	11	28	57	0	0	65	68
	CPE-3	19	5	56	112	13	3	88	120
Sub-Total		113	32	141	282	96	24	351	338
CPI	CPI-1	49	14	27	54	0	0	76	68
	CPI-2	14	4	28	56	0	0	42	60
	CPI-3	76	22	107	214	0	0	183	235
Sub-Total		139	40	162	324	0	0	301	363
HAR	HAR-1	151	43	41	82	2	1	194	125
	HAR-2	68	20	45	90	3	1	116	110
	HAR-3	165	47	134	269	7	2	306	318
Sub-Total		384	110	220	440	13	3	617	553
LUD	LUD-1	481	138	47	94	5	1	533	233
	LUD-2	48	14	32	65	0	0	80	78
	LUD-3	37	11	11	21	0	0	48	32
Sub-Total		566	162	90	180	5	1	661	343
MD	MD-1	1	0	0	1	0	0	2	1
	MD-2	1	0	0	1	0	0	1	1
	MD-3	1	0	0	1	0	0	1	1
	MD-4	1	0	1	1	0	0	2	1
	MD-5	23	7	10	19	0	0	33	26
	MD-6	16	5	7	13	0	0	23	18
	MD-7	44	13	18	37	0	0	62	49
	MD-8	120	34	27	54	0	0	147	88
	MD-9	38	11	14	28	0	0	52	39
	MD-10	122	35	15	30	0	0	137	65
	MD-11	81	23	9	18	0	0	90	41
	MD-12	90	26	9	18	0	0	99	44
	MD-13	142	40	14	28	0	0	156	69
	MD-14	58	17	9	18	0	0	67	34
	MD-15	18	5	5	9	0	0	23	14
	MD-16	26	7	11	21	0	0	36	28
	MD-17	59	17	18	36	0	0	77	53
	MD-18	20	6	6	13	0	0	26	19
	MD-19	380	109	83	165	1	0	464	274
	MD-20	52	15	6	12	0	0	58	27
	MD-21	104	30	17	33	0	0	121	63
Sub-Total		1397	399	278	557	1	0	1677	956
MM1	MM1-1	117	34	3	6	0	0	120	39
	MM1-2	689	197	57	114	0	0	746	311
	MM1-3	38	11	1	1	0	0	39	12
	MM1-4	69	20	1	2	0	0	70	22
	MM1-5	1011	289	75	151	1	0	1087	440
	MM1-6	262	75	6	13	0	0	268	87
	MM1-7	434	124	21	41	1	0	456	166
	MM1-8	17	5	10	21	0	0	28	26
	MM1-9	420	120	51	102	118	29	588	250
	MM1-10	1279	366	29	59	0	0	1309	424
	MM1-11	251	72	6	12	0	0	257	83
	MM1-12	116	33	3	5	0	0	119	39
Sub-Total		4703	1344	263	526	120	29	5086	1899
MM2	MM2-1	60	17	42	84	64	16	166	117
	MM2-2	9	3	7	14	1	0	17	17
	MM2-3	49	14	59	119	15	4	124	136
	MM2-4	13	4	14	28	0	0	27	32
	MM2-5	18	5	30	60	3	1	51	66
	MM2-6	31	9	39	78	6	2	76	89
	MM2-7	1	0	1	1	0	0	1	1
	MM2-8	114	33	78	155	8	2	200	190
	MM2-9	331	95	33	66	0	0	364	161
	MM2-10	33	9	26	52	0	0	59	62
	MM2-11	4	1	3	6	3	1	10	7
	MM2-12	63	18	77	155	0	0	141	173
	MM2-13	45	13	31	63	0	0	76	76
	MM2-14	48	14	66	132	0	0	114	146
	MM2-15	40	11	24	49	0	0	65	60
	MM2-16	4	1	3	6	0	0	6	7
Sub-Total		862	246	534	1068	102	25	1497	1339

Main Catch	Sub-Catch	Pig		Cattle		Fowl		Total	
		BOD	TN	BOD	TN	BOD	TN	BOD	TN
MM3	MM3-1	86	25	38	76	1	0	125	101
	MM3-2	296	85	124	248	102	25	523	358
	MM3-3	67	19	49	99	30	7	146	125
	MM3-4	90	26	63	127	98	24	252	176
	MM3-5	28	8	20	39	31	8	78	55
	MM3-6	2	1	2	3	0	0	4	4
	MM3-7	20	6	15	30	1	0	36	36
	MM3-8	3	1	2	5	2	1	8	6
	MM3-9	91	26	52	104	1	0	144	131
	MM3-10	97	28	80	160	1	0	179	188
	MM3-11	29	8	22	43	0	0	50	52
	MM3-12	86	25	69	137	0	0	155	162
Sub-Total		896	256	536	1072	268	66	1700	1394
MU1	MU1-1	109	31	18	37	0	0	127	68
	MU1-2	53	15	8	17	0	0	62	32
	MU1-3	15	4	12	23	0	0	26	28
	MU1-4	3	1	1	2	0	0	4	3
	MU1-5	9	3	3	6	0	0	12	9
	MU1-6	3	1	1	2	0	0	4	3
	MU1-7	23	7	6	12	0	0	29	18
	MU1-8	1	0	0	1	0	0	2	1
	MU1-9	38	11	17	34	0	0	56	45
	MU1-10	56	16	95	191	4	1	155	208
Sub-Total		311	89	162	324	4	1	477	414
MU2	MU2-1	216	62	19	38	2	0	237	100
	MU2-2	109	31	10	20	1	0	120	51
	MU2-3	55	16	5	10	1	0	60	26
	MU2-4	99	28	15	31	20	5	134	64
	MU2-5	395	113	41	81	4	1	440	195
	MU2-6	103	29	10	20	1	0	114	50
Sub-Total		977	279	100	201	28	7	1105	487
PYA	PYA	299	86	63	126	0	0	363	212
Sub-Total		299	86	63	126	0	0	363	212
SAZ	SAZ-1	110	31	31	62	0	0	141	94
	SAZ-2	75	21	41	82	0	0	116	103
	SAZ-3	453	129	151	302	63	15	666	446
	SAZ-4	262	75	90	181	12	3	364	258
	SAZ-5	24	7	7	15	1	0	32	22
	SAZ-6	601	172	210	419	136	33	946	624
	SAZ-7	1786	510	409	818	239	58	2434	1387
	SAZ-8	10	3	6	12	0	0	16	14
Sub-Total		3320	948	945	1891	450	110	4715	2949
STA	STA	51	14	37	73	27	7	114	95
Sub-Total		51	14	37	73	27	7	114	95
STR	STR-1	434	124	150	300	7	2	591	426
	STR-2	32	9	46	92	2	1	81	102
	STR-3	109	31	141	282	0	0	251	313
Sub-Total		576	165	337	674	10	2	923	841
TOP	TOP-1	345	99	56	112	3	1	404	212
	TOP-2	101	29	71	142	0	0	172	171
	TOP-3	61	17	89	178	0	0	150	195
	TOP-4	7	2	15	31	0	0	22	33
Sub-Total		514	147	232	463	3	1	748	611
VAC	VAC-1	111	32	111	222	199	49	421	302
	VAC-2	1	0	11	22	0	0	12	23
	VAC-3	2	1	43	87	0	0	45	87
	VAC-4	24	7	34	68	0	0	58	75
Sub-Total		138	39	199	399	199	49	536	487
Total		15245	4356	4299	8599	1325	325	20870	13279

TABLE 2.6.5 SUMMARY OF POLLUTION LOAD

Main Catch	Sub-Catch	Domestic (kg/d)		Industry (kg/d)		Livestock (kg/d)		Landuse (kg/d)		Total (kg/d)		% of Load*	
		BOD	TN	BOD	TN	BOD	TN	BOD	TN	BOD	TN	BOD	TN
CPE	CPE-1	3048	471	526	54	198	150	0	53	3772	729	3.6	1.6
	CPE-2	181	30	0	0	65	68	0	85	247	182	0.2	0.4
	CPE-3	189	39	0	0	88	120	0	128	277	288	0.3	0.6
Sub-Total		3419	540	526	54	351	338	0	266	4295	1199	4.1	2.6
CPI	CPI-1	0	0	553	48	76	68	0	51	629	167	0.6	0.4
	CPI-2	325	65	3	0	42	60	0	72	371	197	0.4	0.4
	CPI-3	2938	456	0	0	183	235	0	129	3121	821	3.0	1.7
Sub-Total		3263	521	557	48	301	363	0	252	4120	1185	3.9	2.5
HAR	HAR-1	1039	163	42	4	194	125	0	79	1274	372	1.2	0.8
	HAR-2	4452	686	936	60	116	110	0	89	5504	945	5.3	2.0
	HAR-3	113	27	0	0	306	318	0	281	419	625	0.4	1.3
Sub-Total		5603	876	978	65	617	553	0	449	7198	1943	6.9	4.1
LUD	LUD-1	0	0	0	0	533	233	0	122	533	355	0.5	0.8
	LUD-2	298	102	161	17	80	78	0	145	540	342	0.5	0.7
	LUD-3	159	29	0	0	48	32	0	63	206	124	0.2	0.3
Sub-Total		456	131	161	17	661	343	0	330	1279	822	1.2	1.7
MD	MD-1	15	3	0	0	2	1	0	1	16	6	0.0	0.0
	MD-2	0	0	0	0	1	1	0	42	1	43	0.0	0.1
	MD-3	3	1	0	0	1	1	0	26	4	28	0.0	0.1
	MD-4	0	0	0	0	2	1	0	28	2	29	0.0	0.1
	MD-5	5	1	0	0	33	26	0	43	37	70	0.0	0.1
	MD-6	14	3	0	0	23	18	0	18	36	39	0.0	0.1
	MD-7	5	1	0	0	62	49	0	8	67	58	0.1	0.1
	MD-8	539	92	31	5	147	88	0	39	717	225	0.7	0.5
	MD-9	38	9	0	0	52	39	0	58	90	106	0.1	0.2
	MD-10	0	0	0	0	137	65	0	21	137	86	0.1	0.2
	MD-11	2	0	0	0	90	41	0	171	92	212	0.1	0.5
	MD-12	12	3	0	0	99	44	0	2	111	49	0.1	0.1
	MD-13	24	6	0	0	156	69	0	19	179	93	0.2	0.2
	MD-14	11	3	0	0	67	34	0	37	78	74	0.1	0.2
	MD-15	0	0	0	0	23	14	0	1	23	16	0.0	0.0
	MD-16	9	2	0	0	36	28	0	3	45	33	0.0	0.1
	MD-17	0	0	0	0	77	53	0	31	77	84	0.1	0.2
	MD-18	262	48	99	1	26	19	0	27	387	94	0.4	0.2
	MD-19	91	22	0	0	464	274	0	63	555	359	0.5	0.8
	MD-20	33	8	0	0	58	27	0	75	91	110	0.1	0.2
	MD-21	11	3	0	0	121	63	0	56	132	122	0.1	0.3
Sub-Total		1072	204	130	6	1677	956	0	769	2879	1936	2.7	4.1
MM1	MM1-1	29	7	0	0	120	39	0	12	149	58	0.1	0.1
	MM1-2	174	41	22	1	746	311	0	62	943	415	0.9	0.9
	MM1-3	0	0	0	0	39	12	0	23	39	35	0.0	0.1
	MM1-4	63	15	0	0	70	22	0	9	133	46	0.1	0.1
	MM1-5	527	92	2	0	1087	440	0	187	1617	720	1.5	1.5
	MM1-6	71	17	13	1	268	87	0	7	352	113	0.3	0.2
	MM1-7	0	0	0	0	456	166	0	10	456	176	0.4	0.4
	MM1-8	0	0	0	0	28	26	0	262	28	288	0.0	0.6
	MM1-9	2548	1199	2988	617	588	250	0	26	6124	2092	5.8	4.5
	MM1-10	64	15	0	0	1309	424	0	66	1373	505	1.3	1.1
	MM1-11	5	1	0	0	257	83	0	20	261	105	0.2	0.2
	MM1-12	514	84	1799	498	119	39	0	119	2432	739	2.3	1.6
Sub-Total		3995	1471	4825	1117	5086	1899	0	804	13906	5292	13.3	11.3
MM2	MM2-1	1107	177	329	30	166	117	0	60	1602	385	1.5	0.8
	MM2-2	2	1	0	0	17	17	0	55	20	72	0.0	0.2
	MM2-3	160	38	0	0	124	136	0	3	284	178	0.3	0.4
	MM2-4	63	15	0	0	27	32	0	144	90	191	0.1	0.4
	MM2-5	0	0	0	0	51	66	0	61	51	127	0.0	0.3
	MM2-6	174	39	9	0	76	89	0	132	259	260	0.2	0.6
	MM2-7	0	0	0	0	1	1	0	48	1	50	0.0	0.1
	MM2-8	60	14	0	0	200	190	0	6	260	210	0.2	0.4
	MM2-9	880	133	13	4	364	161	0	14	1257	312	1.2	0.7
	MM2-10	77	18	0	0	59	62	0	151	136	231	0.1	0.5
	MM2-11	0	0	0	0	10	7	0	38	10	46	0.0	0.1
	MM2-12	108	25	0	0	141	173	0	83	248	281	0.2	0.6
	MM2-13	684	114	771	53	76	76	0	72	1531	315	1.5	0.7
	MM2-14	98	23	0	0	114	146	0	1	212	170	0.2	0.4
	MM2-15	239	44	9616	192	65	60	0	136	9919	432	9.5	0.9
	MM2-16	0	0	0	0	6	7	0	70	6	77	0.0	0.2
Sub-Total		3652	642	10738	281	1497	1339	0	1075	15888	3337	15.2	7.1

Main Catch	Sub-Catch	Domestic (kg/d)		Industry (kg/d)		Livestock (kg/d)		Landuse (kg/d)		Total (kg/d)		% of Load*	
		BOD	TN	BOD	TN	BOD	TN	BOD	TN	BOD	TN	BOD	TN
MM3	MM3-1	312	50	0	0	125	101	0	76	438	227	0.4	0.5
	MM3-2	27	6	0	0	523	358	0	121	550	486	0.5	1.0
	MM3-3	182	31	0	0	146	125	0	34	328	190	0.3	0.4
	MM3-4	0	0	0	0	252	176	0	99	252	275	0.2	0.6
	MM3-5	0	0	0	0	78	55	0	196	78	251	0.1	0.5
	MM3-6	17	4	0	0	4	4	0	75	21	83	0.0	0.2
	MM3-7	2	0	0	0	36	36	0	74	37	110	0.0	0.2
	MM3-8	0	0	0	0	8	6	0	24	8	30	0.0	0.1
	MM3-9	2792	417	1828	4658	144	131	0	2	4764	5208	4.5	11.1
	MM3-10	136	32	0	0	179	188	0	24	315	244	0.3	0.5
	MM3-11	59	14	0	0	50	52	0	3	109	69	0.1	0.1
	MM3-12	8	2	0	0	155	162	0	67	163	231	0.2	0.5
Sub-Total		3535	557	1828	4658	1700	1394	0	795	7063	7403	6.7	15.8
MU1	MU1-1	0	0	0	0	127	68	0	108	127	175	0.1	0.4
	MU1-2	774	144	104	6	62	32	0	77	939	260	0.9	0.6
	MU1-3	296	53	417	34	26	28	0	51	740	165	0.7	0.4
	MU1-4	0	0	0	0	4	3	0	30	4	33	0.0	0.1
	MU1-5	0	0	0	0	12	9	0	11	12	19	0.0	0.0
	MU1-6	0	0	0	0	4	3	0	23	4	26	0.0	0.1
	MU1-7	0	0	0	0	29	18	0	9	29	27	0.0	0.1
	MU1-8	488	75	0	0	2	1	0	25	490	101	0.5	0.2
	MU1-9	24	6	0	0	56	45	0	2	80	53	0.1	0.1
	MU1-10	344	57	0	0	155	208	0	54	499	319	0.5	0.7
Sub-Total		1926	336	521	40	477	414	0	389	2924	1179	2.8	2.5
MU2	MU2-1	0	0	0	0	237	100	0	43	237	144	0.2	0.3
	MU2-2	4737	773	2057	181	120	51	0	20	6913	1025	6.6	2.2
	MU2-3	0	0	0	0	60	26	0	11	60	37	0.1	0.1
	MU2-4	17	4	0	0	134	64	0	25	151	93	0.1	0.2
	MU2-5	0	0	0	0	440	195	0	83	440	278	0.4	0.6
	MU2-6	0	0	0	0	114	50	0	27	114	77	0.1	0.2
Sub-Total		4753	777	2057	181	1105	487	0	210	7915	1654	7.6	3.5
PYA	PYA	221	52	22	2	363	212	0	176	606	442	0.6	0.9
Sub-Total		221	52	22	2	363	212	0	176	606	442	0.6	0.9
SAZ	SAZ-1	0	0	0	0	141	94	0	57	141	151	0.1	0.3
	SAZ-2	36	9	134	33	116	103	0	161	286	306	0.3	0.7
	SAZ-3	22	5	0	0	666	446	0	363	689	814	0.7	1.7
	SAZ-4	615	106	749	65	364	258	0	261	1727	690	1.6	1.5
	SAZ-5	0	0	0	0	32	22	0	17	32	39	0.0	0.1
	SAZ-6	1019	244	33	1	946	624	0	343	1999	1212	1.9	2.6
	SAZ-7	8095	1258	11749	8960	2434	1387	0	557	22278	12162	21.3	25.9
	SAZ-8	0	0	0	0	16	14	0	9	16	24	0.0	0.1
Sub-Total		9788	1622	12665	9059	4715	2949	0	1767	27167	15398	25.9	32.8
STA	STA	1088	199	103	4	114	95	0	122	1306	420	1.2	0.9
Sub-Total		1088	199	103	4	114	95	0	122	1306	420	1.2	0.9
STR	STR-1	327	90	39	11	591	426	0	313	957	839	0.9	1.8
	STR-2	141	34	145	6	81	102	0	81	367	223	0.4	0.5
	STR-3	2472	398	573	77	251	313	0	284	3295	1073	3.1	2.3
Sub-Total		2940	521	756	94	923	841	0	679	4619	2135	4.4	4.5
TOP	TOP-1	0	0	232	2	404	212	0	188	636	401	0.6	0.9
	TOP-2	189	70	0	0	172	171	0	234	361	475	0.3	1.0
	TOP-3	987	152	0	0	150	195	0	175	1137	522	1.1	1.1
	TOP-4	0	0	0	0	22	33	0	60	22	93	0.0	0.2
Sub-Total		1176	222	232	2	748	611	0	657	2156	1491	2.1	3.2
VAC	VAC-1	558	105	3	0	421	302	0	182	982	589	0.9	1.3
	VAC-2	40	9	0	0	12	23	0	70	52	102	0.0	0.2
	VAC-3	171	41	0	0	45	87	0	116	217	244	0.2	0.5
	VAC-4	170	30	0	0	58	75	0	91	228	196	0.2	0.4
Sub-Total		939	185	3	0	536	487	0	459	1478	1131	1.4	2.4
Total		47828	8858	36104	15628	20870	13279	0	9199	104801	46965	100	100

*: % of pollution load to the study area

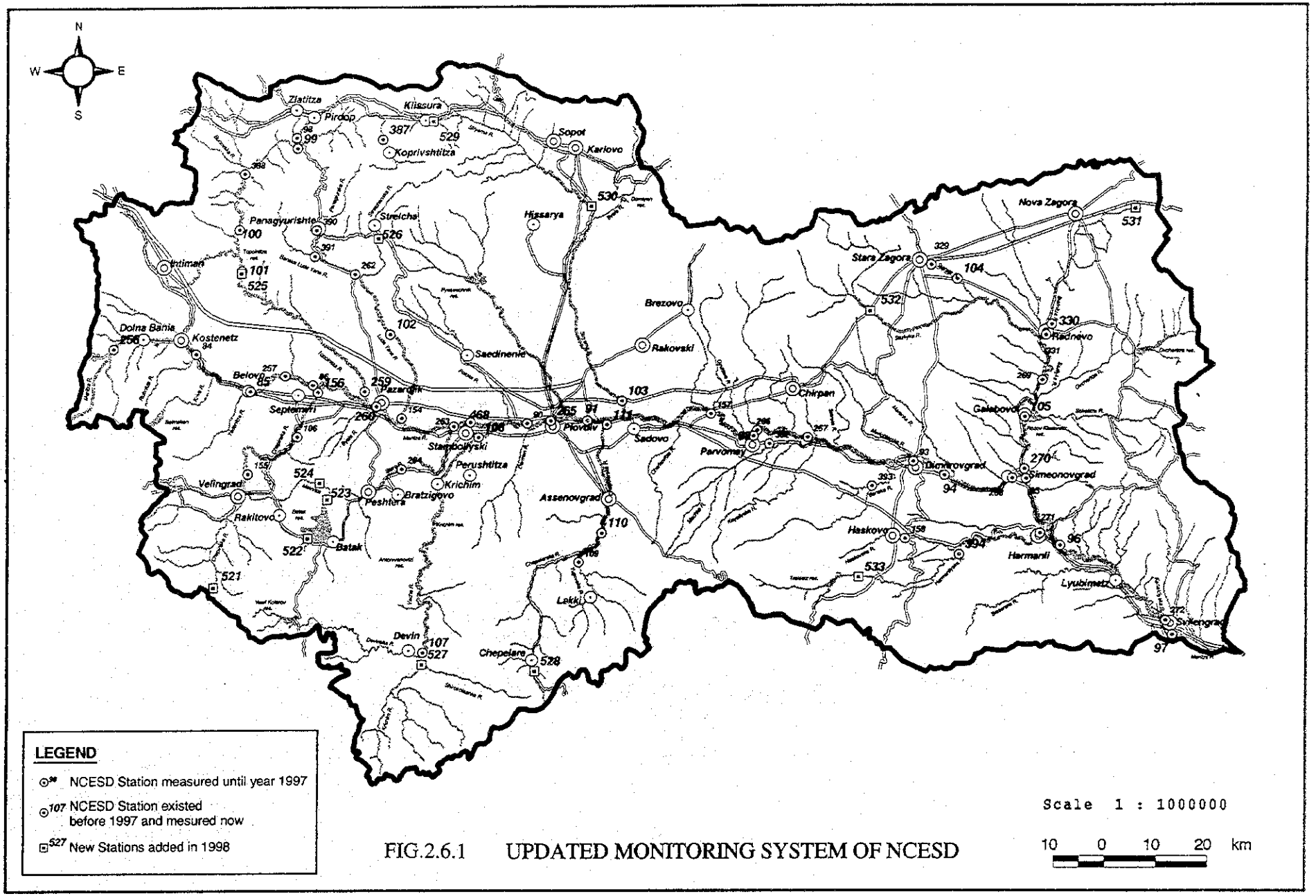


FIG.2.6.1 UPDATED MONITORING SYSTEM OF NCESD

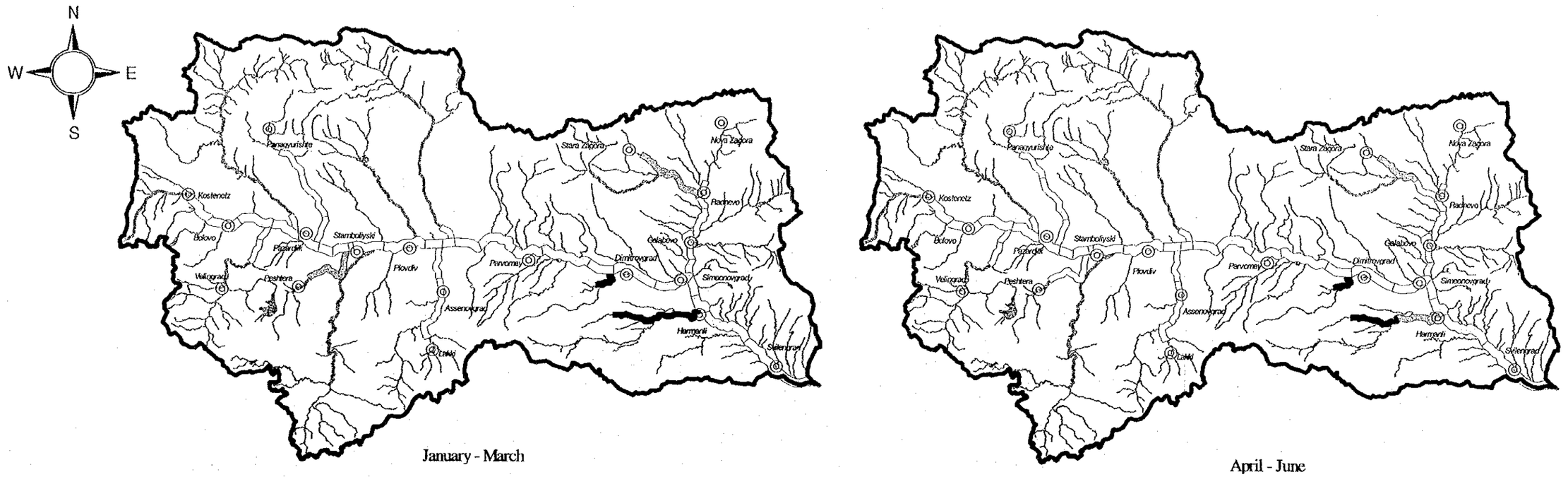
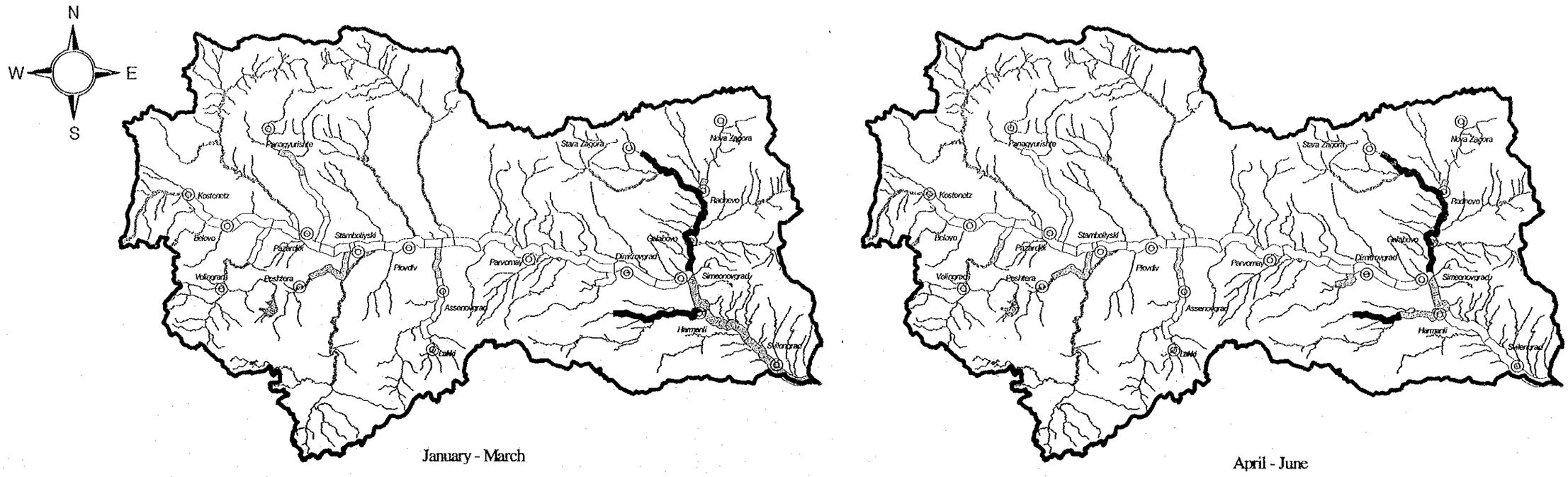


FIG.2.6.2 SEASONAL WATER QUALITY OF BOD IN 1994 - 1996

SOURCE : NCESD



January - March

April - June

July - September

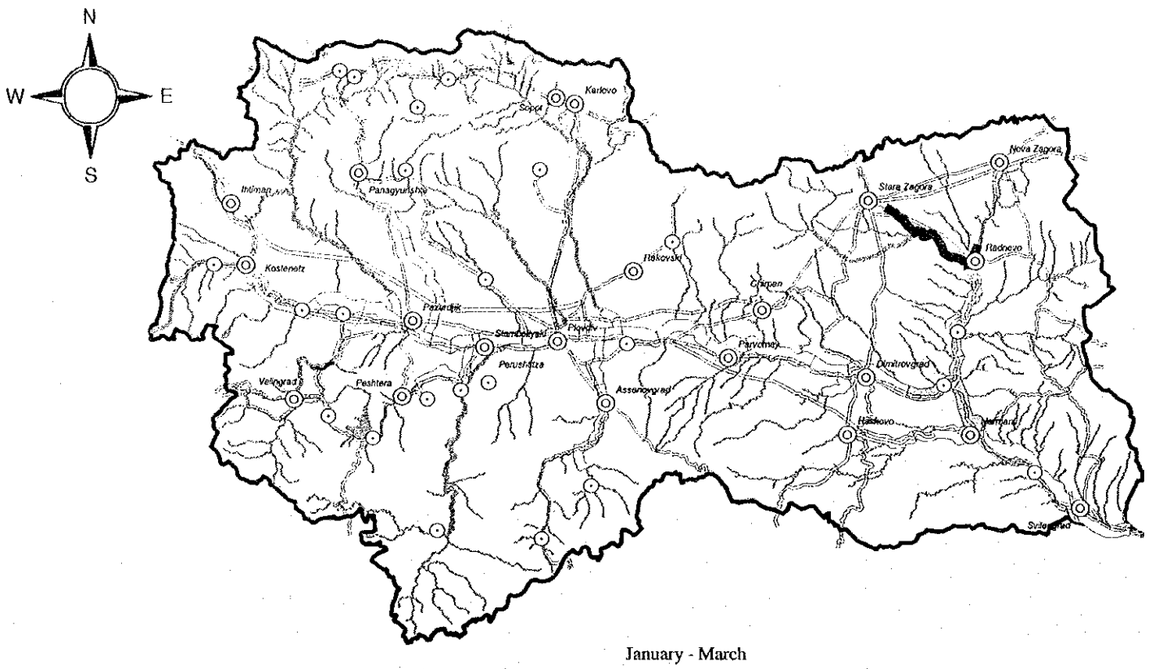
October - December

LEGEND

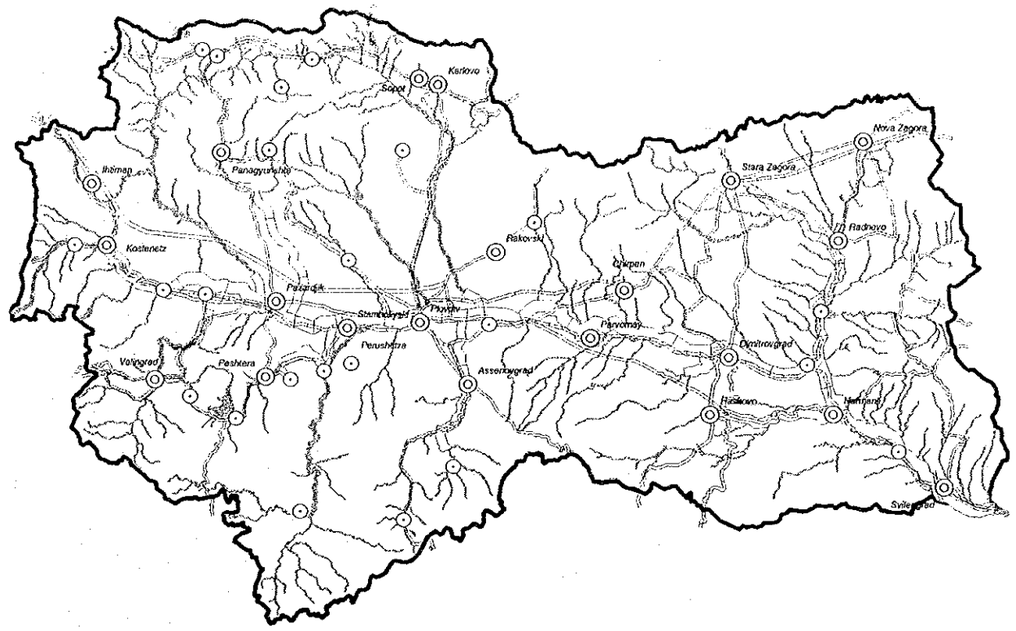
- category I
- category II
- category III
- worse than category III

FIG.2.6.3 SEASONAL WATER QUALITY OF NH4 IN 1994 - 1996

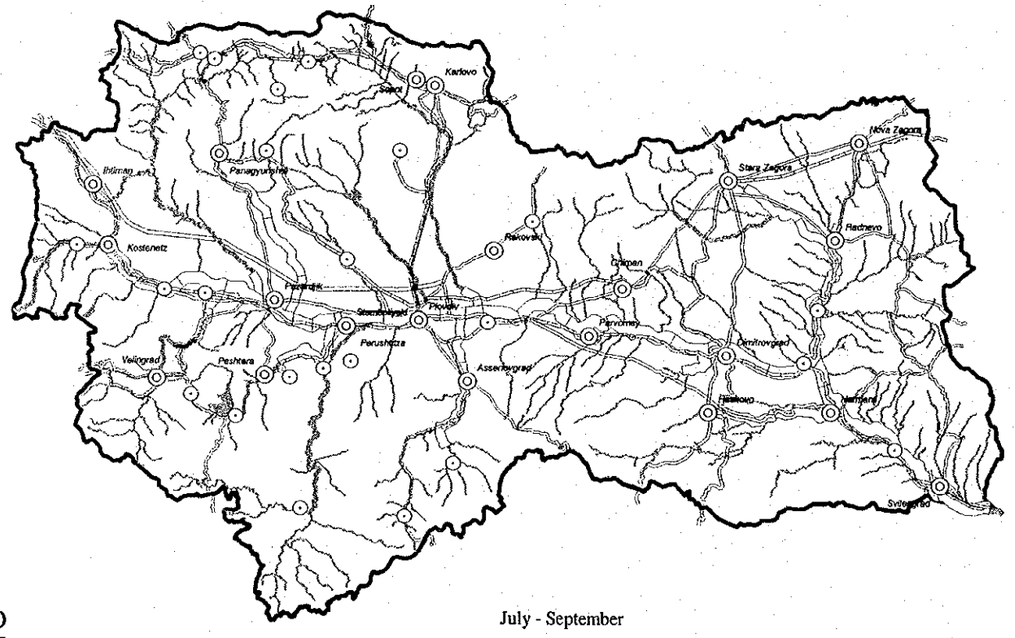
SOURCE : NCESD



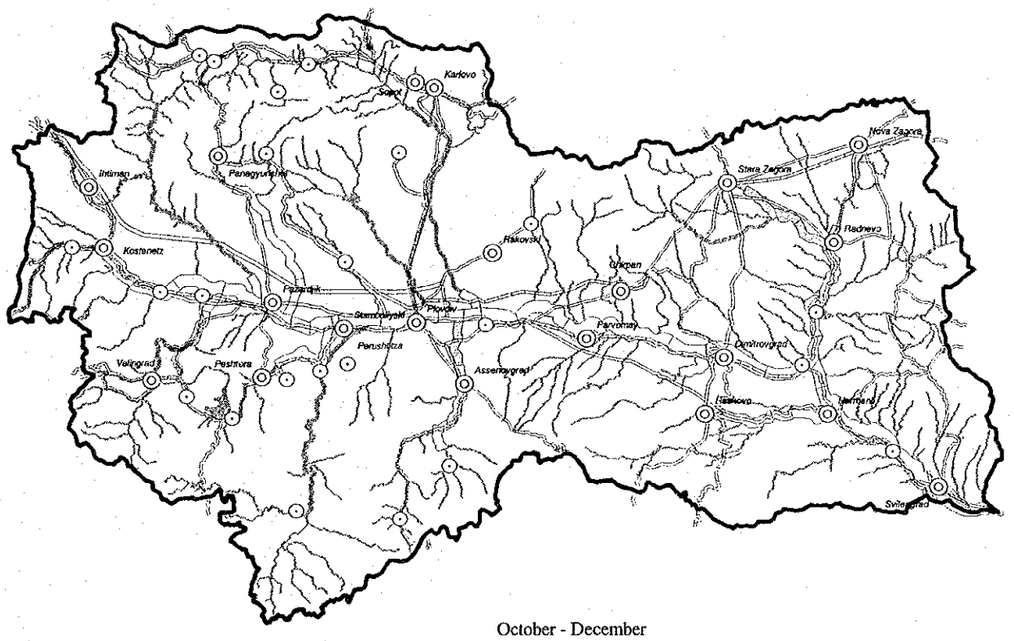
January - March



April - June



July - September



October - December

LEGEND

- category I
- category II
- category III
- worse than category III

FIG.2.6.4 SEASONAL WATER QUALITY OF NO3 IN 1994-1996

SOURCE : NCESD

FIG.2.6.5 BIOLOGICAL ASSESSMENT OF WATER QUALITY

FIG.2.6.5 BIOLOGICAL ASSESSMENT OF WATER QUALITY

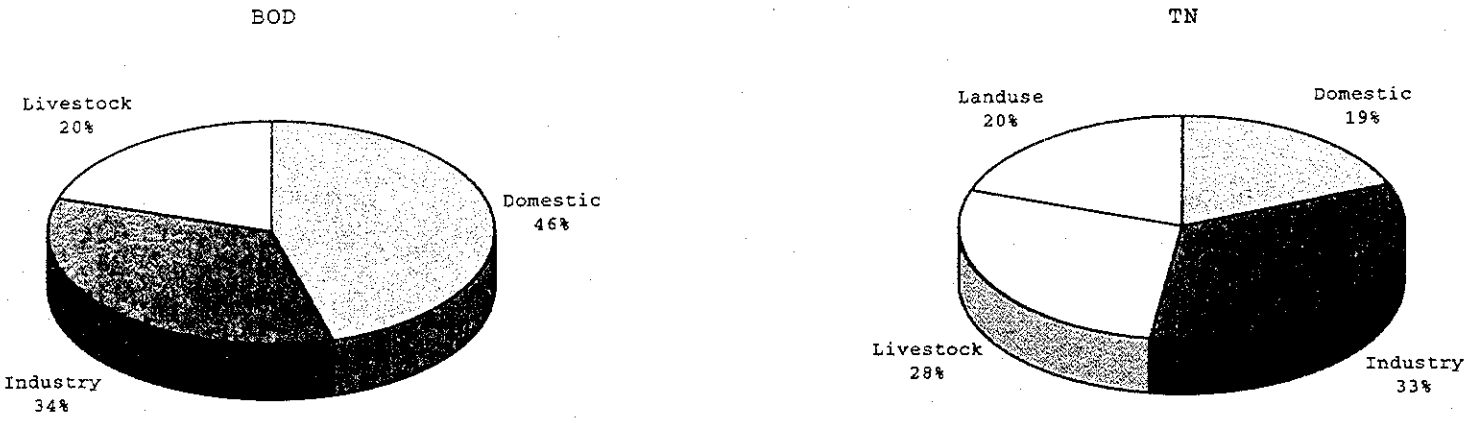


FIG. 2.6.6 BOD AND TN BY POLLUTION SOURCE

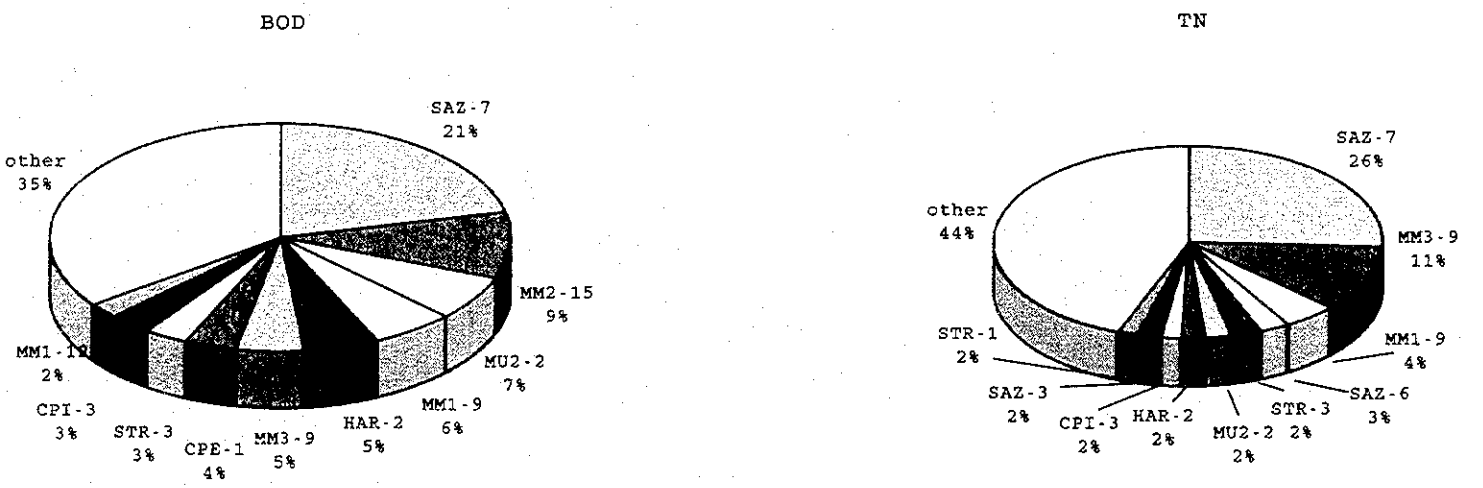
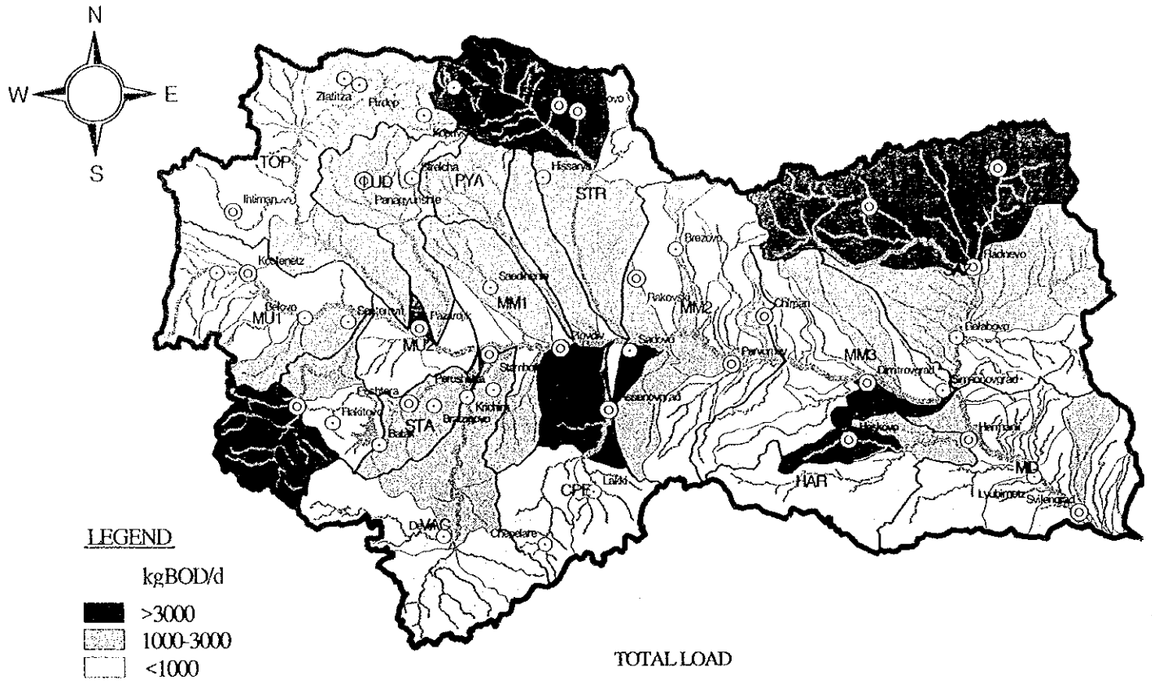
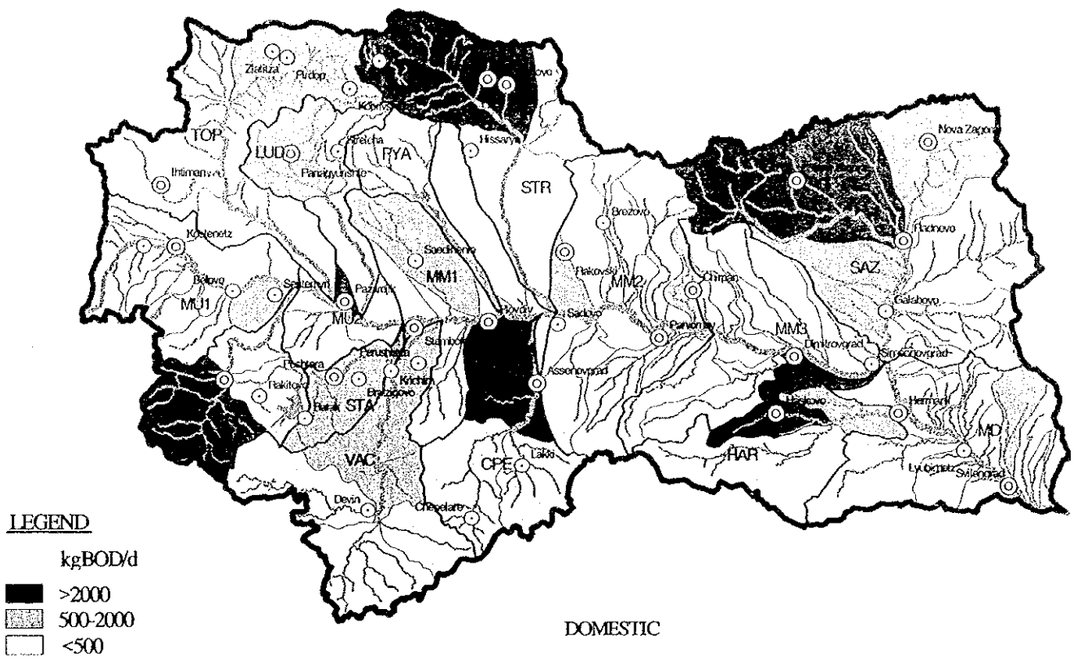


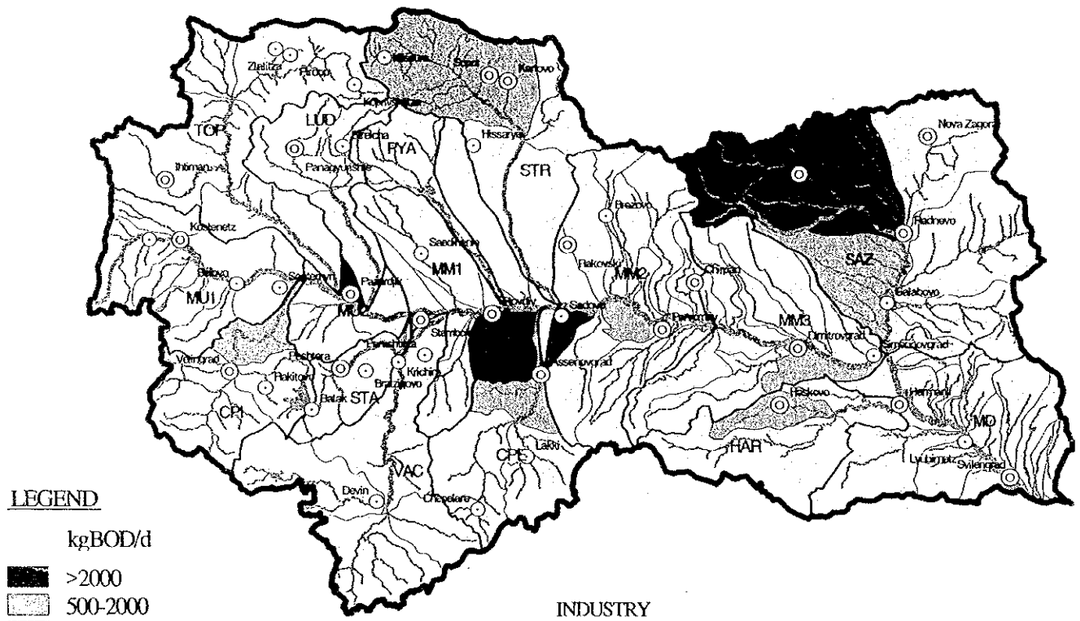
FIG. 2.6.7 POLLUTION LOAD PER SUB-CATCHEMNT



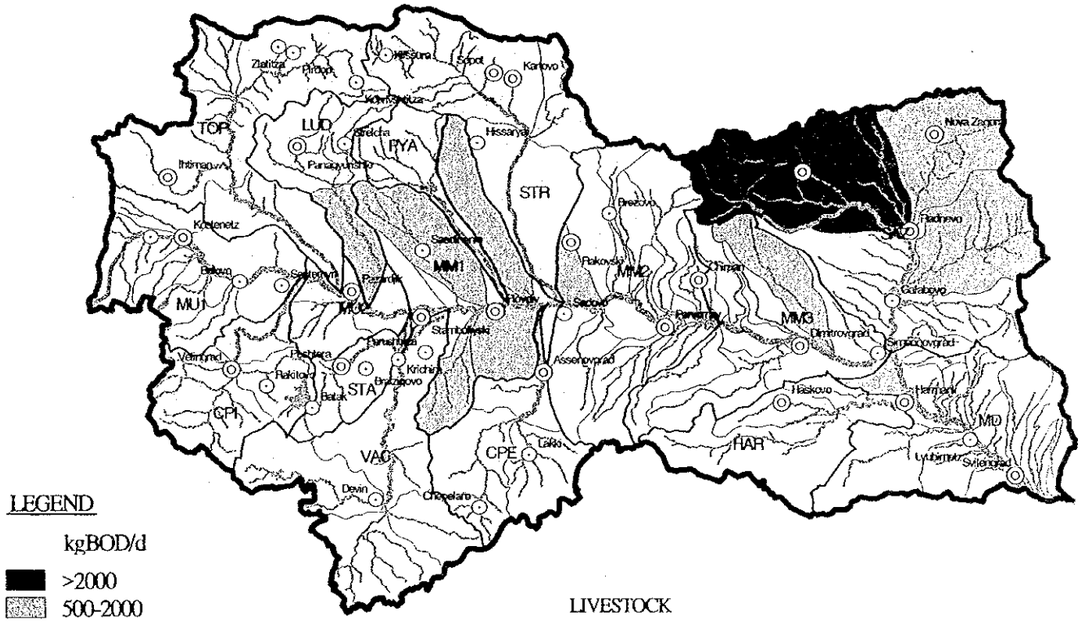
TOTAL LOAD



DOMESTIC

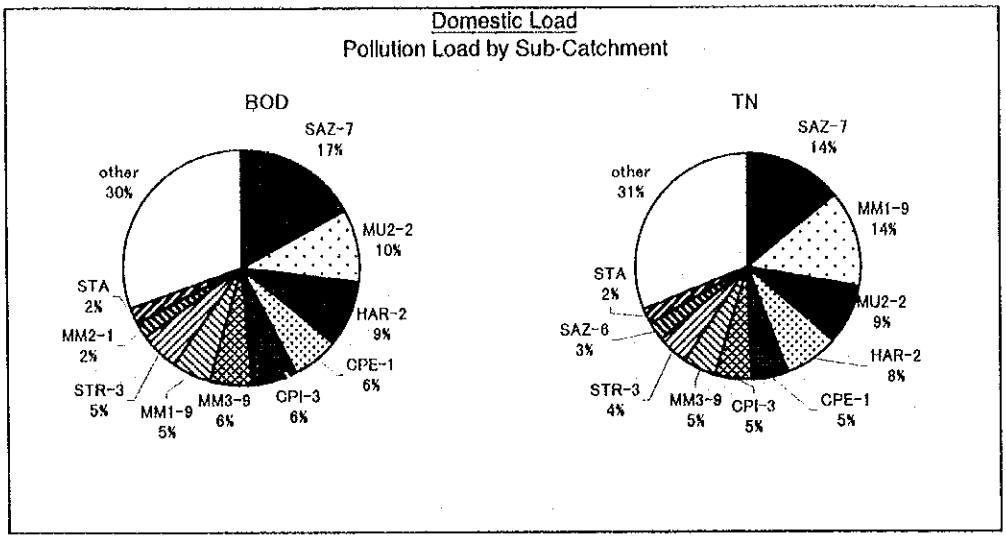


INDUSTRY



LIVESTOCK

FIG.2.6.8 BOD LOAD BY POLLUTION SOURCE



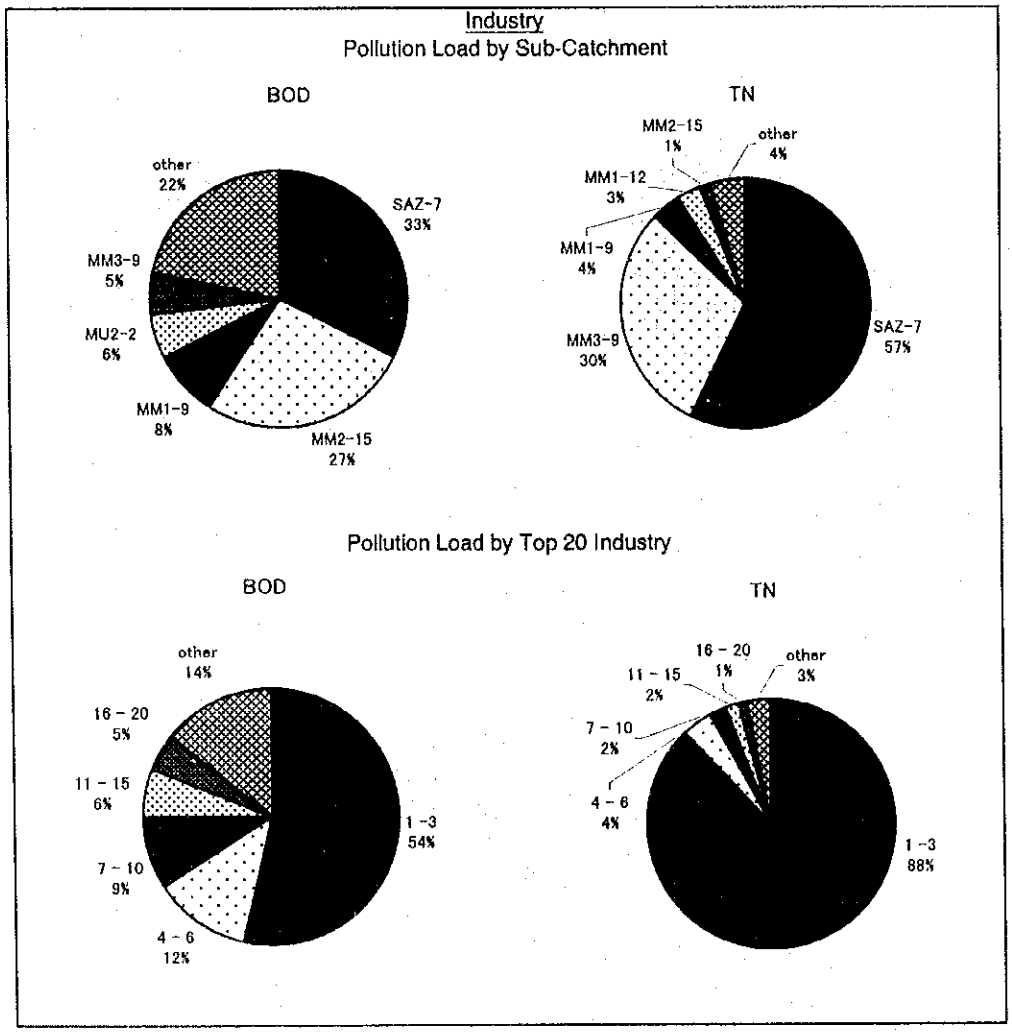
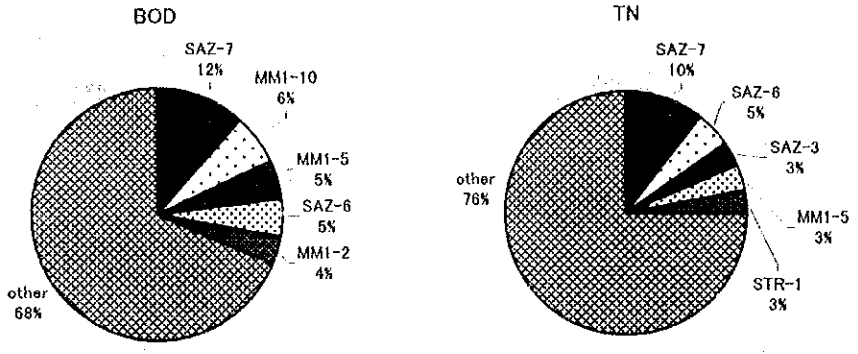


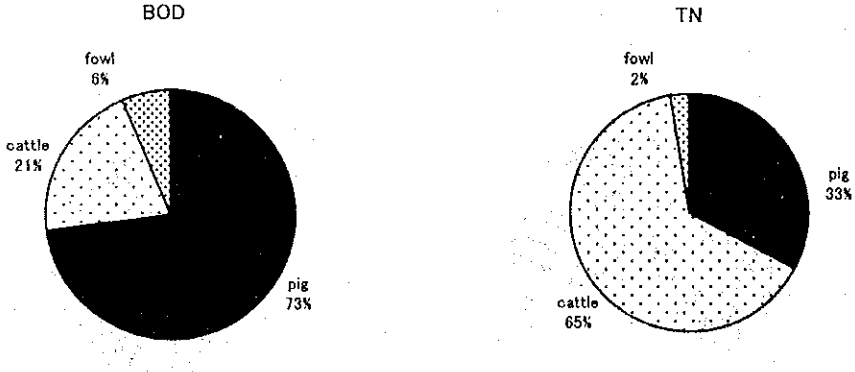
FIG 2.6.9 COMPOSITION OF POLLUTION BY POLLUTION SOURCE

Livestock

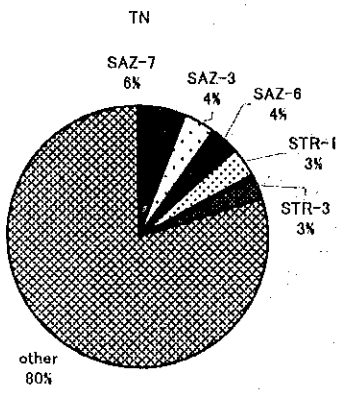
Pollution Load by Sub-Catchment



Pollution Load by Animal



Landuse



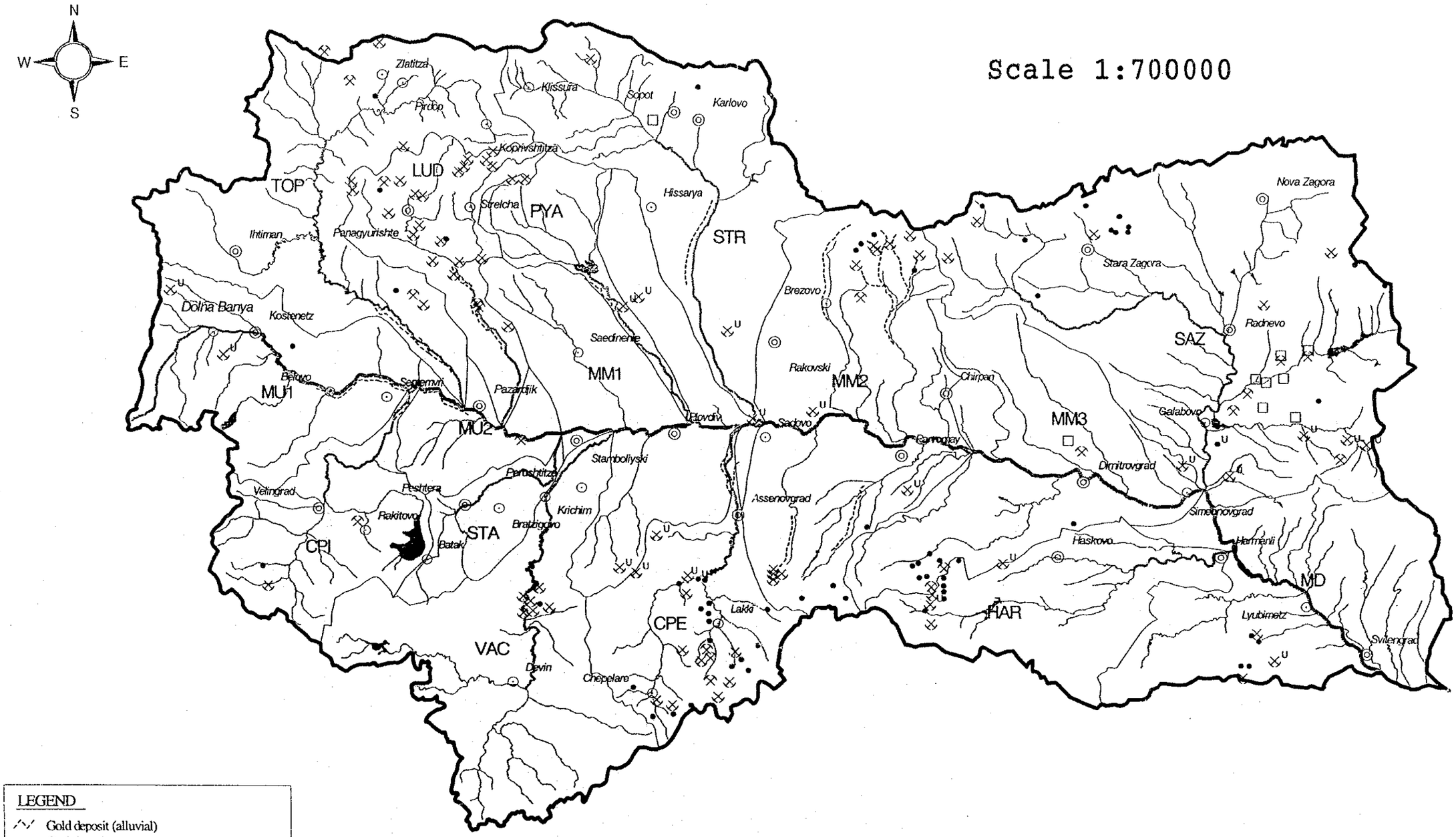


FIG.2.6.10 LOCATION OF MINING