SUPPORTING REPORT B

Water Quantity

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B WATER QUANTITY

B.1 General

In the present supporting report, the results of the study for water quantity, especially for surface water, are described. The detail of ground water quantity and quality is discussed separately in *Supporting Report D.*

Meteorological and hydrological characteristics in the study area are summarized in *Chapter B.2*. *Chapter B.3* introduces the existing condition of water use in Bulgaria. *Chapter B.4* demonstrates results of interview survey on the general problems of water in the related municipalities. *Chapter B.5* shows water balance including inter-basin water transfer under the existing condition. The estimated water resources potential and water balance for several water use conditions using integrated river basin analysis model described in *Supporting Report E* are demonstrated in *Chapter B.6* and *Chapter B.7*, respectively. Finally, program of measures for improving water quantity condition is described in *Chapter B.8*.

In addition to the above, in relation to the GIS-DB development works for the pilot river basins in DRBD (Yantra River Basin) and BSBD (Kamchia River Basin), exiting water balance in these two river basins are preliminary analyzed. The results are shown in *Annex A.3*.

B.2 Meteorology and Hydrology

B.2.1 Observation Network

Meteorological and hydrological observation data are fundamental elements for river basin management. They support to consider actual water balance over a river basin.

In general, Bulgaria has a good tradition to be aware of importance of such observed data. Some paper reports on the observation in the beginning of 20 century are still kept in good condition in National Institute of Meteorology and Hydrology (NIMH). Hydrological Reference Book[1)] summarizes hydrological conditions over the country using observed data before 1975. The meteorological conditions up to 1970 are well described in Meteorological Reference Book[2), 3), 4)] and precipitation condition up to 1985 is also summarized[5)].

NIMH has long been responsible for observing, transmitting, processing and storing meteorological and hydrological data. Almost all of the data had been published yearly before the beginning of 1980s. However, limited data are available as public domain nowadays. To obtain full set of data, it is necessary to contact NIMH directly, which sometimes requires a contract. The type of monitoring stations kept by NIMH is shown in the following table.

Type of Monitoring Stations by NIMH

Type of Station (*1)	Item (*1)	Frequency (*1)	Observer (*1)	Total number (*1)	Number for operational database (*1)	Number of available station in August 2006 (*2)
Synoptic	Meteorological Data	Every 3 hours every day	Professional staff	40	40	40
Climatic	Meteorological Data	Every day at 7, 14, 21 o'clock	Voluntary staff	100	70	95
Rainfall	Precipitation	Every day at 7 o'clock when it happens	Voluntary staff	290	0	286
Hydrometric	River level (can be converted to discharge)	Every day at 8, 20 o'clock	Voluntary staff	204	52	208
Groundwater spring	Water level	Daily or Weekly	Voluntary staff or routs of professional staff	101	37	(*3)
Groundwater artesion well	Water level	Daily or Weekly	Voluntary staff or routs of professional staff	22	2	(*3)
Groundwater well	Water table	Weekly or Monthly	Routs of professional staff	285	91	(*3)

(*1) Source: http://www.hydro.bg, NIMH dada flow
(*2) Source: List provided by NIMH to The Study Team on August 2006 as a form of .shp file
(*3) There is duplication of some stations in .shp files. So, it is difficult to count the number.

There are two types of stations with respect to the data transmission. One is “Operational stations” which transmit data at real or near real time. Another one is “Regime stations” in which data are submitted to the NIMH branches as a form of paper monthly.

Maintenance of the monitoring stations is key issue. It is easy for the monitoring stations to be deteriorated without proper maintenance supported by appropriate budget allocation. Figure B.2.1 shows an example of damaged hydrometric station during 2005 floods. To keep observed data in good quality, such damaged stations should be recovered as soon as possible. Special attention should be paid that a lot of voluntary staffs contribute to the observations and their efforts have been supported the observation network.

Figures B.2.2 – B.2.4 show the location for meteorological (synoptic and climatic) stations, precipitations stations and hydrometric stations in the whole territory of Bulgaria. The detail lists are shown in *Annex B.1*. The location of these stations is basically based on the list provided by NIMH to The Study Team on August 2006 as a form of .shp file. However, in WABD, location of almost all of the stations in their territory has been confirmed by themselves. In EABD, location of more than half of hydrometric stations have been confirmed by themselves, and many of the rest have been confirmed by several site visits by EABD C/P and the Study Team members during the Study. In case that the location is confirmed, its confirmed coordinate is used as the location of the stations.

Among the meteorological stations in Figure B.2.2, historical monthly averaged data for precipitation, temperature, relative humidity in some stations (at least, 8 stations for 1960-2004, 13 stations for 1990-2004) are available from Statistical Yearbook[6)] published by National Statistical Institute. Data for some other stations after the middle of 1990s are available from Bulletin issued by MoEW.

Totally 286 precipitation stations are shown in the list by NIMH. MoEW have received the daily data for 2000-2005 for almost all of the precipitation stations under the contract between MoEW and NIMH. Among those stations, daily data in 253 stations for 2000-2005 are available without missing duration. Thiessen polygons for the 253 selected stations are also shown in Figure B.2.3. It is utilized in the Study to calculate area-averaged precipitation from the data in the 253 selected stations.

Totally 216 hydrometric stations are shown in Figure B.2.4, of which 208 stations are from the list by NIMH and the rest are from the information given by WABD. MoEW have received the daily data for 2000-2005 for almost all of the hydrometric stations under the contract between MoEW and NIMH.

B.2.2 Meteorology

(1) Overview of the Country

Bulgaria located in the southeast of Europe, which is close to the Asian continent and the subtropical Mediterranean region. The major part of Bulgaria belongs to the European moderate-central zone in climatic aspect. However, the southern and south-eastern regions are strongly affected by the Mediterranean continental-subtropical zone.

(a) Spatial Pattern of Annual Precipitation and Potential Evapo-Transpiration

Spatial pattern of annual precipitation over the country is shown in Figure B.2.5. The figure is prepared using WORLDCLIM[7), 8)] database, which shows averaged condition during 1950-2000. The WORLDCLIM database contains long-term averaged 1km mesh monthly precipitation and temperature based on observed data with correction considering altitude. The pattern is similar to one shown in the previous literature[9)] that sited an atlas published in 1982. Most of lowland Bulgaria has annual precipitation of 500-700mm. In the mountain area, annual precipitation is much higher; in some places, annual precipitation exceeds 900mm. It is noted that compared to the previous literature, the WORLDCLIM database tends to give lower annual precipitation in the mountain region. It reflects the spatially averaged annual precipitation over the country. The WORLDCLIM gives 609mm, although the previous literature showed 680mm.

Figure B.2.6 shows spatial pattern of annual Potential Evapo-Transpiration (PET). The PET is calculated based on monthly averaged temperature given by the WORLDCLIM database, applying Thornthwaite method[10)]. The pattern is again similar to one shown in the previous literature. In the mountain region gives lower annual PET than 600mm. Lowland area has more than 700mm of annual PET.

Potential annual water balance pattern can be drawn by the pattern of precipitation minus PET, which is shown in Figure B.2.7. In most of Bulgaria, annual PET exceeds annual precipitation. Only the mountain area has positive value of precipitation minus PET. As have discussed in the previous literature, the mountain area, in which the positive value can appear, plays a critical role for water resources in Bulgaria.

In the mountain area, not only rainfall but also snowfall contributes to annual precipitation. Winter snow accumulation and subsequent melting process is thus very important component when considering water resources in Bulgaria.

(b) Temporal Variation of Meteorological Condition

Spatially averaged annual precipitation over the country in 2000-2005 is calculated based on the observed data in the selected 253 precipitation stations considering Thiessen coefficient for each station. Because of the density of the stations, it could be one the most reliable values. On the other hand, simply averaged annual precipitation of the 13 meteorological stations, in which data is available from Statistical Yearbook for long term, is calculated. There is a good correlation between those in 2000-2004 data, as shown Figure B.2.8.

Figure B.2.9 shows the spatially averaged annual precipitation using the selected 253 precipitation stations in 2000-2005 as well as adjusted average of annual precipitation of 13 meteorological stations in 1960-1999 using the correlation shown in Figure B.2.8. In the recent years, the annual precipitation fluctuates very much year by year. In 2000, the precipitation was extremely low; less than 400mm. More than 900mm annual precipitation occurs in 2005.

The long-term averaged (1960-2005) monthly variation of precipitation at the representative meteorological stations, whose data are available in 1960-2005 from Statistical Yearbook, is shown in Figure B.2.10. In general, the precipitation is the highest in May and June. In the southern region (Haskovo, Sandanski), high precipitation is observed also in winter time. In the Black Sea region (Varna, Bourgas), the monthly precipitation variation is small compared to other regions.

Figure B.2.11 shows the monthly variation of temperature and relative humidity at the representative meteorological stations. Pattern of the variation of the temperature is almost same in all of the stations. However, average temperature varies place by place. The relative humidity in winter time is about 80% in all of the stations. In the Black Sea region, the relative humidity in summer time tends to be higher than the other regions.

Potential Evapo-Transpiration (PET) is calculated by two methods. One is Thornthwaite method, which requires only monthly temperature. Another one is Ivanov's method[11)], which is said to be famous in Bulgaria. PET by Ivanov's method is a function of monthly temperature and relative humidity, which indicates that its result is more sensitive to relative humidity. Figure B.2.12 shows the monthly variation of the calculated PET.

(c) Change of Precipitation with Elevation

Figure B.2.13 shows relationship between elevation and average annual precipitation amount in 2000-2005 based on the observed data at precipitation stations. It can be understood that the higher elevation gives the larger amount of precipitation in general.

(2) East Aegean Sea River Basin Directorate

(a) Long-term Averaged Meteorological Conditions

Long-term averaged (1950-2000) annual precipitation and PET based on WORLDCLIM database for each river basin in EABD are calculated as the following table.

Average Annual Precipitation and PET for River Basins in EABD

River Basin	Annual Precipitation (mm)	Annual PET (mm)
Tundzha	639	689
Maritsa	611	669
Arda	632	672
Biala	633	720

Source: JICA Study Team based on WORLDCLIM database

Annual PET is higher than annual precipitation in all of the basins in EBAD. It indicates that quantitative water resource is under severe condition in EABD in general.

Figures B.2.14 – B.2.16 show long-term averaged (1950-2000) annual precipitation, annual PET, annual precipitation minus PET for each catchment in EABD.

(b) Statistical Analysis on Precipitation

There are limited numbers of meteorological stations in EABD (Pazardzhik, Kazanlak and Haskovo) for available long-term data of precipitation in the study. The average precipitation in EABD territory for long-term has been estimated using the relationship between average precipitation of those three meteorological stations and spatially averaged one by precipitation stations in EABD territory. The relationship and the estimated precipitation are shown in *Annex B.2*.

Statistical analysis for the estimated long-term annual precipitation has been conducted. Pearson Type-III distribution was selected for probability density function, after confirming that it fit best the given data set among several well known probability density functions. The results of the fitting are shown in *Annex B.2*

As shown in the later chapter for hydrology, annual average water quantity is related to not only 1-year total precipitation but also 2-year total precipitation. The following table shows the probable 1-year total and 2-year total precipitation.

Statistical Analysis for Estimated Long-term Annual Precipitation for EABD Territory

Probability of Exceedence	1Year Total Precipitation (mm)	2Years Total Precipitation (mm)
95%	472	1010
90%	512	1085
75%	578	1200
50%	656	1325
25%	734	1423
10%	804	1516

Source: JICA Study Team

Based on the above table, probability for averaged precipitation in EABD in 2000-2005 is evaluated as follows.

Evaluation of Probability of Exceedence for Precipitation Amount in EABD

Year	1 Year Total		2 Years Total	
	Precipitation Amount (mm)	Probability of Exceedence	Precipitation Amount (mm)	Probability of Exceedence
2000	388	>95%	1073	90%
2001	603	75%	991	>95%
2002	781	15%	1384	33%
2003	643	30-70%	1424	25%
2004	643	30-70%	1286	30-70%
2005	925	<5%	1568	5%

Source: JICA Study Team

From the above table, the followings are confirmed.

- Year 2004 is almost average year in terms of both 1-year and 2-year total precipitation in EABD territory.
- Both year 2000 and year 2001are extremely dry in EABD territory.
- Year 2005 is extremely wet in EABD territory.

Precipitation amount during summer time (3 months (July –September)) for the three meteorological stations in EABD have also been analyzed statistically. The details are shown in *Annex B.2*. The following table shows probable 3months total precipitation in the three stations.

Statistical Analysis for Estimated Long-term Precipitation during Summer time (3months (July-September)) for Three Meteorological Stations in EABD

Probability of Exceedence	3Months Total Precipitation (mm) Pazardzhik	3Months Total Precipitation (mm) Kazanlak	3Months Total Precipitation (mm) Haskovo
95%	26	53	37
90%	40	69	51
75%	68	96	76
50%	104	139	116
25%	144	190	162
10%	185	245	210

Source: JICA Study Team

Based on the above table, evaluation of probability is as follows.

Evaluation of Probability of Exceedence for Precipitation during Summer time in EABD

Year	Pazardzhik		Kazanlak		Haskovo	
	Precipitation (mm)	Probability of Exceedence	Precipitation (mm)	Probability of Exceedence	Precipitation (mm)	Probability of Exceedence
2000	27	95%	100	85%	57	85%
2001	121	30-70%	130	30-70%	118	30-70%
2002	213	5%	338	<5%	307	<5%
2003	59	80%	108	70%	104	30-70%
2004	126	30-70%	269	10%	107	30-70%
2005	257	<5%	361	<5%	231	<5%

Source: JICA Study Team

It is understood that years 2001 and 2004 are almost average year in terms of 3 months total precipitation.

(3) West Aegean Sea River Basin Directorate

(a) Long-term Averaged Meteorological Conditions

Long-term averaged (1950-2000) annual precipitation and PET based on WORLDCLIM database for each river basin in WABD are calculated as the following table.

Average Annual Precipitation and PET for River Basins in WABD

River Basin	Annual Precipitation (mm)	Annual PET (mm)
Struma	566	629
Mesta	630	577
Dospat	664	551

Source: JICA Study Team

In Mesta and Dospat river basins, annual precipitation is higher than annual PET, which indicates high water resources potential. On the other hand, relatively low annual precipitation is observed in Struma river basin.

Figures B.2.17 – B.2.19 show long-term averaged (1950-2000) annual precipitation, annual PET, annual precipitation minus PET based on for each catchment in WABD.

(b) Statistical Analysis on Precipitation

There are limited numbers of meteorological stations in WABD (Kiustendil and Sandanski) for available long-term data of precipitation in the study. The average precipitation in WABD territory for long-term has been estimated using the relationship between average precipitation of those three meteorological stations and spatially averaged one by precipitation stations in WABD territory. The relationship and the estimated precipitation are shown in *Annex B.2*.

Statistical analysis for the estimated long-term annual precipitation has been conducted. Pearson Type-III distribution was selected for probability density function, after confirming that it fit best the given data set among several well known probability density functions. The results of the fitting are shown in *Annex B.2*

As shown in the later chapter for hydrology, annual average water quantity is related to not only 1-year total precipitation but also 2-year total precipitation.

The following table shows the probable 1-year total and 2-year total precipitation.

Statistical Analysis for Estimated Long-term Annual Precipitation for WABD Territory

Probability of Exceedence	1Year Total Precipitation (mm)	2Years Total Precipitation (mm)
95%	442	952
90%	490	1048
75%	578	1181
50%	644	1304
25%	715	1397
10%	773	1458

Source: JICA Study Team

Based on the above table, probability for averaged precipitation in WABD in 2000-2005 is evaluated as follows.

Evaluation of Probability of Exceedence for Precipitation Amount in WABD

Year	1 Year Total		2 Years Total	
	Precipitation Amount (mm)	Probability of Exceedence	Precipitation Amount (mm)	Probability of Exceedence
2000	322	95%>	1029	90%
2001	559	80%	881	95%>
2002	786	10%	1344	40%
2003	671	30-70%	1457	10%
2004	698	30-70%	1369	30-70%
2005	835	5%<	1532	5%<

Source: JICA Study Team

From the above table, the followings are confirmed.

- Year 2004 is almost average year in terms of both 1-year and 2-year total precipitation in WABD territory.
- Both year 2000 and year 2001 are extremely dry in WABD territory.
- Year 2005 is extremely wet in WABD territory.

Precipitation amount during summer time (3 months (July –September)) for the three meteorological stations in WABD have also been analyzed statistically. The details are shown in *Annex B.2*. The following table shows probable 3months total precipitation in the two stations.

Statistical Analysis for Estimated Long-term Precipitation during Summer time (3months (July-September)) for Three Meteorological Stations in WABD

Probability of Exceedence	3Months Total Precipitation (mm) Kiustendil	3Months Total Precipitation (mm) Sandanski
95%	42	21
90%	59	35
75%	87	61
50%	127	92
25%	171	127
10%	215	162

Source: JICA Study Team

Based on the above table, evaluation of probability is as follows.

Evaluation of Probability of Exceedence for Precipitation during Summer time in WABD

Year	Kiustendil		Sandanski	
	Precipitation (mm)	Probability of Exceedence	Precipitation (mm)	Probability of Exceedence
2000	65	90%	25	95%
2001	82	80%	133	25%
2002	278	5%	204	<5%
2003	78	80%	98	30-70%
2004	178	25%	127	25%
2005	214	10%	168	10%

Source: JICA Study Team

There is no average year in 2000-2005 in terms of 3 months total precipitation.

B.2.3 Hydrology

(1) Overview of the Country

(a) Major Rivers

List of major rivers for the whole country is presented in Table B.2.1. In the table, the length and the total catchment area are calculated using the GIS-DB developed in the present study. The Iskar River is the longest river that has 338km in total. The Maritsa River Basin is the largest basin that has about 21,292km^2 in total catcthment area. Longitudinal profiles of the major rivers, which are derived from DEM, are presented in Figure B.2.20.

(b) Preliminary Water Balance across the Country

Water balance across the country can be schematized as shown in the following figure. Precipitation over the country except loss such as evapo-transpiration finally drained by two major directions: One is directly to Danube and Black Sea, and another is to neighbouring countries such as Turkey, Greece, Serbia and Romania. There also exists external inflow from Serbia and Macedonia in Struma River Basin. It should be noted that some minor inflow and outflow between Bulgaria and neighbouring countries are not shown in the figure.

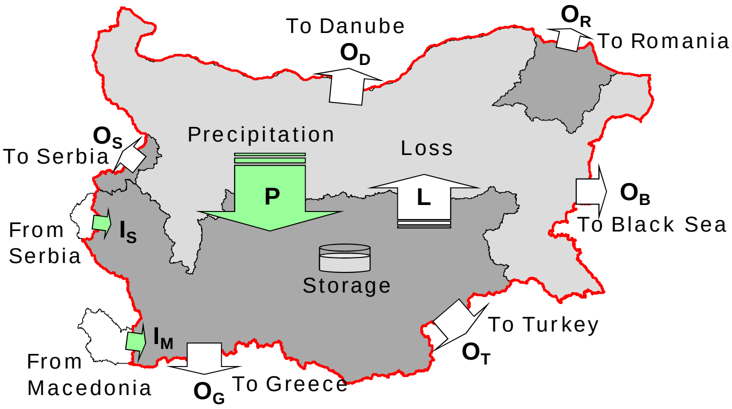
When dealing with short-term water balance, which is usually monthly to seasonal, basin storage should be taken into account. The basin storage includes both natural and artificial storage such as reservoir storage. However, in case of long-term water balance, the basin storage is usually negligible compared to other factors.

The following table shows the long-term averaged water balance across the country. It is assumed that the basin storage is negligible. One can see that more than 70 % of precipitation is lost. About 16% flows to neighbouring countries and about 12% flows directly to Danube and Black Sea. Amount of external inflow is small compared to other factors when considering nation-wide water balance. However, it could be important for local scale water balance. It should be noted that the water balance is affected by human impact such as inter-basin water transfer and water abstraction. For example, evapo-transpiration loss could be increased by water transfer for irrigation purpose from low PET region to high PET region.

Summary of Long-term Averaged Water Balance across the Country

				Long-Term Average (million m^3)	Ratio to Precipitation (%)
In	Precipitation (*1)		P	67,604	100.0
	External Inflow (*2)	Inflow from Serbia	I_S	493	0.7
		Inflow from Macedonia	I_M		
Out	Total Loss (*3)		L	48,664	72.0
	Outflow to Danube & Black Sea (*2)	Outflow to Danuba	O_D	8,260	12.2
		Outflow to Black Sea	O_B		
	Outflow to Neighbouring Countries (*2)	Outflow to Turkey	O_T	11,173	16.5
		Outflow to Greece	O_G		
		Outflow to Serbia	O_S		
		Outflow to Romania	O_M		

(*1) Average Annual Precipitation for 1950-2000 by WORLDCLIM (609mm/year) is used.
(*2) Source: National Statistical Institute: Environment 2004
(*3) It is assumed that total loss is equal to total inflow minus total outflow.



Source: JICA Study Team

Water balance in 5 hydrological years during 2000-2005 year by year, as well as the averaged one during 2000-2005, has been also examined (see Table B.2.2). It is assumed that the basin storage could be negligible when calculating the water balance in single hydrological year. It is also assumed that a hydrological year starts in November and ends in October, referring the annual flow pattern for major rivers shown in Table B.2.1 and previous literature[12)]. The averaged percentage of total loss in 5 hydrological years during 2000-2005 is similar to the long-term averaged one. However, the total loss in single hydrological year varies every year. It seems to be affected by precipitation amount in the previous hydrological year. When the previous hydrological year is dry, the total loss tends to be high. This tendency is also seen in Figure B.2.24 and B.2.29, which shows the relationship between total precipitation amount and annual average runoff.

One of the possible reasons for the changeable water balance year by year may be artificial storage in reservoirs. However, as shown in the later chapter, total storage by significant reservoirs within single year is up to about 20% of total effective storage volume, which is about 1,200 mil m^3. It is about 1.5% of total precipitation in average in 2000-2005. This amount is not enough to explain the changeable water balance year by year. Therefore, it is highly possible that the changeable water balance year by year is mainly because of natural hydrological process.

(c) Hypothesis on Hydrological Process

Mechanism of the changeable water balance year by year in Bulgaria is very interesting topics from hydrological point of view. It may be also related to effective management of water resources in Bulgaria. Therefore, it is recommended for academic institutes to investigate more intensively on the mechanism of the changeable water balance year by year in future.

One of hypotheses on the mechanism of the changeable water balance year by year based on experience on analysis on runoff process and modelling in the present study is shown below.

- Hypothesis
    - Key factors are snow and its melting process. In Bulgaria, annual runoff volume is strongly affected by snow melting flow.
    - Snow accumulation usually starts at around November and snow melting starts at around March. During the snow accumulation, almost all of precipitation is stored as snow pack on the surface. Precipitation rarely infiltrates during the winter time (November to March). Therefore, water contents in surface soil during the winter time are determined only by the condition of surface soil before the snow accumulation started at around November. The condition of surface soil at around November is strongly affected by the precipitation amount during summer time of the previous year. If the previous year is dry, the water contents of surface soil at around November are very low, and vice versa.
    - The condition of surface soil at around March, at which snow melting starts, affects runoff process very much. If the water contents of the surface soil at around March are low, melting water firstly has to fill the large storage volume of surface soil by infiltration. After the surface soil is almost saturated, much runoff can appear. During the filling process for the surface soil, large amount of evapo-transpiration loss is expected. In this case, runoff amount becomes relatively small. On the other hand, if the water contents of the surface soil at around March are high, melting water can be easily runoff to rivers without filling storage volume of surface soil. In this case, relatively large amount of runoff is expected, because of relatively small evapo-transpiration loss of melting water which is infiltrated to surface soil.
    - Because the water contents of the surface water contents at around March, at which snow melting starts, is strongly affected by the precipitation amount during summer time of the previous year, as have already discussed, the runoff volume is affected not only by the precipitation amount of the same year but also by the one of the previous year.

The process described in the hypothesis could appear only at the region with semi-arid climate condition with large amount of snow on winter time.

The above hypothesis has not yet been proved scientifically. However, if it is almost true, monitoring of surface soil condition during winter time may give useful information for predicting available runoff volume for water resources for the coming spring and summer time.

Also, the precipitation amount in the previous year can be one of good indicators for possible water resources for the current year, which can be utilized for risk management of water resources. For example, if the precipitation amount is small in the current year, risk of shortage of water resources for the next year becomes relatively high. To avoid the risk, it is recommended that reservoir should try to keep the original storage volume for the next year as much as possible, even if there is a lack of water resources in the current year. It means that single year operation of reservoir to avoid the risk is recommended.

(2) East Aegean Sea River Basin Directorate

(a) Main River Network

There are four major rivers in EABD; the Tundzha, Maritsa, Adra and Biala. The Tundzha River flows to Turkey, and the Arda and Biala Rivers flow to Greece. The Maritsa River flows to the border between Turkey and Greece. All of the rivers merge to one river which goes through again the border between Turkey and Greece, and finally reaches to Aegean Sea.

Main river network in EABD is shown in Figure B.2.21. In the figure, different line type represents different slope of the river segment. In the Maritsa and Tunzda Rivers, slope of the middle to lower reach is less than 1/1,000. Left tributary of the Maritsa River is generally milder than right tributary. The Arda and Biala Rivers have relatively steep slope.

(b) Disturbed Runoff Condition

There are several hydrometric stations to observe channel discharge. Based on the observed discharge, runoff condition can be investigated. One should remind that the observed discharge reflects the disturbed condition by human impact such as water abstraction and transfer. Figure B.2.22 shows representative hydrometric stations and those watershed areas in EABD.

Long-term changes of observed annual average discharge for the representative hydrometric stations are shown in Figure B.2.23. In the figures, no data are shown when data are not available for the present stage of the study. However, this does not always mean that the data is not available in NIMH.

Figure B.2.24 shows relationship between 1-, 2-, 3- year total precipitation and annual average discharge (runoff). It can be seen that correlation between 2- year total precipitation and annual average discharge is the highest.

Figure B.2.25 shows the long-term averaged monthly variation of discharge for selected hydrometric stations, using the currently available data during 1945-2005. Lowest flow condition appears in August for the Tundzha, Maritsa and Arda Rivers.

The peak flow appears in March in the Tundzha and Maritsa Rivers and in January in the Arda River. Difference between discharges in dry period and wet period is higher in the Arda River than that in the Tundzha and Maritsa Rivers.

In hydrological year 2000-2005, annual unit runoff (mm) from each watershed for the representative hydrometric stations is calculated. They are shown in Table B.2.3, together with runoff rate that is defined as (unit runoff) / (precipitation). The followings are identified.

- In general, dry year and its consequent year have lower runoff rate for the entire watershed.
- The Tundzha River except the uppermost watershed of HMS 74650 has significantly low runoff rate, which ranges 0.08-0.14. This indicates significant amount of water is abstracted from the river and/or the catchment.
- In the Maritsa River, the watersheds of HMS 72460 and 72520 have relatively high runoff rate, which is more than 0.4. This is mostly because of less human impact in these watersheds. The runoff rate for the rest watershed ranges 0.17-0.43, most of which are less than 0.25. This also indicates heavy water abstraction from the river and/or the catchment.
- All of the HMSs in the Arda River shown here is located at the upstream of reservoirs in the main stream of the Arda River. The runoff rate is generally high compared to those in the Tundzha and Maritsa Rivers.West Aegean Sea Basin Directorate

(3) West Aegean Sea River Basin Directorate

(a) Main River Network

There are three major rivers in WABD; Struma, Mesta and Dospat. All of these rivers flow to Greece. The Struma River receives external inflow from Serbia and Macedonia.

Main river network in WABD is shown in Figure B.2.26. In the figure, different line type represents different slope of the river segment. In the middle to lower reach of the Struma and Mesta Rives, slope is between 1/1,000 and 1/100. Tributaries of both the Struma and Mesta Rivers are generally very steep. Slope of the Dospat River in Bulgarian territory is more than 1/100.

(b) Disturbed Runoff Condition

There are several hydrometric stations to observe channel discharge. Based on the observed discharge, runoff condition can be investigated. One should remind that the observed discharge reflects the disturbed condition by human impact such as water abstraction and transfer. Figure B.2.27 shows representative hydrometric stations and those watershed areas in WABD.

Long-term changes of observed annual average discharge for the representative hydrometric stations in WABD are shown in Figure B.2.28. In the figures, no data are shown when data are not available for the present stage of the study. However, this does not always mean that the data is not available in NIMH.

Figure B.2.29 shows relationship between 1-, 2-, 3- year total precipitation and annual average discharge (runoff). It can be seen that correlation between 2- year total precipitation and annual average discharge is the highest.

Figure B.2.30 shows the long-term averaged monthly variation of discharge for selected hydrometric stations, using the currently available data during 1945-2005. Lowest flow condition and peak flow condition appear in August and in May, respectively, for the Struma and Mesta Rivers. Difference between discharges in dry period and wet period is higher in the Mesta River than that in the Struma River.

In hydrological year 2000-2005, annual unit runoff (mm) from each watershed for the representative hydrometric stations is calculated. They are shown in Table B.2.4, together with runoff rate that is defined as (unit runoff) / (precipitation). In the Struma River, runoff from the watershed of HMS 51360 & 51560 is excluded in order to investigate the runoff characteristics within the Bulgarian territory. The followings are identified.

- In general, dry year and its consequent year have lower runoff rate for the entire watershed.
- Uppermost watersheds of HMS 51700 in the main channel of the Struma River has significantly low runoff rate, which is less than 0.2. Runoff rate tends to increase toward the downstream in the Struma River.
- In the Mesta River, runoff rate is generally high compared to other rivers in EABD and WABD, which ranges 0.4-0.7.

B.3 Water Use Condition

B.3.1 Overview of Water Use

(1) Gross Water Abstraction

Gross water abstraction in the recent years is shown in the following table. The table is prepared based on the Bulletin for environment in 2000 – 2005 issued by National Statistical Institute.

Gross Water Abstraction

	1991	1995	1997	1998	1999	2000	2001	2002	2003	2004	2005	Average 2000-2005
Total	9,417	6,718	7,940	8,294	7,136	6,378	6,251	6,938	7,289	6,643	6,407	6,651
	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)	(100)
Non-Fresh Water	669	392	407	389	318	246	418	349	371	362	390	356
	(7.1)	(5.8)	(5.1)	(4.7)	(4.5)	(3.9)	(6.7)	(5.0)	(5.1)	(5.4)	(6.1)	(5.4)
Fresh Water	8,748	6,326	7,534	7,905	6,818	6,132	5,833	6,589	6,918	6,282	6,017	6,295
	(92.9)	(94.2)	(94.9)	(95.3)	(95.5)	(96.1)	(93.3)	(95.0)	(94.9)	(94.6)	(93.9)	(94.6)
Ground Water Total	1,446	907	798	793	585	574	525	493	467	434	447	490
	(15.4)	(13.5)	(10.1)	(9.6)	(8.2)	(9.0)	(8.4)	(7.1)	(6.4)	(6.5)	(7.0)	(7.4)
Surface Water Total	7,302	5,418	6,735	7,112	6,233	5,558	5,308	6,096	6,451	5,848	5,570	5,805
	(77.5)	(80.7)	(84.8)	(85.8)	(87.3)	(87.1)	(84.9)	(87.9)	(88.5)	(88.0)	(86.9)	(87.3)
from Reservoirs						1,886	1,504	1,421	2,373	2,068	1,843	1,849
						(29.6)	(24.1)	(20.5)	(32.6)	(31.1)	(28.8)	(27.8)
from Inland Rivers						215	179	200	320	221	222	226
						(3.4)	(2.9)	(2.9)	(4.4)	(3.3)	(3.5)	(3.4)
from Danube						3,233	3,430	4,307	3,577	3,391	3,360	3,550
						(50.7)	(54.9)	(62.1)	(49.1)	(51.0)	(52.4)	(53.4)

Unit: million m^3 / year

Source: NSI, Environment, 2000-2005, rearranged by JICA Study Team

Both fresh water and non-fresh water are abstracted and used. However, the ratio of non-fresh water is just about 5% of the total abstracted water. Almost all of non-fresh water is used for industrial purpose. Among the abstracted fresh water, about 50% is directly abstracted from the Danube. It is mainly used for industrial purpose, especially for power plants.

Remained abstracted water is from inland part of Bulgaria. Totally about 2,600 million m^3 / year, which is about 5% of annual total precipitation over the country and about 15% of annual total disturbed runoff, are abstracted. About 2,100 million m^3 / year are from surface water, 90% of which is through reservoirs. Ground water abstraction is about 500 million m^3 / year in average in the recent 5 years. However, the amount of ground water abstraction tends to decrease gradually.

(2) Water Abstraction and Use by Sectors and Sources

Water supply system can be divided into the following two categories.

- Public Water Supply System
- Others, including Self-Supply System

Based on the data in the Bulletin by NSI, the ratio between the amount of water provided by public water supply system and that by others is about 1:2 as shown in the following table. The water provided by "the others" can not be ignored when considering water balance.

Water Abstraction and Use by Sectors and Sources (Average during 2000 – 2005)

	Total	Public Water Supply					Others (including Self-Water Suply)				
		Total	SW			GW	Total	SW			GW
			Total	Reservoir	Others			Total	Reservoir	Others	
Abstraction	2,746	1,041	683	494	189	358	1,704	1,573	1,355	217	132
		Total					Total				
Loss	1,271	632					639				
		Total	Domestic Sector	Industry	Agriculture		Total	Domestic Sector	Industry	Agriculture	
Use	1,474	409	336	71	3		1,065	18	868	179	

unit: million m^3 /year
SW: Surface Water
GW: Ground Water
Source: NSI, Environment, 2000-2005, rearranged by JICA Study Team
Note: The abstracted and used water from the Danube and non-fresh water are excluded.

In the public water supply system, ground water source contributes significantly. Its amount is about one third of the total abstracted water. Almost all of the water provided by public water supply system is used for domestic sector. The loss during the transportation of the water is more than 60%, which should be improved for effective use of the water.

The others including self-supply system relies on surface water more, especially on reservoir. About 80% of the abstracted water is from reservoir. The water is used mainly for industrial and agricultural purposes. However, industrial water use is about four times larger than agricultural water use. The loss is also large. About 40% of the abstracted water is not used and lost somewhere.

The following table shows water use in hydroelectric power plant (HPP) and sent water after use during 2000 - 2005. About 1,500 million m^3 / year are sent to other purposes after the water is used for HPP. Although actual water use by agriculture is not so big as shown in the table, about 50% of the used water is sent for agricultural purpose. Part of this water may be lost somewhere and/or converted to be used for other purposes. The proper control of this water could be one of important issues for efficient use of water. It should be noted that the amount of the sent water varies drastically year by year. It could be influenced by available water in reservoirs.

Water Use in Hydroelectric Power Plant (HPP) and Sent Water after Use in 2000 - 2005

	2000	2001	2002	2003	2004	2005	Average 2000 - 2005
Fresh Water Use	6,682	4,098	6,649	8,466	9,445	15,075	8,403
Sent Water after Use	1,205	700	1,416	2,011	1,876	1,801	1,502
Irrigation	710	232	699	1,099	1,012	1,142	816
Domestic Sector	192	124	160	185	238	144	174
Industry	303	345	557	727	626	515	512

unit: million m^3 / year
Source: NSI, Environment, 2000-2005, rearranged by JICA Study Team

(3) Total Wastewater Discharged

The following table shows total wastewater discharge. It can be recognized as one of returned water after water use. One can see that about two third of the total actually used water in domestic, industrial and agricultural purposes is returned to rivers as wastewater. However, it should be noted that considering the high loss rate of abstracted water, amount of actual return flow is much smaller compared to the abstracted water amount. About 70% of wastewater discharged is categorized as treated waste water.

Total Wastewater Discharge in 2000-2005

	2000	2001	2002	2003	2004	2005	Average 2000 - 2005
Total Waste Water Discharged	879	785	746	1,194	1,192	823	937
Treated	550	488	517	951	943	587	673
Non-Treated	328	297	230	243	248	236	264

unit: million m^3 / year

Source: NSI, Environment, 2000-2005, rearranged by JICA Study Team

B.3.2 Existing Water Supply Systems in Bulgaria

There are 51 major water supply and sewerage (WSS) companies in Bulgaria. They are composed of state owned company (13), state and municipality owned company (16) and municipality owned company (22). Table B.3.1 shows the existing water supply systems, which are operated by the major WSS Companies in Bulgaria. This table also includes the information of sewerage systems.

Table B.3.2 summarizes municipalities under service of each WS&S Company in EABD and WABD. The table and Figure B.3.1 show surface water dependency of each WS&S Company in EABD and WABD. One can see that surface water dependency varies with each WS&S Company and municipality. In general, surface water dependency is high in WABD territory and is low in EABD territory. In lower reach of Maritsa river basin and Tundzha river basin, surface water dependency is less than 5%, which means that there is heavy use of ground water for domestic water in these regions. More detailed data are shown in *Annex B.3*.

Among the water supply networks, share of asbestos cement pipe is 74 % and that of steel pipe is 15 % in Bulgaria. These two kinds if pipes are the most deteriorated pipes causing significant loss of water such as 50 to 60%, which are highly necessary to be replaced to HDPE pipes and others. The following photos show the condition of the deteriorated asbestos pipes etc., which are exhibited in Kyustendil WSS Company.

Cracked Asbestos Cement Pipe (above) and Corroded Steel Pipe (below)

Damaged Asbestos Cement Pipe by penetration of Wooden Root

B.3.3 Outline of Irrigation

(1) Current Condition

Irrigation had been one of big water users. Figure B.3.2 shows the change of irrigated area and used water volume. In 1980s, irrigated area was about 10,000 km^2, which was about 10% of the total land area in Bulgaria. Used water for the irrigation at that time was about 3,500 million m^3/ year. It is more than the total abstracted water (excluding the Danube and non-fresh water) in the recent years. However, in the beginning of 1990s, it decreased very rapidly. It becomes now about 200-300 km^2. The used water is also decreased to 100 – 200 million m^3/ year, which is about 1 – 2 % of that in 1980s. As shown in the previous section, the used water by hydro electric power plant is still transferred to irrigation purpose without being used for its actual purpose fully.

Yearly change of irrigated crops (share of irrigated area for each crop against total irrigated area) in recent years is shown in Table B.3.3. Maize is dominating irrigated crops. The production of rice is increasing gradually.

(2) Irrigation System

Although the irrigated area has been reduced, there is potential irrigation system, which was once fully operated as irrigation area. Table B.3.4 summarizes total potential irrigation area for the entire Bulgaria, EABD and WABD territories. There are 21 irrigation branches in Bulgaria. Each irrigation branch has many irrigation systems. List of the irrigation systems is shown in *Annex.B.4*.

Figure B.3.3 shows the irrigation area set-up by irrigation system for EABD and WABD. Irrigation areas are categorized by water supply condition. In EABD, especially in Maritsa and Tundzha river basins, there are wide irrigation areas whose water source is significant reservoirs. On the other hand, many of irrigation areas in WABD utilize water taken by rivers.

(3) Water Use and Abstraction by Irrigation System

Table B.3.5 summarizes average water use and estimated abstracted volume by irrigation system in 2001-2005 according to the data provided by Irrigation Systems Ltd. Loss rate is very high in general. For efficient utilization of the water, it is necessary to improve the current condition. More detailed data are shown in *Annex B.4*.

It should be noted that the estimated abstracted water volume by Irrigation System Ltd. does not always reflect actually situation, because of the difficulty of getting correct data under the current institutional situation. For the study on water balance in the present study, the abstracted water volume for irrigation system, especially for the one related to significant reservoirs, are estimated by the other data sources such as the record of operation of significant reservoir and the water quantity measured at hydrometric stations.

B.3.4 Significant Reservoirs and Water Transfer

In Bulgaria, there are a number of reservoirs and lakes. Among those, totally 51 reservoirs are specified as significant reservoirs in the Water Act (see Figure B.3.4 for the list of significant reservoir and those locations). Total volume of the significant reservoirs is about 6,600 million m^3. It is almost one third of the average total annual runoff volume from the territory of Bulgaria in the current disturbed condition. The technical parameters for the significant reservoirs are shown in *Annex B.5*.

Figure B.3.5 shows change in percentage of total stored water volume against total effective volume of significant reservoirs during 1999 – 2003. Regarding annual fluctuating pattern of the stored water volume in the reservoirs, maximum volume usually appears in June and minimum appears in December to February. One can see that volume of stored water in reservoirs does not recover to its full capacity within single hydrological year. During 1999-2003, the stored water volume recovered to 80% of the total effective volume in maximum case. In 2001 and 2002, the recovery was just up to 60%. This is presumably because of reduction of inflow to the reservoirs due to low precipitation in 2000 and 2001. From January 2002 to January 2003, total volume in the reservoirs was increased about 20% of the total effective volume, which is almost equal to 1,200 million m^3 (It is assumed that the effective volume is 90% of total volume.).

Water balances in some of the significant reservoirs in 2000-2005 based on the records of water balance that have been submitted to MOEW are shown in *Annex B.6*.

For estimating detail water balance considering operation of the significant reservoirs, the data stored in MoEW are basically used. However, there were many difficulties for utilizing the data. The followings are assumed in the present study..

- Even in the data stored to MoEW, there is lack of information for water use condition for 2000-2001. For 2000-2001, the condition of water use has been assumed referring the water use condition of 2002-2005.
- Some reservoirs gather water through feeder channels from neighboring river basins. However, the data in MoEW show only total inflow volume. Based upon the available information on the design scheme of significant reservoirs, how the feeder channels contribute to inflow to the significant reservoirs in EABD and

WABD has been assumed. The assumptions are summarized in *Annex B.7*, which has been used for estimation of water balance in the present study.

- One of unclear factors when one considers the water balance is how the used water for Hydroelectric power plant (HPP) is re-used for another purpose. It is not always clearly shown in the records submitted to MoEW. Considering possible water balance based upon the available information such as water quantity measured at hydrometric stations, re-used water has been assumed. There are two patterns assumed as follows.
  - *Pattern 1*: All of used water for HPP is re-used for irrigation purpose and does not come back to downstream reach of the river that HPP locates.
  - *Pattern 2*: All of used water for HPP comes back to downstream reach of the river that HPP locates. Only the water for irrigation that is specified in the records is used for irrigation purpose.
- Another unclear factor is share of industrial water supply and domestic water supply. The records in MOEW show only total water use for industrial and domestic water. In the present study, the share between industrial and domestic water supply has been assumed based on permitted water volume.

The assumption for water use and transfer of each reservoir in the present study is described in *Annex B.8*.

Figures B.3.6 – B.3.8 summarize main water transfer related to the significant reservoirs in EABD and WABD. Very complicated artificial water transfers can be seen in the figures. Typical water transfers are:

- The Struma and Mesta River Basins to the Belmeken Reservoir (the Maritsa River Basin),
- The Mesta River Basin to the Dospat Reservoir (the Dospat River Basin),
- The Dospat Reservoir (the Dospat River Basin) to the Vacha River Basin (the Vacha Reservoir) (the Maritsa River Basin),
- The Dospat River Basin to the Batak Reservoir (the Maritsa River Basin),
- Upper part of the Vacha River Basin (the Maritsa River Basin) to the Batak Reservoir (the Maritsa River Basin),
- The Koprinka Reservoir (the Tundzha River Basin) to the Maritsa River Basin, and
- The Zhrebchevo Reservoir (the Tundzha River Basin) to the Maritsa River Basin.

Figure B.3.9 shows photos for some facilities during site visits by the Study Team.

The following average volume of inter-basin water transfer in 2001 – 2005 is estimated based on the data stored in MoEW under the above-mentioned assumptions.

- The Struma River Basin to the Maritsa River Basin: 37 million m^3/year
- The Mesta River Basin to the Maritsa River Basin: 42 million m^3/year
- The Mesta River Basin to the Dospat River Basin: 63 million m^3/year
- The Dospat River Basin to the Maritsa River Basin: 140 million m^3/year
- The Tundzha River Basin to the Maritsa River Basin: 254 million m^3/year

B.4 Water Balance for Existing Condition

In this section, water balance for existing condition (2001 - 2005) is presented. The water balance for each river basin was estimated using the result of the calibrated rainfall-runoff model, the operation record of significant reservoirs and the permission data for water use etc. The Simple Model introduced in *Supporting Report E* was used to calculate the water balance.

Tables B.4.1 and B.4.2 show average annual water balance at downstream end (national border) of river basin in 2001 - 2005 and one for summer time (July –September), respectively.

In the table, the definitions of the terms used are as follows.

- Quasi-Natural Flow (NF)
  - Flow without human disturbances such as abstraction, discharge, transfer
  - Likely natural, however, not exactly natural.
  - In the model, regime change of local reservoir is not taken into account.
- Potential Flow with Significant Reservoir (PF)
  - Flow with influence of significant reservoir, but no abstraction from reservoir
  - Potentially usable water amount after regime change by significant reservoir
- Disturbed Flow (DF)
  - Existing condition
  - It can be expressed as follows.
    - (Potential Flow) – (Total abstracted water) + (Total discharged water)

Figures B.4.1 – B.4.7 show locations of the reference points in each basin and the water balance along main stream of each river basin. More data and figures on water balance at reference points are shown in *Annex B.9*. Detail spatial distribution of 1) water balance, 2) ratio of abstracted water amount against potential flow, 3) maximum permitted water amount for local HPP against potential flow, and 4) ratio of waste water discharge against disturbed flow for EABD and WABD are shown in Figures B.4.8 – B.4.11 and Figures B.4.12 – B.4.15, respectively. From the above table and figures, the followings can be identified.

Existing Water Balance in WABD

Struma	• There is inter-basin water transfer from the Struma River to the Maritsa River Basin. The transfer from the Struma River reduces potential flow in the Struma River about 2% of quasi-natural flow at the downstream end (country border) of the Struma River. It does not affect so much to overall water balance in the Struma River Basin. It is less than the volume of abstracted water for use in the Struma River Basin; about 5% of potential flow. However, it should be noted that the effect of water transfer at local scale may not be ignored (see Figure 2.4.20 for detail spatial distribution of water balance). • In upstream portion of the Pchelina Reservoir, water abstraction for domestic and industrial water use is relatively high. At downstream portion of the Studena Reservoir does have very small amount of water, because of water abstraction by the Studena Reservoir. • Ratio of wastewater discharge against disturbed flow is about 7%. It is expected that higher pollution can be expected in the reach with higher ratio of wastewater discharge. This high ratio can be seen along small tributary with big cities, especially at upstream portion of the Pchelina Reservoir.
Mesta and Dospat	• There are inter-basin water transfers from the Mesta and Dospat rivers to the Maritsa River Basin. The transfer from the Mesta River reduces potential flow in the Mesta River about 10% of quasi-natural flow at the downstream end (country border) of the Mesta River, although water abstraction for use in the Mesta River Basin is much smaller than the transferred volume. • Impact of water transfer from the Dospat Reservoir on the downstream portion of the Dospat River is very large. Almost two third of quasi-natural flow does not reach to the downstream end (country border) of the Dospat River. • Special attention should be paid to water abstraction from a weir at Gotse Delchev. The water abstracted from this weir is used not only for irrigation but also for local hydroelectric power plant. In summer time, the abstraction form this weir significantly reduces the water quantity of mainstream of the Mesta River, although it is limited to some stretches. • Ratio of wastewater discharge against disturbed flow is about 3%.

Existing Water Balance in EABD

Arda and Biala	• There is no inter-basin transfer in the Arda River Basin. However, loss in reservoirs such as evaporation reduces annual average potential flow. It should be noted that the potential flow significantly increases in summer time because of regime change by reservoir operation.
Tundzha	• There are inter-basin water transfers from the Tundzha River to Maritsa River Basin. Those transfers significantly reduce potential flow in the Tundzha River about 25% of quasi-natural flow in the Tundzha River. In the Tundzha River Basin, volume of water abstraction is also very large. About 30% of potential flow is abstracted. Because of these, actual flow is almost half of quasi-natural flow. It can be said that the Tundzha River Basin is significantly modified in terms of water quantity condition. • More than 80% of water abstraction is for irrigation purpose. As have already discussed, loss of irrigation water use is very large. To reduce loss of irrigation water use and to control irrigation water properly is one of key factors for improvement of river condition. • Ratio of wastewater discharge against disturbed flow is about 7%. It is expected that higher pollution can be expected in the reach with higher ratio of wastewater discharge. This high ratio can be seen along small tributary with large cities.
Maritsa	• The Maritsa River receives much water from the neighboring river basins. This makes potential flow in the Maritsa River almost 10% higher than the quasi-natural flow. Some of transferred water is lost by evaporation in reservoirs. About 20% of potential flow is abstracted for water use in the Maritsa River Basin. Without the water transfer, river condition may become much worse if the same level of water abstraction is kept. • More than 80% of water abstraction is for irrigation purpose. As have already discussed, loss of irrigation water use is very large. To reduce loss of irrigation water use and to control irrigation water properly is one of key factors for improvement of river condition. • Ratio of wastewater discharge against disturbed flow is about 7%. It is expected that higher pollution can be expected in the reach with higher ratio of wastewater discharge. This high ratio can be seen along small tributary with large cities.

B.5 Results of Interview Survey on the Problems of Water

In order to know how municipalities people feel about the problems of water especially drinking water supply and sewerage, JICA Study Team conducted interview survey to some of the municipality offices. The visited municipalities are as follows;

EABD Area	
Maritsa River Basin	Asenovgrad, Velingrad, Pazardzhik, Panagyurishte, Plovdiv, Hisarya, Karlovo, Stara Zagora, Galabovo, Dimitrovgrad, Haskovo and Svilengrad
Tundzha River Basin	Kazanlak, Sliven, Yambol and Elhovo
Arda River Basin	Smolyan and Ivaylovgrad
WABD Area	
Struma River Basin	Pernik, Dupnitsa, Kyustendil, Blagoevgrad and Sandanski
Mesta River Basin	Razlog, Bansko and Gotse Delchev
Dospat River Basin	Dospat

The results of the interview survey are summarized in Table B.5.1. The major problems are described below.

- Problems related to Drinking Water Supply
  - The most serious problem is the old or deteriorated pipes with asbestos cement and steel pipes with high loss and frequent accidents. This problem also cause problem of shortage of water due to high loss and also low water pressure in the pipe.
  - In general, quantity of water supply is sufficient. However about 1/5 of the municipalities in the survey answered about the insufficient of water sources. Furthermore, most of the municipalities, which answered about the insufficient water sources belong to WABD area. This is probably due to the fact that the WABD areas depend more on surface water than groundwater in general.
  - There are problem of manganese in water mainly in EABD areas.
  - There is a problem of lack or insufficient water purification plants.

- Problems related to Sewerage
  - The most serious problem is the lack of wastewater treatment plants in many municipalities.
  - Insufficient coverage of sewerage system is also rather big problem.
  - There is serious problem of insufficient or no treatment of industrial water as well as big animal breeding farms. They discharge directly into the rivers and water bodies almost without treatment.
  - Sewer pipes are old and deteriorated in general, and it is also serious problem.

- Problems of Floods
  - Most of the municipalities answered that they have suffered flood damages in recent years including 2005 and 2006.
  - Flood damage happened to the houses, town and villages, infrastructures including road and bridge, railroad, water supply system, sewerage system, agricultural lands and bank protection and dikes.
  - However, warning of floods to the people and evacuation of the people was insufficient.

- Problems of Accidental Pollution
    - About 40 to 50 % of the municipalities in the interview survey answered that they have experienced accidental pollution. However, the situation of the accidental pollution is not so clear.

List of Water Supply Networks in EABD and WABD based on the Answers to the Questionnaires to the Water Supply and Sewerage Companies can be seen in *Annex B.10*

List of Development Plans of Municipalities in EABD and WABD is presented in *Annex B.11*.

B.6 Water Resources Potential

In Bulgaria, almost all of the observed water quantities at hydrometric stations are under disturbed condition. The measured disturbed water quantities have been traditionally used for the statistical analysis for estimating available water resources with different probability, although it may be difficult to know quasi-natural water resources.

In the present study, probable water quantities are estimated based on the calibrated rainfall-runoff model. Firstly, quasi-natural water quantities are estimated under the precipitation with different probability. Secondly, by assuming the reservoir operation pattern, potential flows under influence of significant reservoirs are estimated. The estimated water quantities can be regarded as water resources potential, especially for surface water.

For setting the meteorological conditions for the rainfall-runoff model, the following principles are applied.

- Precipitation amount in continues 2-year should be considered, because 2-year total precipitation amount seems to be related to water quantity more than one in a single year.
- Precipitation pattern in the representative year is used by adjusting total precipitation amount.
- Temperature pattern in the representative year is used.

The results of the statistical analysis for precipitation in EABD and WABD, which was discussed in Section B.2.2, show that year 2004 is almost average year in terms of precipitation amount. Therefore, in the present study, year 2004 is selected as the representative year for considering water resources.

The precipitation amount in continuous 2-year is given as follows (refer to Figure B.6.1).

- For the 1st year, 1-year total precipitation amount for x % probability of exceedence (A) is given.
- 2-year total precipitation amount for x % probability of exceedence (B) is firstly calculated. Then, 1-year total precipitation amount for 2nd year (C) is given by (B-A).

Table B.6.1 and B.6.2 show the given precipitation amount for the simulation for EABD and for WABD, respectively.

Given Precipitation Amount for Simulation for EABD

Probability of Exceedence	1-year Total Precipitation Amount (mm)		Ratio against Precipitation Amount in 2004	
	1st Year	2nd Year	1st Year	2nd Year
95%	472	538	0.734	0.837
90%	512	573	0.796	0.891
75%	578	622	0.899	0.967

Year 2004	643

Source: JICA Study Team

Given Precipitation Amount for Simulation for WABD

Probability of Exceedence	1-year Total Precipitation Amount (mm)		Ratio against Precipitation Amount in 2004	
	1st Year	2nd Year	1st Year	2nd Year
95%	442	510	0.633	0.731
90%	490	558	0.702	0.799
75%	578	603	0.828	0.864

Year 2004	698

Source: JICA Study Team

Precipitation pattern in year 2004 is then adjusted by total precipitation amount for x % probability of exceedence as shown in Figure B.6.2.

Continuous 2-year simulations have been conducted using the calibrated NAM model. Initial condition for the simulation has been set as same as the condition at the beginning of year 2004 for the existing condition. The simulated result shows that the runoff volume in the 2nd year is almost always smaller than the one in the 1st year, although the precipitation amount in the 2nd year is larger. This seems to be because of the influence of smaller precipitation amount in summer time in the 1st year. In the present study, drought condition is main interest. Therefore, for safety, the result in the 2nd year is utilized for further analysis.

The results of rainfall-runoff simulation are imported to the Simple Model_ver_Potential. Then, quasi-natural water quantities for x % probability of exceedence are estimated.

The Simple Model_ver_Potential is utilized for estimating potential flow with significant reservoirs. For estimating potential flows with influence of significant reservoirs, the followings are assumed.

- Outflow volume
  - Annual Total Outflow = Annual Total Inflow is assumed
  - Same outflow pattern as the one in the representative year (2004) with adjustment to attain “Annual Total Outflow = Annual Total Inflow” is applied.
- Transfer by feeder channels
  - Average transfer rate during 2001-2005 is applied.

The estimated probable water quantities at the downstream end (country border) of each river basin for quasi-natural flow and potential flow are shown below.

Probable Water Quantity at the Downstream End (Country Border) of Each River Basin

		Struma	Mesta	Dospat	Arda	Biala	Tundzha	Maritsa
Average Year (2004)	Quasi-Natural Flow (NF)	66.79	34.22	6.82	63.30	2.64	31.79	103.66
	Potential Flow (PF)	65.35	30.58	2.40	50.09	2.64	22.50	113.85
Probability of Exceedence 75%	Quasi-Natural Flow (NF)	51.62	23.65	5.06	47.87	0.83	28.34	80.04
	Potential Flow (PF)	50.67	21.05	1.88	43.89	0.83	21.06	91.37
Probability of Exceedence 90%	Quasi-Natural Flow (NF)	39.43	20.01	3.88	39.20	0.55	19.62	61.98
	Potential Flow (PF)	38.65	17.84	1.43	35.89	0.55	14.54	70.34
Probability of Exceedence 95%	Quasi-Natural Flow (NF)	31.04	13.25	2.99	33.61	0.43	14.66	51.68
	Potential Flow (PF)	30.40	11.86	1.10	30.74	0.43	11.01	57.96

Unit: m^3/s

The year with 95% of probability of exceedence (equivalent to drought with 1/20) provides almost half water quantity compared to one in the average year.

Figures B.6.3 – B.6.9 show the estimated probable water quantity (75%, 90% and 95%) for both quasi-natural flow and potential flow with significant reservoir for each river basin. More detailed results can be explored by the Simple Model_ver_Permit2.

B.7 Water Resources Potential and Demand Analysis

Balance of water resources potential and water demand under several scenarios are analyzed. Because condition of irrigation water use gives most significant impact on water balance, several scenarios on irrigation water use are analyzed under the following situations.

- Drinking Water Demand
  - To keep current surface water dependency
  - Unit water use = 220litter/day /person
  - Loss rate =50%
- Industrial Water Demand
  - No change from current condition (Increase by GDP growth, but recycling rate will also increase)
- Irrigation Water Demand
  - To keep current unit water demand for each irrigation branch
  - For current loss rate, the value showed by Irrigation Systems Ltd. is used.

The Simple Model_ver_Demand is used for the analysis.

(1) The Struma River Basin

Figures B.7.1 and B.7.2 show the balance between water resources potential and water demand along main stream of the Struma River Basin for several scenarios. Based on the results, the followings are discussed.

- Ratio of water demand against potential water resource is high in upstream area and low in downstream area. It is not spatially well balanced. At upstream of the confluence with the Dzherman River, water resources potential is quite limited compared to water demand. Demand control could be required for drinking, industrial and irrigation water.
- On the other hand, from downstream reach of the confluence with the Dzherman River, water resources potential is rather large compared to water demand.
- Under current loss rate (48 to 74%) and current unit water demand for irrigation water, about 40% of potential irrigation area can be irrigated with almost no water flow at the confluence with the Dzherman River in the Struma River when precipitation amount is 75% probability of exceedence. When we consider river environmental condition, at least minimum water should be kept. In this case, possible irrigation area is less than 40% of the potential area.
- Under the condition that loss rate is 30% with current unit water demand for irrigation water, almost 100% of potential irrigation area can be irrigated with almost no water flow at the confluence with the Dzherman River in the Struma River when precipitation amount is 75% probability of exceedence. Considering necessity of minimum environmental flow, possible irrigation area is less than 100% of the potential area.

(2) The Mesta River Basin

Figures B.7.3 and B.7.4 show the balance between water resources potential and water demand along main stream of the Mesta River Basin for several scenarios. Based on the results, the followings are discussed.

- Water resources potential is large enough compared to water demand.
- Ratio of water demand against potential water resource is large in downstream area and small in upstream area in general.
- Under current loss rate (64%) and current unit water demand for irrigation water, almost 100% of potential irrigation area can be irrigated with about 20% of potential water flow being kept at the reach near Gotche Dolchev to the downstream end of the Mesta River when precipitation amount is 75% probability of exceedence.
- Under the condition that loss rate is 30% with current unit water demand for irrigation water, almost 100% of potential irrigation area can be irrigated with about 50% of potential water flow being kept at the reach near Gotche Dolchev to the downstream end of the Mesta River when precipitation amount is 75% probability of exceedence.
- However, water resources balance at local level should be further investigated using more detailed data. Especially, it should be careful on effect of water abstraction for local hydro power plant.

(3) The Arda River Basin

Figure B.7.5 shows the balance between water resources potential and water demand along main stream of the Arda River Basin for several scenarios. Based on the results, the followings are discussed.

- Water resources potential is generally large enough against water demand along main channel of the Arda River.
- Under current loss rate (73%) and current unit water demand for irrigation water, about 100% of potential irrigation area can be irrigated without significant impact on main channel of the Arda River.
- However, water resources balance at local level should be further investigated using more detailed data. Generally, annual water resources seem to be enough. To utilize water resources more in drought season, local reservoir or pond could be useful.

(4) The Tundzha River Basin

Figures B.7.6 and B.7.7 show the balance between water resources potential and water demand along main stream of the Tundzha River Basin for several scenarios. Based on the results, the followings are discussed.

- Ratio of water demand against potential water resource is large in upstream area and small in downstream area. It is not spatially well balanced. This is mainly because of decrease of water resources potential in the upstream area due to water transfer from the Koprinka Reservoir to the Maritsa river basin.
- Reduction of water resources potential at the area between the Koprinka Reservoir and the Zhrebchebo Reservoir can be constraints against recovering of irrigation activity in the area. If the current water transfer will be kept, demand control may be required in this area.
- Under current loss rate (61-84%) and current unit water demand for irrigation water, about 35% of potential irrigation area can be irrigated with almost no water flow at the reach from the Zhrebchebo Reservoir to Yambol in the Tundzha River when precipitation amount is 75% probability of exceedence. When we consider river environmental condition, at least minimum water should be kept. In this case, possible irrigation area is less than 35% of the potential area.
- In the current situation, almost all of water can be abstracted at the reach from the Zhrebchebo Reservoir to Yambol according to the permission issued to irrigation purpose. On the other hand, actually irrigated area in this area (Mainly Sliven branch) is less than 10% according to the record provided by Irrigation Systems Ltd. Water abstraction in this area is obviously too much compared to actual demand. Proper control of water abstraction based on actual demand is necessary.
- Under the condition that loss rate is 30% with current unit water demand for irrigation water, almost 70% of potential irrigation area can be irrigated with almost no water flow at the reach from the Zhrebchebo Reservoir to Yambol in the Tundzha River when precipitation amount is 75% probability of exceedence. Considering necessity of minimum environmental flow, possible irrigation area is less than 70% of the potential area.

(5) The Maritsa River Basin

Figures B.7.8 and B.7.9 show the balance between water resources potential and water demand along main stream of the Maritsa River Basin for several scenarios. Based on the results, the followings are discussed.

- Water demand against potential water resource is spatially rather well balanced from upstream to downstream of the Maritsa River.
- Without water transfer from other basins, water resources potential against water demand would be very small.
- Under current loss rate (60 to 74%) and current unit water demand for irrigation water, about 15% of potential irrigation area can be irrigated with almost no water

flow in the Maritsa River when precipitation amount is 75% probability of exceedence. When we consider river environmental condition, at least minimum water should be kept. In this case, possible irrigation area is less than 15% of the potential area.

- Under the condition that loss rate is 30% with current unit water demand for irrigation water, about 30% of potential irrigation area can be irrigated with almost no water flow in the Maritsa River when precipitation amount is 75% probability of exceedence. Considering necessity of minimum environmental flow, possible irrigation area is less than 30% of the potential area.

B.8 Programme of Measures for Water Quantity Improvement

B.8.1 Programme of Measures for Water Supply Improvement

(1) Direction of Structural Measures

- Improvement of water supply pipes to reduce water loss, mainly for asbestos cement and steel pipes

(2) Necessary Length of Pipes to Be Improved in Bulgaria and Rough Cost Estimation

The existing asbestos cement pipes and the steel pipes are necessary to be replaced for reducing the loss of water from the pipes as well as remove potential health threats to people by asbestos cement.

For a reference, Table B.8.1 shows the necessary length of pipes to be replaced together with rough cost estimation for all over Bulgaria. To estimate the cost, information of length of pipes with their composition of pipe diameter for different population size of towns were collected and analyzed. Based on this analysis and unit price of pipe, unit construction cost for water supply pipes are estimated, and applied for estimating the construction cost.

(3) Necessary Length of Pipes to Be Improved for Some Sample Municipalities in EABD and WABD and Rough Cost Estimation

In order to study feasibility for improving water supply pipe networks, based on the limited answers to the questionnaire to WSS Companies in EABD and WABD to JICA Study Team by August 2007, some sample municipalities are selected for further analysis. They are Haskovo, Yambol and Kardhali in EABD and Kyustendil in WABD.

The following table shows the estimated cost for improvement of the water supply pipes in these 4 municipalities. Total estimated cost of improvement for these municipalities will be EUR. 325,847,000.

Improvement of Water Supply Networks of 4 Sample Municipalities

No.	Municipality	WSS Co.	Owner	Related Basin District	Served populat. by WS	Existing Pipes for Water Supply: Asbestos cement (m)	Steel (m)	Cast iron (m)	PVC + HDPE (m)	Other (m)	Total length (m)	Informat. Necessary Improve. (m)
1	Haskovo	Haskovo	State	EABD	98,697	461,171	156,429		627	3,702	621,929	12,610
2	Yambol	Yambol	State	EABD	79,235	136,745	59,450		5,962	12,246	214,403	
3	Kardzhali	Kardzhali	State & Municp.	EABD	64,847	231,858	24,786	0	21,301	22,549	300,494	166,000
4	Kyustendil	Kyustendil	State & Municp.	WABD	66,298	669,409	172,903	12,212	19,553	113,074	987,151	
	Total				**309,077**	**1,499,183**	**413,568**	**12,212**	**47,443**	**151,571**	**2,123,977**	

No.	Municipality	WSS Co.	Owner	Related Basin District	Estimated Necessary Improvement of WS Pipes: Replace-ment Length of Pipe (AS+ST) (m)	Unit Cost (EUR / m)	Direct Cost (A) (EUR)	Engineering Cost (5% of A) (EUR)	Administration Cost (5 % of A) (EUR)	Physical Contingency (10% of A) (EUR)	Total Cost (EUR)
1	Haskovo	Haskovo	State	EABD	617,600	160	98,816,000	4,940,800	4,940,800	9,881,600	118,579,200
2	Yambol	Yambol	State	EABD	196,195	160	31,391,200	1,569,560	1,569,560	3,139,120	37,669,440
3	Kardzhali	Kardzhali	State & Municp.	EABD	256,644	150	38,542,437	1,927,122	1,927,122	3,854,244	46,250,924
4	Kyustendil	Kyustendil	State & Municp.	WABD	842,312	151	127,474,993	6,373,750	6,373,750	12,747,499	152,969,991
	Total				**1,912,751**	**622**	**296,224,629**	**14,811,231**	**14,811,231**	**29,622,463**	**355,469,555**

Note: Estimated cost is without VAT.

Data Source:
1) Answer to the questionnaires to the WSS Companies in EABD and WABD areas by the end of August 2007, which have been received by this Study.

The following table shows possible reduction of water supply loss by the above improvement. In this calculation, per-capita water consumption is supposed to be 220 l/day/person in the future condition. By the improvement, about 22 million m^3 of water can be saved for these 4 municipalities.

Water Loss Reduction by the Improvement of Water Supply Networks of 4 Sample Municipalities

No.	Municipality	WSS Co.	Owner	Related Basin District	Served populat. by WS	Water Demand (m^3/day)	Water Demand (m^3/year)	Necessary Supplied Water with current physical loss (50%) (m^3/year)	Necessary Supplied Water with improved physical loss (10%) (m^3/year)	Difference of Necessary Supplied Water (m^3/year)	Remarks: Current Supplied Water (m^3/year)
1	Haskovo	Haskovo	State	EABD	98,697	21,713	7,925,369	15,850,738	8,805,966	7,044,773	10,320,000
2	Yambol	Yambol	State	EABD	79,235	17,432	6,362,571	12,725,141	7,069,523	5,655,618	14,432,000
3	Kardzhali	Kardzhali	State & Municp.	EABD	64,847	14,266	5,207,214	10,414,428	5,785,793	4,628,635	5,148,000
4	Kyustendil	Kyustendil	State & Municp.	WABD	66,298	14,586	5,323,729	10,647,459	5,915,255	4,732,204	2,062,000
	Total				**309,077**	**67,997**	**24,818,883**	**49,637,766**	**27,576,537**	**22,061,229**	**31,962,000**

Note 1) Per-capita water demand in the future is supposed to be 220 l/day.
2) Served population by watter supply in 2015 is supposed to be same as the current served population.

B.8.2 Programme of Measures for Irrigation Facility Improvement

(1) Introduction

The agricultural lands cover about a half of the country and the agriculture is one of fundamental sectors in the country. The stability of agricultural production will be the base for sustainable development of rural areas. The irrigation facilities are basic infrastructure for stable agricultural production. The country had developed about 1,240,000 ha during the old order by 1980s, however, currently the potential irrigation area is about 500,000 ha, of which irrigation systems are owned by the government and managed by Irrigation System Co. (IS).

In 1980s the irrigation area covered over 1,000,000 ha and used water resources as much as 3,500 million m^3/ year, but in new order the agricultural sectors has not rebuilt yet. The current used irrigation areas are estimated at the level of 20,000 ha to 30,000 ha and used water 100 to 200 million m^3/ year.

The irrigation systems and facilities are deteriorated and reported having big water losses over 60-70 % because of poor maintenance. The existing irrigation systems were designed only for the original scale of irrigation, but not for small scale or controlled irrigation. The current water loss is by far large than the reported volume. The irrigation area and water are supposed to be increased in future and the existing irrigation systems should be improved in order to provide irrigation water properly to the demands and to reduce the loss in the system.

(2) Direction of Improvement

(a) Structural Measures

Improvement of irrigation facilities aims to provide irrigation area with optimum water volume and to make efficient water use including reduction of water loss.

Basic concepts for improvement are as follows:

- The existing irrigation systems are deteriorated with high water loss over 60-70%, and needed renovation for utilize the systems,
- Although real water consumption is small, water abstraction seems by far bigger due to water loss and poor intake facilities and distribution facilities (gate and canal),
- It will be necessary for the region to renovate the irrigation system considering the efficient water use based on the current and future demands of irrigation water, and
- Irrigation improvement will be one of the key improvements for sustainable water use and also for the sustainable development of agriculture and regional development based on the efficient water abstraction and use.

(b) Non-structural measures

For water quantity management and improvement purposes necessary measures are as follows:

- To review and improve the current water use permissions to conduct optimum water intake and use , and also the water transfer to other river basin,
- To conduct monitoring the volume at water intakes by installing measurement devices by water users for intake sides as well as Basin Directorate at key locations in the rivers,
- To improve the quality of data required for water quantity management, including collaboration with National Institute for Meteorology and Hydrology(NIMH) as well as other relevant institutes, and
- To establish a system for a good coordination among RBDs, MoAF and related municipalities for implementation of the proposed project.

(3) Objectives for Irrigation Water Improvement

The objectives for irrigation water improvement:

- to use water resources efficiently;
- to supply irrigation water due to the demand by improving irrigation facilities and reducing a high level of loss in the irrigation systems

(4) Management Organization

All the state owned facilities (water reservoirs, canals, pumping stations and compensating basins) are managed by Irrigation System Co.(IS), which is 100% owned by the MoAF. The company has 21 regional branches, of which 12 branches are located in EABD/WABD. They are as follows:

- EABD: Sliven,Yambol, Stara Zagora, Haskovo, Plovdiv, Pazardijik, Sofia
- WABD: Pernik, Dupnitsa,Gotse delchev and Sandanski.

The location of each irrigation branch is shown in Figures 6.3.1 and 6.3.2. The irrigation branches and proposed improvement area are 3,164,686 dca in EABD and 507,383 dca in WABD as shown in the following tables.

Irrigation Branches and potential Areas in EABD

	Irrigation Branch	Potential area (dca)	Area fit for irrigation (dca)	Number of irrigation systems
1	Burgas	32,467	28,634	2
2	Haskovo	483,386	291,542	47
3	Pazardzhik	577,990	261,813	6
4	Plovdiv	1,061,163	720,410	15
5	Sliven	331,168	256,983	1
6	Sofia	39,013	39,013	1
7	Stara Zagora	385,156	360,047	6
8	Yambol	254,343	231,972	4
	Sub total	**3,164,686**	**2,190,414**	**82**

Irrigation Branches and potential Areas in WABD

	Irrigation Branch	Potential area (dca)	Area fit for irrigation (dca)	Number of irrigation systems
1	Dupnitsa	135,817	114,870	6
2	Gotse Delcev	82,010	59,508	3
3	Pernik	148,646	132,581	23
4	Sandanski	140,910	127,808	9
	Sub Total	**507,383**	**434,767**	**41**

Some of the former state and cooperative property are managed and maintained by the established 74 Irrigation Associations registered in Bulgaria, 32 associations are located in WABD/EABD

The overall coordination and supervision of the management and maintenance is carries out by the Executive Agency of Irrigation and Drainage of the Ministry of Agriculture and Forestry. This agency carries out all activities related to planning and, management and control of the irrigation and drainage systems throughout Bulgaria.

(5) Improvement of Existing Irrigation Systems in EABD and WABD

The existing systems are required to be improved with their facilities including construction of new intake structures, renovation/rehabilitation of intake structures, distribution structures, etc.. The detailed data of facilities for improvement, the cost estimated are shown in Tables B.8.2 and B.8.3. The total costs estimated for the improvement are shown as follows:

- EABD
  - 8 irrigation branches composed of 82 irrigation systems, total irrigation area: 3,164, 686 dca,
  - Total project cost: EUR 230.7 million
- WABD
  - 4 irrigation branches composed of 41 irrigation systems, total irrigation area: 507,383 dca
  - Total project cost: EUR 44.7 million

It should be noted that the total costs shown here are composed of construction cost, administration cost (5% of construction cost), engineering service cost (10% of construction cost) and physical contingency cost (10% of construction cost).

(6) Priority Irrigation System for Improvement

The irrigation systems are classified into three groups considering the assumed improvement of water use efficiency and also expected development effects and the 1st group is selected as the priority group for early implementation. The priority irrigation systems are listed as follows;

1st Group for Implementation:

EABD: 2 irrigation branches composed of 4 irrigation systems, total irrigation area: 949,480 dca.

EABD	
Irrigation Branch	*Irrigation System*
1. Provdiv	Topolnitsa
	Stryama-Chirpan
2. Pazardzhik	Topolnitsa
	Aleko pazardzhik
	Karabunar

WABD: 4 irrigation branches composed of 9 irrigation systems, total irrigation area: 217,827 dca.

WABD	
Irrigation Branch	*Irrigation System*
1. Pernik	Kjustendil
2. Sandanski	Sandanska Bistritsa
	Mendovo-Karvrakirovo
	Strumeshnitsa
3. Gotse Delcev	Gotse Delcev

Total construction cost of the priority group is as follows:

- EABD: 84 million Euro
- WABD: 20 million Euro

Also the total costs shown here are composed of construction cost, administration cost (5% of construction cost), engineering service cost (10% of construction cost) and physical contingency cost (10% of construction cost).

2nd Group for implementation:

EABD: 5 branches composed of 7 irrigation systems, total irrigation area: 1,060,300 dca

WABD: 1 branch composed of 23 irrigation systems, total irrigation areas area: 82,010 dca.

Total project costs:

EABD: EUR 83.2 million

WABD: EUR 14.5 million

3rd Group for Implementation:

EABD: 8 irrigation branches composed of 70 irrigation systems, total irrigation areas: 1,154,906 dca.

WABD: 1 branch composed of 9 irrigation systems, total irrigation areas area: 289,556 dca.

Total project cost:

EABD: EUR 63.1 million

WABD: EUR 13.7 million

(7) Implementation Plan of the Improvement Measures

For implementing the proposed improvement of irrigation systems the implementation plan are as follows:

- Implementing agency: Leading implementing agency shall be MoAF, and cooperating organizations shall be composed of RBD and the related municipalities, considering effective water use and sustainable regional development.
- Implementation:
    - 1st group shall be improved in structural measures as a pilot project by 2015 and activities for water management and regional development shall be started.
    - 2nd and 3rd groups shall be prepared for the implementation by 2015 and improved in structural measures by 2021 and activities for water management and regional development shall be started.

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Supporting Report B

Tables

Table B.2.1 List of Major Rivers

No	Name	Length (km) (*1)	Total Cacthment Area (km^2) (*1)	Average Discharge (m^3/s) (*2)	Annual Flow Patterns (*2)	
					Maximum	Minimum
1	Ogosta	135	4,282	18	April	August
2	Iskar	338 (*3)	8,634	54	April	August
3	Vit	157 (*4)	3,228	15	May	October
4	Osam	199 (*5)	2,838	15	May	October
5	Yantra	219	7,862	42	April	October
6	Rusensli Lom	165 (*6)	2,985	5	March	September
	Others		13,007			
	DRBD total		42,837			
7	Kamchia	191	5,363	22	April	October
	Other		15,603			
	BSBD total		20,966			
8	Tundzha	310	7,901	38	April	October
9	Maritsa	302	21,292	108	March-May	August
10	Arda	229	5,213	73	January	September
11	Biala	70	636			
	Other		823			
	EABD total		35,230			
12	Struma	266	10,852 (8,541 in Bulgaria)	80	May	August
13	Mesta	122 (*7)	2,785	32	May	August-October
14	Dospat	79	635			
	Other		5			
	WABD total		11,966			

(*1) Source: JICA Study Team
(*2) Source: Knight and Staneva, The Water Resources of Bulgaria. An Overview, GeoJournal, 40-4, pp.347-362, 1996.
(*3) includes Beli Iskar River, (*4) includes Beli Vit River, (*5) includes Cherni Osam River
(*6) includes Beli Lom River, (*7) includes Bela Mesta River

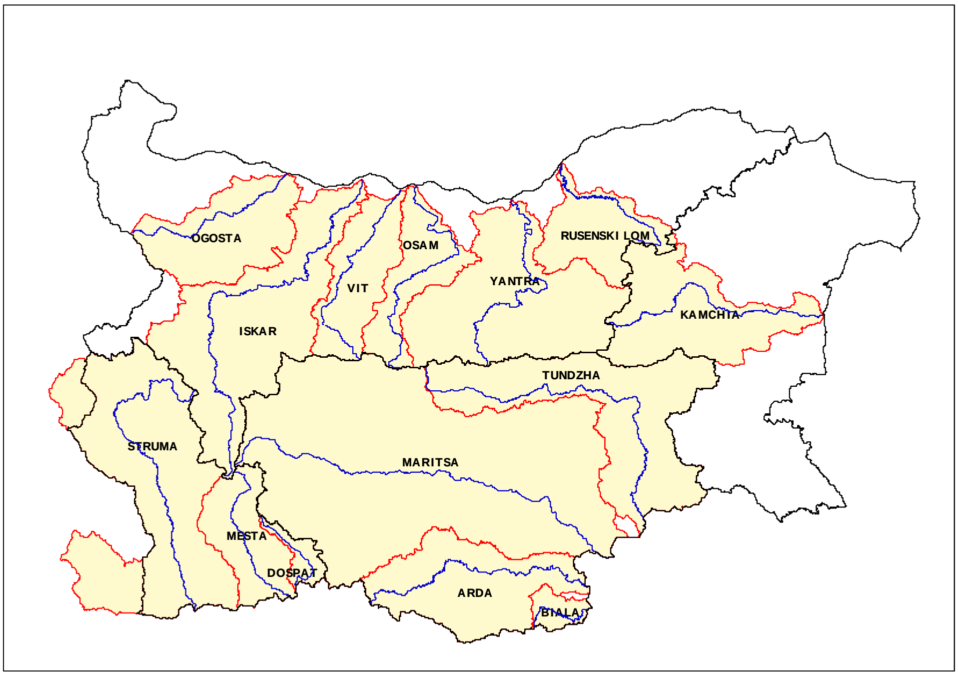


Table B.2.2 Preliminary Water Balance across the Country in 2000-2005 under Assumption that Basin Storage is Negligible

Hydrological year				2000 -2001	2001 -2002	2002 -2003	2003 -2004	2004 -2005	Average in 2000-2005
	Precipitation Amount (*1)	(million m^3)	P	55,703	84,275	68,614	70,054	104,115	76,552
In (%)	Precipitation		P	100.0	100.0	100.0	100.0	100.0	100.0
	External Inflow (*2)	Inflow from Serbia	I_S	0.2	0.2	0.4	0.3	0.4	0.3
		Inflow from Macedonia	I_M						
Out (%)	Total Loss (*3)		L	84.9	84.8	66.6	75.5	66.4	74.8
	Outflow to Danuba & Black Sea (*2)	Outflow to Danuba	O_D	5.9	6.6	13.3	9.3	17.2	11.1
		Outflow to Black Sea	O_B						
	Outflow to Neighbouring Countries (*2)	Outflow to Turkey	O_T	9.3	8.8	20.5	15.6	16.8	14.4
		Outflow to Greece	O_G						
		Outflow to Serbia	O_S						
		Outflow to Romania	O_M						

(*1) It is calculated based on data in the selected 253 precipitation stations.
(*2) It is calculated based on observed discharge data in hydrometric stations. It is assumed that the runoff volume per unit area from ungaged catchment is same as the averaged one in gauged catchment.
(*3) It is assumed that total loss is equal to total inflow minus total outflow. However, this assumption would not be valid for water balance in single hydrological year. Therefore, the total loss could include basin storage.

Table B.2.3 Annual Unit Runoff and Runoff Rate in Watershed of Representative HMS in EABD during 2000-2005

Source: JICA Study Team

Tundzha River

Number	Watershed Area (km²)	Annual Unit Runoff (mm)							Runoff Rate					
		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005	Long-term Average	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005
74500	1128	18	22	50	36	123	50	70	0.04	0.03	0.11	0.06	0.14	0.08
74650	288	146	272	300	251	664	327	392	0.25	0.33	0.47	0.31	0.59	0.41
74750	2250	61	52	146	37	226	105	172	0.11	0.06	0.24	0.05	0.22	0.14
74800	4876	16	16	64	51	144	58	63	0.03	0.02	0.12	0.07	0.15	0.08
74850	5560	22	26	80	60	200	78	109	0.04	0.04	0.15	0.09	0.21	0.11

Maritsa River

Number	Watershed Area (km²)	Annual Unit Runoff (mm)							Runoff Rate					
		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005	Long-term Average	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005
71420	880	75	103	182	148	234	148	164	0.13	0.13	0.24	0.22	0.26	0.20
71480	911	75	170	233	127	433	208	227	0.13	0.22	0.35	0.22	0.42	0.29
71700	745	284	255	439	326	499	361	323	0.48	0.29	0.52	0.47	0.43	0.43
71800	4022	32	58	167	91	278	125	137	0.06	0.08	0.23	0.15	0.29	0.17
72460	817	153	306	452	292	547	350	370	0.24	0.37	0.68	0.41	0.59	0.46
72520	800	103	267	448	214	505	307	250	0.19	0.36	0.70	0.36	0.51	0.44
72700	7933	92	100	238	153	304	177	185	0.16	0.13	0.34	0.24	0.32	0.25
72850	12835	58	81	151	97	199	117	184	0.10	0.11	0.23	0.16	0.22	0.17
73480	2768	66	69	152	127	245	132	157	0.14	0.11	0.31	0.21	0.28	0.22
73550	954	82	166	144	165	219	155	141	0.15	0.22	0.23	0.28	0.26	0.23
73750	19831	48	105	193	139	288	155	156	0.09	0.15	0.31	0.23	0.32	0.23
73850	20818	100	136	230	167	304	188	151	0.19	0.19	0.37	0.27	0.34	0.28

Arda & Biala Rivers

Number	Watershed Area (km²)	Annual Unit Runoff (mm)							Runoff Rate					
		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005	Long-term Average	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005
61700	861	292	336	715	627	913	577	633	0.35	0.34	0.70	0.63	0.92	0.60
61500	1152	270	230	495	281	558	367	507	0.37	0.26	0.50	0.32	0.55	0.41
61550	500	185	281	500	345	538	370	502	0.25	0.23	0.50	0.41	0.46	0.37
62800	507	93	178	451	96	315	227	331	0.18	0.19	0.51	0.17	0.36	0.30

Table B.2.4 Annual Unit Runoff and Runoff Rate in Watershed of Representative HMS in WABD during 2000-2005

Source: JICA Study Team

Struma River

Number	Watershed Area (km²)	Annual Unit Runoff (mm) except Watershed of HMS 51360 & 51560							Runoff Rate					
		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005	Long-term Average	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005
51430	398	19	149	193	174	330	173	253	0.04	0.18	0.30	0.27	0.36	0.25
51700	2172	34	60	145	89	203	106	143	0.07	0.08	0.25	0.15	0.23	0.16
51750	4334	82	135	226	164	285	178	230	0.17	0.19	0.37	0.28	0.35	0.28
51800	6862	76	157	268	203	337	208	247	0.16	0.21	0.42	0.33	0.41	0.32
51880	10300	91	175	351	328	349	259	309	0.19	0.24	0.53	0.51	0.43	0.39

Mesta River

Number	Watershed Area (km²)	Annual Unit Runoff (mm)							Runoff Rate					
		2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005	Long-term Average	2000-2001	2001-2002	2002-2003	2003-2004	2004-2005	Average in 2000-2005
52400	444	241	403	624	547	627	488	461	0.55	0.57	0.87	0.83	0.75	0.72
52700	262	122	202	357	319	527	305	403	0.25	0.26	0.43	0.43	0.56	0.40
52800	1523	150	273	479	383	527	362	394	0.32	0.37	0.63	0.56	0.59	0.51
52850	2278	135	210	440	347	545	336	356	0.28	0.28	0.57	0.49	0.60	0.47

Table B.3.1 Summary of the Existing Water Supply and Sewerage Systems in Bulgaria

No.	Name of Water Supply and Sewerage Company (WSS Co.)	Owner	Related Basin District	Water Supply System																	Sewerage System				
						Supplied Water				Water Purification and Storage				Pipes for Water Supply											
				Number of municip. supplied	Served populat. by WS	From surface water	From groundwater	From dam	Total supplied water	Water Purifica. Plants	Pump Sts.	WS Reservoirs and Tanks		Asbestos cement	Steel	Cast iron	PVC + HDPE	Other	Total length	Informat. Necessary Improve.	Served populat. By SW	WWTPs	Sewer Pump Stations	Sewer networks	Informat. Necessary Improve.
						(1000 m3/year)	(1000 m3/year)	(1000 m3/year)	(1000 m3/year)	(no.)	(no.)	(no.)	(m3)	(m)	(m)	(m)	(m)	(m)	(m)	(m)		(no.)	(no.)	(m)	(m)
1	Burgas	State	BSBD	14	424,080	0	4,453	62,572	67,025	2	243	447		2,471,360	923,855	75,547	32,752	201,486	3,705,000		280,940	5	39	462,420	3,395,215
2	Dobrich	State	BSBD	8	225,987	0	35,712	0	35,712	0	77	265		2,975,000	181,000	4,000	52,000	52,000	3,264,000		102,500	5	7	208,400	3,156,000
3	Shumen	State & Municp.	BSBD	10	214,880	0	7,570	12,030	19,600	0	151	252		1,857,607	442,894	33,496	3,550	0	2,337,547		132,098	0	0	189,000	2,300,501
4	Varna	State & Municp.	BSBD	12	461,126	0	59,935	31,168	91,103	0	136	322		3,207,775	432,270	212,556	14,692	833,707	4,701,000		327,980	13	18	686,217	3,640,045
			Sub-total	**44**	**1,326,073**	**0**	**107,670**	**105,770**	**213,440**	**2**	**607**	**1,286**		**10,511,742**	**1,980,019**	**325,599**	**102,994**	**1,087,193**	**14,007,547**		**843,518**	**23**	**64**	**1,546,037**	**12,491,761**
5	Pleven	State	DRBD	10	314,965	0	25,710	0	25,710	0	344	275		2,461,471	527,336	8,692	47,771	8,730	3,054,000		163,100	1	1	294,959	2,988,807
6	Razgrad	State	DRBD	5	133,122	0	24,400	0	24,400	0	88	134		1,271,700	306,720	6,200	5,480	0	1,590,100		65,442	2	0	104,000	1,578,420
7	Vidin	State	DRBD	11	149,382	796	7,627	0	8,423	0	50	147		1,432,572	100,621	29,636	92,968	0	1,655,797		69,623	0	3	68,424	1,533,193
8	Sofia-district	State	DRBD & EABD	21	218,509	5,200	9,800	5,300	20,300	3	161	311		2,289,400	751,400	16,600	32,400	206,200	3,296,000		148,600	2	0	424,900	3,040,800
9	Gabrovo	State & Municp.	DRBD	3	100,927	2,238	1,947	24,000	28,185	2	45	282		910,230	48,480	27,000	21,430	99,860	1,107,000		91,794	1	0	157,460	958,710
10	Isperih	State & Municp.	DRBD	3	47,727	555	2,215	0	2,770	0	23	33		500,900	171,100	31,800	0	31,200	735,000						672,000
11	Lovech	State & Municp.	DRBD	7	137,323	5,837	17,016	0	22,853	0	100	267		1,334,140	354,822	3,600	18,092	44,346	1,755,000		55,780	0	0	87,285	1,688,962
12	Montana	State & Municp.	DRBD	10	148,096	530	6,305	27,465	34,300	1	55	125		1,252,100	167,980	3,700	59,926	17,294	1,501,000		58,999	1	1	104,792	1,420,080
13	Russe	State & Municp.	DRBD	8	275,538	0	28,000	0	28,000	0	110	187		1,846,008	364,123	122,370	107,281	408,218	2,848,000		147,684	0	1	117,576	2,210,131
14	Silistra	State & Municp.	DRBD	7	142,786	0	11,943	0	11,943	0	137	147		1,707,308	47,280	24,661	72,555	0	1,851,804		56,461	0	1	105,118	1,754,588
15	Targovishte	State & Municp.	DRBD	3	99,205	0	1,832	7,500	9,332	1	120	221		1,313,615	65,576	2,156	2,559	22,094	1,406,000		54,685	0	0	123,923	1,379,191
16	Veliko Tarnovo	State & Municp.	DRBD	9	266,229	574	7,209	29,631	37,415	1	190	277		2,387,936	252,647	30,180	9,893	239,344	2,920,000		142,520	1	0	286,580	2,640,583
17	Vratsa	State & Municp.	DRBD	10	242,975	0	22,276	18,076	40,352	0	195	276		2,311,842	302,967	52,460	25,174	0	2,692,443		110,000	1	1	209,200	2,614,809
18	Berkovitsa	Municipality	DRBD	1	21,466	220	252	0	472	0	1	18		173	20,294	0	147		20,614		16,529	0	0	61,500	20,467
19	Botevgrad	Municipality	DRBD	1	41,203	1,356	293	1,120	2,769	1	2	25		282,943	32,191	0	2,300		317,434		29,516	1	0	59,247	315,134
20	Knezha	Municipality	DRBD	1	17,501	0	3,073	0	3,073	0	9	2		188,910	1,700	0	1,690		192,300		4,720	0	0	12,140	190,610
21	Kubrat	Municipality	DRBD	1	28,357	0	0	0	0	0	15	30		227,275	99,883	0	3,161		330,319		0	0	0	0	327,158
22	Sevlievo	Municipality	DRBD		*40,989*				0					551,755	38,388	0	6,811		596,954						590,143
23	Sofia City	Municipality	DRBD	1	1,177,577	26,300	284	264,000	290,584	2	11	48		878,000	1,105,000	812,000	455,000		3,250,000		1,094,410	1	0	1,550,000	
24	Svishtov	Municipality	DRBD	1	50,000	0	6,000	0	6,000	0	39	30		360,000	80,000	0	20,000		460,000		35,000	0	0	80,000	440,000
25	Troyan	Municipality	DRBD						0																
			Sub-total	**113**	**3,653,877**	**43,606**	**176,181**	**377,092**	**596,879**	**11**	**1,695**	**2,835**		**23,508,278**	**4,838,508**	**1,171,055**	**984,638**	**1,077,286**	**31,579,765**		**2,344,863**	**11**	**8**	**3,847,104**	**26,363,786**
26	Haskovo (*)	State	EABD	***9***	***194,895***		***16,874***		***16,874***	***1***	***86***	218	***96,461***	***1,861,319***	***229,800***	***3,027***	***7,176***	***20,606***	***2,121,928***	***27,420***	***142,706***	***0***	***1***	***211,000***	***1,380***
27	Pazardzhik	State	EABD	3	165,426	0	19,950	0	19,950	0	84	72		749,680	162,511	116	31,980	0	944,287		96,067	0	3	119,642	912,191
28	Plovdov	State	EABD	16	720,416	3,685	90,980	0	94,665	5	132	236		3,187,898	332,965	75,404	27,921	1,581,812	5,206,000		497,552	2	0	755,152	3,520,863
29	Smolyan	State	EABD	11	141,013	1,185	8,211	0	9,396	8	35	229		1,015,171	215,940	2,619	36,424	120,846	1,391,000		88,794	1	0	259,858	1,231,111
30	Stara Zagora	State	EABD	18	388,182	0	55,306	0	55,306	0	331	224		2,418,375	444,124	65,344	75,736	310,421	3,314,000		245,160	3	1	352,016	2,862,499
31	Yambol (*)	State	EABD	***5***	***145,948***	***0***	***23,527***	***0***	***23,527***	***0***	***199***	120	***52,689***	***1,420,653***	***311,865***	***0***	***34,488***	***26,369***	***1,793,375***		***69,027***	***0***	***4***	***132,328***	
32	Dimitrovgrad	State & Municp.	EABD	1	64,981	0	2,517	0	2,517	1	20	25		465,000	36,000	20,300	16,698	0	537,998		43,000	0	0	75,750	501,000
33	Kardzhali (*)	State & Municp.	EABD	***7***	***140,175***	***69***	***3,986***	***5,328***	***9,383***	***1***	***70***	103	***39,760***	***1,059,464***	***74,958***	***0***	***121,432***	***65,955***	***1,321,809***	***692,000***	***65,405***	***0***	***0***	***141,947***	***145,015***
34	Sliven	State & Municp.	EABD	4	234,000	158	18,767	7	18,932	0	74	152		1,301,000	537,000	10,000	17,000	14,000	1,879,000		125,000	2	0	161,151	1,838,000
35	Batak	Municipality	EABD	1	7,000	0	219	350	569	0	0	6		66,000	15,000	0	1,500		82,500		7,000	0	0	10,100	81,000
36	Belovo	Municipality	EABD	1	12,000	560	680	0	1,240	1	3	5		45,000	3,000	0	1,200		49,200		3,000	0	0	6,500	48,000
37	Bratsigovo	Municipality	EABD																						
38	Panagyurishte	Municipality	EABD	1	31,000	664	1,600	0	2,264	3	9	15		76,000	60,000	0	2,000		138,000		21,000	0	0	38,000	136,000
39	Peshtera	Municipality	EABD	1	25,000	718	525	0	1,243	1	4	9		95,000	25,000	4,000	3,000		127,000		22,000	0	0	50,000	120,000
40	Rakitovo	Municipality	EABD	1	16,200	110	650	0	760	0	0	5		32,000	1,200	0	2,100		35,300		14,000	0	0	27,200	33,200
41	Strelcha	Municipality	EABD	1	6,000	500	60	0	560	1	4	7		46,020	23,610	0	10,070		79,700		3,000	0	0	7,038	69,630
42	Velingrad	Municipality	EABD	1	41,450	3,261	2,733	0	5,994	1	9	31		250,236	2,070	41,031	4,800		298,137		36,000	0	0	96,470	252,306
			Sub-total	**81**	**2,333,686**	**10,910**	**246,585**	**5,685**	**263,179**	**23**	**1,060**	**1,457**	**188,910**	**14,088,816**	**2,475,043**	**221,841**	**393,525**	**2,140,009**	**19,319,234**		**1,478,711**	**8**	**9**	**2,444,152**	**11,752,195**
43	Blagoevgrad	State	WABD	10	219,629	12,145	8,681	348	21,174	2	15	115		947,639	416,836	9,226	35,055	19,244	1,428,000		167,180	0	0	374,001	1,364,475
44	Kyustendil (*)	State & Municp.	WABD	***8***	***103,211***	***1,620***	***1,100***	***553***	***3,273***		***78***	124	***50,815***	***1,159,066***	***276,962***	***27,348***	***31,753***	***184,740***	***1,679,869***	***1,479,600***	***54,052***	***1***	***0***	***153,730***	***58,000***
45	Pernik	State & Municp.	WABD	6	105,867	315	6,771	21,632	28,718	3	37	186		1,005,034	217,607	38,258	1,075	97,026	1,359,000		115,944	1	0	418,045	1,222,641
46	Breznik	Municipality	WABD						0																
47	Dupnitsa	Municipality	WABD	1	51,715	5,960	515	1,986	8,461	0	8	20		113,718	89,644	16,273	9,949		229,584		38,700	1	0	54,075	203,362
48	Kovachevtsi	Municipality	WABD																						
49	Kresna	Municipality	WABD																						
50	Petrich	Municipality	WABD	1	65,000	941	436	0	1,377	0	6	31		310,290	9,970	700	3,300		324,260		30,000	0	0	90,000	320,260
51	Sandanski	Municipality	WABD	1	43,943	1,980	3,161	0	5,141	0	1	33		301,594	37,373	0	3,214		342,181		34,195	0	0	60,445	338,967
			Sub-total	**27**	**589,365**	**22,961**	**20,664**	**24,519**	**68,144**	**5**	**145**	**509**	**50,815**	**3,837,341**	**1,048,392**	**91,805**	**84,346**	**301,010**	**5,362,894**		**440,071**	**3**	**0**	**1,150,296**	**3,507,705**
			Total	**265**	**7,903,001**	**77,477**	**551,100**	**513,066**	**1,141,643**	**41**	**3,507**	**6,087**	**239,725**	**51,946,177**	**10,341,962**	**1,810,300**	**1,565,503**	**4,605,498**	**70,269,440**	**2,199,020**	**5,107,163**	**45**	**81**	**8,987,589**	**54,115,447**

Data Source: 1) "Management and Development Strategy for Water Supply and Sewerage Sector in the Republic of Bulgaria", MoRDPW, 2004
2) WSS Companies with (*) mark and gray color are based on the answer to the questionnaires to the WSS Companies in EABD and WABD areas by the end of August 2007, which have been received by this Study.

Table B.3.2 WS&S Company and Municipality under Service in EABD and WABD

Source: WS&S Company

WS&S Company	Surface Water Dependency (%)	Municipality
Batak WS&S Co	61.5	Batak
Belovo WS&S Co	45.2	Belovo
Blagoevgrad WS&S Co	59.0	Bansko
		Belitsa
		Blagoevgrad
		Garmen
		Gotse Delchev
		Hadzhidimovo
		Razlog
		Satovcha
		Simitli
		Yakoruda
Bratsigovo WS&S Co	0.0	Bratsigovo
Burgas District WS&S Co	93.4	Aytos
		Karnobat
		Sungurlare
Dimitrovgrad WS&S Co	0.0	Dimitrovgrad
		Dolna banya
Dupnitsa WS&S Co	93.7	Dupnitsa
Gabrovo WS &S Co	93.1	Tryavna
Haskovo WS&S Co	0.0	Harmanli
		Haskovo
		Ivaylovgrad
		Lyubimets
		Madzharovo
		Mineralni bani
		Simeonovgrad
		Svilengrad
Kardzhali WS&S Co	57.5	Ardino
		Chernoochene
		Dzhebel
		Kardzhali
		Kirkovo
		Krumovgrad
		Momchilgrad
Kovachevtsi WS&S Co	76.4	Kovachevtsi
Kresna WS&S Co	59.0	Kresna
Kyustendil WS&S Co	66.4	Boboshevo
		Bobov dol
		Kocherinovo
		Kyustendil
		Nevestino
		Rila
		Sapareva banya
		Treklyano
Panagyurishte WS&S Co	29.3	Panagyurishte
Pazardzhik WS&S Co	0.0	Lesichovo
		Pazardzhik
		Septemvri
Pernik WS&S Co	76.4	Breznik
		Pernik
		Tran
		Zemen
Peshtera WS&S Co	57.8	Peshtera
Petrich WS&S Co	68.3	Petrich
		Radomir
Plovdiv WS&S Co	3.9	Brezovo
		Hisarya
		Kaloyanovo
		Karlovo
		Krichim
		Kuklen
		Laki
		Maritsa
		Parvomay
		Perushtitsa
		Plovdiv
		Rakovski
		Rodopi
		Sadovo
		Saedinenie
		Sopot
		Stamboliyski
		Asenovgrad

WS&S Company	Surface Water Dependency (%)	Municipality
Rakitovo WS&S Co	14.5	Rakitovo
Sandanski WS&S Co	38.5	Sandanski
Sliven WS&S Co	0.9	Kotel
		Nova Zagora
		Sliven
		Tvarditsa
Smolyan WS&S Co	12.6	Banite
		Borino
		Chepelare
		Devin
		Madan
		Nedelino
		Rudozem
		Smolyan
		Zlatograd
		Dospat
Sofia District WS&S Co	51.7	Anton
		Chavdar
		Chelopech
		Ihtiman
		Koprivshtitsa
		Kostenets
		Mirkovo
		Pirdop
		Samokov
		Zlatitsa
Sofia Water WS&S Co	99.1	Stolichna
Stambolovo WS&S Co	0.0	Stambolovo
Stara Zagora WS&S Co	0.0	Bratya Daskalovi
		Chirpan
		Galabovo
		Gurkovo
		Kazanlak
		Maglizh
		Nikolaevo
		Opan
		Pavel banya
		Radnevo
		Stara Zagora
		Topolovgrad
Strelcha WS&S Co	89.3	Strelcha
Strumyani WS&S Co	59.0	Strumyani
Velingrad WS&S Co	54.4	Velingrad
Yambol WS&S Co	0.0	Bolyarovo
		Elhovo
		Straldzha
		Tundzha
		Yambol

Table B.3.3 Yearly Change of Irrigated Crops

Source: Irrigation Systems Ltd.

YEAR	Irrigated Area (km^2)	Used Water (million m^3)	Maize (%)	Tobacco (%)	Vegetables (%)	Perennial plants (%)	Rice (%)	Others (%)
1996	1,034	236	43.9	9.3	9.8	6.1	3.1	27.9
1997	428	202	34.3	16.7	19.0	3.9	10.9	15.1
1998	389	174	29.5	17.7	27.8	3.8	9.3	11.9
1999	245	87	29.8	23.7	19.0	4.5	7.2	15.8
2000	476	208	37.6	13.9	11.5	10.1	6.1	20.9
2001	384	166	37.1	17.6	15.2	6.0	10.1	14.0
2002	308	144	30.9	18.8	22.2	4.1	12.5	11.7
2003	347	164	33.6	19.0	20.0	5.0	13.3	9.1
2004	320	154	31.2	18.7	12.9	3.7	15.3	18.1
2005	192	133	19.5	18.9	22.9	4.4	26.6	7.8

Table B.3.4 Potential Irrigation Area

Source: Irrigation Systems Ltd.

	Irrigation Branch	Total Potential Irrigation Area (ha)	Total Suitable Area (ha)	Total Potential Irrigation Area in EABD(ha)	Total Potential Irrigation Area in WABD(ha)
1	Burgas	19,922	17,841	3,247	0
2	Varna	17,246	14,313	0	0
3	Veliko Tarnovo	42,683	19,707	0	0
4	Vidin	20,737	12,458	0	0
5	Vratsa	47,224	37,427	0	0
6	Gotse Delchev	8,201	5,951	0	8,201
7	Dupnitsa	13,582	11,487	0	13,582
8	Montana	22,750	19,724	0	0
9	Pazardzhik	57,799	26,181	57,799	0
10	Pernik	16,045	13,380	0	15,052
11	Pleven	53,127	34,840	0	0
12	Plovdiv	106,159	72,083	106,159	0
13	Ruse	57,573	47,057	0	0
14	Sandanski	15,790	13,611	0	15,790
15	Sliven	34,232	25,698	34,232	0
16	Sofia	29,555	22,245	3,901	0
17	Stara Zagora	38,516	36,005	38,516	0
18	Targovishte	26,123	20,967	0	0
19	Haskovo	50,491	30,502	50,491	0
20	Shumen	37,398	32,885	0	0
21	Yambol	25,434	23,197	25,434	0
	Total	**740,584**	**537,558**	**319,778**	**52,625**

Table B.3.5 Average Water Use and Abstraction by Irrigation System in 2001-2005

Source: Irrigation Systems Ltd.

#	Irrigation Systems PLC, Branch name	Toital Potential Irrigation Area (ha)	Areas watered as 1st step in irrigation period (ha)	Quantity of water used (10^3 м^3/ year)	Irrigation Water Delivered (Estimated Abstracted Water) (10^3 м^3/ year)	Percentage of Irrigated area agasint Total Potential Area (%)	Loss Rate (%)	Unit Water Used (m^3/ha/year)
		A	B	C	D	B/A x 100	(D-C)/D x 100	1000 x C/B
1	Burgas	19,922	210	278	850	1.05	67.3	1,325
2	Varna	17,246	649	943	5,404	3.77	82.6	1,452
3	Veliko Tarnovo	42,683	365	518	2,304	0.86	77.5	1,419
4	Vidin	20,737	497	562	1,722	2.40	67.3	1,132
5	Vratsa	47,224	691	1,050	2,014	1.46	47.8	1,520
6	Gotse Delchev	8,201	1,122	1,930	5,396	13.68	64.2	1,721
7	Dupnitsa	13,582	371	603	2,025	2.73	70.2	1,625
8	Montana	22,750	346	413	657	1.52	37.1	1,192
9	Pazardzhik	57,799	4,527	49,401	140,353	7.83	64.8	10,912
10	Pernik	16,045	219	323	1,238	1.37	73.9	1,471
11	Pleven	53,127	1,500	1,994	6,562	2.82	69.6	1,329
12	Plovdiv	106,159	9,177	61,295	152,219	8.64	59.7	6,679
13	Ruse	57,573	407	460	1,009	0.71	54.4	1,130
14	Sandanski	15,790	457	1,228	2,357	2.89	47.9	2,690
15	Sliven	34,232	2,287	4,218	12,289	6.68	65.7	1,845
16	Sofia	29,555	434	516	1,530	1.47	66.3	1,188
17	Stara Zagora	38,516	2,401	15,878	41,457	6.23	61.7	6,613
18	Targovishte	26,123	1,500	2,062	7,408	5.74	72.2	1,374
19	Haskovo	50,491	1,650	3,123	11,699	3.27	73.3	1,893
20	Shumen	37,398	900	1,282	5,524	2.41	76.8	1,424
21	Yambol	25,434	1,218	1,553	9,522	4.79	83.7	1,275
	Total	**740,584**	**30,928**	**149,629**	**413,539**	**4.18**	**63.8**	**4,838**

Table B.4.1 Average Annual Water Balance at Downstream End (Country Border) of River Basin in 2001- 2005

Source: JICA Study Team

	Struma	Mesta	Dospat	Arda	Biala	Tundzha	Maritsa
Quasi-Natural Flow (NF) (m^3/s)	**71.32**	**30.79**	**6.46**	**61.72**	**4.46**	**39.57**	**116.44**
Potential Flow (PF) (m^3/s)	**69.89**	**27.47**	**2.35**	**53.95**	**4.46**	**29.60**	**126.10**
Disturbed Flow (DF) (m^3/s)	**71.35**	**27.69**	**2.41**	**53.95**	**4.47**	**21.99**	**108.12**
(PF-NF)/NF (%)	*-2.01*	*-10.77*	*-63.65*	*-12.60*	*0.00*	*-25.19*	*8.29*
(DF-NF)/NF (%)	*0.04*	*-10.04*	*-62.68*	*-12.60*	*0.19*	*-44.44*	*-7.14*
(DF-PF)/PF (%)	*2.09*	*0.82*	*2.68*	*-0.00*	*0.19*	*-25.73*	*-14.26*
Accumulated Abstracted Water for Irrigation (IRR) (m^3/s)	**0.152**	**0.169**	**0.000**	**0.020**	**0.000**	**8.563**	**20.698**
Accumulated Abstracted Water for Drinking Water (DWS) (m^3/s)	**1.698**	**0.094**	**0.000**	**0.468**	**0.000**	**0.471**	**0.699**
Accumulated Abstracted Water for Industrial Water (IWS) (m^3/s)	**1.871**	**0.262**	**0.000**	**0.594**	**0.000**	**0.055**	**3.218**
Accumulated Total Water Abstraction (TotalAbst) (m^3/s)	**3.721**	**0.524**	**0.000**	**1.083**	**0.000**	**9.089**	**24.614**
IRR/PF (%)	*0.22*	*0.62*	*0.00*	*0.04*	*0.00*	*28.93*	*16.41*
DWS/PF (%)	*2.43*	*0.34*	*0.00*	*0.87*	*0.00*	*1.59*	*0.55*
IWS/PF (%)	*2.68*	*0.95*	*0.00*	*1.10*	*0.00*	*0.19*	*2.55*
TotalAbst/PF (%)	*5.32*	*1.91*	*0.00*	*2.01*	*0.00*	*30.70*	*19.52*
Accumulated Domestic WasteWater Discharge (DWW) (m3/s)	**1.744**	**0.367**	**0.056**	**0.816**	**0.008**	**1.339**	**5.863**
Accumulated Industrial WasteWater Discharge (IWW) (m^3/s)	**3.440**	**0.384**	**0.007**	**0.265**	**0.000**	**0.134**	**0.774**
Accumulated Total WasteWater Discharge (TotalWW) (m^3/s)	**5.184**	**0.751**	**0.063**	**1.081**	**0.008**	**1.473**	**6.638**
DWW/DF (%)	*2.44*	*1.33*	*2.31*	*1.51*	*0.19*	*6.09*	*5.42*
IWW/DF (%)	*4.82*	*1.39*	*0.30*	*0.49*	*0.00*	*0.61*	*0.72*
TotalWW/DF (%)	*7.27*	*2.71*	*2.61*	*2.00*	*0.19*	*6.70*	*6.14*

In the table, the definitions of the terms used are as follows.

- Quasi-Natural Flow (NF)
  - Flow without human disturbances such as abstraction, discharge, transfer
  - Likely natural, however, not exactly natural.
  - In the model, regime change of local reservoir is not taken into account.
- Potential Flow with Significant Reservoir (PF)
  - Flow with influence of significant reservoir, but no abstraction from reservoir
  - Potentially usable water amount after regime change by significant reservoir
- Disturbed Flow (DF)
  - Existing condition
  - It can be expressed as follows.
    - (Potential Flow) – (Total abstracted water) + (Total discharged water)

Table B.4.2 Average Water Balance at Downstream End (Country Border) of River Basin for Summer Time (July- September) in 2001- 2005

Source: JICA Study Team

	Struma	Mesta	Dospat	Arda	Biala	Tundzha	Maritsa
Quasi-Natural Flow (NF) (m^3/s)	**29.05**	**13.40**	**3.42**	**17.31**	**0.46**	**27.51**	**83.16**
Potential Flow (PF) (m^3/s)	**29.06**	**11.82**	**1.47**	**26.48**	**0.46**	**26.56**	**117.57**
Disturbed Flow (DF) (m^3/s)	**30.05**	**11.72**	**1.53**	**26.31**	**0.47**	**12.03**	**76.29**
(PF-NF)/NF (%)	*0.02*	*-11.78*	*-57.14*	*52.95*	*0.00*	*-3.48*	*41.37*
(DF-NF)/NF (%)	*3.43*	*-12.59*	*-55.31*	*51.93*	*1.80*	*-56.28*	*-8.26*
(DF-PF)/PF (%)	*3.41*	*-0.91*	*4.29*	*-0.67*	*1.80*	*-54.70*	*-35.11*
Accumulated Abstracted Water for Irrigation (IRR) (m^3/s)	**0.412**	**0.504**	**0.000**	**0.063**	**0.000**	**15.392**	**43.925**
Accumulated Abstracted Water for Drinking Water (DWS) (m^3/s)	**1.762**	**0.094**	**0.000**	**0.582**	**0.000**	**0.553**	**0.692**
Accumulated Abstracted Water for Industrial Water (IWS) (m^3/s)	**2.018**	**0.262**	**0.000**	**0.612**	**0.000**	**0.055**	**3.297**
Accumulated Total Water Abstraction (TotalAbst) (m^3/s)	**4.192**	**0.859**	**0.000**	**1.257**	**0.000**	**16.000**	**47.914**
IRR/PF (%)	*1.42*	*4.26*	*0.00*	*0.24*	*0.00*	*57.96*	*37.36*
DWS/PF (%)	*6.06*	*0.79*	*0.00*	*2.20*	*0.00*	*2.08*	*0.59*
IWS/PF (%)	*6.94*	*2.21*	*0.00*	*2.31*	*0.00*	*0.21*	*2.80*
TotalAbst/PF (%)	*14.43*	*7.26*	*0.00*	*4.75*	*0.00*	*60.25*	*40.75*
Accumulated Domestic WasteWater Discharge (DWW) (m3/s)	**1.744**	**0.367**	**0.056**	**0.816**	**0.008**	**1.339**	**5.863**
Accumulated Industrial WasteWater Discharge (IWW) (m^3/s)	**3.440**	**0.384**	**0.007**	**0.265**	**0.000**	**0.134**	**0.774**
Accumulated Total WasteWater Discharge (TotalWW) (m^3/s)	**5.184**	**0.751**	**0.063**	**1.081**	**0.008**	**1.473**	**6.638**
DWW/DF (%)	*5.80*	*3.13*	*3.64*	*3.10*	*1.77*	*11.14*	*7.69*
IWW/DF (%)	*11.45*	*3.27*	*0.47*	*1.01*	*0.00*	*1.11*	*1.01*
TotalWW/DF (%)	*17.25*	*6.41*	*4.11*	*4.11*	*1.77*	*12.25*	*8.70*

In the table, the definitions of the terms used are as follows.

- Quasi-Natural Flow (NF)
  - Flow without human disturbances such as abstraction, discharge, transfer
  - Likely natural, however, not exactly natural.
  - In the model, regime change of local reservoir is not taken into account.
- Potential Flow with Significant Reservoir (PF)
  - Flow with influence of significant reservoir, but no abstraction from reservoir
  - Potentially usable water amount after regime change by significant reservoir
- Disturbed Flow (DF)
  - Existing condition
  - It can be expressed as follows.
    - (Potential Flow) – (Total abstracted water) + (Total discharged water)

Table B.5.1 Results of the Interview Survey on the Water Problems to Some Municipalities in EABD and WABD

No.	Problems and On-going / Near Future Projects	Municipality																										
		Pernik	Dupnitsa	Kyustendil	Blagoevgrad	Sandanski	Razlog	Bansko	Gotse Delchev	Dospat	Asenovgrad	Velingrad	Pazardzhik	Panagyurishte	Plovdiv	Hisarya	Karlovo	Stara Zagora	Galabovo	Dimitrovgrad	Haskovo	Svilengrad	Kazanlak	Sliven	Yambol	Elhovo	Smolyan	Ivaylovgrad
	Basin District	W	W	W	W	W	W	W	W	W	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E	E
A.	**Water Supply Systems (WS)**																											
A-1	**Problems**																											
1)	Insufficient water quantity of water sources	x		x	x			x		x	x																	
2)	Water sources (shallow wells) are affected by surface water pollution														x													
3)	Manganese problem of water sources					x									x					x	P			x	x			
4)	Insufficient quality of tap water									P				x					x						x			
5)	Water regime due to insufficient water sources or quantity	x			x					x	P								x									
6)	Water regime due to high loss and frequent accidents of water pipes													x				x	x									
7)	Old or deteriorated pipes with asbestos cement and steel pipes with high loss and frequent accidents	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
8)	Lack or insufficient purification plant		x		x	x					x													x	x			
9)	Old or insufficient capacity of water purification plant	x		x																	x							
A-2	**On-going Projects**																											
1)	Replacement of water supply pipes			P		P	P	P										x						P			P	
2)	Construction of new WS system					P																						
3)	Construction of purification plant					x																		x				
B.	**Sewerage Systems (SW)**																											
B-1	**Problems**																											
1)	Insufficient coverage of SW	x		x								x	x	x		x	x				x	x					x	
2)	Insufficient capacity of sewer pipes																	x	x									
3)	Old or deteriorated sewer pipes	x					x			x				x									x		x		x	
4)	No municipal WWTP				x	x	x	x	x	x	x	x	x	x			x	x	x	x		x			x	x	x	x
5)	Insufficient capacity or deterioration of the existing WWTP			x												x								x				
6)	Inflow of industrial wastewater which cannot be treated by the WWTP		x												x								x					
7)	Insufficient or no industrial WWTP	x	x		x				x		x			x	x									x		x		x
8)	No treatment plants for animal breeding farms		x						x	x					x								x			x		
B-2	**On-going Projects**																											
1)	Construction or renovation of municipal WWTP			x	x		x						x					x		x	x			x			x	
2)	Replacement of sewer pipes			x	P	P												x		P				x			P	
3)	Construction of new sewer system		P	P		P				P				P			P		P					x				
C.	**Floods**																											
C-1	**Problems and Flood Damage**																											
1)	Floods in recent years	x																								x		
2)	Flood in 2005										x		x	x	x		x			x		x				x		
3)	Flood in 2006									x				x					x	x				x	x	x	x	x
4)	Floods by heavy rainfall										x			x					x	x								
5)	Floods by insufficient river capacity																			x		x						
6)	Floods by dam's problem												x	x					x									
7)	Flood by insufficient drainage						x													x				x				
8)	Damage to houses/buildings	x					x			x				x	x		x		x	x		x				x		
9)	Damage to town/village areas																								x	x		
10)	Damage to agricultural land/crops									x			x	x	x		x			x						x		
11)	Damage to roads / railroad incl. bridge	x								x	x		x	x	x		x		x			x			x		x	
12)	Damage to water supply system												x															x
13)	Damage to sewerage system													x	x		x					x						
14)	Damages to banks or protection dikes		x							x	x		x		x				x						x			
C-2	**Flood Warning and Evacuation**																											
1)	Warning to people was done.									x					x					x								
2)	Information by mass media only													x														
3)	Evacuation of people was done.													x	x				x	x						x		
C-2	**Response and Recovery**																											
1)	Strengthen/repair or temporally dikes														x		x			x		x						
2)	Removal of obstacles to flow													x	x		x		x									
3)	Draining of water																								x			
4)	Repair of road or bridge										x		x	x					x									
5)	Repair of water supply system												x															
6)	Repair of sewerage system																											
7)	Disinfection of flooded area																x											
8)	Discharge release from reservoirs																x											
C-3	**Mitigation Measures**																											
1)	River improvement including bank protection and dike									x					x													
2)	Drainage improvement																											

Notes:
1) Basin District: E - EABD, W - WABD
2) P: partial problem or partial areas have problems or some parts have been improved or repaired.

Table B.8.1 Water Supply Networks to be Improved in Bulgaria

No.	WSS Co.	Owner	Related Basin District	Number of municip. supplied	Served populat. by WS	Existing Pipes for Water Supply							Estimated Necessary Improvement of WS Pipes						
						Asbestos cement (AS) (m)	Steel (ST) (m)	Cast iron (m)	PVC + HDPE (m)	Other (m)	Total length (m)	Informat. Necessary Improve. (m)	Replacement Length of Pipe (AS+ST) (m)	Unit Cost (EUR / m)	Direct Cost (A) (EUR)	Engineering Cost (5% of A) (EUR)	Administration Cost (5 % of A) (EUR)	Physical Contingency (10% of A) (EUR)	Total Cost (EUR)
1	Burgas	State	BSBD	14	424,080	2,471,360	923,855	75,547	32,752	201,486	3,705,000		3,395,215	160	543,234,400	27,161,720	27,161,720	54,323,440	651,881,280
2	Dobrich	State	BSBD	8	225,987	2,975,000	181,000	4,000	52,000	52,000	3,264,000		3,156,000	160	504,960,000	25,248,000	25,248,000	50,496,000	605,952,000
3	Shumen	State & Municp.	BSBD	10	214,880	1,857,607	442,894	33,496	3,550	0	2,337,547		2,300,501	160	368,080,160	18,404,008	18,404,008	36,808,016	441,696,192
4	Varna	State & Municp.	BSBD	12	461,126	3,207,775	432,270	212,556	14,692	833,707	4,701,000		3,640,045	160	582,407,200	29,120,360	29,120,360	58,240,720	698,888,640
			Sub-total	**44**	**1,326,073**	**10,511,742**	**1,980,019**	**325,599**	**102,994**	**1,087,193**	**14,007,547**		**12,491,761**	**160**	**1,998,681,760**	**99,934,088**	**99,934,088**	**199,868,176**	**2,398,418,112**
5	Pleven	State	DRBD	10	314,965	2,461,471	527,336	8,692	47,771	8,730	3,054,000		2,988,807	160	478,209,120	23,910,456	23,910,456	47,820,912	573,850,944
6	Razgrad	State	DRBD	5	133,122	1,271,700	306,720	6,200	5,480	0	1,590,100		1,578,420	160	252,547,200	12,627,360	12,627,360	25,254,720	303,056,640
7	Vidin	State	DRBD	11	149,382	1,432,572	100,621	29,636	92,968	0	1,655,797		1,533,193	160	245,310,880	12,265,544	12,265,544	24,531,088	294,373,056
8	Sofia-district	State	DRBD & EABD	21	218,509	2,289,400	751,400	16,600	32,400	206,200	3,296,000		3,040,800	160	486,528,000	24,326,400	24,326,400	48,652,800	583,833,600
9	Gabrovo	State & Municp.	DRBD	3	100,927	910,230	48,480	27,000	21,430	99,860	1,107,000		958,710	160	153,393,600	7,669,680	7,669,680	15,339,360	184,072,320
10	Isperih	State & Municp.	DRBD	3	47,727	500,900	171,100	31,800	0	31,200	735,000		672,000	136	91,716,307	4,585,815	4,585,815	9,171,631	110,059,569
11	Lovech	State & Municp.	DRBD	7	137,323	1,334,140	354,822	3,600	18,092	44,346	1,755,000		1,688,962	160	270,233,920	13,511,696	13,511,696	27,023,392	324,280,704
12	Montana	State & Municp.	DRBD	10	148,096	1,252,100	167,980	3,700	59,926	17,294	1,501,000		1,420,080	160	227,212,800	11,360,640	11,360,640	22,721,280	272,655,360
13	Russe	State & Municp.	DRBD	8	275,538	1,846,008	364,123	122,370	107,281	408,218	2,848,000		2,210,131	160	353,620,960	17,681,048	17,681,048	35,362,096	424,345,152
14	Silistra	State & Municp.	DRBD	7	142,786	1,707,308	47,280	24,661	72,555	0	1,851,804		1,754,588	160	280,734,080	14,036,704	14,036,704	28,073,408	336,880,896
15	Targovishte	State & Municp.	DRBD	3	99,205	1,313,615	65,576	2,156	2,559	22,094	1,406,000		1,379,191	160	220,670,560	11,033,528	11,033,528	22,067,056	264,804,672
16	Veliko Tarnovo	State & Municp.	DRBD	9	266,229	2,387,936	252,647	30,180	9,893	239,344	2,920,000		2,640,583	160	422,493,280	21,124,664	21,124,664	42,249,328	506,991,936
17	Vratsa	State & Municp.	DRBD	10	242,975	2,311,842	302,967	52,460	25,174	0	2,692,443		2,614,809	160	418,369,440	20,918,472	20,918,472	41,836,944	502,043,328
18	Berkovitsa	Municipality	DRBD	1	21,466	173	20,294	0	147		20,614		20,467	115	2,363,426	118,171	118,171	236,343	2,836,111
19	Botevgrad	Municipality	DRBD	1	41,203	282,943	32,191	0	2,300		317,434		315,134	131	41,365,560	2,068,278	2,068,278	4,136,556	49,638,672
20	Knezha	Municipality	DRBD	1	17,501	188,910	1,700	0	1,690		192,300		190,610	112	21,405,846	1,070,292	1,070,292	2,140,585	25,687,015
21	Kubrat	Municipality	DRBD	1	28,357	227,275	99,883	0	3,161		330,319		327,158	121	39,581,734	1,979,087	1,979,087	3,958,173	47,498,081
22	Sevlievo	Municipality	DRBD		*40,989*	551,755	38,388	0	6,811		596,954		590,143	131	77,363,144	3,868,157	3,868,157	7,736,314	92,835,773
23	Sofia City	Municipality	DRBD	1	1,177,577	878,000	1,105,000	812,000	455,000		3,250,000		1,983,000	160	317,280,000	15,864,000	15,864,000	31,728,000	380,736,000
24	Svishtov	Municipality	DRBD	1	50,000	360,000	80,000	0	20,000		460,000		440,000	138	60,852,440	3,042,622	3,042,622	6,085,244	73,022,928
25	Troyan	Municipality	DRBD																
			Sub-total	**113**	**3,653,877**	**23,508,278**	**4,838,508**	**1,171,055**	**984,638**	**1,077,286**	**31,579,765**		**28,346,786**	**157**	**4,461,252,298**	**223,062,615**	**223,062,615**	**446,125,230**	**5,353,502,757**
26	Haskovo (*)	State	EABD	***9***	***194,895***	***1,861,319***	***229,800***	***3,027***	***7,176***	***20,606***	***2,121,928***	***27,420***	2,091,119	160	334,579,040	16,728,952	16,728,952	33,457,904	401,494,848
27	Pazardzhik	State	EABD	3	165,426	749,680	162,511	116	31,980	0	944,287		912,191	160	145,950,560	7,297,528	7,297,528	14,595,056	175,140,672
28	Plovdov	State	EABD	16	720,416	3,187,898	332,965	75,404	27,921	1,581,812	5,206,000		3,520,863	160	563,338,080	28,166,904	28,166,904	56,333,808	676,005,696
29	Smolyan	State	EABD	11	141,013	1,015,171	215,940	2,619	36,424	120,846	1,391,000		1,231,111	160	196,977,760	9,848,888	9,848,888	19,697,776	236,373,312
30	Stara Zagora	State	EABD	18	388,182	2,418,375	444,124	65,344	75,736	310,421	3,314,000		2,862,499	160	457,999,840	22,899,992	22,899,992	45,799,984	549,599,808
31	Yambol (*)	State	EABD	***5***	***145,948***	***1,420,653***	***311,865***	***0***	***34,488***	***26,369***	***1,793,375***		1,732,518	160	277,202,880	13,860,144	13,860,144	27,720,288	332,643,456
32	Dimitrovgrad	State & Municp.	EABD	1	64,981	465,000	36,000	20,300	16,698	0	537,998		501,000	150	75,293,186	3,764,659	3,764,659	7,529,319	90,351,823
33	Kardzhali (*)	State & Municp.	EABD	***7***	***140,175***	***1,059,464***	***74,958***	***0***	***121,432***	***65,955***	***1,321,809***	***692,000***	1,134,422	160	181,507,520	9,075,376	9,075,376	18,150,752	217,809,024
34	Sliven	State & Municp.	EABD	4	234,000	1,301,000	537,000	10,000	17,000	14,000	1,879,000		1,838,000	160	294,080,000	14,704,000	14,704,000	29,408,000	352,896,000
35	Batak	Municipality	EABD	1	7,000	66,000	15,000	0	1,500		82,500		81,000	104	8,415,981	420,799	420,799	841,598	10,099,177
36	Belovo	Municipality	EABD	1	12,000	45,000	3,000	0	1,200		49,200		48,000	108	5,179,248	258,962	258,962	517,925	6,215,098
37	Bratsigovo	Municipality	EABD																
38	Panagyurishte	Municipality	EABD	1	31,000	76,000	60,000	0	2,000		138,000		136,000	123	16,741,736	837,087	837,087	1,674,174	20,090,083
39	Peshtera	Municipality	EABD	1	25,000	95,000	25,000	4,000	3,000		127,000		120,000	118	14,196,120	709,806	709,806	1,419,612	17,035,344
40	Rakitovo	Municipality	EABD	1	16,200	32,000	1,200	0	2,100		35,300		33,200	111	3,693,865	184,693	184,693	369,387	4,432,638
41	Strelcha	Municipality	EABD	1	6,000	46,020	23,610	0	10,070		79,700		69,630	103	7,178,923	358,946	358,946	717,892	8,614,707
42	Velingrad	Municipality	EABD	1	41,450	250,236	2,070	41,031	4,800		298,137		252,306	131	33,168,399	1,658,420	1,658,420	3,316,840	39,802,079
43			**Sub-total**	**81**	**2,333,686**	**14,088,816**	**2,475,043**	**221,841**	**393,525**	**2,140,009**	**19,319,234**		**16,563,859**	**158**	**2,615,503,138**	**130,775,157**	**130,775,157**	**261,550,314**	**3,138,603,765**
44	Blagoevgrad	State	WABD	10	219,629	947,639	416,836	9,226	35,055	19,244	1,428,000		1,364,475	160	218,316,000	10,915,800	10,915,800	21,831,600	261,979,200
45	Kyustendil (*)	State & Municp.	WABD	***8***	***103,211***	***1,159,066***	***276,962***	***27,348***	***31,753***	***184,740***	***1,679,869***	***1,479,600***	1,436,028	160	229,764,480	11,488,224	11,488,224	22,976,448	275,717,376
46	Pernik	State & Municp.	WABD	6	105,867	1,005,034	217,607	38,258	1,075	97,026	1,359,000		1,222,641	160	195,622,560	9,781,128	9,781,128	19,562,256	234,747,072
47	Breznik	Municipality	WABD																
48	Dupnitsa	Municipality	WABD	1	51,715	113,718	89,644	16,273	9,949		229,584		203,362	140	28,404,181	1,420,209	1,420,209	2,840,418	34,085,017
49	Kovachevtsi	Municipality	WABD																
50	Kresna	Municipality	WABD																
51	Petrich	Municipality	WABD	1	65,000	310,290	9,970	700	3,300		324,260		320,260	150	48,135,398	2,406,770	2,406,770	4,813,540	57,762,478
52	Sandanski	Municipality	WABD	1	43,943	301,594	37,373	0	3,214		342,181		338,967	133	45,236,977	2,261,849	2,261,849	4,523,698	54,284,372
			Sub-total	**27**	**589,365**	**3,837,341**	**1,048,392**	**91,805**	**84,346**	**301,010**	**5,362,894**		**4,885,733**		**765,479,595**	**38,273,980**	**38,273,980**	**76,547,960**	**918,575,515**
	Total			**265**	**7,903,001**	**51,946,177**	**10,341,962**	**1,810,300**	**1,565,503**	**4,605,498**	**70,269,440**		**62,288,139**	**158**	**9,840,916,791**	**492,045,840**	**492,045,840**	**984,091,679**	**11,809,100,149**

Note: Estimated cost is without VAT.

Data Source: 1) "Management and Development Strategy for Water Supply and Sewerage Sector in the Republic of Bulgaria", MoRDPW, 2004

2) WSS Companies with (*) mark and gray color are based on the answer to the questionnaires to the WSS Companies in EABD and WABD areas by the end of August 2007, which have been received by this Study.

Table B.8.2 Rehabilitation of Irrigation System List (EABD)

Priority	Regional Branch	Irrigation System: IS	IS_ID	Potential area (dka=0.1ha)	Suitable area (dka=0.1ha)	Intake structure: ITS — Name of intake (RI : River Intake , WI : Water Intake)	Intake structure: ITS — Capacity (m^3/s)	Irrigation canal — Length (m)	Reservoir — Number of Dam	Reservoir — Volume (10^3 m^3)	Pump station — Number of Pump	Pump station — Total capacity (liter/sec)	Other structures on the canal (number) — Distribution points: DP	Distribution structures: DS	Siphon: S	Tunnel: T	Aqueduct: A	Required cost for improvement (EURO) — Type of rehabilitation — New Intake structure	Renovation ITS, DP, DS, S, T, A	Rehabilitation ITS, DP, DS, S, A, T	Lining of canal	Cost for rehabilitation — Const. cost	Machinery cost	Electricity cost	TOTAL	10 % design, 5 % for control acuities, 10 % physical contingency	TOTAL cost
1	Pazardzhik	Topolnitsa	70	121,968	39,217	Lesichevo weir WI	15.0	117,738	1	137,000	0	0.0	317	0	22	0	12	0	4,500	3,154,550	10,646,583	13,805,633	655,970	400,000	14,861,603	3,715,401	18,577,004
	Pazardzhik	Aleko-Pazardzhik	73	240,353	111,750	Zlokuchene WI, Pasha ark WI	18.0	157,522	0	0	2	1,490.0	359	0	25	0	11	0	40,649	2,300,800	11,316,510	13,657,959	305,346	68,000	14,031,305	3,507,826	17,539,131
	Pazardzhik	Karabunar	71	88,602	48,013	Momina klisura WI, Boshulsko dere WI	7.5	168,410	0	0	0	0.0	417	0	58	2	28	50,000	27,375	3,534,000	7,264,946	10,876,321	83,072	42,000	11,001,393	2,750,348	13,751,741
	Plovdiv	Stryama-Chirpan	132	132,800	92,907	Ivan Vazovo WI	17.0	82,453	1	20	0	0.0	0	93	0	11	0	0	12,000	1,048,500	6,202,576	7,263,076	1,074,500	0	8,337,576	2,084,394	10,421,970
	Plovdiv	Topolnitsa	130	365,757	274,789	Potoka RI km8 + 300, WI of Kachana main drianage channel-1 km 0+476, WI of Pelinitsa main drainage channel-1 km 2+986, WI main drainage channel-5 , Strelcha WI, Chernozem weir WI	10.7	213,796	5	213,300	0	0.0	375	8	48	0	63	50,000	164,440	3,922,500	15,085,136	19,222,076	80,900	5,500	19,308,476	4,827,119	24,135,595
			Sub Total	949,480	566,676	Sub Total	68.2	739,919	7	350,320	2	1,490.0	1,468	101	153	13	114	100,000	248,964	13,960,350	50,515,751	64,825,065	2,199,788	515,500	67,540,353	16,885,088	84,425,441
2	Haskovo	Trakiets	186	136,899	70,568	N/A	0.0	128,790	2	115,260	2	1,925.0	228	0	21	3	19	0	43,250	1,575,900	6,770,818	8,389,968	26,000	31,000	8,446,968	2,111,742	10,558,710
	Plovdiv	Karavelovo	125	19,549	11,357	N/A	0.0	18,133	2	5,600	1	48.0	43	0	6	0	2	0	25,825	98,200	372,502	496,527	1,225	500	498,252	124,563	622,815
	Plovdiv	Plovdiv	127	68,666	51,377	Polatovo weir	10.0	67,556	0	0	0	3,000.0	80	0	7	0	10	150,000	38,500	599,500	4,309,417	5,097,417	7,450	0	5,104,867	1,276,217	6,381,084
	Plovdiv	Rozino	126	7,196	1,000	Saraysoyu WI	0.3	10,507	0	0	0	0.0	24	0	2	0	0	0	22,000	65,500	251,015	338,515	0	0	338,515	84,629	423,144
	Sliven	Sredna Tundzha	155	331,168	256,983	Binkos weir intake,Mechkarevo weir, The bridge of Samuilovo intake	47.0	198,801	0	400,000	6	4,390.0	213	3	23	4	14	0	41,299	3,571,330	19,809,165	23,439,794	1,275,570	19,500	24,714,864	6,178,716	30,893,580
	Stara Zagora	Stara Zagora	169	355,606	337,677	Saltachnitsa RI, Stara RI, Maglizhka RI, Dabovska RI, Tundzha RI (serving Yagoda PS) , Suytliyka RI	0.8	222,400	0	0	3	3,965.0	491	5	75	0	11	27,000	49,900	3,370,500	21,265,441	24,712,841	71,800	106,220	24,890,861	6,222,715	31,113,576
	Yambol	Sredna Tundzha	243	141,216	136,679	N/A	0.0	21,575	1	855	0	0.0	12	0	1	0	8	0	10,000	341,000	2,210,503	2,561,503	40,000	0	2,601,503	650,376	3,251,879
			Sub Total	1,060,300	865,641	Sub Total	58.1	667,762	5	521,715	12	13,328.0	1,091	8	135	7	64	177,000	230,774	9,621,930	54,988,861	65,036,565	1,422,045	157,220	66,595,830	16,648,958	83,244,788
3	Burgas	Tserkovski	6	6,362	3,664	Azmak RI	2.0	8,660	1	6,500	0	0.0	4	0	3	0	0	0	12,000	51,600	340,941	404,541	0	0	404,541	101,135	505,676
	Burgas	Kayabash	8	26,105	24,970	N/A	0.0	15,911	6	12,266	0	0.0	10	0	0	0	6	0	22,000	99,200	738,068	859,268	5,000	2,500	866,768	216,692	1,083,460
	Haskovo	Brod IA	197	6,687		N/A	0.0	7,740	0	0	1	1,400.0	29	0	2	0	0	0	0	169,000	175,974	344,974	52,000	56,000	452,974	113,244	566,218
	Haskovo	Ezerovo IA	195	11,704	4,144	Varbishka RI	0.7	17,231	1	5,500	0	0.0	26	0	3	0	4	0	18,000	82,000	463,746	563,746	11,000	0	574,746	143,687	718,433
	Haskovo	Dimitrovgrad IA	198	1,557		N/A	0.0	890	0	0	1	1,000.0	1	0	2	1	0	0	4,000	115,000	34,000	153,000	27,000	38,000	218,000	54,500	272,500
	Haskovo	Trakiets-VII	193	65,387	64,387	Banska RI	0.8	0	1	25,000	6	2,810.0	0	0	0	0	0	0	17,000	295,800	0	337,800	44,800	192,400	575,000	143,750	718,750
	Haskovo	Garvanovo IA	194	8,035	7,001	N/A	0.0	0	0	0	2	918.0	0	0	0	0	0	0	0	20,000	0	20,000	2,000	15,000	37,000	9,250	46,250
	Haskovo	Bolyartsi IA	241	2,000	2,000	N/A	0.0	0	1	260	0	0.0	0	0	0	0	0	0	0	0	0	2,600	0	0	2,600	650	3,250
	Haskovo	Nevestino IA	234	506	506	N/A	0.0	1,898	0	7	1	140.0	0	0	0	0	0	0	8,500	66,000	0	74,500	0	18,000	92,500	23,125	115,625
	Haskovo	Zvinitsa IA	224	4,282	4,282	N/A	0.0	0	1	1,230	0	0.0	0	0	0	0	0	0	0	59,000	0	59,000	50,000	5,000	114,000	28,500	142,500
	Haskovo	Prileptsi IA	230	3,870	3,870	N/A	0.0	0	0	0	2	680.0	0	0	0	0	0	0	5,000	17,000	0	22,000	5,500	4,000	31,500	7,875	39,375
	Haskovo	Daskalovo-Yavoritsa IA	222	1,700		N/A	0.0	0	1	371	0	0.0	0	0	0	0	0	0	0	0	0	3,710	0	0	3,710	928	4,638
	Haskovo	Petelovo IA	220	3,805	3,341	N/A	0.0	0	2	705	0	0.0	0	0	0	0	0	0	0	25,000	0	25,000	5,000	0	30,000	7,500	37,500
	Haskovo	Minzuhar IA	227	1,593	1,593	N/A	0.0	0	1	560	0	0.0	0	0	0	0	0	0	0	0	0	5,600	0	0	5,600	1,400	7,000
	Haskovo	Dyadovsko IA	228	2,548	2,548	N/A	0.0	0	1	544	0	0.0	0	0	0	0	0	0	8,000	0	0	8,000	5,000	0	13,000	3,250	16,250
	Haskovo	Zagorsko IA	236	570	440	N/A	0.0	0	0	0	1	84.0	0	0	0	0	0	0	0	16,500	0	16,500	16,000	0	32,500	8,125	40,625
	Haskovo	Iskril IA	237	1,250	1,250	N/A	0.0	0	0	0	1	56.0	0	0	0	0	0	0	0	70,000	0	70,000	25,000	25,000	120,000	30,000	150,000
	Haskovo	Dobromirtsi-Benkovski	232	15,383	15,383	N/A	0.0	443	1	8,000	0	0.0	0	0	0	0	5	0	8,000	48,000	17,199	73,199	15,000	0	88,199	22,050	110,249
	Haskovo	Parvitsa IA	233	2,698	2,298	Drainage WI Parvitsa	0.2	0	0	0	1	100.0	0	0	0	0	0	0	6,000	40,000	0	46,000	10,000	30,000	86,000	21,500	107,500
	Haskovo	Gruevo IA	235	1,645	1,645	N/A	0.0	0	0	0	1	210.0	0	0	0	0	0	0	0	96,000	0	96,000	21,000	25,000	142,000	35,500	177,500
	Haskovo	Momina salza IA	238	1,060	910	N/A	0.0	0	1	175	0	0.0	0	0	0	0	0	0	0	0	0	2,000	0	0	2,000	500	2,500
	Haskovo	Nanovitsa IA	226	3,400	3,400	N/A	0.0	0	2	1,025	0	0.0	0	0	0	0	0	0	0	20,000	0	20,000	0	0	20,000	5,000	25,000
	Haskovo	Lale IA	225	2,350	2,350	Drainage WI Nanovishka river	100.0	0	1	350	1	84.0	0	0	0	0	0	0	5,000	0	0	8,500	0	0	8,500	2,125	10,625
	Haskovo	Karamfil-Sindeltsi IA	223	1,875	1,570	N/A	0.0	0	1	572	0	0.0	0	0	0	0	0	0	5,000	0	0	5,000	0	0	5,000	1,250	6,250
	Haskovo	Kamenyane IA	240	800	800	Drainage WI Krumovitsa river	60.0	0	0	0	2	104.0	0	0	0	0	0	0	5,000	60,000	0	65,000	16,000	24,000	105,000	26,250	131,250
	Haskovo	Strandzhevo IA	221	3,820	3,820	N/A	0.0	0	0	0	1	342.0	0	0	0	0	0	0	0	24,000	0	24,000	12,000	2,000	38,000	9,500	47,500
	Haskovo	Knizhovnik IA	188	8,390	3,146	N/A	0.0	9,386	1	2,516	0	0.0	25	0	4	0	0	0	12,000	140,400	242,236	394,636	20,000	0	414,636	103,659	518,295
	Haskovo	Sirakovo IA	189	5,220	3,840	N/A	0.0	1,811	1	2,172	0	0.0	2	0	0	0	0	0	0	17,500	45,467	62,967	10,000	0	72,967	18,242	91,209
	Haskovo	Mandra IA	187	4,640	4,640	N/A	0.0	0	1	1,498	0	0.0	0	0	0	0	0	0	3,000	111,000	0	114,000	10,000	0	124,000	31,000	155,000
	Haskovo	Krivo pole IA	190	8,660	8,660	N/A	0.0	0	1	2,820	1	354.0	0	0	0	0	0	0	10,000	15,200	0	25,200	7,100	11,000	43,300	10,825	54,125
	Haskovo	Gledka IS	191	6,640		N/A	0.0	0	1	2,320	0	0.0	0	0	0	0	0	0	0	31,100	0	31,100	10,000	0	41,100	10,275	51,375
	Haskovo	Troyan-Navasen	202	10,640		N/A	0.0	0	1	6,000	2	572.0	0	0	0	0	0	0	0	203,000	0	263,000	40,000	81,000	384,000	96,000	480,000
	Haskovo	Polyanovo	204	10,970	10,970	N/A	0.0	0	0	8	1	800.0	0	0	0	0	0	0	5,000	130,000	0	135,000	50,000	50,000	235,000	58,750	293,750
	Haskovo	Izvorovo	201	11,490	7,348	N/A	0.0	0	1	3,810	0	0.0	0	0	0	0	0	0	6,000	22,000	0	28,000	12,000	5,000	45,000	11,250	56,250
	Haskovo	Dositeevo	200	30,482	26,255	N/A	0.0	0	1	9,000	1	1,350.0	0	0	0	0	0	0	0	150,000	0	240,000	40,000	70,000	350,000	87,500	437,500
	Haskovo	Oreshets	203	7,400	7,400	N/A	0.0	0	0	12	0	0.0	0	0	0	0	0	0	6,000	0	0	6,000	0	0	6,000	1,500	7,500
	Haskovo	Preslavets	205	8,451		N/A	0.0	12,000	0	0	1	1,050.0	8	0	3	0	0	0	0	127,000	371,325	498,325	25,000	30,000	553,325	138,331	691,656
	Haskovo	Harmanli-greenhouse	207	1,880		N/A	0.0	3,950	0	0	1	245.0	12	0	0	0	0	0	0	48,000	70,225	118,225	5,000	20,000	143,225	35,806	179,031
	Haskovo	Harmanli drop	206	936		N/A	0.0	0	0	0	1	64.0	0	0	0	0	0	0	0	40,000	0	40,000	10,000	25,000	75,000	18,750	93,750
	Haskovo	Biser	209	35,377	10,590	N/A	0.0	42,832	3	2,070	1	1,660.0	31	0	7	0	1	0	0	230,000	2,122,076	2,363,776	10,000	0	2,373,776	593,444	2,967,220
	Haskovo	Novo selo	211	9,006		N/A	0.0	8,160	0	5	1	880.0	48	0	1	0	0	0	3,000	209,000	255,062	467,062	30,000	50,000	547,062	136,766	683,828
	Haskovo	Momkovo	212	17,091	5,572	N/A	0.0	12,049	0	0	1	1,260.0	1	0	5	0	0	0	0	78,500	340,471	418,971	5,000	0	423,971	105,993	529,964
	Haskovo	Svilengrad	210	1,980		N/A	0.0	3,340	0	0	0	0.0	12	0	0	0	1	0	0	16,000	62,315	78,315	0	0	78,315	19,579	97,894
	Haskovo	Lyubimets-1	217	8,100		N/A	0.0	7,600	0	0	1	800.0	14	0	2	0	0	0	0	60,000	207,920	267,920	0	0	267,920	66,980	334,900
	Haskovo	Gugutka	215	3,583	1,188	Arpa dere RI	280.0	0	0	0	1	280.0	0	0	0	0	0	0	10,000	20,000	0	30,000	5,000	10,000	45,000	11,250	56,250
	Haskovo	Dolno Lukovo	216	895	895	N/A	0.0	0	0	0	1	130.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Haskovo	Mandaritsa	219	1,411		N/A	0.0	0	0	0	1	200.0	0	0	0	0	0	0	0	80,000	0	80,000	30,000	30,000	140,000	35,000	175,000
	Haskovo	Bunarcha-Kapitan	208	4,720	2,932	N/A	0.0	0	1	2,336	0	0.0	0	0	0	0	0	0	0	0	0	23,360	0	0	23,360	5,840	29,200
	Pazardzhik	Varvara	72	73,517	37,210	Vetren dol WI, Eli dere RI	5.2	64,104	0	0	0	0.0	183	0	39	0	23	0	51,081	907,000	3,181,067	4,139,148	29,765	0	4,168,913	1,042,228	5,211,141
	Pazardzhik	Velingrad	75	17,582	6,664	Kleptuza WI, Velingrad-2 PS WI, Manerovi skali WI	1.3	61,484	1	1,105	1	990.0	70	0	34	0	12	30,000	22,401	512,820	1,807,422	2,372,643	37,611	43,000	2,453,254	613,314	3,066,568
	Pazardzhik	Peshtera	74	35,968	18,959	Gerena WI, Kozarski ark WI, GG	0.0	36,337	0	0	0	0.0	97	0	3	0	2	20,000	20,900	245,500	1,255,287	1,541,687	4,440	0	1,546,127	386,532	1,932,659
	Plovdiv	Domlyan	128	70,816	35,494	Kurtovo WI	7.5	57,244	3	28,914	0	0.0	82	0	13	3	11	0	66,620	585,000	2,933,579	3,585,199	1,000	1,060	3,587,259	896,815	4,484,074
	Plovdiv	Chaya	1233	57,237	32,458	N/A	0.0	78,119	1	70	0	0.0	179	0	7	0	0	0	12,000	591,800	4,006,432	4,610,232	60,000	0	4,670,232	1,167,558	5,837,790
	Plovdiv	Popovitsa	1246	38,484	24,751	Cherkezitsa WI	1.2	39,964	0	0	2	4,600.5	99	0	17	0	2	0	0	480,000	1,637,589	2,117,589	0	50,000	2,167,589	541,897	2,709,486
	Plovdiv	Sushitsa	1232	19,925	15,465	N/A	0.0	4,750	1	4,600	0	0.0	8	0	1	0	0	0	0	106,000	175,449	281,449	50,000	15,000	346,449	86,612	433,061
	Plovdiv	Bryagovo	1242	29,519	16,669	N/A	0.0	25,466	1	9,050	0	0.0	57	0	7	0	0	0	7,000	239,500	1,022,899	1,269,399	10,000	0	1,279,399	319,850	1,599,249
	Plovdiv	Vacha	122	115,852	75,385	Krichim WI, Bash weir WI	68.5	128,250	0	0	0	0.0	229	3	25	0	4	0	30,000	1,430,500	8,267,713	9,728,213	90,000	30,000	9,848,213	2,462,053	12,310,266
	Plovdiv	40-te izvora	1231	27,495	27,253	N/A	0.0	13,202	1	3,800	0	0.0	45	0	2	0	0	0	3,000	139,000	487,934	667,934	0	0	667,934	166,984	834,918
	Plovdiv	Lenovo	1244	26,178	23,228	N/A	0.0	12,250	2	7,780	0	0.0	26	0	10	0	0	0	0	133,000	1,415,000	1,625,800	0	0	1,625,800	406,450	2,032,250
	Plovdiv	Mechka	1243	35,238	14,023	N/A	0.0	19,578	1	6,800	1	0.0	24	0	16	0	0	0	5,200	257,900	767,852	1,030,952	0	0	1,030,952	257,738	1,288,690
	Plovdiv	Parvomay	124	46,451	24,254	Beliya kamak WI	1.2	30,934	2	229	2	4,460.0	43	0	11	0	1	0	26,000	259,500	1,045,874	1,331,374	50,000	0	1,381,374	345,344	1,726,718
	Sofia	Ihtiman gravity	162	39,013	39,013	Baba RI (to B. dere)	1.2	21,578	1	11,100	0	0.0	12	0	0	8	0	0	8,000	92,000	783,212	894,212	0	0	894,212	223,553	1,117,765
	Stara Zagora	Dobri Dol	171	13,279	10,854	N/A	0.0	3,228	1	3,465	4	1,754.0	0	0	2	0	0	0	27,000	130,000	126,543	283,543	79,800	37,500	400,843	100,211	501,054
	Stara Zagora	Naydenovo	173	2,412	1,395	N/A	0.0	6,203	1	800	0	0.0	20	0	0	0	0	0	11,400	22,000	120,526	153,926	2,000	0	155,926	38,982	194,908
	Stara Zagora	Dolno Novo Selo	174	3,888	3,138	N/A	0.0	6,000	1	1,200	1	50.0	12	0	2	0	0	0	4,000	20,000	96,126	132,126	0	0	132,126	33,032	165,158
	Stara Zagora	IP-Chirpan PS IA	172	3,590	602	N/A	0.0	0	1	455	0	0.0	0	0	0	0	0	0	0	0	0	4,550	0	0	4,550	1,138	5,688
	Stara Zagora	Yulievo	170	6,381	6,381	N/A	0.0	2,896	0	0	1	630.0	5	0	1	0	1	0	0	74,200	180,000	254,200	3,600	200	258,000	64,500	322,500
	Yambol	Bolyarovo	246	49,754	49,754	N/A	0.0	4,573	2	44,860	0	0.0	2	0	1	0	0	0	12,000	44,400	317,051	373,451	6,000	3,000	382,451	95,613	478,064
	Yambol	Elhovo	245	39,954	22,120	Popovska RI	2.0	29,915	1	12,600	4	1,550.0	6	0	2	1	0	0	19,600	96,270	856,098	971,968	41,350	25,620	1,038,938	259,735	1,298,673
	Yambol	Yambol	244	23,419	23,419	Zaporna vrata intake	5.0	37,635	1	2,770	1	1,000.0	15	0	1	1	0	0	8,600	129,500	1,848,501	1,989,601	6,000	0	1,990,601	497,650	2,488,251
			Sub Total	1,154,906	758,097	Sub Total	536.8	837,611	56	237,229	53	32,607.5	1,437	3	226	14	73	50,000	513,302	9,598,690	37,819,179	48,354,991	1,112,966	1,024,280	50,487,237	12,621,809	63,109,046
			Total	3,164,686	2,190,414	Total	663.0	2,245,292	68	1,109,264	67	47,426	3,996	112	514	34	251	327,000	993,040	33,180,970	143,323,791	178,216,621	4,734,799	1,697,000	184,623,420	46,155,855	230,779,275

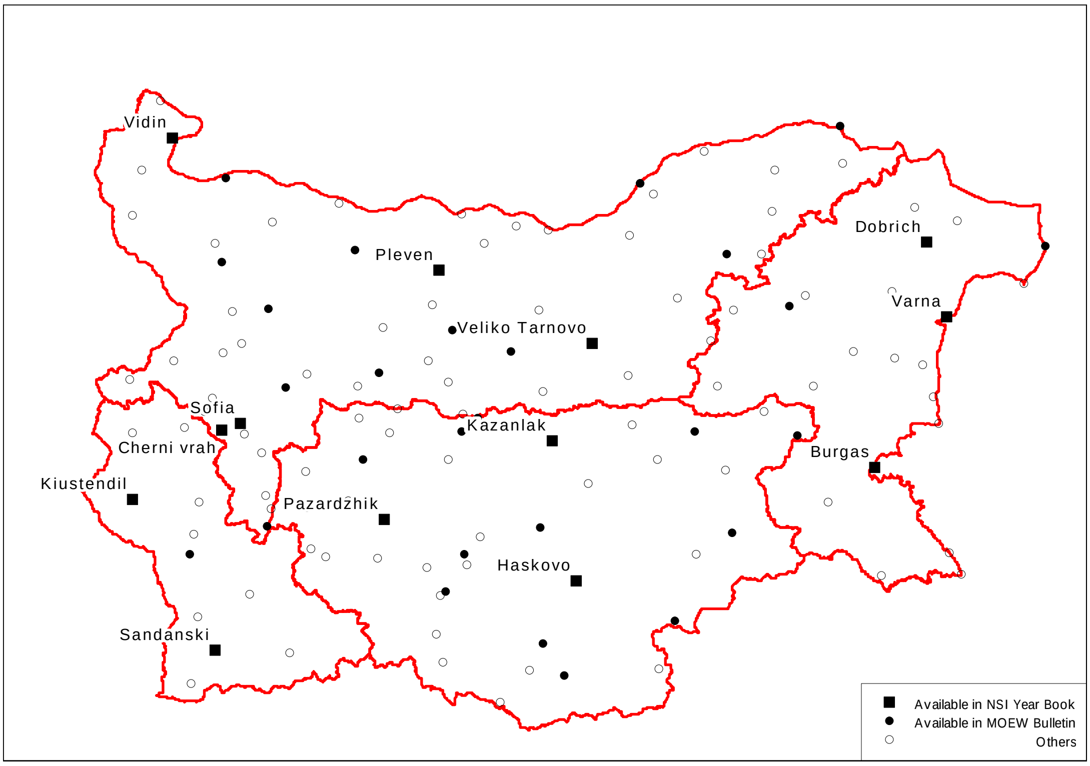
Table B.8.3 Rehabilitation of Irrigation System List (WABD)

Priority	Regional Branch	Irrigation System: IS	IS_ID	Potential area dka	Suitable area dka	Intake structure: ITS		Irrigation canal	Reservoir		Pump station		Other structures on the canal (number)					Required cost for improvement (EURO)									
																		Type of rehabilitation				Cost for rehabilitation					
						Name of intake (RI : River Intake , WI : Water Intake)	Capacity (m^3/s)	Length (m)	Number of Dam	Volume (10^3 m^3)	Number of Pump	Total capacity (liter/sec)	Distribution points: DP	Distribution structures: DS	Siphon: S	Tunnel: T	Aqueduct: A	New Intake structure	Renovation ITS, DP, DS, S, T, A	Rehabilitation ITS, DP, DS, S, A, T	Lining of canal	Const. cost	Machinery cost	Electricity cost	TOTAL	10 % design, 5 % for control acuities, 10 % physical contingency	TOTAL cost
1	Gotse Delcev	Gotse Delchev	56	50,818	39,130	Gospodintsi village water intake, Tufcha river intake-MIC-4, Toplika river intake-MIC-8 and MIC-9	19.4	85,910	0	0	1	280	114	0	14	6	10	0	5,000	793,500	4,325,100	5,123,600	25,000	7,500	5,156,100	1,289,025	6,445,125
	Pernik	Svircha IC IA	91	614	614	Svircha water intake	0.1	6,357	0	0	0	0	10	0	0	0	0	0	5,300	59,500	65,189	129,989	32,000	0	161,989	40,497	202,486
	Pernik	Dragovishtitsa	99	13,562	10,657	Dragovishtitsa water intake	2.5	33,490	1	150	0	0	66	0	2	0	1	0	4,000	232,500	1,308,088	1,544,588	113,000	12,000	1,669,588	417,397	2,086,985
	Pernik	Yamborano IA	85	2,038	1,831	N/A	0.0	9,052	0	0	0	0	28	0	4	0	0	0	10,000	60,000	212,782	282,782	7,500	0	290,282	72,571	362,853
	Pernik	Stensko PS IA	101	1,141	874	Stensko water intake	0.4	5,112	0	0	1	400	37	0	1	0	0	0	4,000	68,000	95,402	167,402	6,000	500	173,902	43,476	217,378
	Pernik	Razhdavitsa PS IA	81	1,933	1,609	Razhdavitsa PS water intake	0.4	5,031	0	0	1	440	17	0	1	0	0	0	10,000	47,000	90,972	147,972	11,500	0	159,472	39,868	199,340
	Pernik	Kopilovski gravity channel IC IA	87	5,913	5,913	Struma water intake	3.0	19,567	0	0	1	2,100	25	0	7	0	0	0	45,000	520,000	569,706	1,134,706	132,000	200,000	1,466,706	366,677	1,833,383
	Pernik	Konyavo IC IA	110	5,858	5,858	Konyavski gravity channel water intake	1.4	19,391	0	0	0	0	51	0	2	0	0	0	13,000	131,000	698,086	842,086	0	0	842,086	210,522	1,052,608
	Pernik	Dolna Grashtitsa PS IA	88	1,430		N/A	0.0	267	0	0	0	0	0	0	0	0	0	0	0	5,000	0	5,000	0	0	5,000	1,250	6,250
	Pernik	Katrishte PA IA	89	1,755		Girchevtsi water intake	2.0	3,205	0	0	2	1,090	7	0	0	0	0	0	0	278,500	90,000	368,500	24,000	176,500	569,000	142,250	711,250
	Pernik	Lozno IA PS	84	2,100	2,100	Nov chiflik PS water intake	0.2	0	0	0	1	230	0	0	0	0	0	0	12,000	49,000	0	61,000	28,000	17,000	106,000	26,500	132,500
	Pernik	Nevestino PS IA	83	1,396	896	Nevestino PS water intake	0.8	3,835	0	0	1	615	11	0	1	0	0	0	15,200	21,500	65,244	101,944	18,000	0	119,944	29,986	149,930
	Pernik	Chetirtsi PS IA	108	849	609	Chetirtsi PS water intake	0.4	960	0	0	1	100	2	0	0	0	0	100,000	0	48,400	19,704	168,104	17,000	11,000	196,104	49,026	245,130
	Pernik	Gorna Grashtitsa reservoir IA	100	1,521	1,521	N/A	0.0	1,839	1	200	0	0	16	0	0	0	0	0	9,000	19,000	21,862	49,862	11,200	0	61,062	15,266	76,328
	Pernik	Nikolichevska vada IC	104	100	100	N/A	0.0	1,858	0	0	0	0	3	0	0	0	0	0	0	6,000	20,289	26,289	0	0	26,289	6,572	32,861
	Pernik	Dromuharska vada IC IA	105	248	248	N/A	0.0	5,110	0	0	0	0	5	0	0	0	0	0	0	8,000	72,144	80,144	0	0	80,144	20,036	100,180
	Pernik	Drenov dol IA	96	12,288	8,180	Banska river water intake	1.0	11,277	2	3,505	0	0	2	0	0	0	0	0	13,000	34,000	198,757	245,757	30,000	0	275,757	68,939	344,696
	Pernik	Bersin-Bagrentsi IA	86	20,193	18,544	M-1 Bersin water intake, Granitsa water	0.5	46,111	2	6,800	0	0	142	0	13	0	0	20,000	10,000	313,500	1,036,696	1,380,196	56,700	3,000	1,439,896	359,974	1,799,870
	Pernik	Belia kamak IC IA	107	241	161	N/A	0.0	13,717	0	0	0	0	7	0	0	0	0	0	2,000	35,500	133,822	171,322	1,800	0	173,122	43,281	216,403
	Sandanski	Sandanska Bistritsa	154	37,495	31,754	Water intake to HPP Sandanski compensating basin	0.0	68,160	1	960	1	800	73	0	0	6	0	0	23,775	243,000	1,910,255	2,177,030	122,400	5,000	2,304,430	576,108	2,880,538
	Sandanski	Mendovo-Kavrakirovo	146	3,080	3,080	N/A	0.0	8,500	0	0	0	0	0	0	1	4	0	0	0	36,000	242,576	278,576	12,700	0	291,276	72,819	364,095
	Sandanski	Strumeshnitsa	147	12,733	7,500	Water intake Petrich MIC	1.5	14,608	0	0	0	0	9	0	1	4	8	0	0	165,000	577,596	742,596	20,450	0	763,046	190,762	953,808
			Sub Total	177,306	141,179	Sub Total	33.7	363,357	7	11,615	10	6,055	625	0	47	20	19	120,000	181,275	3,173,900	11,754,270	15,229,445	669,250	432,500	16,331,195	4,082,799	20,413,994
2	Dupnitsa	Boboshevo	61	15,873	12,574	Blazhievski IC water itnake, Usoyski IC water intake, Polski reservoir IC water intake, Buranovo PS water intake, Mursalevo PS water intake	3.1	35,710	0	0	3	1,450	127	0	6	2	8	42,000	52,000	373,000	853,719	1,320,719	28,000	0	1,348,719	337,180	1,685,899
	Dupnitsa	Rila	62	27,330	23,614	Gl. Rilski IC water intake, Drachka ditch IC water intake, Glaven Porominovski IC water intake	3.5	43,106	0	0	0	0	98	0	12	13	12	82,000	10,000	314,000	1,405,913	1,811,913	0	0	1,811,913	452,978	2,264,891
	Dupnitsa	Dupnitsa	60	26,526	16,807	Arakchiyski IC water intake, Glaven Gyurgevski IC water intake	1.2	35,226	0	0	0	0	71	1	8	17	4	76,000	2,500	216,000	759,748	1,054,248	0	0	1,054,248	263,562	1,317,810
	Dupnitsa	Dyakovo reservoir	59	18,234	18,234	Bistritsa derivation water intake, Otovitsa river intake	3.4	36,955	1	35,400	0	0	4	4	5	8	6	0	20,000	515,000	250,636	785,636	69,000	0	854,636	213,659	1,068,295
	Dupnitsa	Blagoevgrad	63	16,029	15,129	Lyav Blagoevgrad MIC water intake, Tuhlarska ditch IC water intake, Tsentralna ditch IC water intake, Water intake to Belo pole PS , Zelen dol PS water intake,	2.3	22,500	0	0	4	2,155	27	0	2	0	3	190,000	25,500	99,000	499,902	814,402	11,840	2,500	828,742	207,186	1,035,928
	Gotse Delcev	Razlog	58	28,692	18,428	N/A	4.6	24,290	1	110	0	0	92	0	4	0	0	0	0	202,000	629,365	831,365	2,000	0	833,365	208,341	1,041,706
	Sandanski	Pirinska Bistritsa	150	38,721	38,721	MIC Pirinska Bistritsa water intake	0.0	73,433	0	0	1	700	174	0	15	4	23	0	14,600	914,380	2,978,351	3,907,331	62,000	0	3,969,331	992,333	4,961,664
	Sandanski	Kozhuh	145	16,128	14,000	N/A	0.0	9,800	0	0	1	1,400	11	0	1	0	0	0	0	72,100	399,489	471,589	13,500	1,600	486,689	121,672	608,361
	Sandanski	Valtata	148	4,738	4,738	N/A	0.0	0	1	900	0	0	0	0	0	0	0	0	0	14,000	0	14,000	14,000	0	28,000	7,000	35,000
	Sandanski	Svoboda	144	10,100	10,100	N/A	0.0	9,460	0	0	1	2,000	0	0	2	1	10	0	0	81,600	227,678	309,278	17,300	0	326,578	81,645	408,223
			Sub Total	202,371	172,345	Sub Total	18.0	290,480	3	36,410	10	7,705	604	5	55	45	66	390,000	124,600	2,801,080	8,004,801	11,320,481	217,640	4,100	11,542,221	2,885,555	14,427,776
3	Dupnitsa	Leshko	64	31,825	28,512	N/A	0.0	9,050	0	0	0	0	3	0	4	0	0	0	0	65,000	426,385	491,385	300	0	491,685	122,921	614,606
	Gotse Delcev	Ablanitsa	57	2,500	1,950	N/A	0.4	0	0	0	1	350	0	0	0	0	0	0	0	30,000	0	30,000	0	30,000	60,000	15,000	75,000
	Pernik	Begunovtsi IA	109	3,000	3,000	Begunovtsi reservoir water intake	0.4	1,658	2	1,554	0	0	0	0	2	0	0	0	19,500	14,500	37,307	71,307	0	0	71,307	17,827	89,134
	Pernik	Dolna Dikanya	76	27,379	25,879	N/A	0.0	4,000	1	7	0	0	0	0	1	0	0	0	3,000	176,500	128,960	308,460	0	0	308,460	77,115	385,575
	Pernik	Izvor	77	18,917	17,817	Izvor reservoir water intake	0.0	10,700	1	7	0	0	14	0	0	0	0	0	10,000	288,000	354,642	652,642	3,000	0	655,642	163,911	819,553
	Pernik	Pchelina	79	18,167	18,167	N/A	0.0	24,761	2	55,325	1	4,125	0	0	11	2	2	0	1,000	385,000	1,631,556	2,028,806	0	0	2,028,806	507,202	2,536,008
	Pernik	Yardzhilovtsi	78	8,003	8,003	Yardzhilovtsi water intake	0.8	0	1	1	1	786	0	0	0	0	0	0	3,000	19,000	0	22,000	0	0	22,000	5,500	27,500
	Sandanski	Ograzhden	153	4,360	4,360	N/A	0.0	19,960	0	0	1	200	40	0	17	0	0	0	0	250,000	692,016	942,016	10,000	0	952,016	238,004	1,190,020
	Sandanski	Asen Itov	152	13,555	13,555	N/A	0.0	29,540	0	0	2	1,700	35	0	10	3	4	0	11,020	214,000	899,907	1,124,927	61,000	0	1,185,927	296,482	1,482,409
			Sub Total	127,706	121,243	Sub Total	1.5	99,669	7	56,895	6	7,161	92	0	45	5	6	0	47,520	1,442,000	4,170,773	5,671,543	74,300	30,000	5,775,843	1,443,961	7,219,804
			Total	507,383	434,767	Total	53.2	753,506	17	104,919	26	20,921	1,321	5	147	70	91	510,000	353,395	7,416,980	23,929,844	32,221,469	961,190	466,600	33,649,259	8,412,315	42,061,574

Supporting Report B

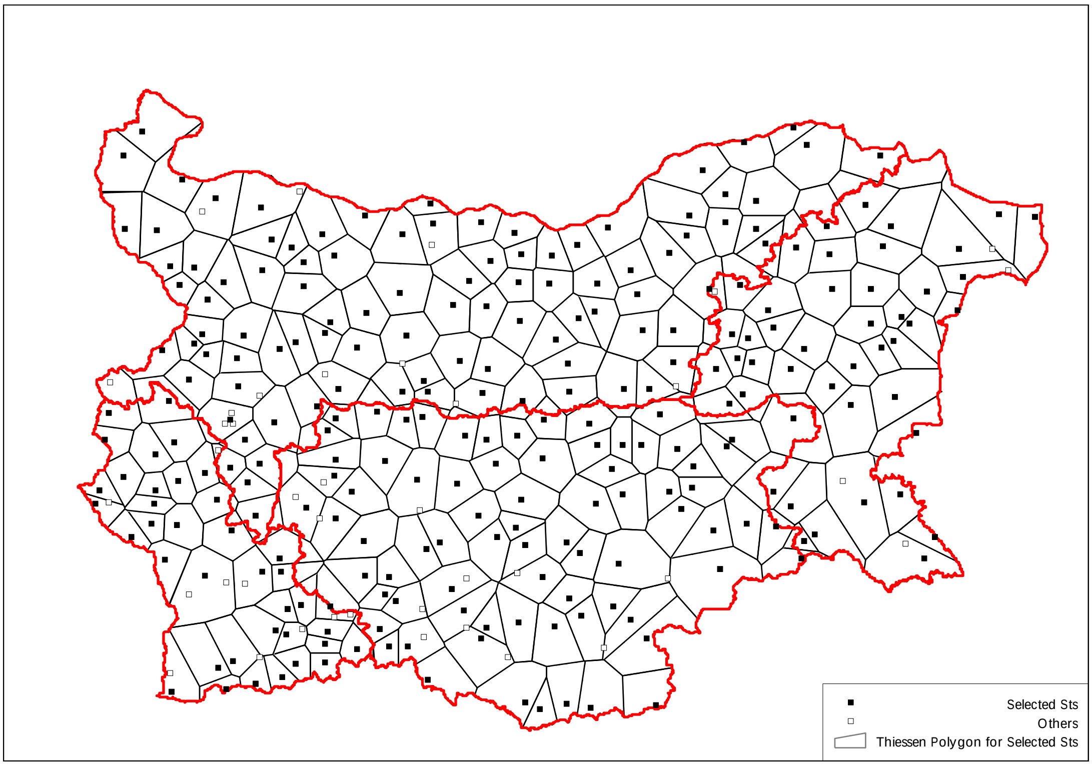
Figures

Figure B.2.1 Damaged Hydrometric Station



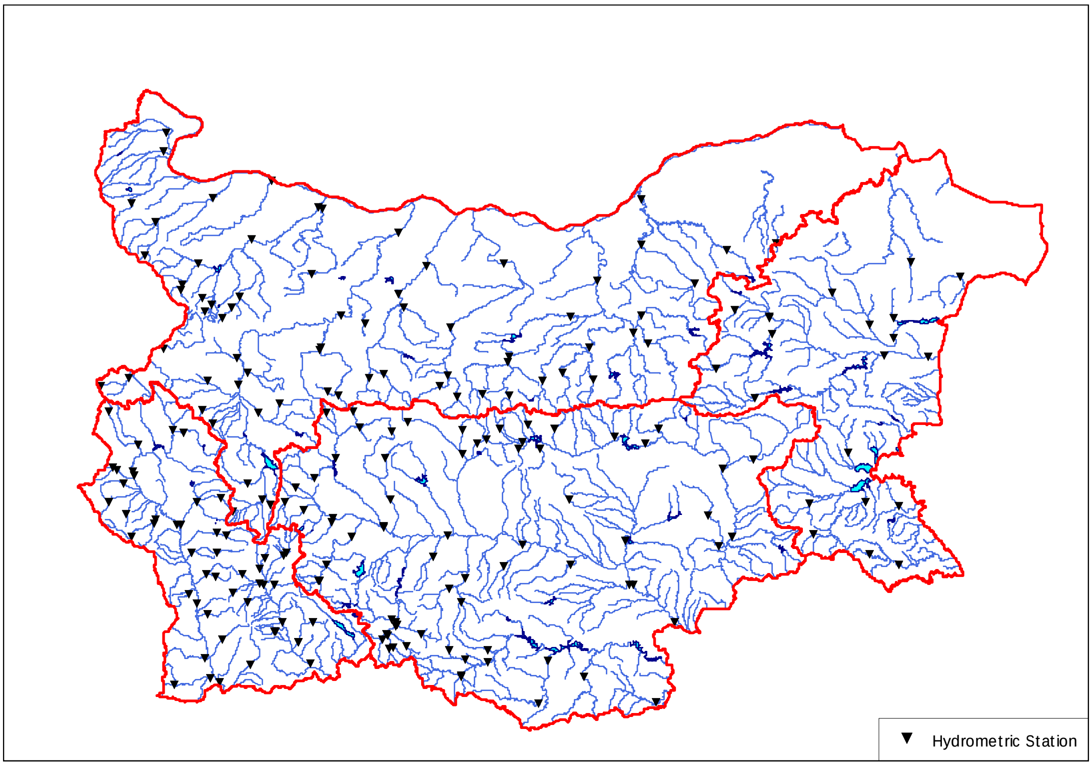
Source: JICA Study Team

Figure B.2.2 Location of Meteorological Stations



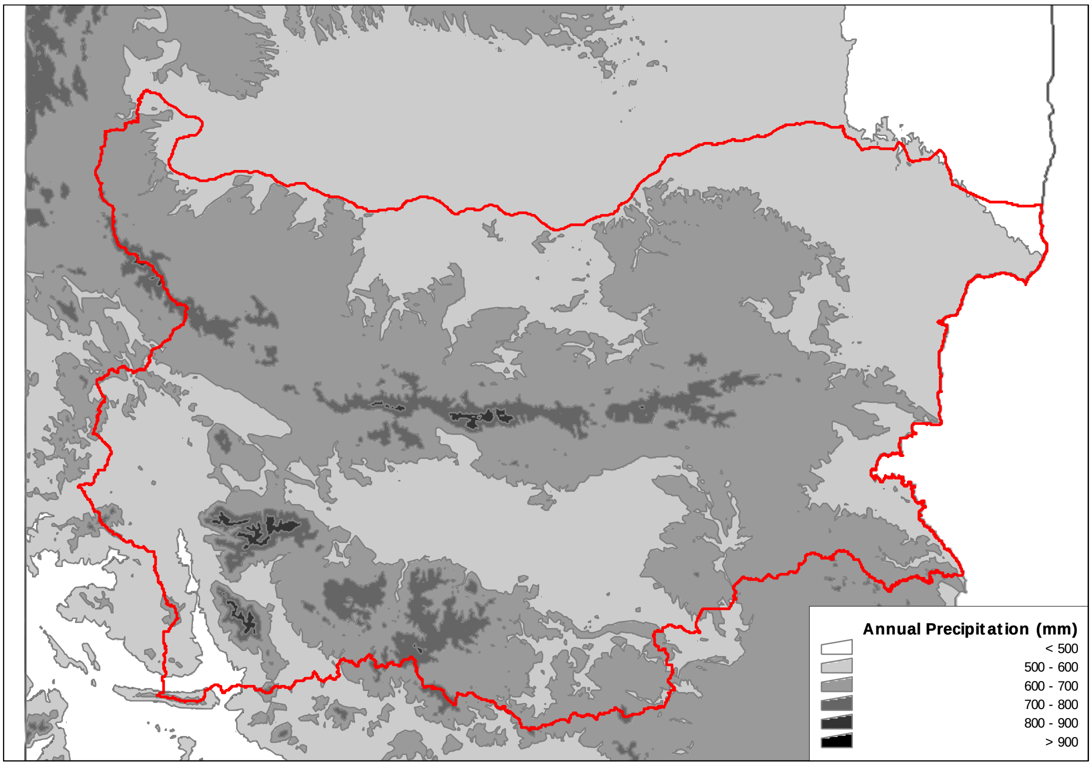
Source: JICA Study Team

Figure B.2.3 Location of Precipitation Stations



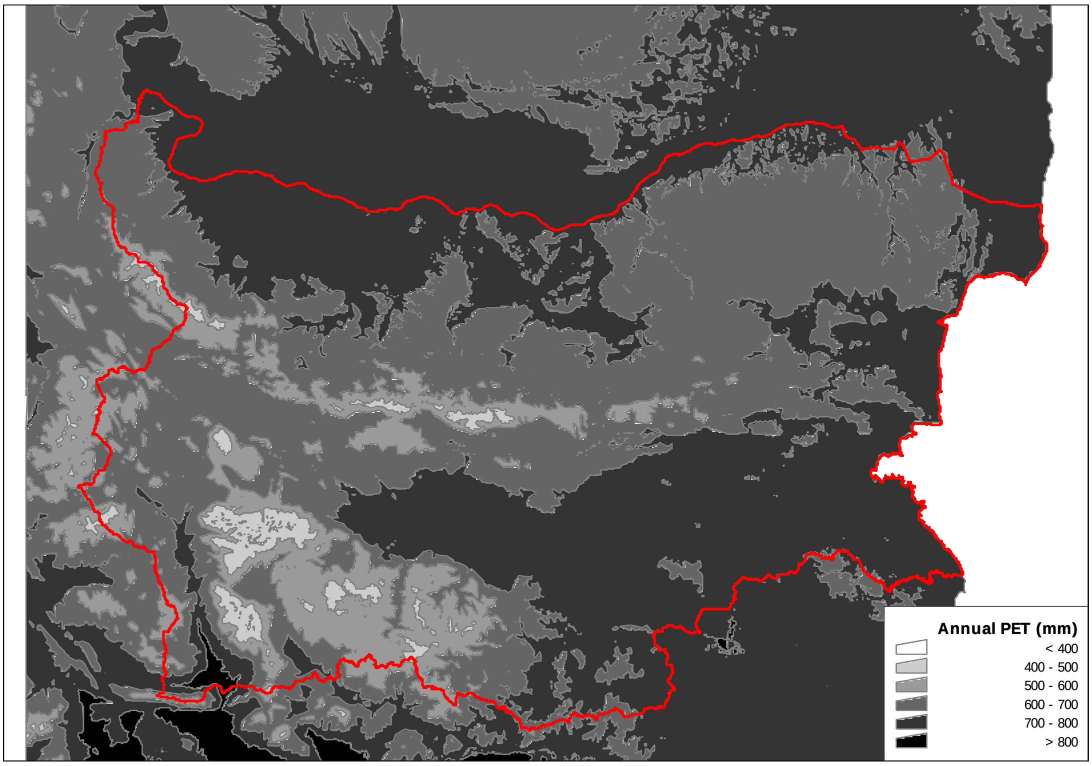
Source: JICA Study Team

Figure B.2.4 Location of Hydrometric Stations



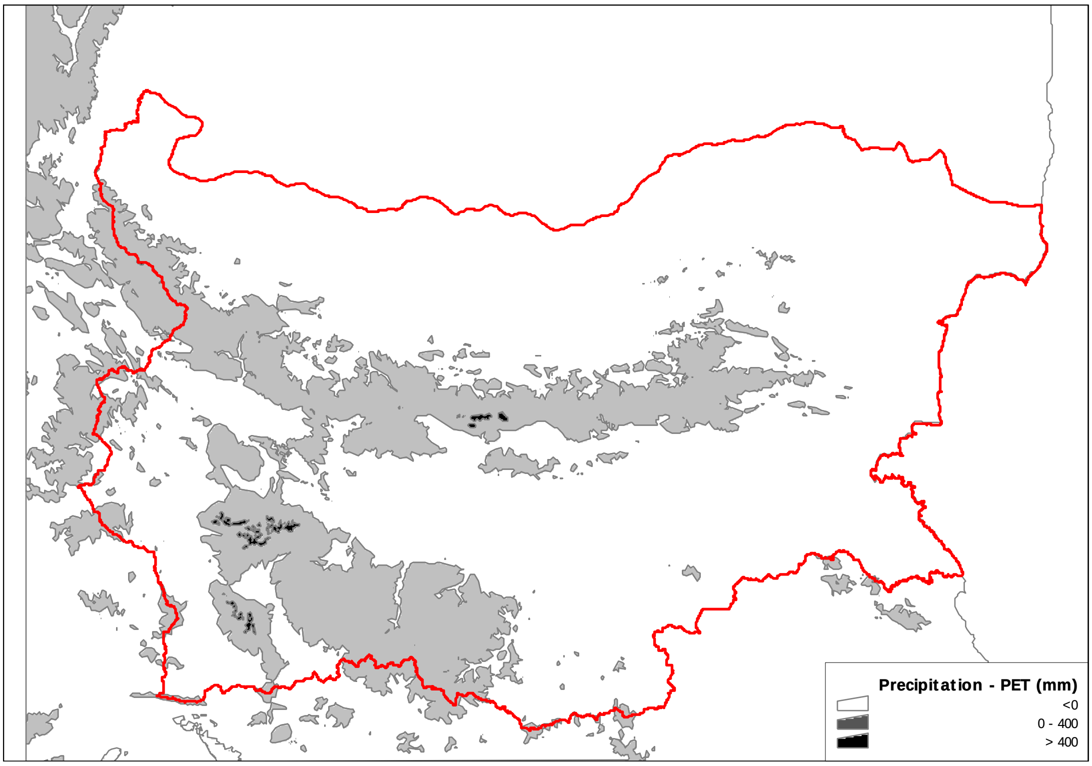
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.5 Averaged Annual Precipitation Pattern during 1950-2000



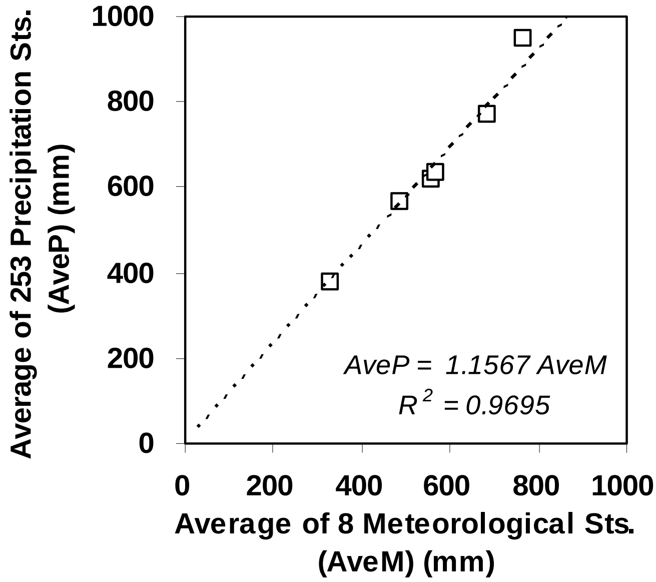
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.6 Averaged Annual PET Pattern during 1950-2000



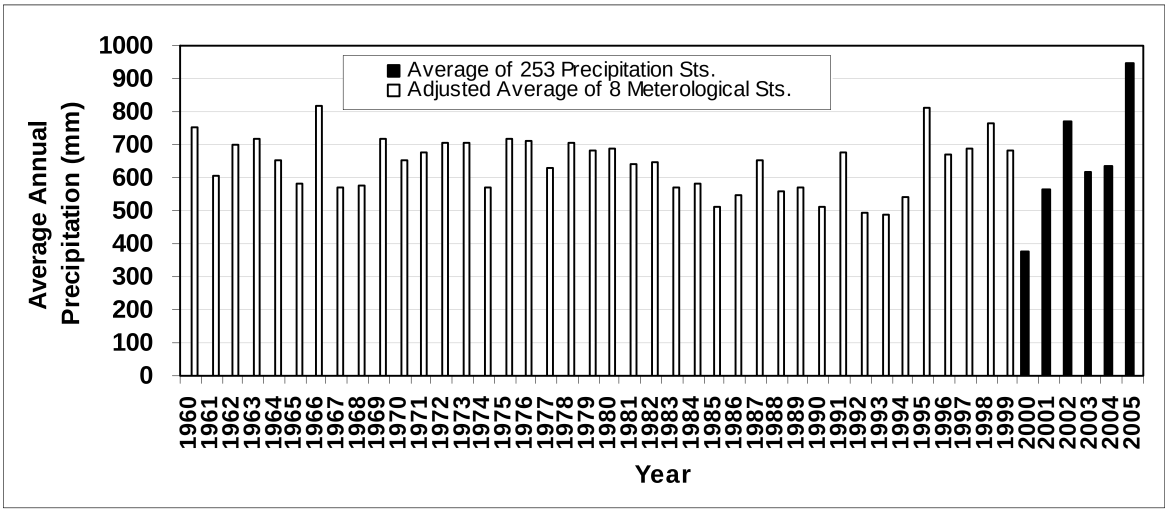
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.7 Annual Precipitation minus PET



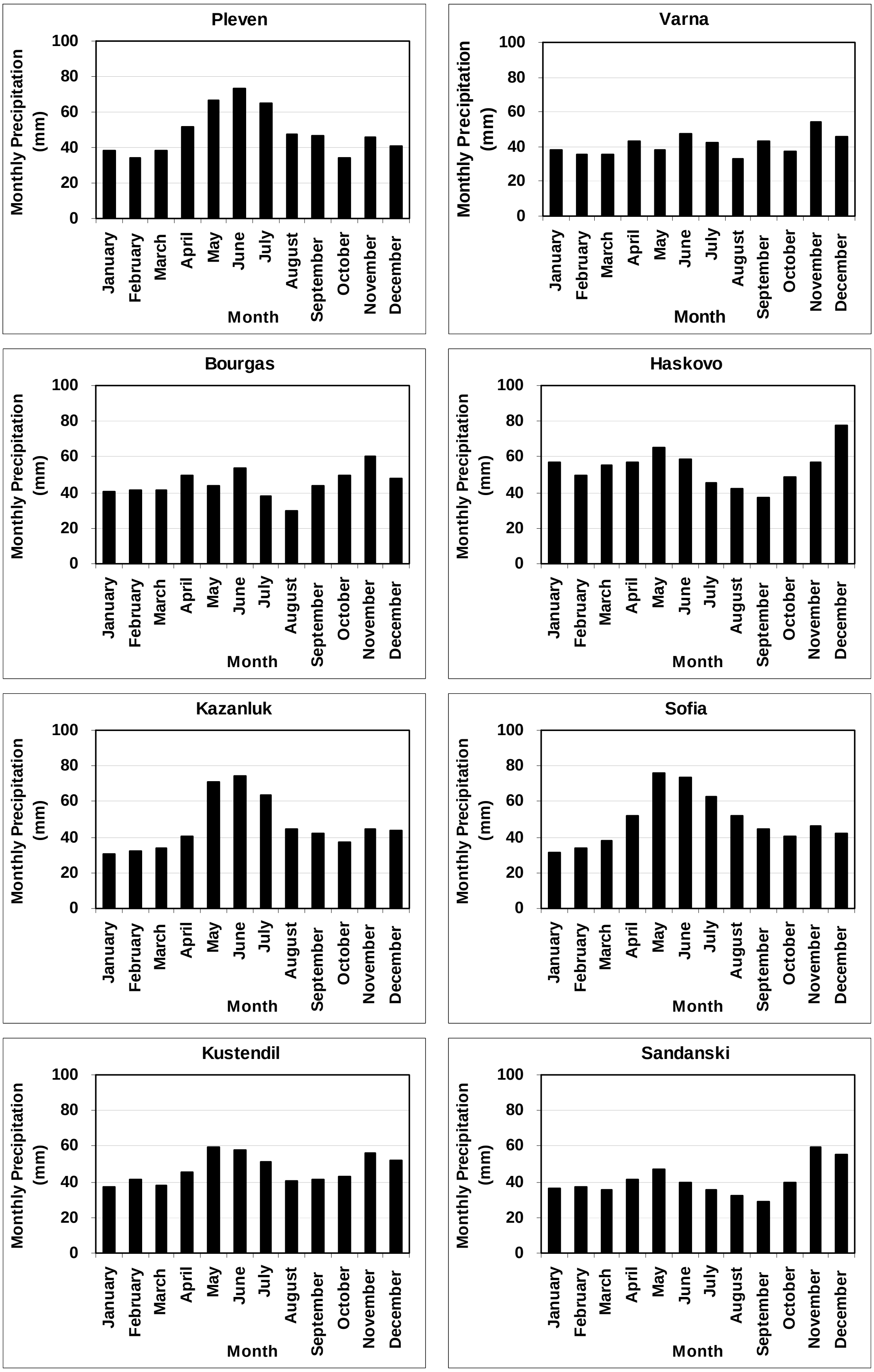
Source: JICA Study Team

Figure B.2.8 Relationship between Average Precipitation of 13 Meteorological Sts. and Average of 253 Precipitation Sts.



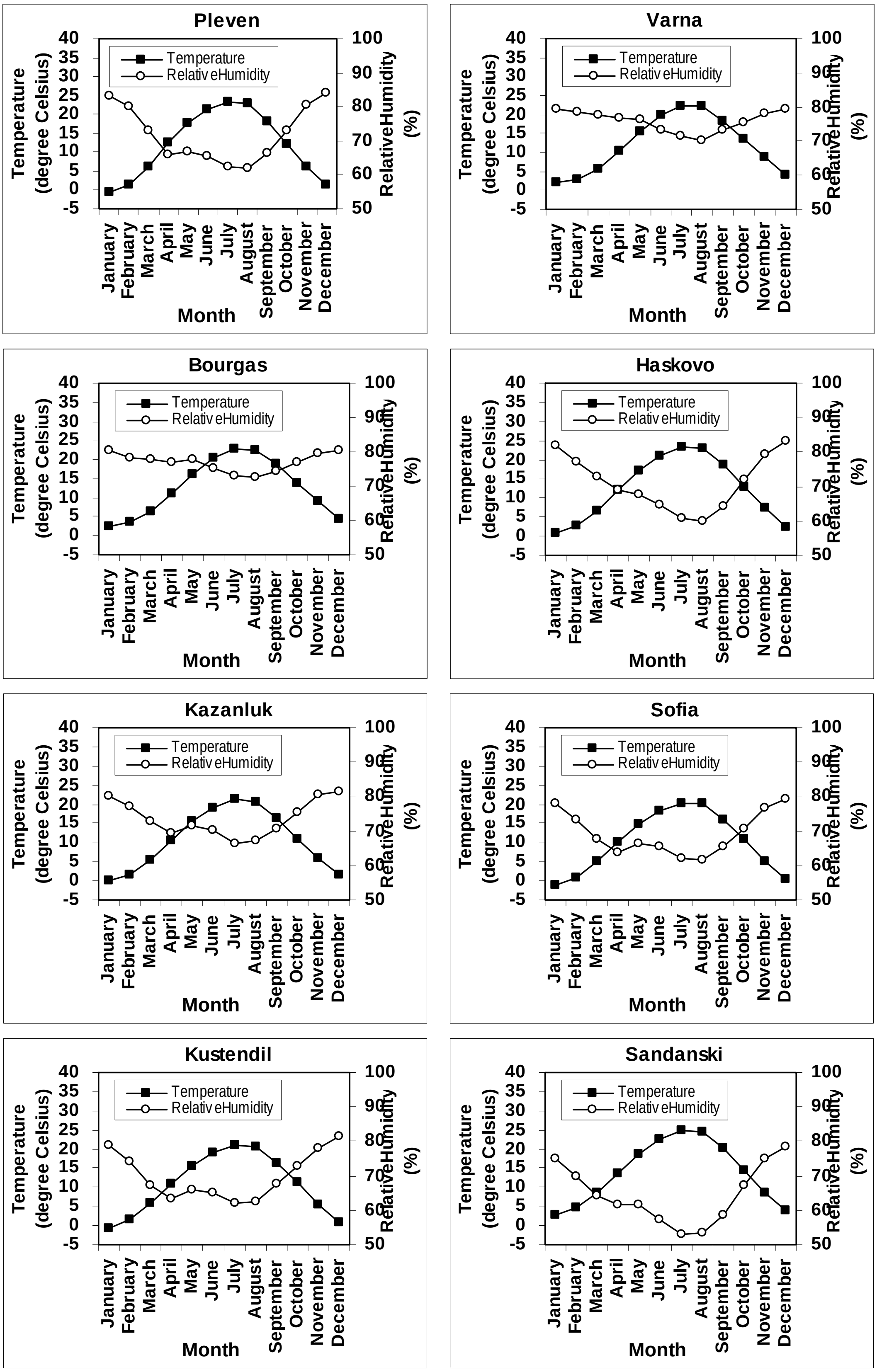
Source: JICA Study Team

Figure B.2.9 Averaged Annual Precipitation in 1960-2005



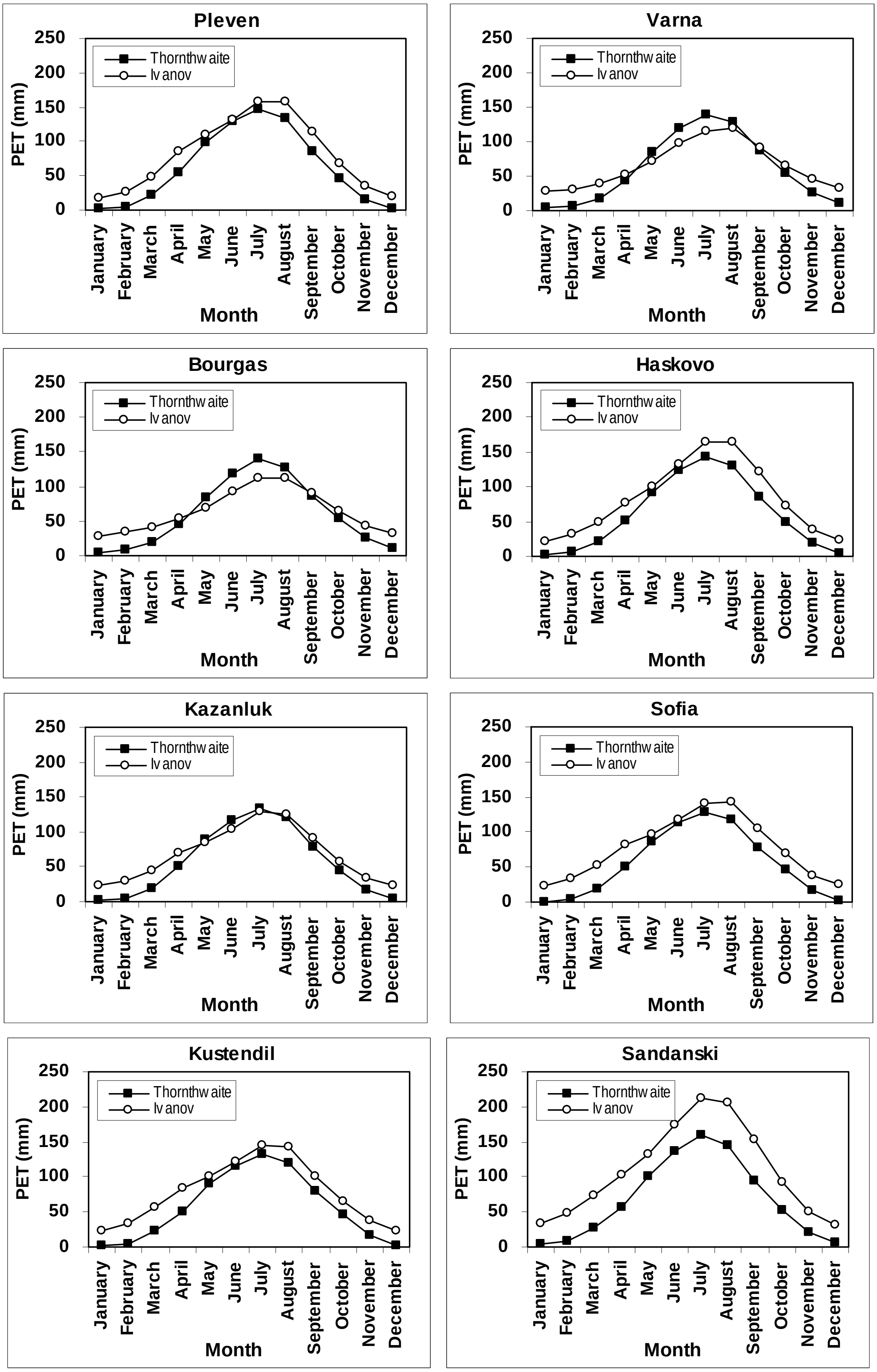
Source: JICA Study Team

Figure B.2.10 Monthly Variation of Precipitation (1960-2005)



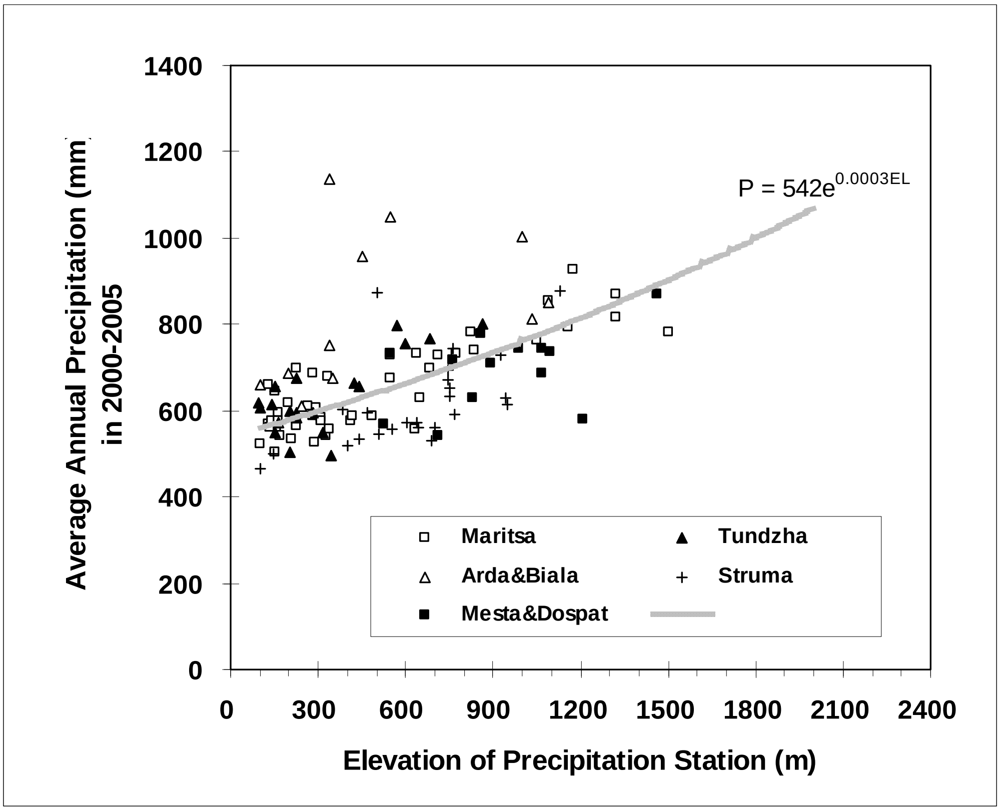
Source: JICA Study Team

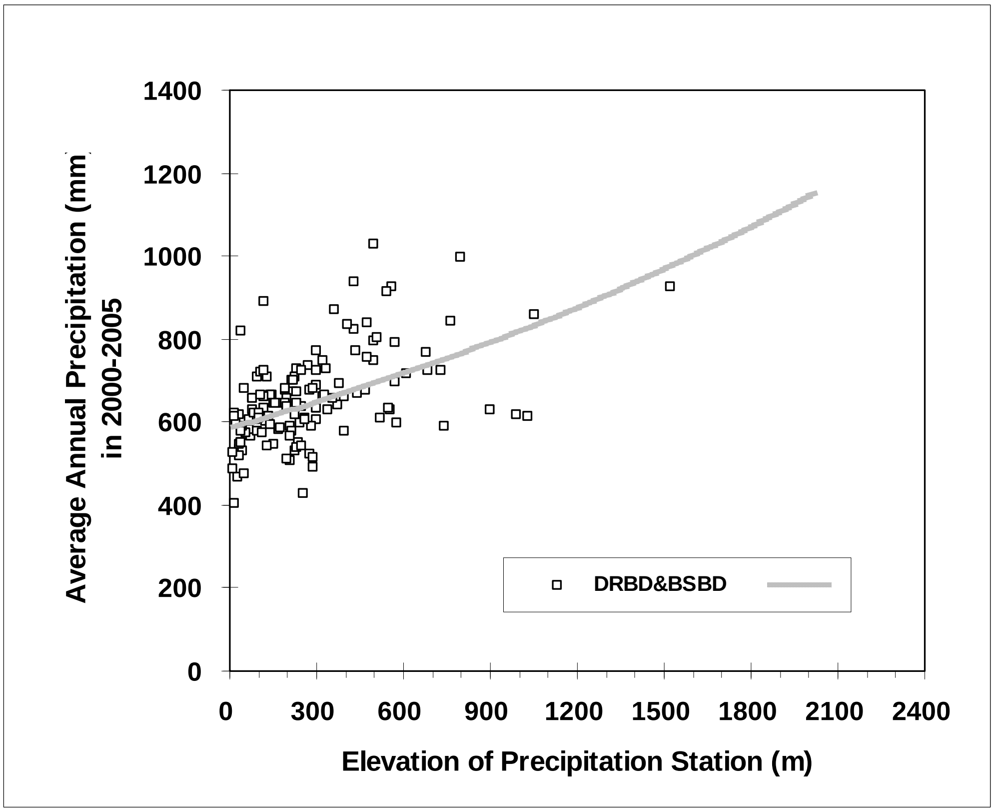
Figure B.2.11 Monthly Variation of Temperature and Relative Humidity (1960-2005)



Source: JICA Study Team

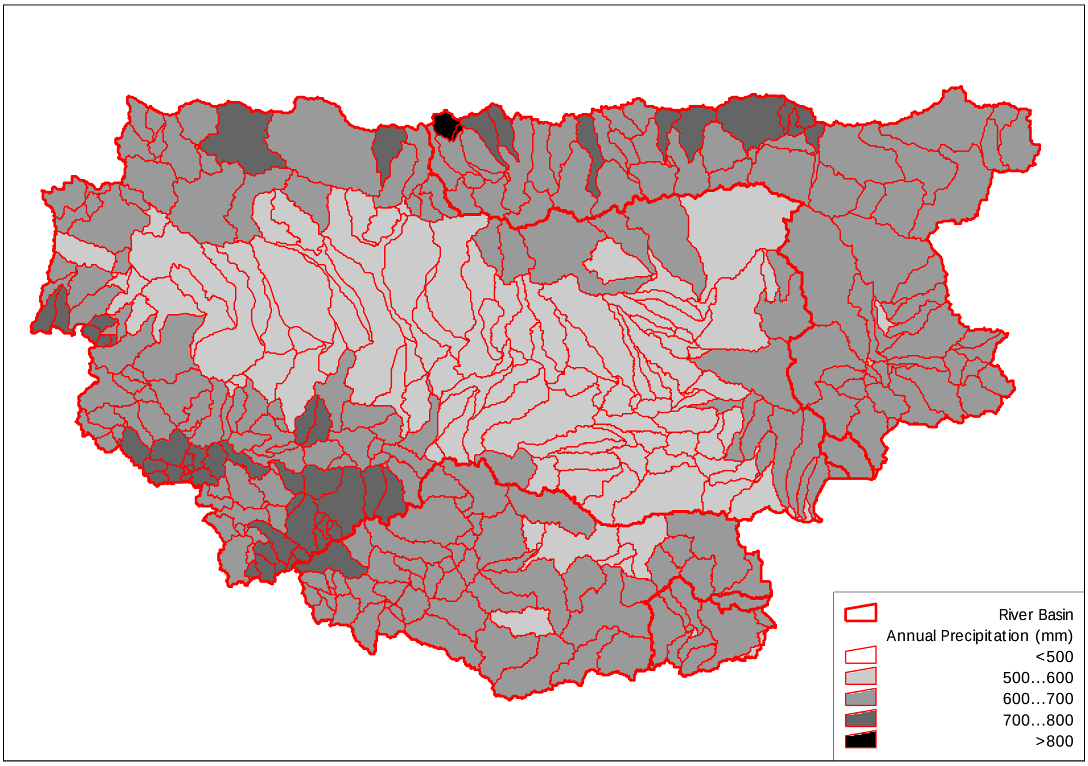
Figure B.2.12 Monthly Variation of PET (1960-2005)





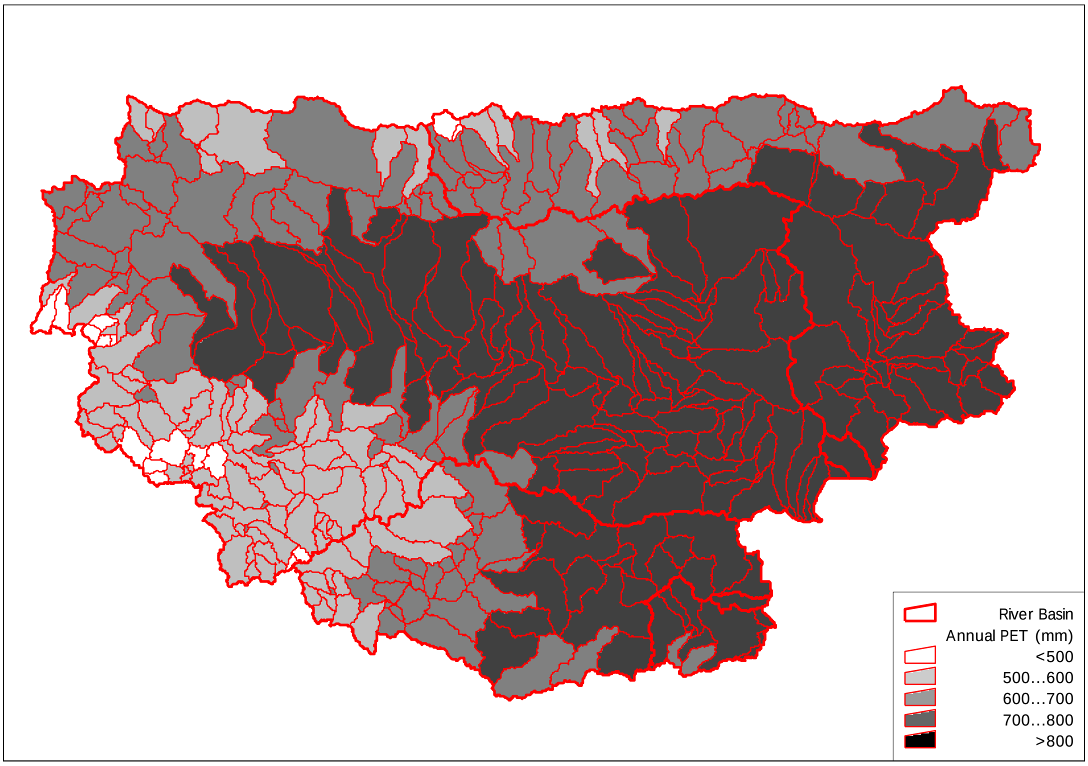
Source: JICA Study Team

Figure B.2.13 Relationship between Elevation and Precipitation



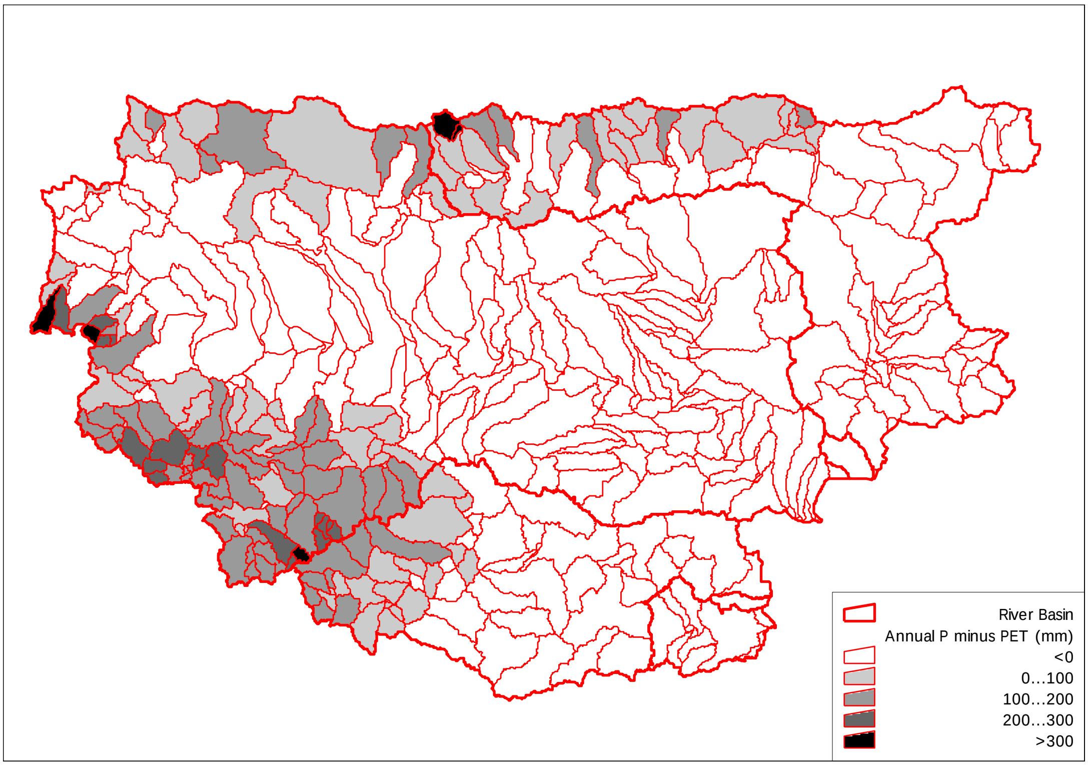
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.14 Long-term Averaged Annual Precipitation for Each Catchment in EABD



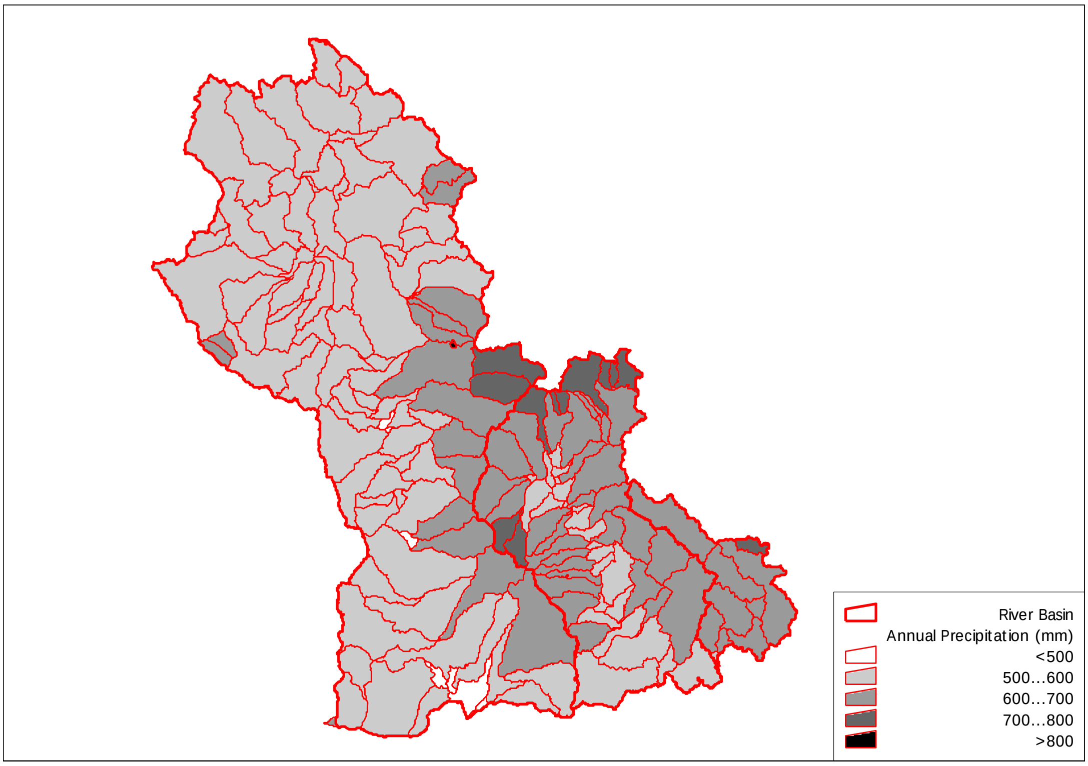
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.15 Long-term Averaged Annual PET for Each Catchment in EABD



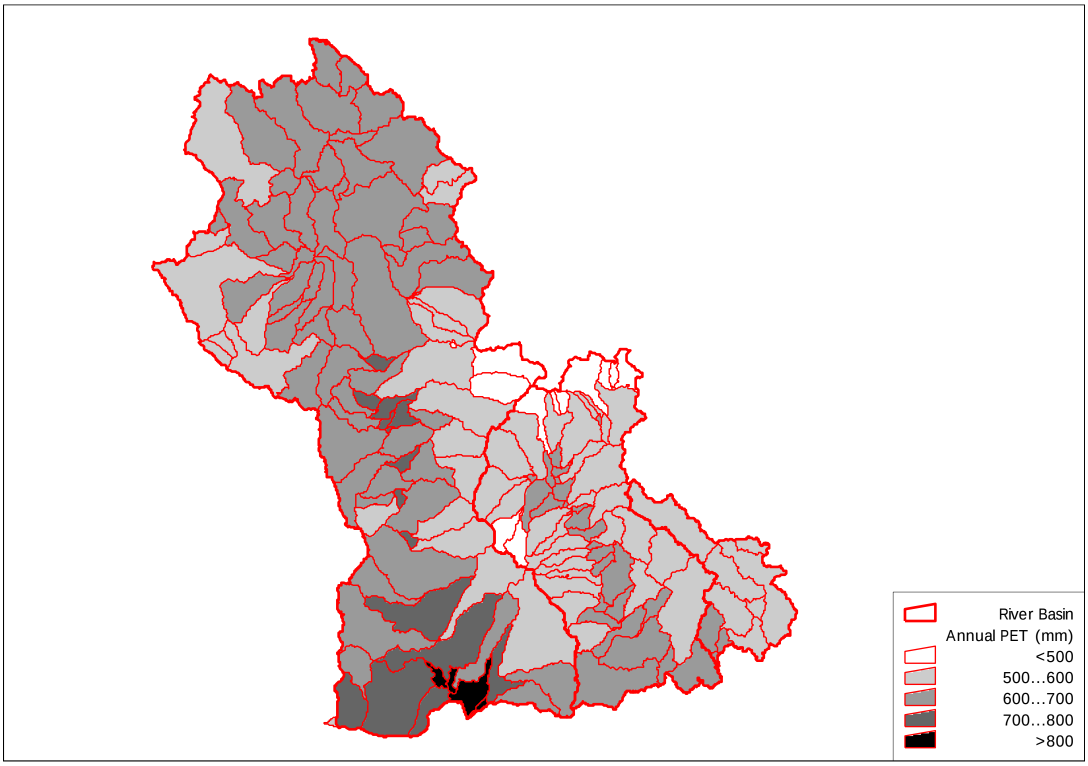
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.16 Long-term Averaged Annual Precipitation minus PET for Each Catchment in EABD



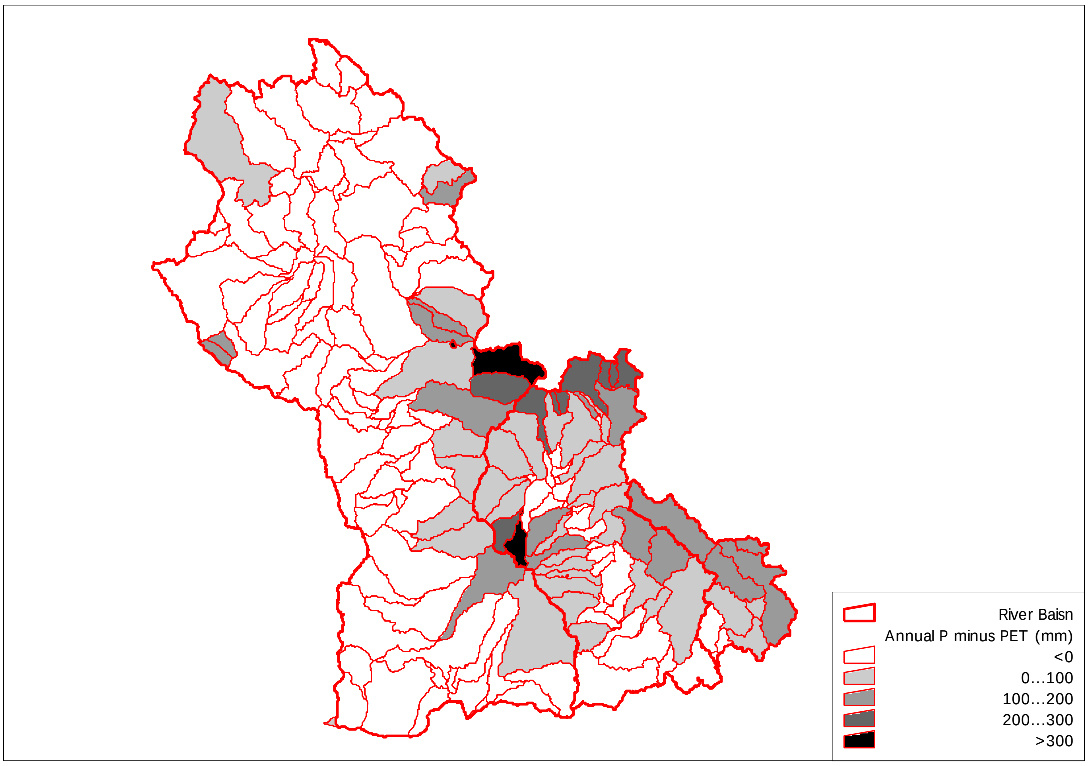
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.17 Long-term Averaged Annual Precipitation for Each Catchment in WABD



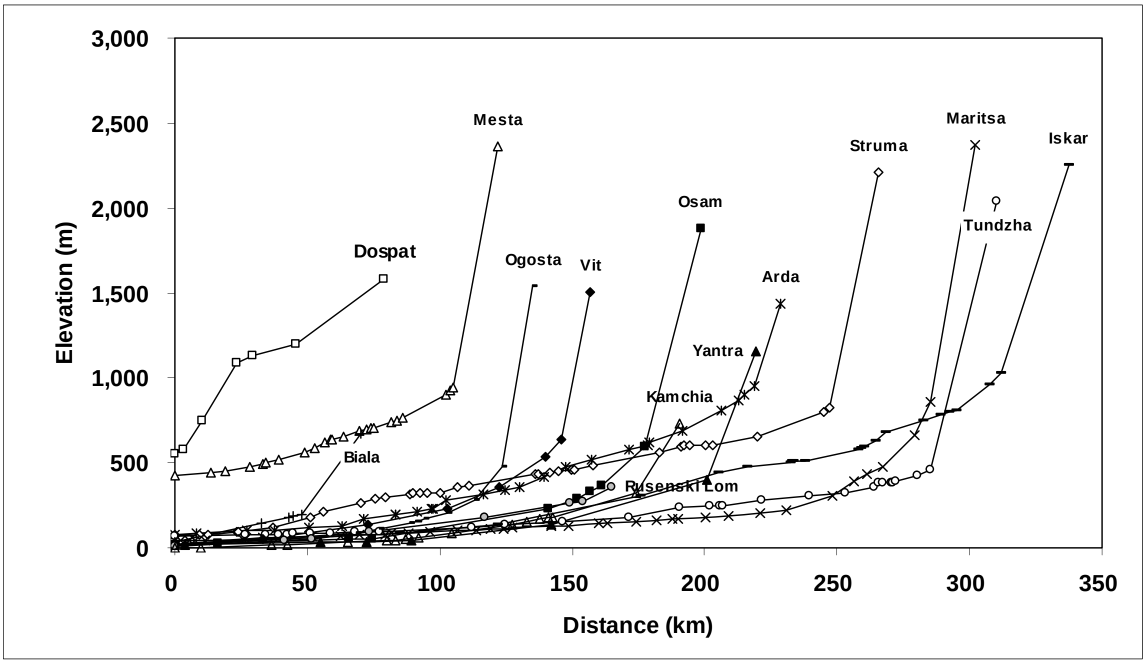
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.18 Long-term Averaged Annual PET for Each Catchment in WABD



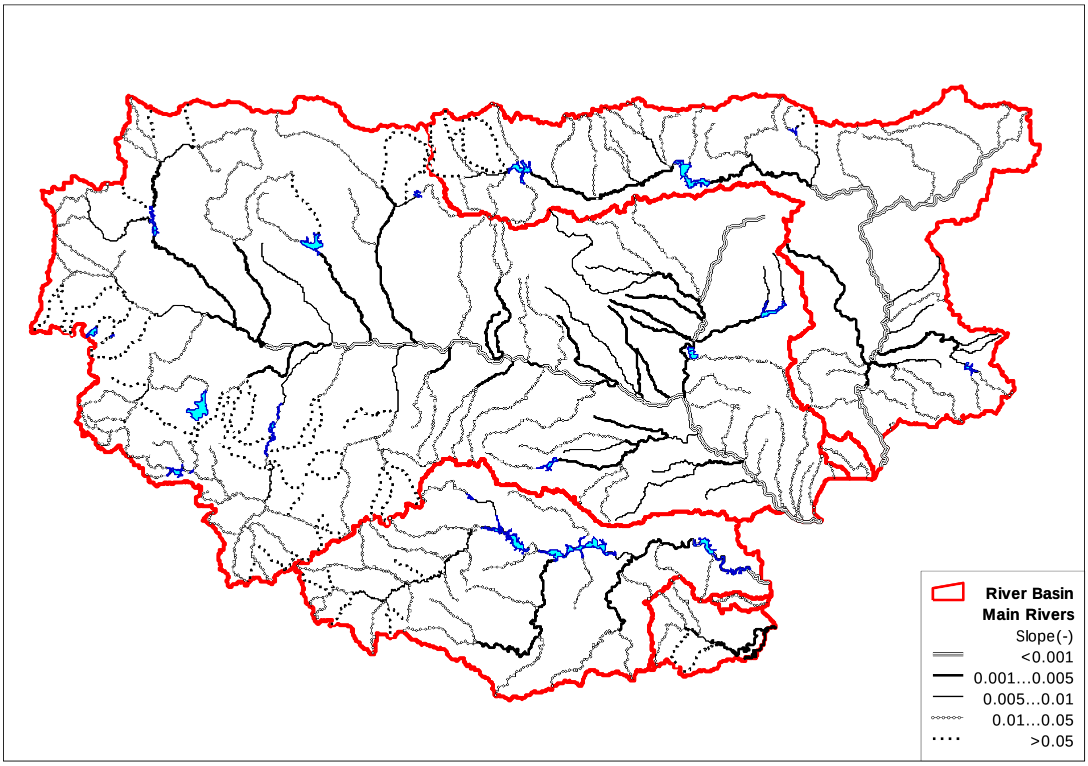
Source: JICA Study Team based on WORLDCLIM database

Figure B.2.19 Long-term Averaged Annual Precipitation minus PET for Each Catchment in WABD



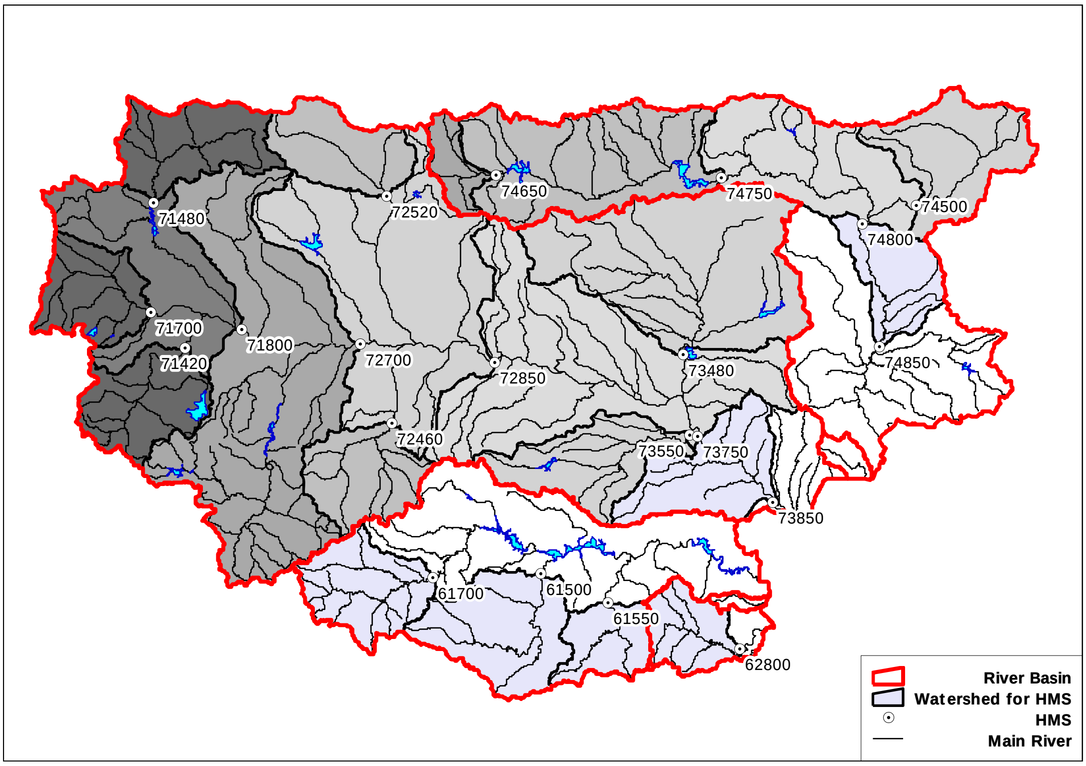
Source: JICA Study Team

Figure B.2.20 Longitudinal Profile of Major Rivers



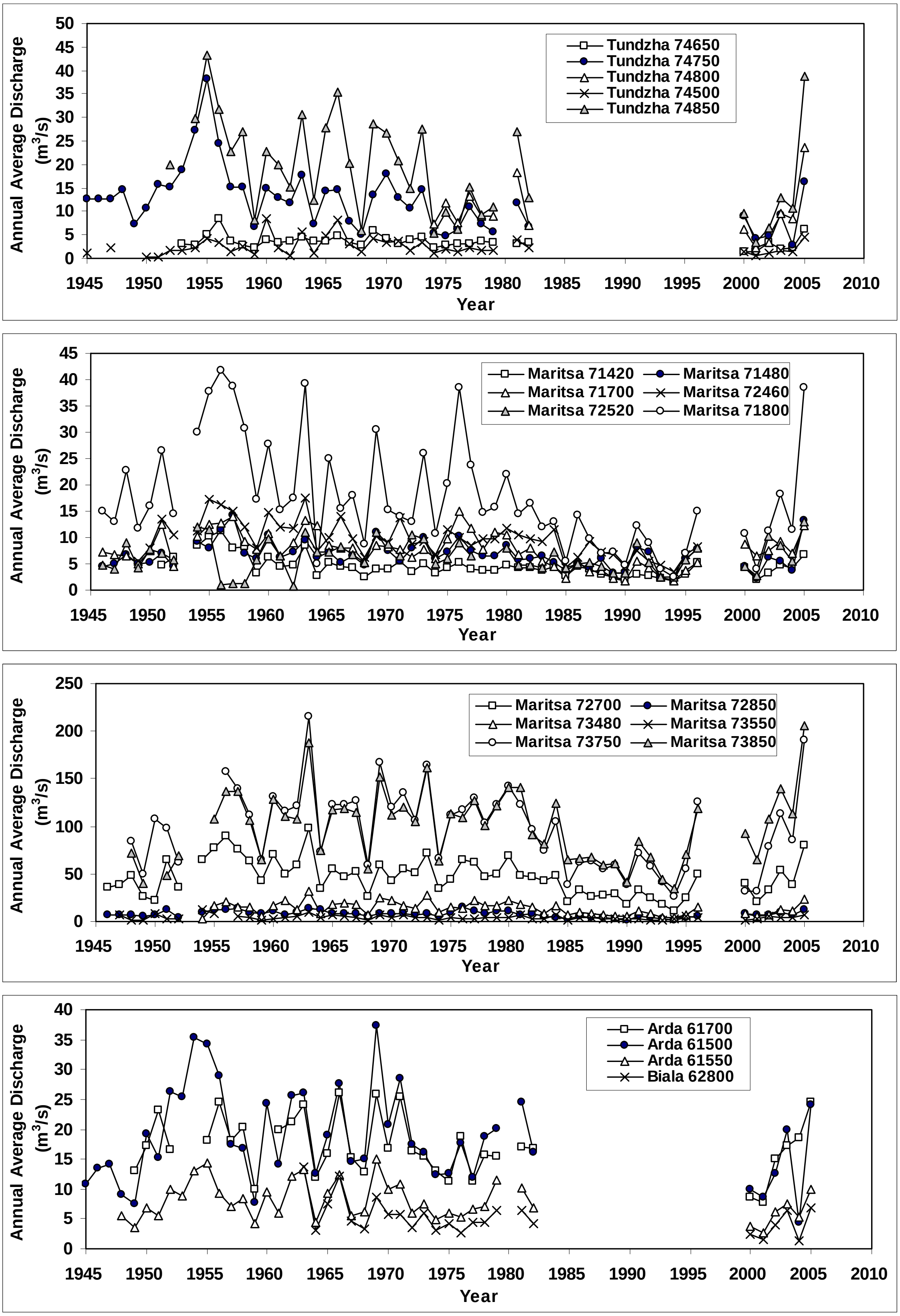
Source: JICA Study Team

Figure B.2.21 Main River Network in EABD



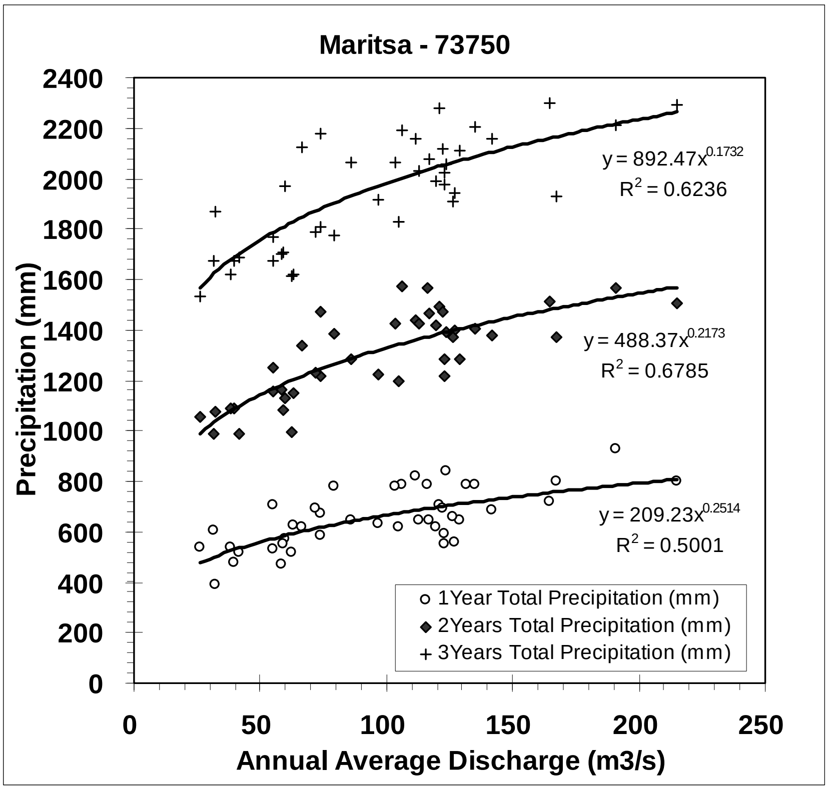
Source: JICA Study Team

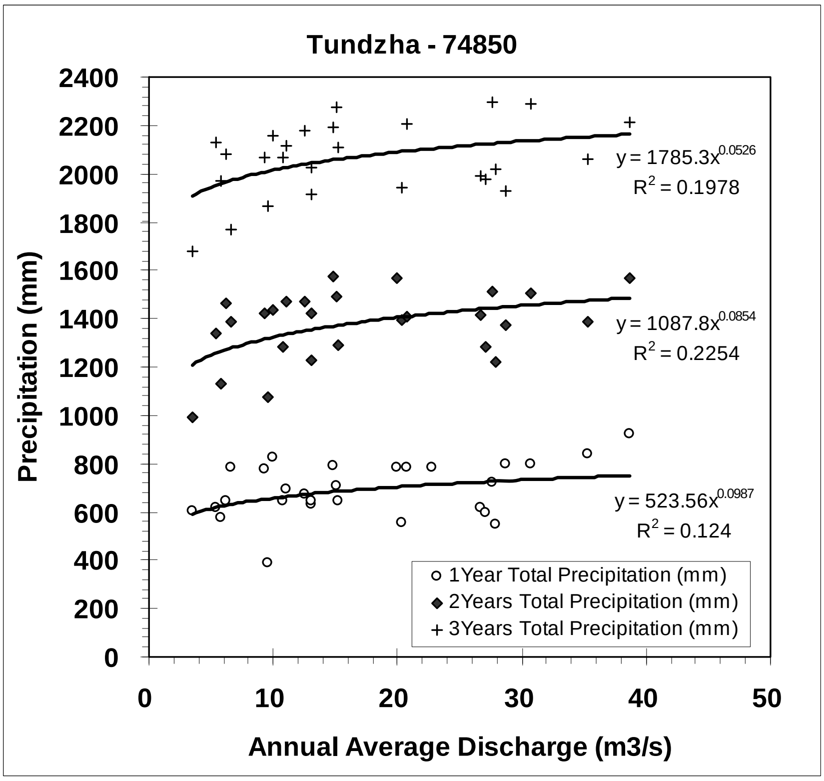
Figure B.2.22 Hydrometric Stations and Those Watershed Areas in EABD



Source: JICA Study Team

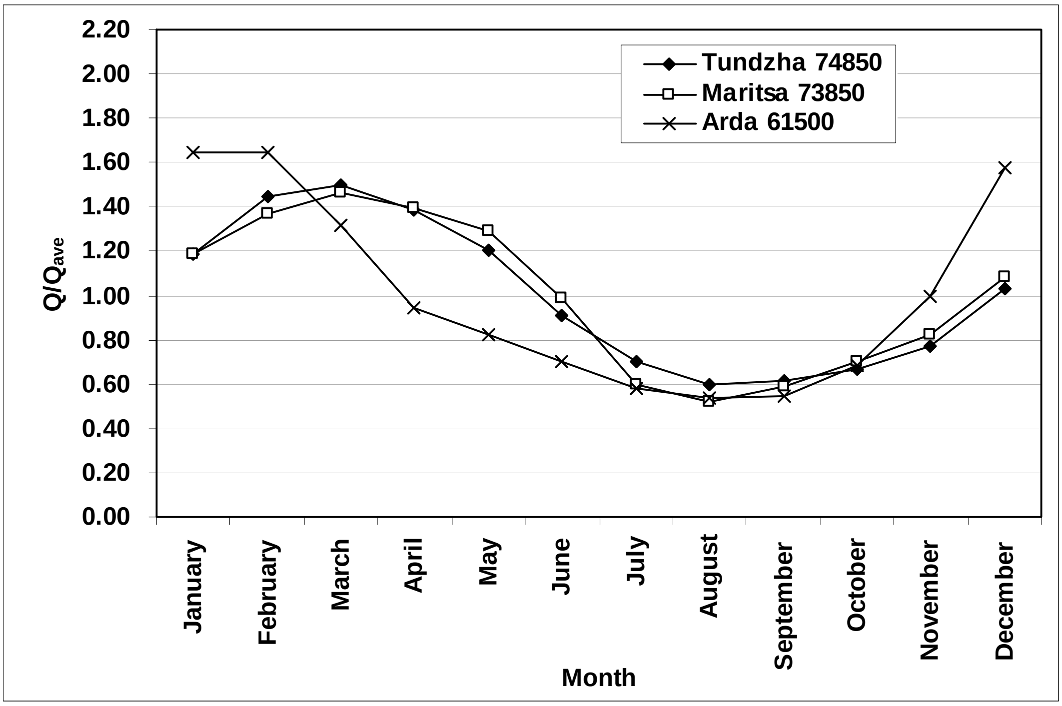
Figure B.2.23 Observed Annual Average Discharge in EABD





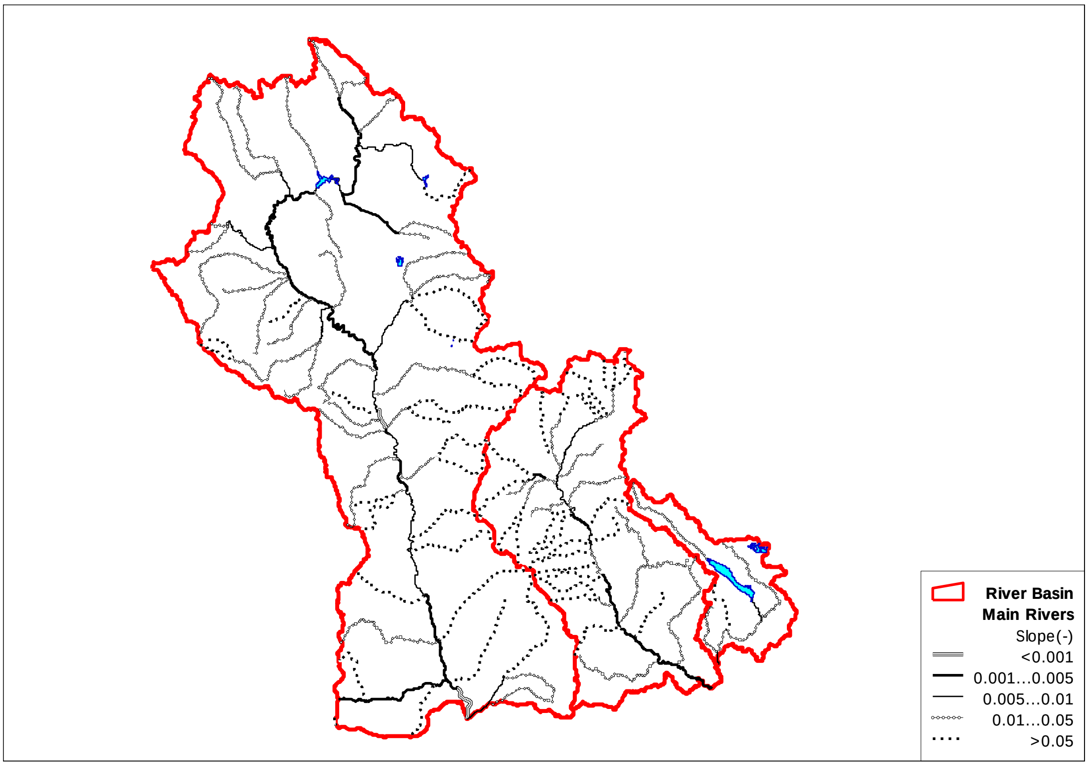
Source: JICA Study Team

Figure B.2.24 Relationship between Total Precipitation and Annual Average Discharge in EABD



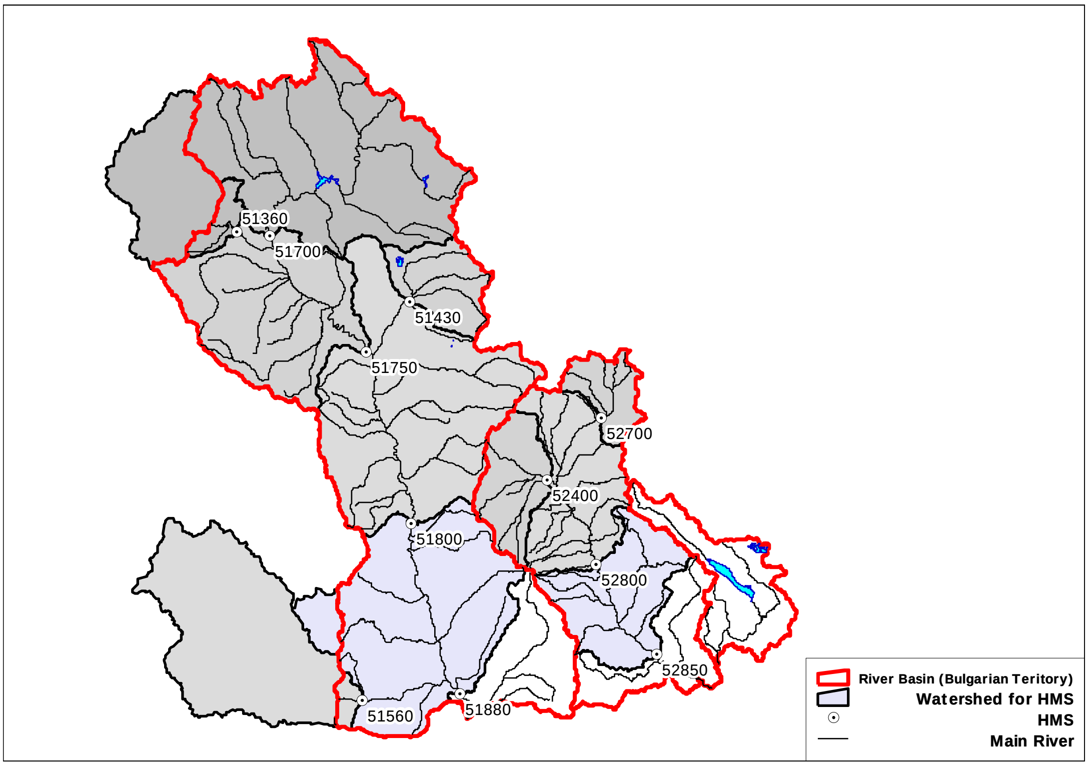
Source: JICA Study Team

Figure B.2.25 Long-term Averaged Monthly Variation of Discharge for Selected Hydrometric Stations in EABD



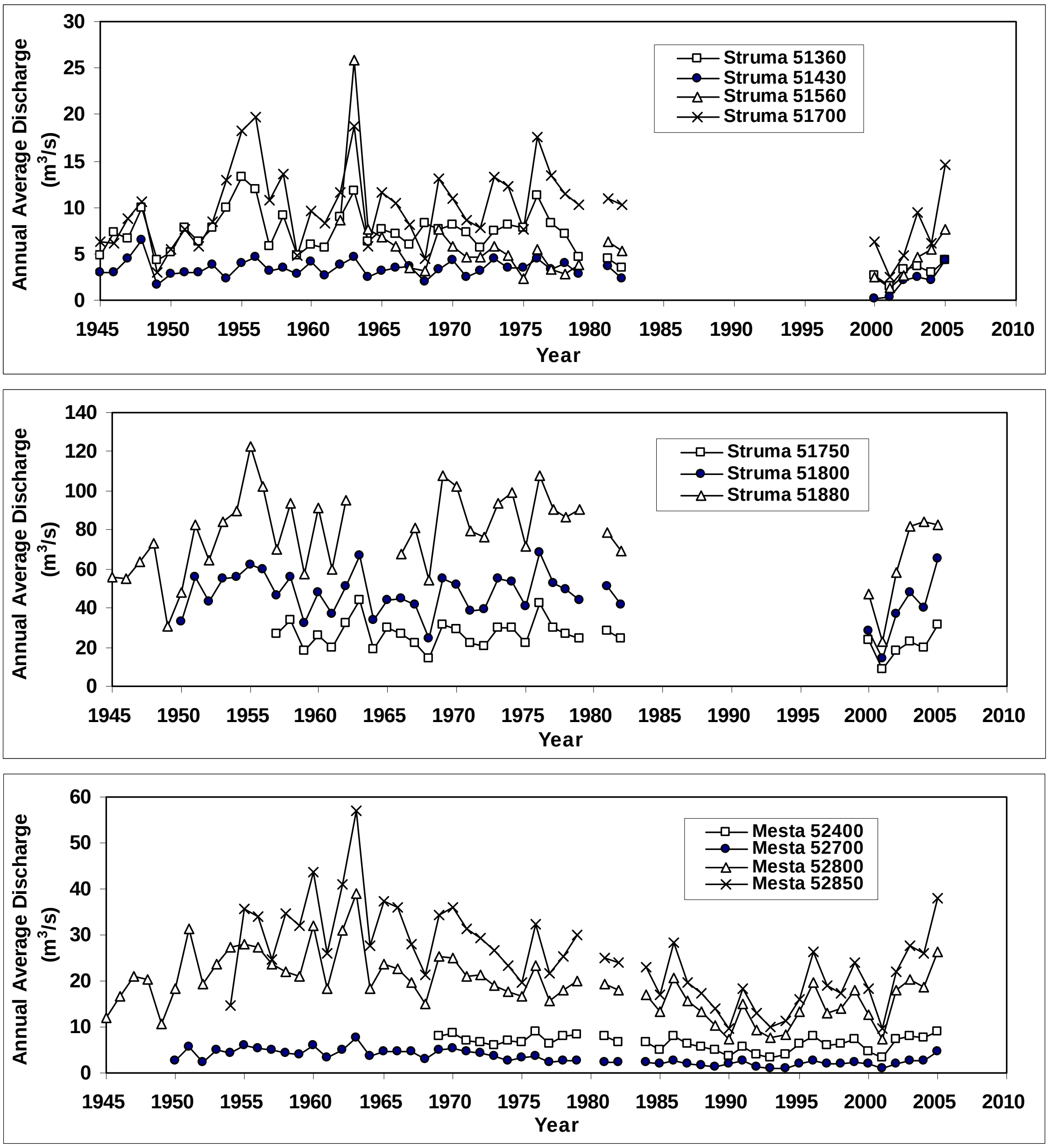
Source: JICA Study Team

Figure B.2.26 Main River Network in WABD



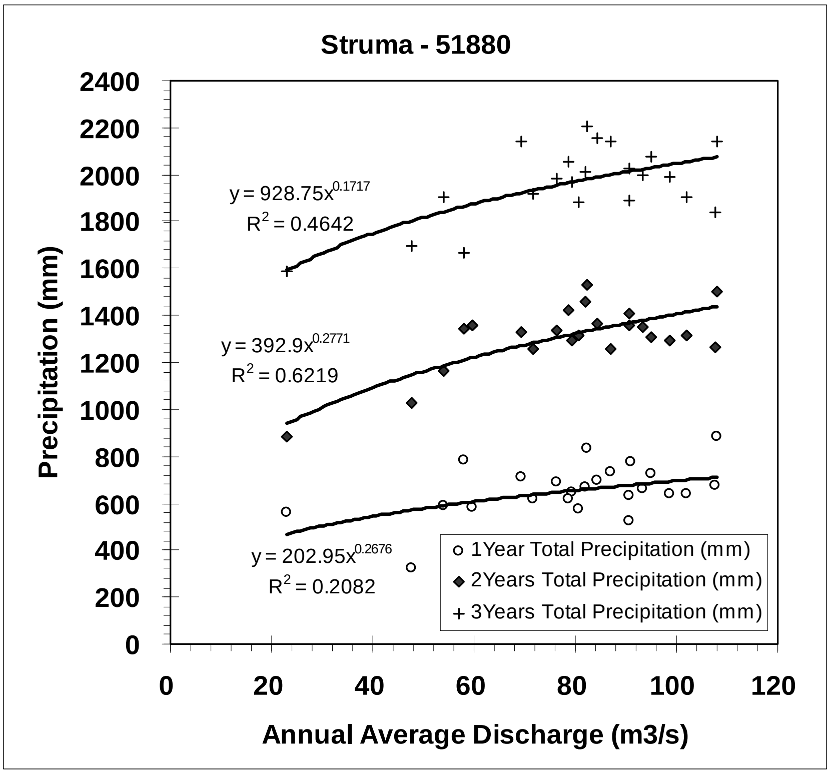
Source: JICA Study Team

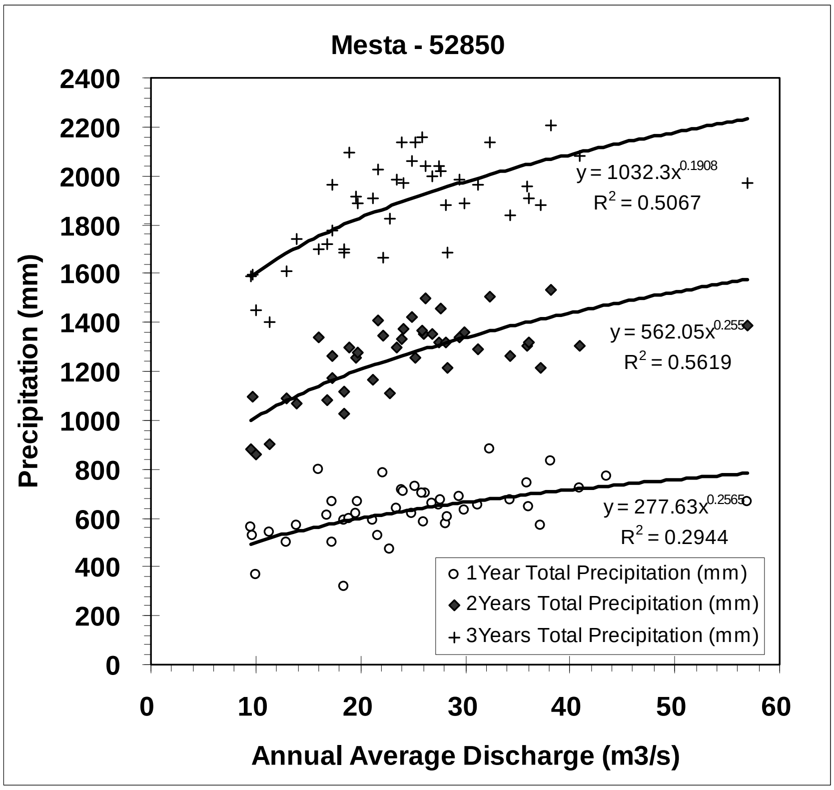
Figure B.2.27 Hydrometric Stations and Those Watershed Areas in WABD



Source: JICA Study Team

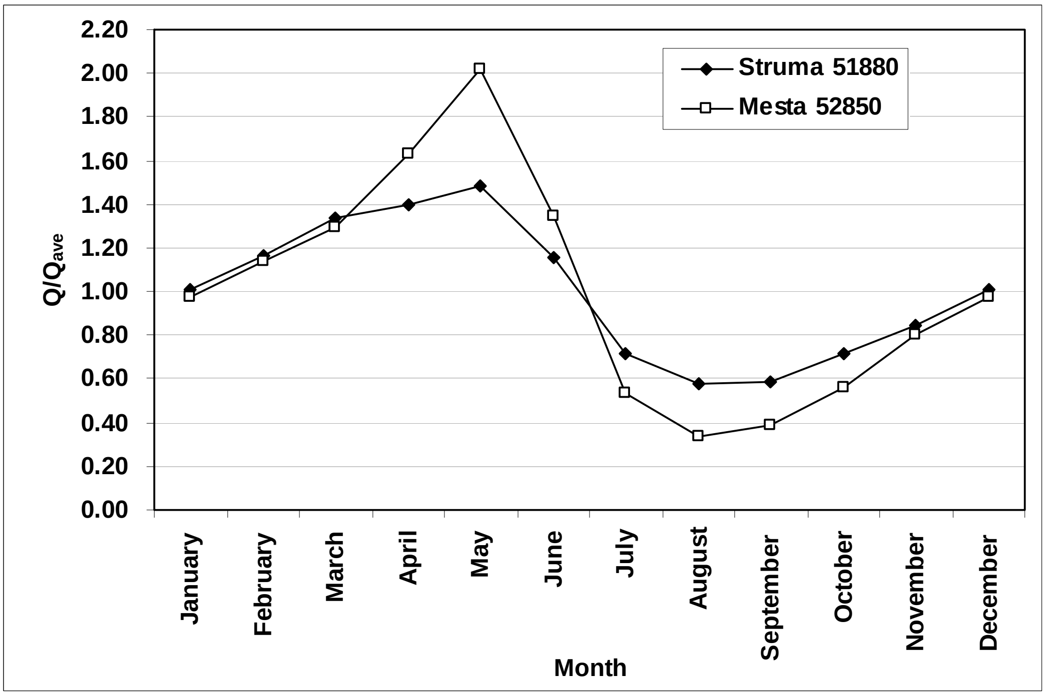
Figure B.2.28 Observed Annual Average Discharge in WABD





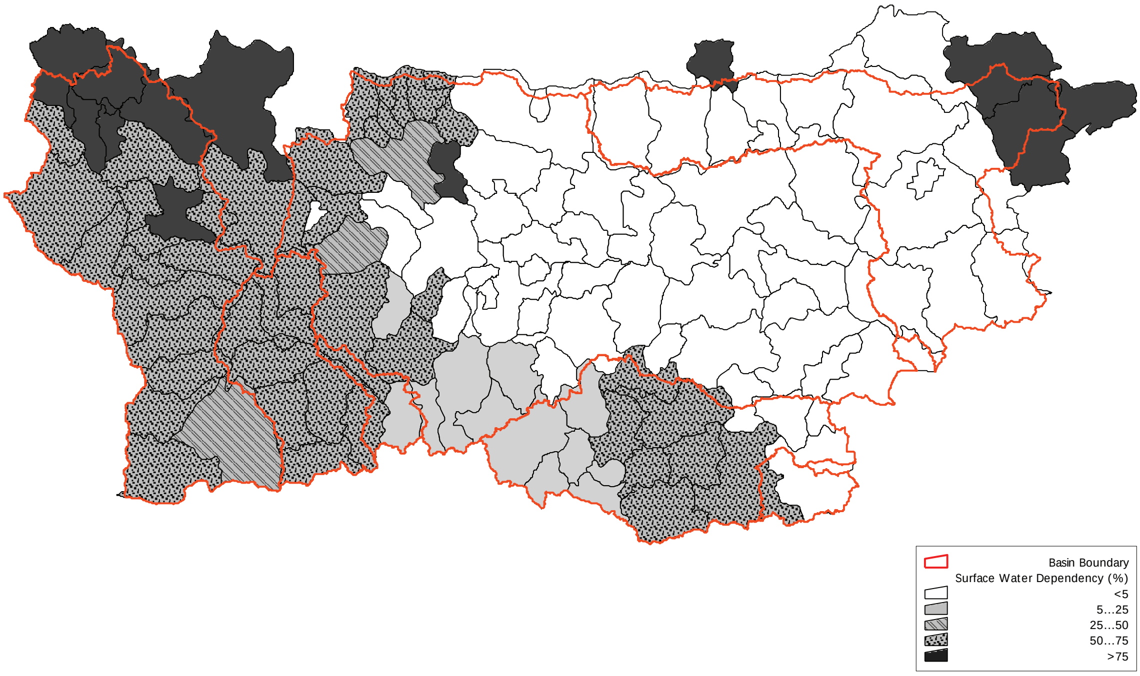
Source: JICA Study Team

Figure B.2.29 Relationship between Total Precipitation and Annual Average Discharge in WABD



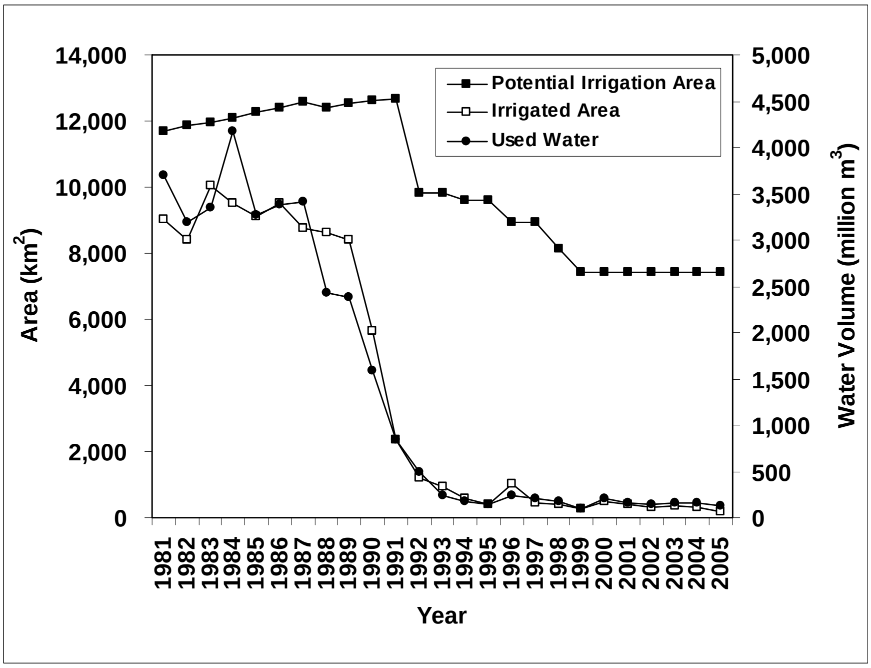
Source: JICA Study Team

Figure B.2.30 Long-term Averaged Monthly Variation of Discharge for Selected Hydrometric Stations in WABD



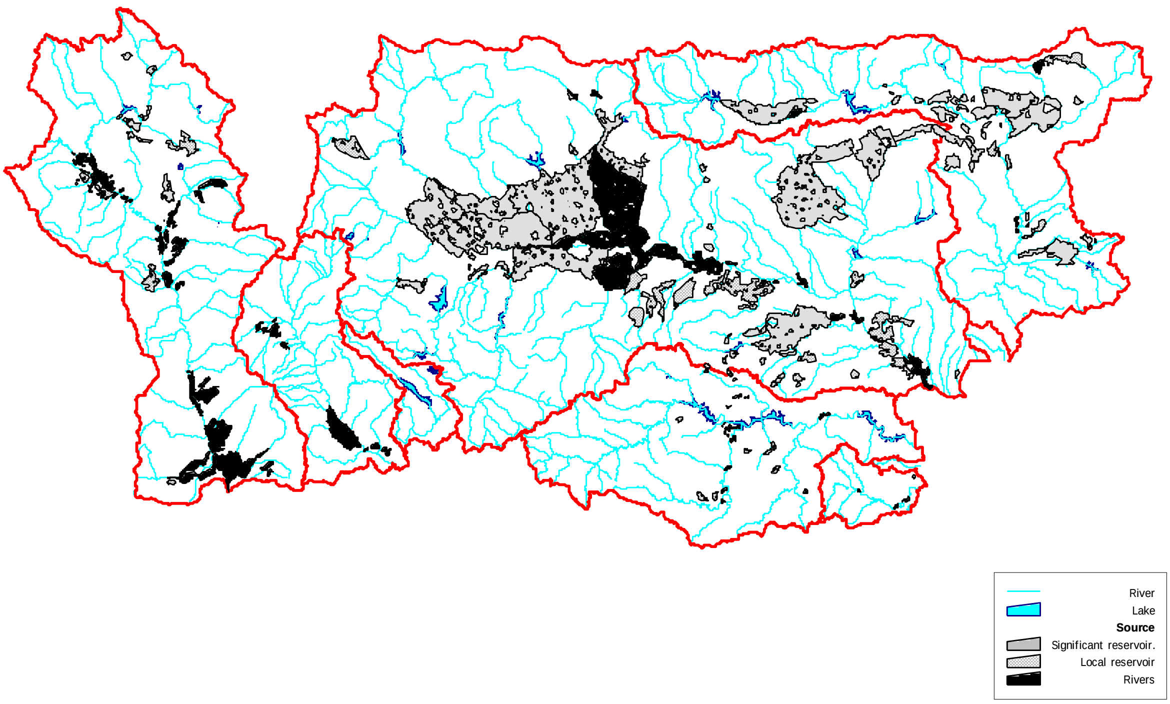
Source: JICA Study Team based on Date by WS&S Company

Figure B.3.1 Surface Water Dependency of Domestic Water Supply in EABD and WABD



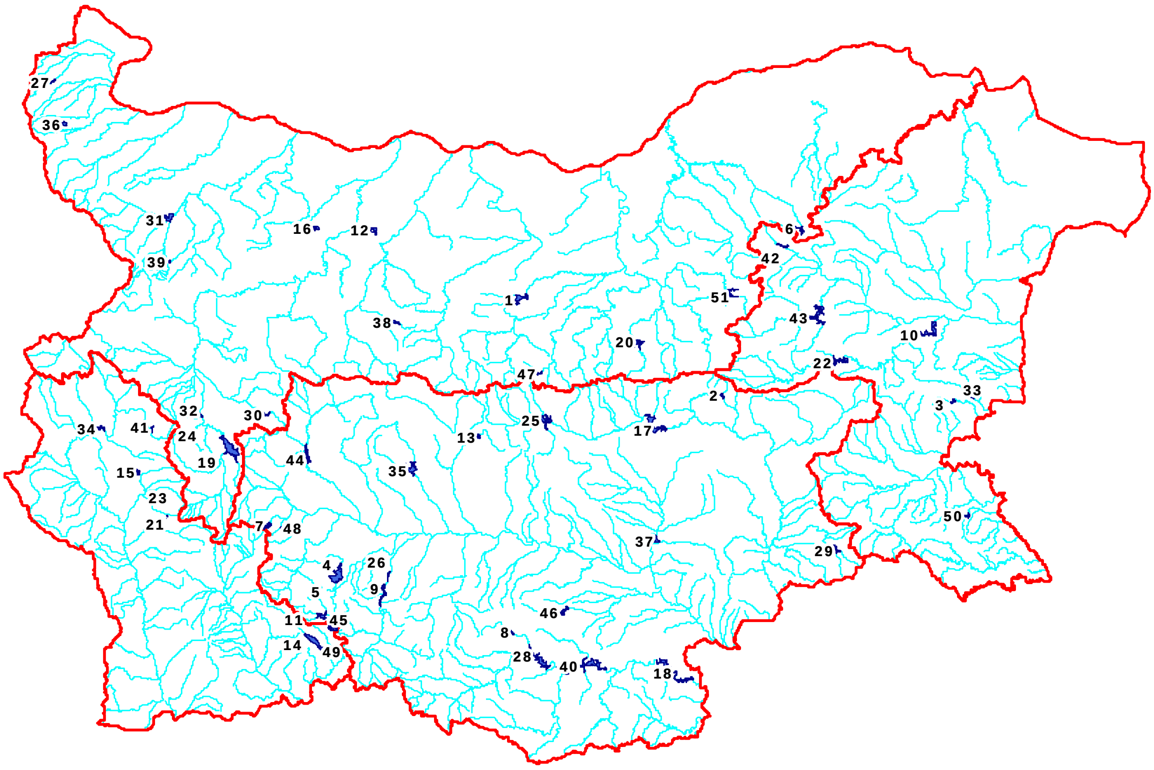
Source: Irrigation Systems Ltd.

Figure B.3.2 Change in Irrigated Area and Used Water



Source: JICA Study Team

Figure B.3.3 Irrigation Area Set-Up by Irrigation System in EABD and WABD

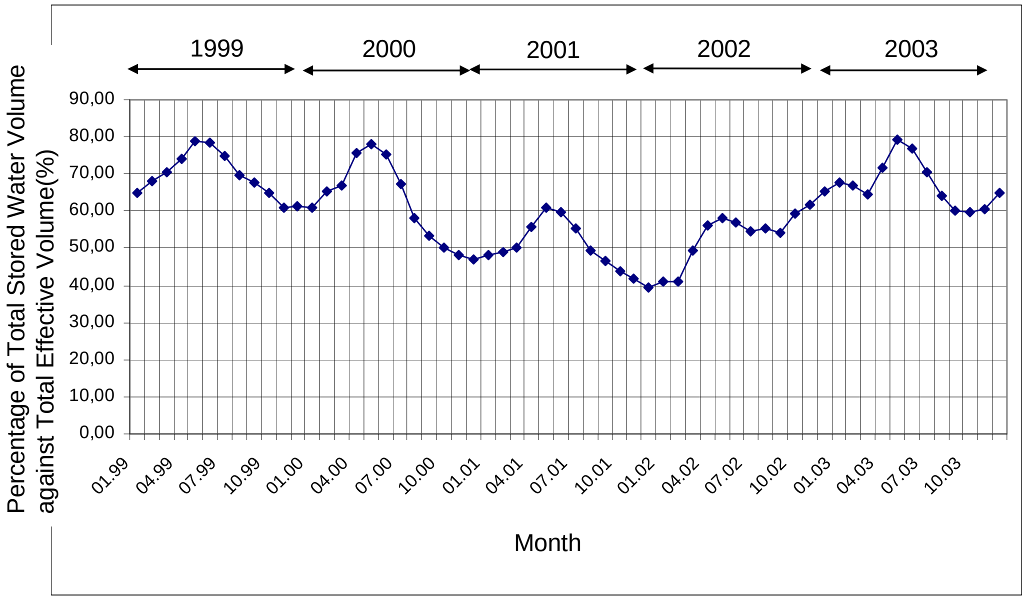


Basin Directorate	Basin	No.	Name	Gross Storage Volume
DRBD	Ogosta	31	Ogosta	505.0
		39	Srechenska Bara	15.5
	Iskar	16	Enitsa	37.6
		19	Iskar	673.0
		24	Kokalyane	2.7
		30	Ognyanovo	35.4
		32	Pancharevo	6.7
	Vit	12	Gorni Dabnik	130.0
		38	Sopot	61.8
	Yantra	1	Aleksandar Stamboliyski	222.0
		20	Yovkovtsi	91.0
		47	Hristo Smirnenski	18.7
		51	Yastrebino	62.8
	Rusenski	6	Beli Lom	25.5
	Topolovetz	27	Kula	20.2
	Vidbol	36	Rabisha	45.0
BSBD	Kamchia	22	Kamchia	229.0
		10	Georgi Traikov	329.0
		42	Saedinenie	12.8
		43	Ticha reservoir	311.8
	Aheloy	3	Aheloy	12.6
	Diavolska	50	Yasna Polyana	35.3
	Hadzhidere	33	Poroy	45.2

Basin Directorate	Basin	No.	Name	Gross Storage Volume
EABD	Tundzha	29	Malko Sharkovo	50.0
		2	Asenovets	28.2
		17	Zhrebchevo	400.0
		25	Koprinka	142.2
	Maritsa	4	Batak	310.0
		5	Beglika	1.6
		7	Belmeken	144.0
		9	Vacha	226.1
		11	Golyam Beglik	62.1
		13	Domlyan	27.0
		26	Krichim	20.3
		35	Pyasachnik	206.5
		37	Rozov Kladenets	20.4
		44	Topolnitsa	137.1
		45	Toshkov Chark	1.8
		46	Trakiets	114.0
		48	Chaira	5.5
	Arda	8	Borovitsa	31.0
		18	Ivaylovgrad	188.0
		28	Kardzhali	532.9
		40	Studen Kladenets	489.0
WABD	Struma	15	Dyakovo	35.0
		21	Kalin	1.0
		23	Karagyol	2.3
		34	Pchelina	54.8
		41	Studena	25.2
	Dospat	14	Dospat	446.0
		49	Shiroka Polyana	24.0
Total				**6,654.5**

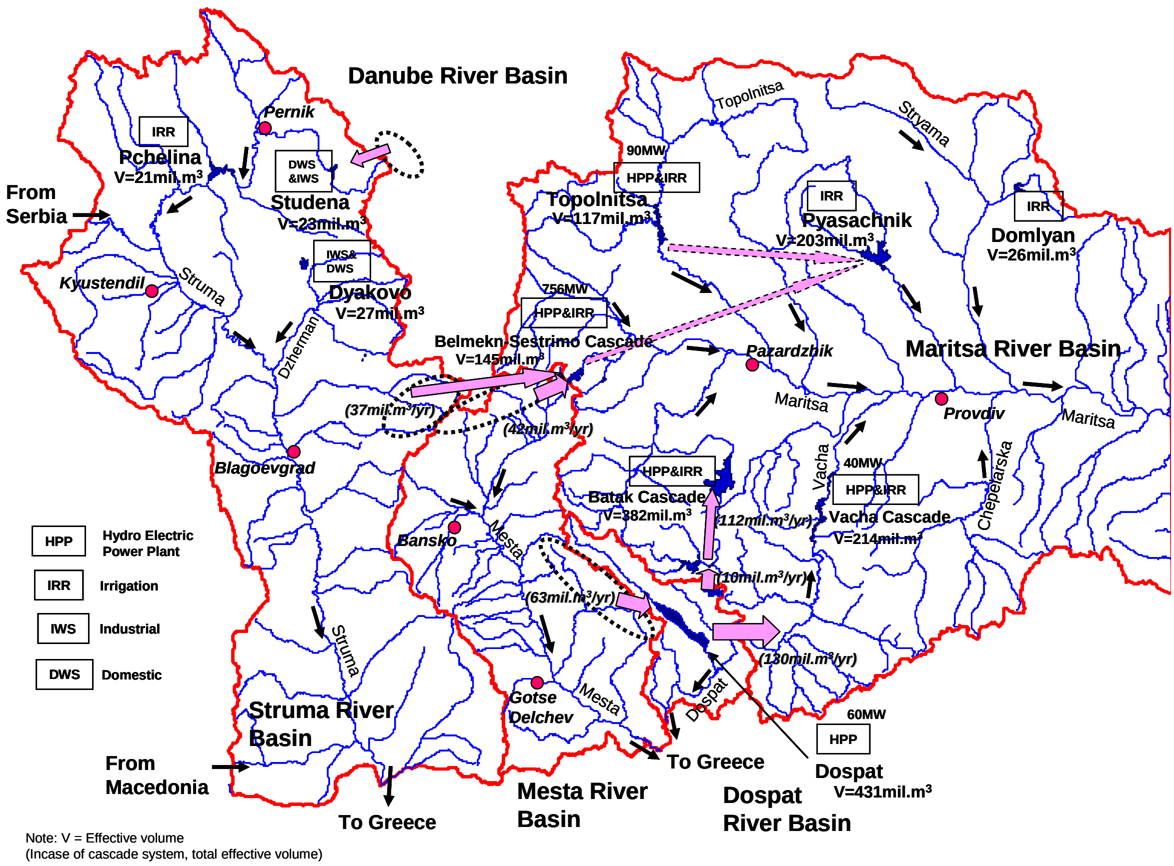
Source: JICA Study Team

Figure B.3.4 Location of Significant Reservoir



Source: MOEW Bulletin

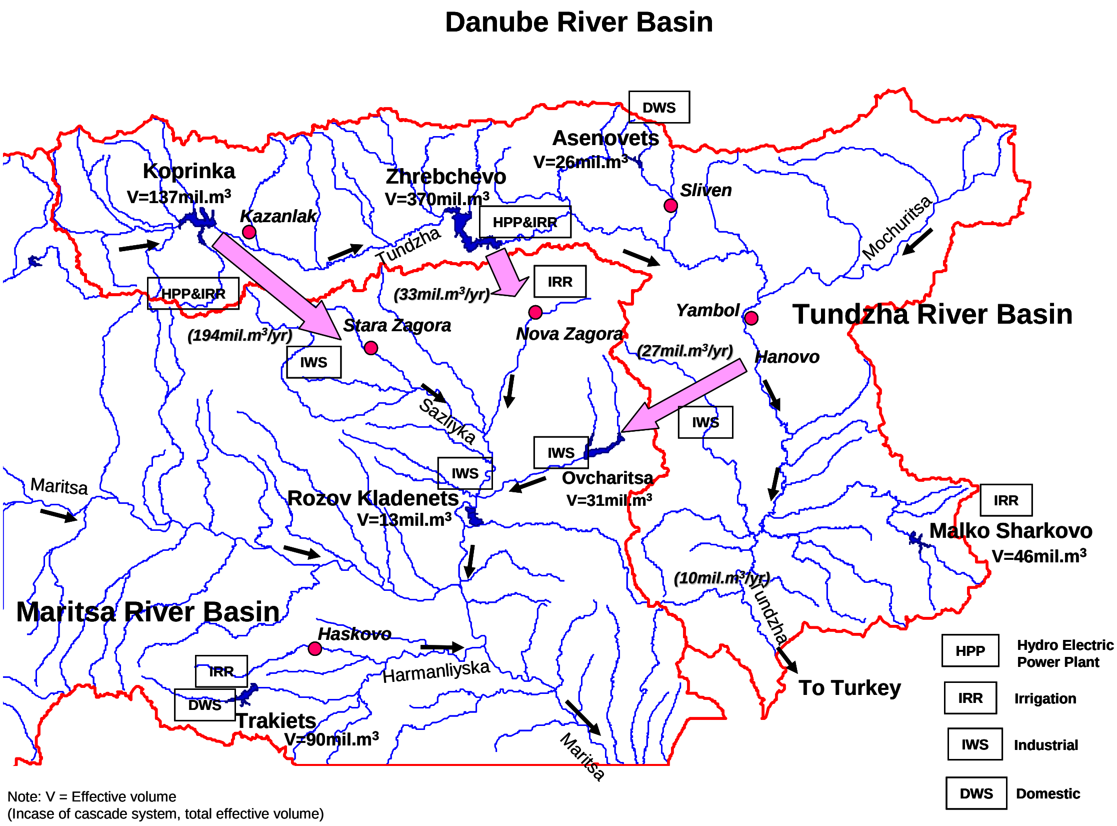
Figure B.3.5 Change in Percentage of Total Stored Water Volume against Total Effective Volume of Significant Reservoirs



Note: ( ) shows the estimated amount of inter-basin water transfer in 2001-2005.

Source: JICA Study Team

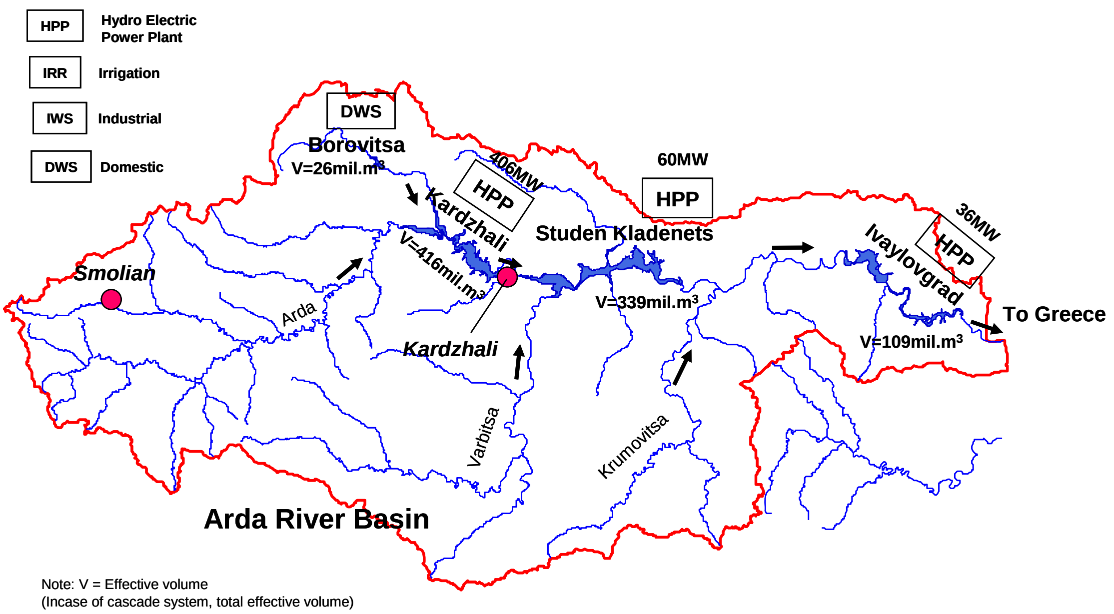
Figure B.3.6 Main Water Transfer Related to Significant Reservoirs among River Basins in EABD, WABD and DRBD



Note: ( ) shows the estimated amount of inter-basin water transfer in 2001-2005.

Source: JICA Study Team

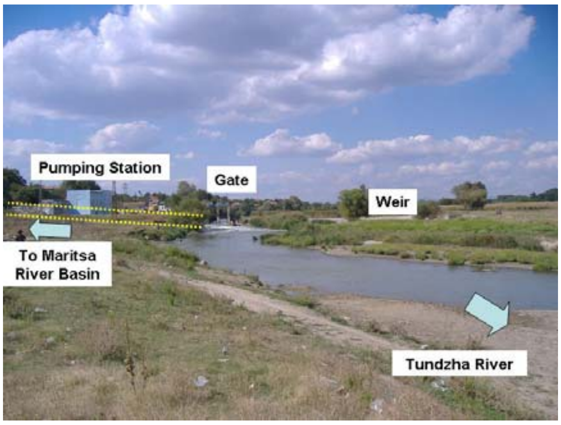
Figure B.3.7 Main Water Transfer Related to Significant Reservoirs among Tundzha, Maritsa and Danube River Basins

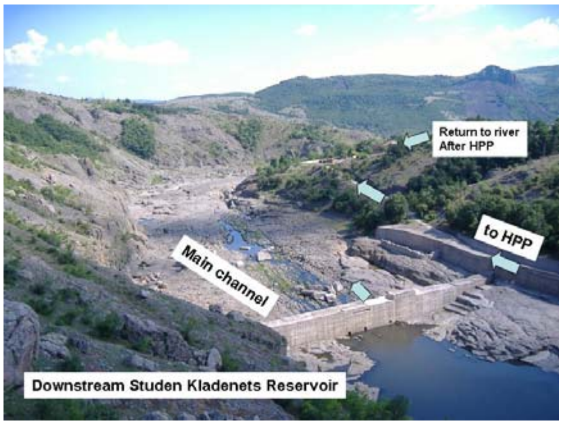


Source: JICA Study Team

Figure B.3.8 Main Water Transfer Related to Significant Reservoirs in Arda River Basin

Koprinka Reseroir **Zhrebchevo Reservoir**



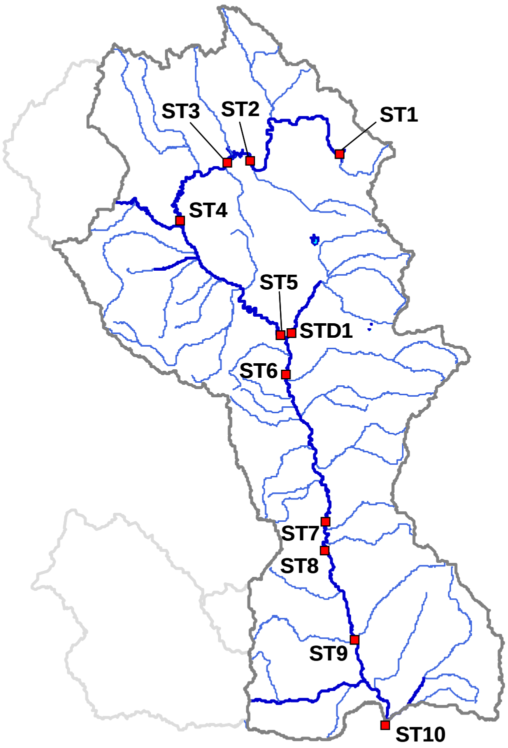


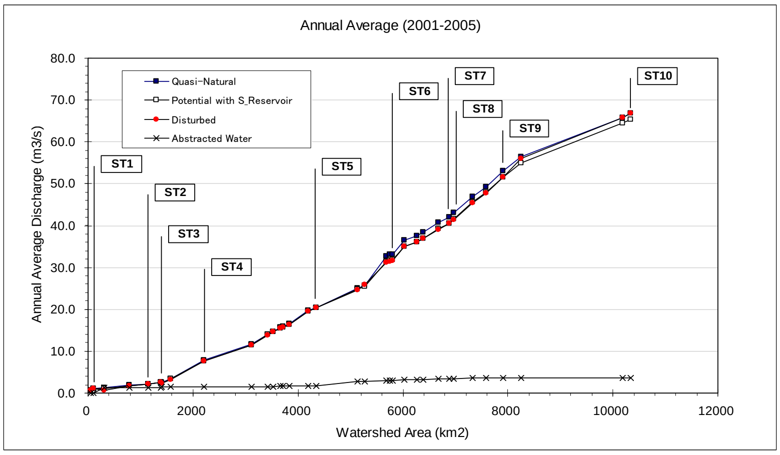
Pumping Station near Hanovo **Studen Kladenets Reservoir**

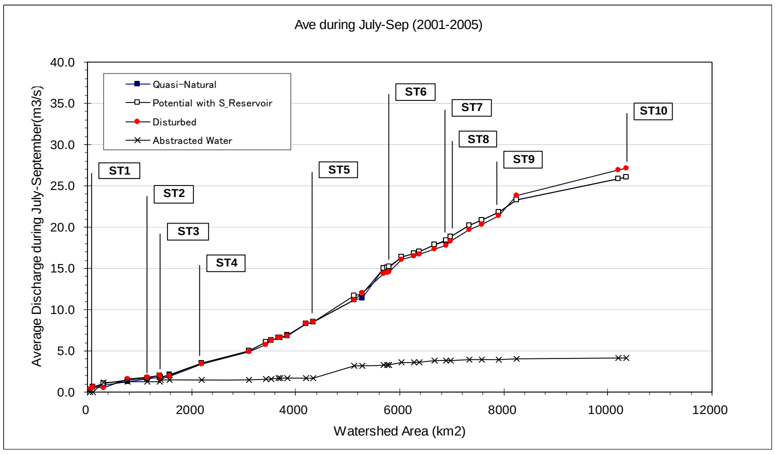
Abstracted water is transferred from the Tundzha River Basin to the Maritsa River Basin

Source: JICA Study Team

Figure B.3.9 Photos for Some Facilities

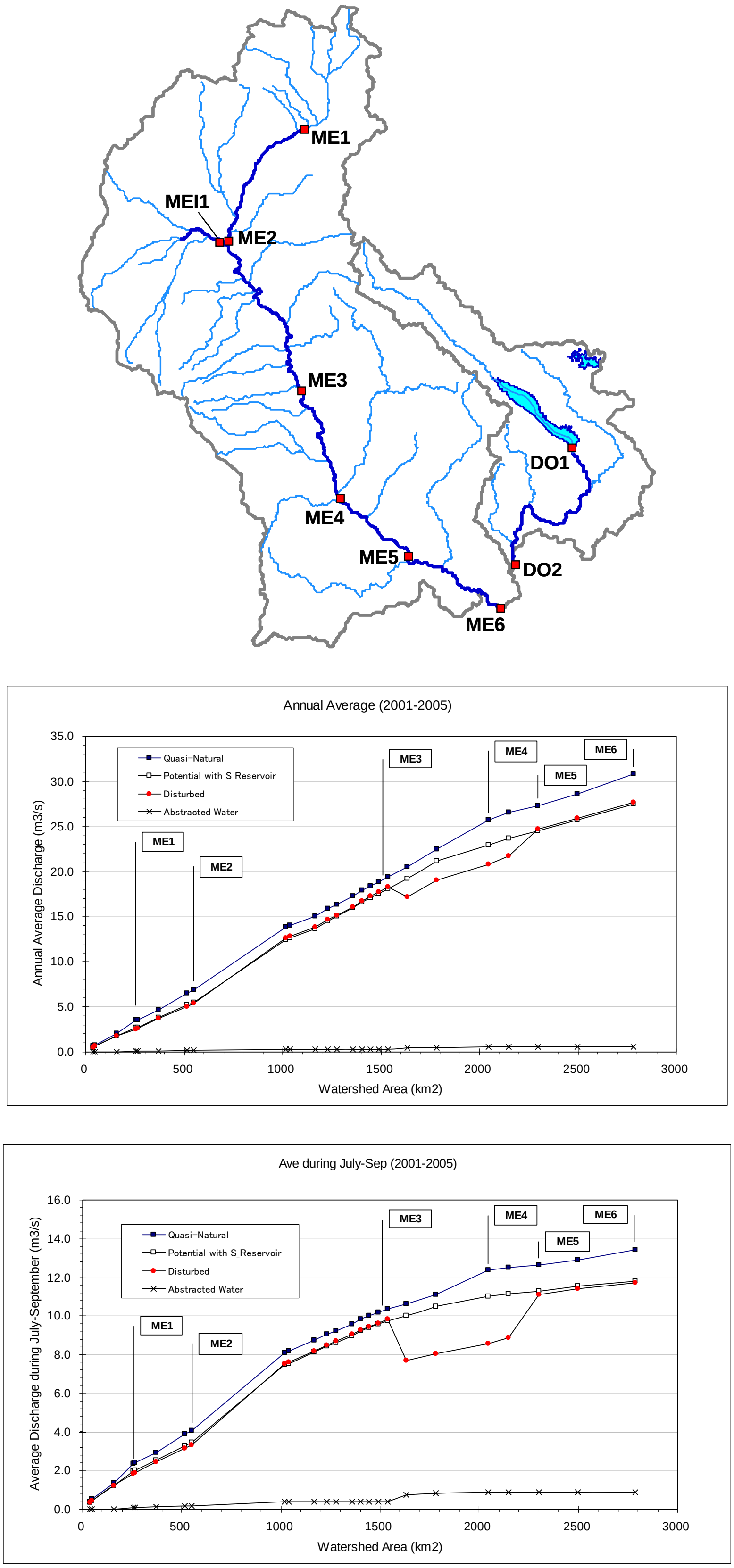






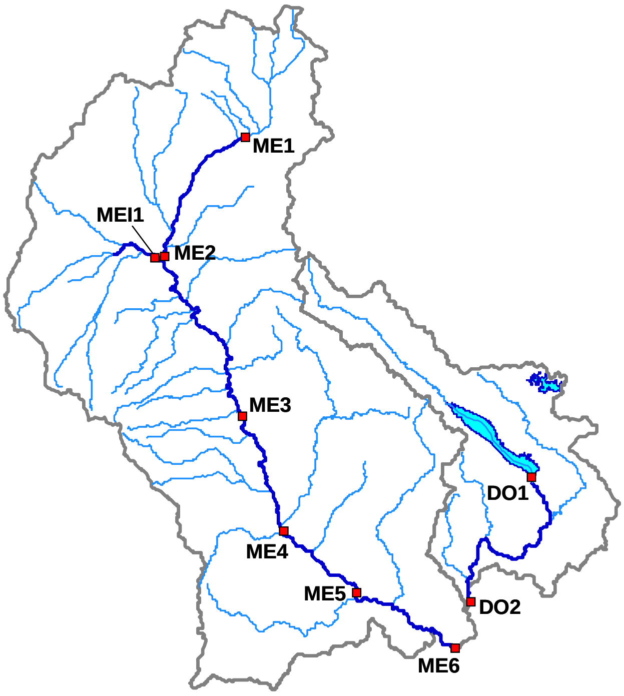
Source: JICA Study Team

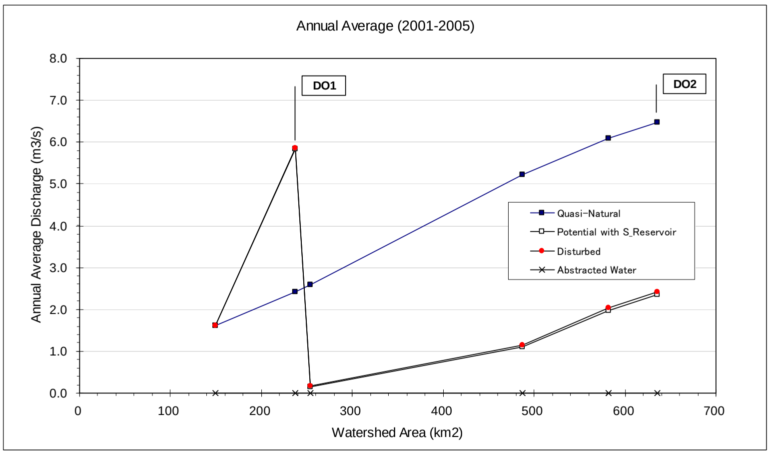
Figure B.4.1 Water Balance along Main Stream of Struma River Basin

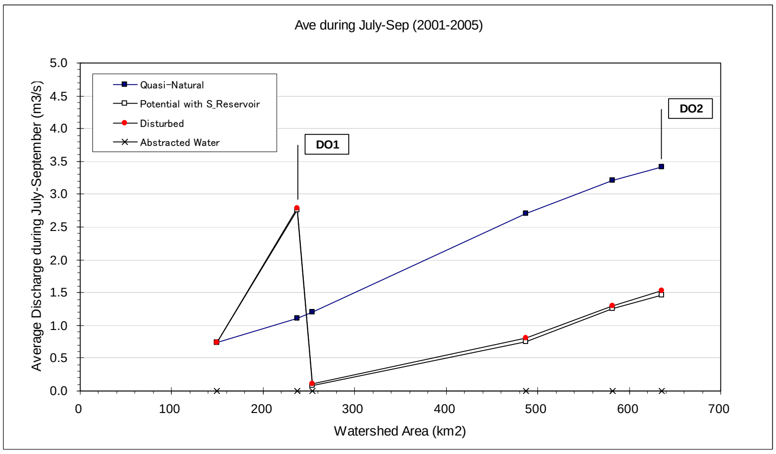


Source: JICA Study Team

Figure B.4.2 Water Balance along Main Stream of Mesta River Basin

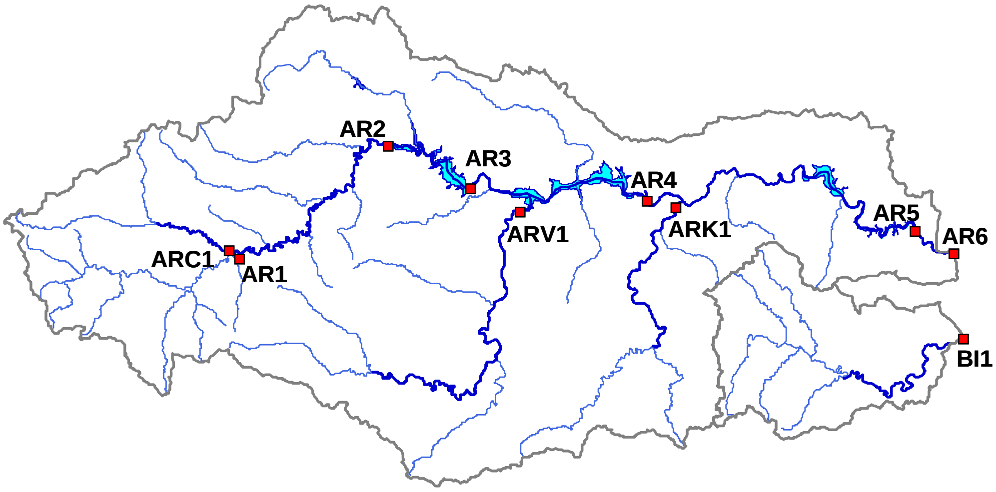


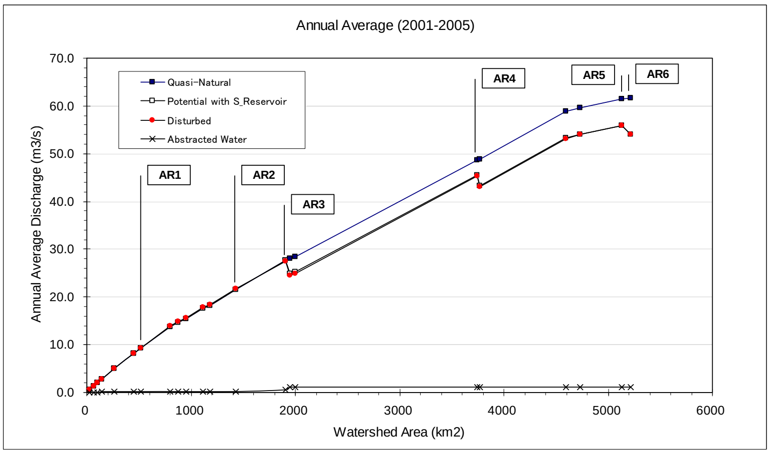


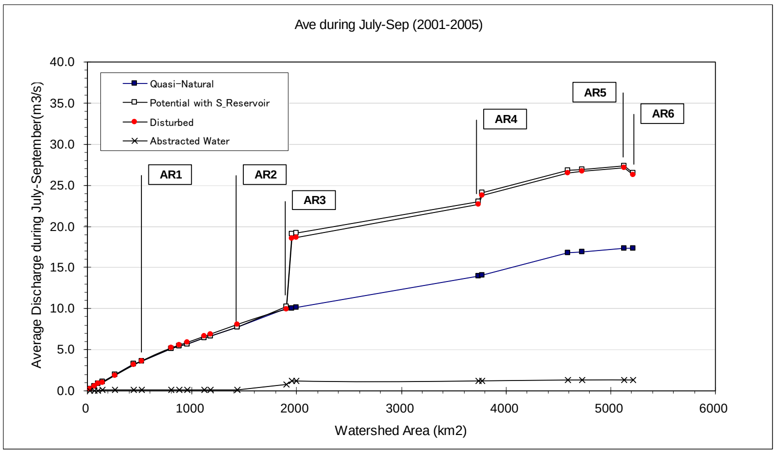


Source: JICA Study Team

Figure B.4.3 Water Balance along Main Stream of Dospat River Basin

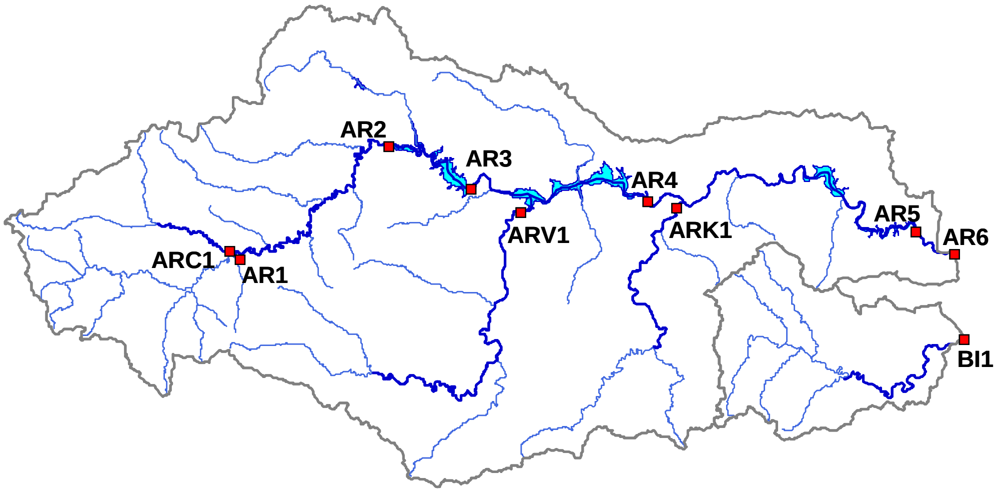


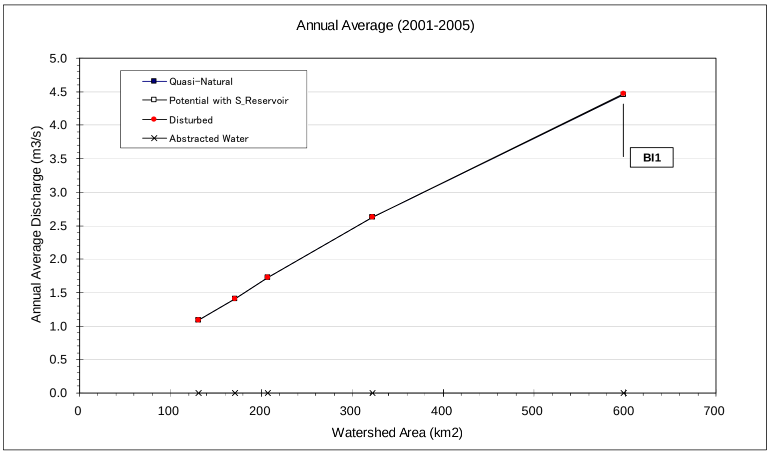


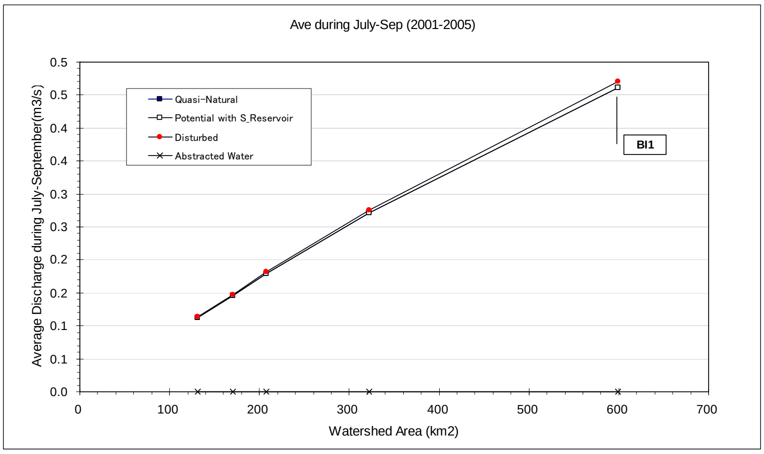


Source: JICA Study Team

Figure B.4.4 Water Balance along Main Stream of Arda River Basin

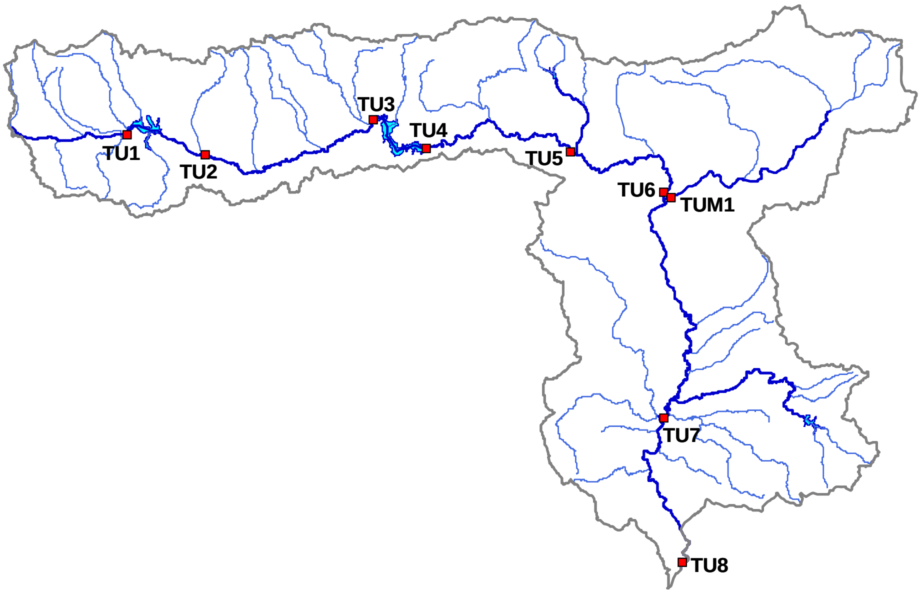


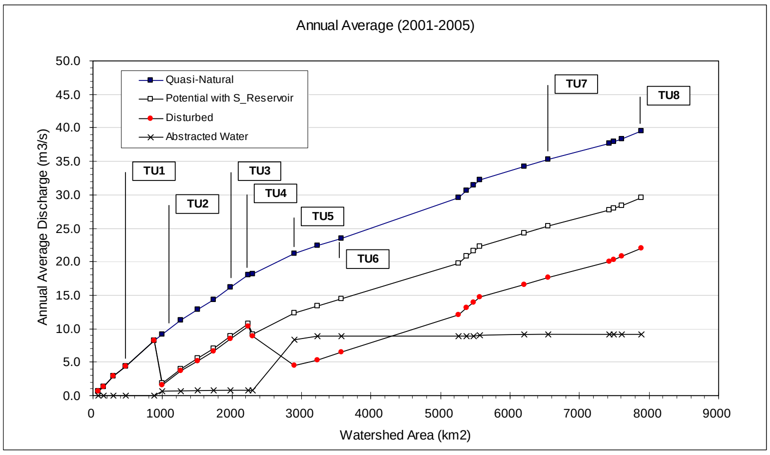


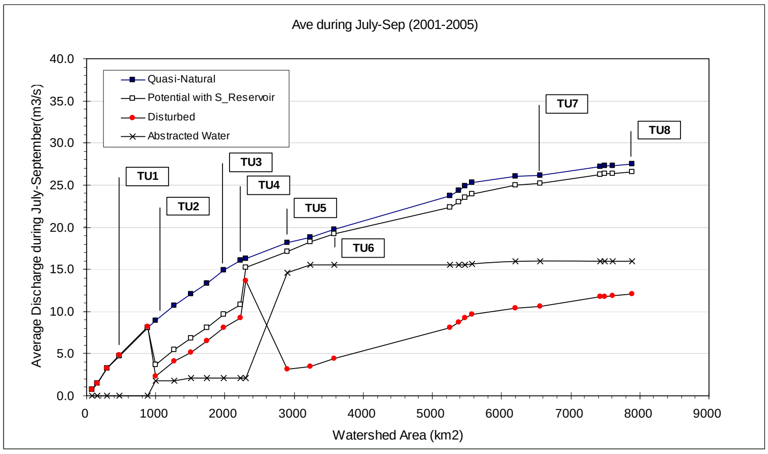


Source: JICA Study Team

Figure B.4.5 Water Balance along Main Stream of Biala River Basin

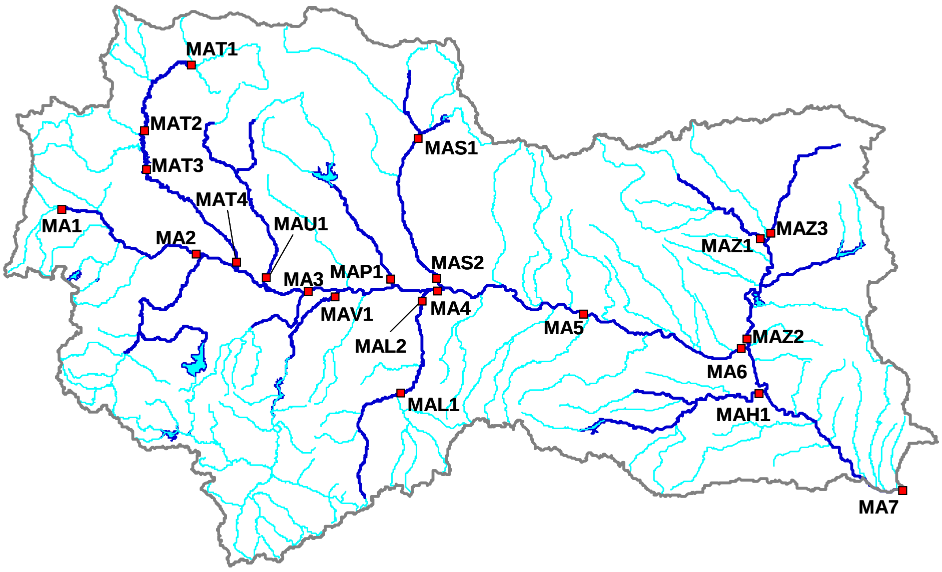


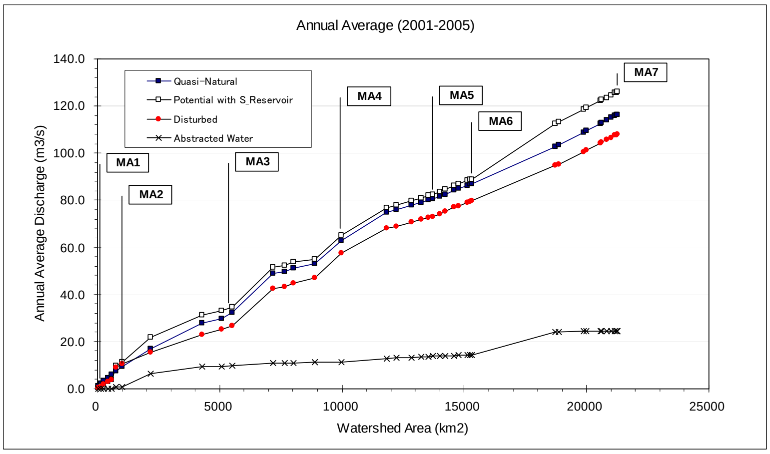


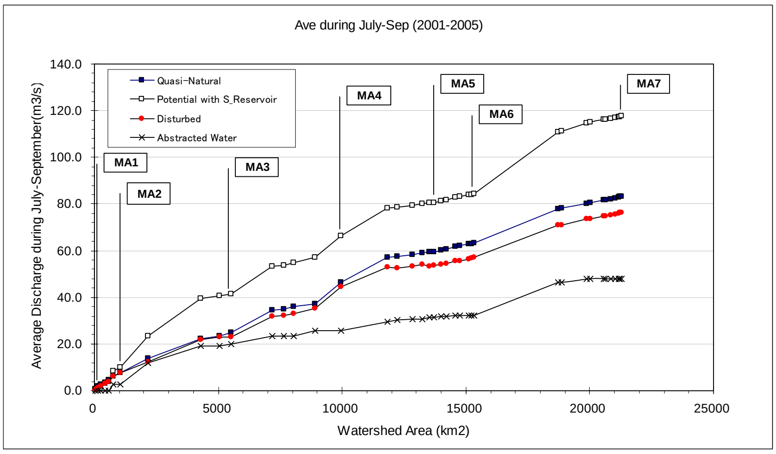


Source: JICA Study Team

Figure B.4.6 Water Balance along Main Stream of Tundzha River Basin







Source: JICA Study Team

Figure B.4.7 Water Balance along Main Stream of Maritsa River Basin

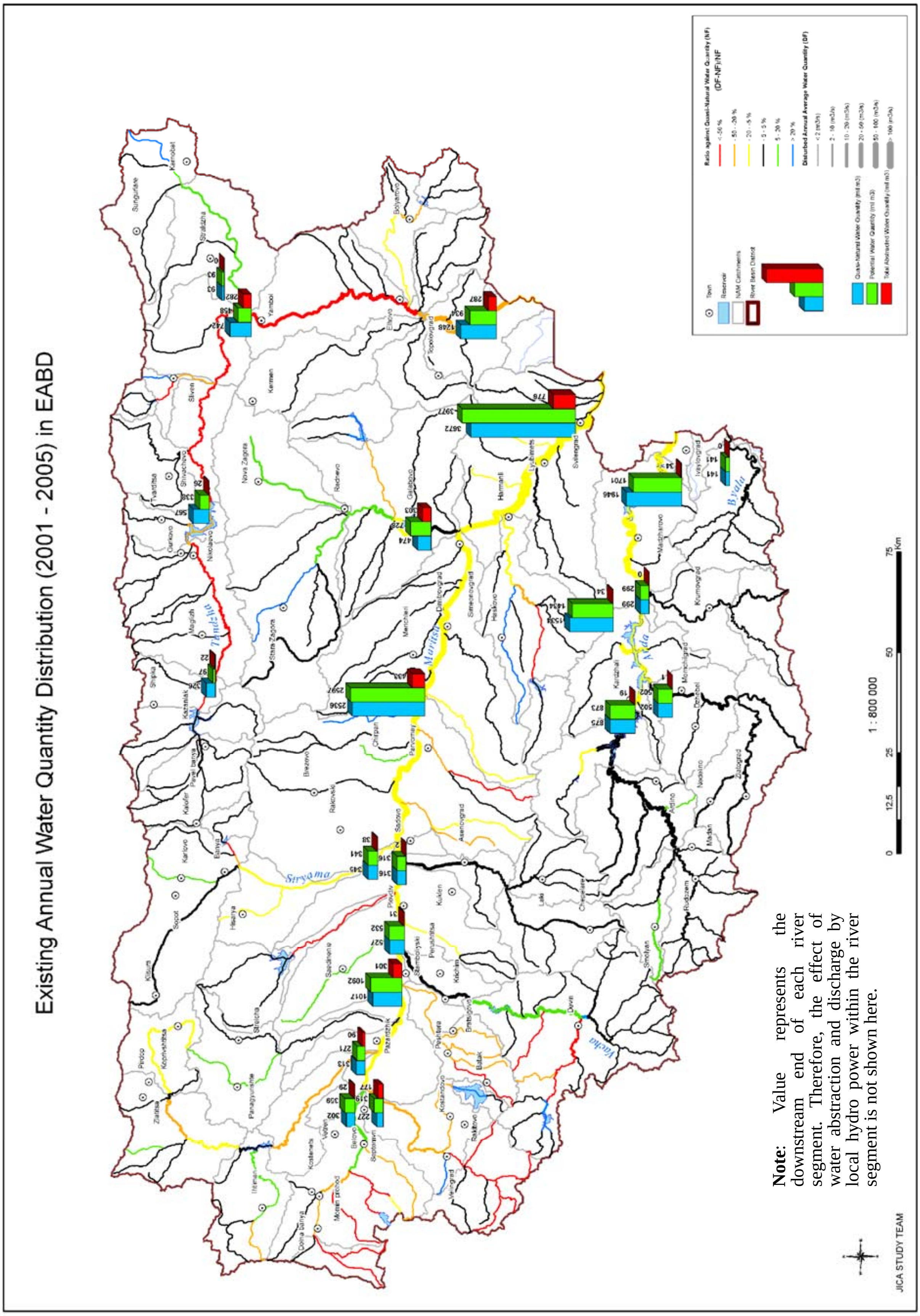


Figure B.4.8 Water Balance including Inter-Basin Water Transfer in EABD (Average in 2001 – 2005)

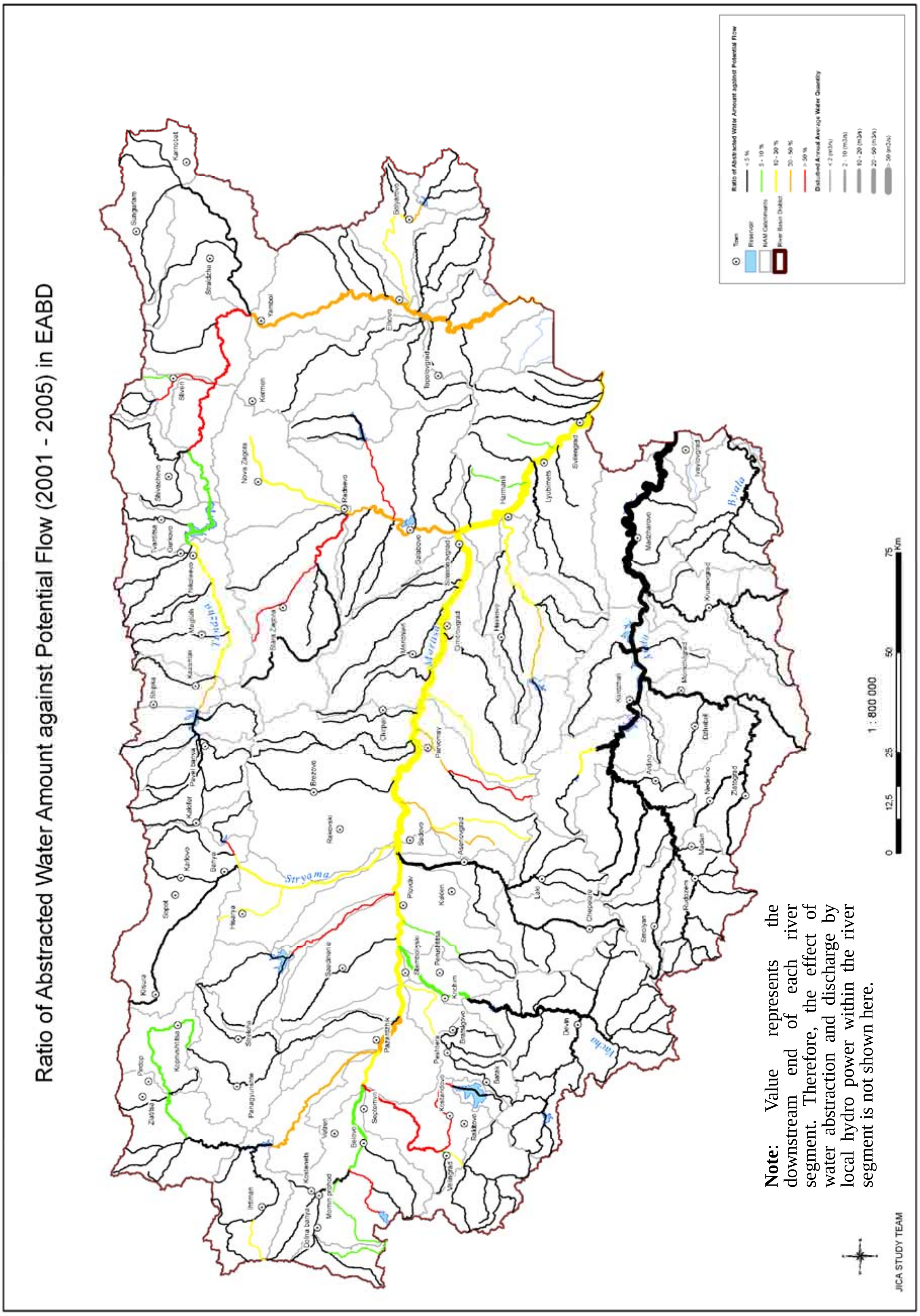


Figure B.4.9 Ratio of Abstracted Water Amount against Potential Flow in EABD (Average in 2001 – 2005)

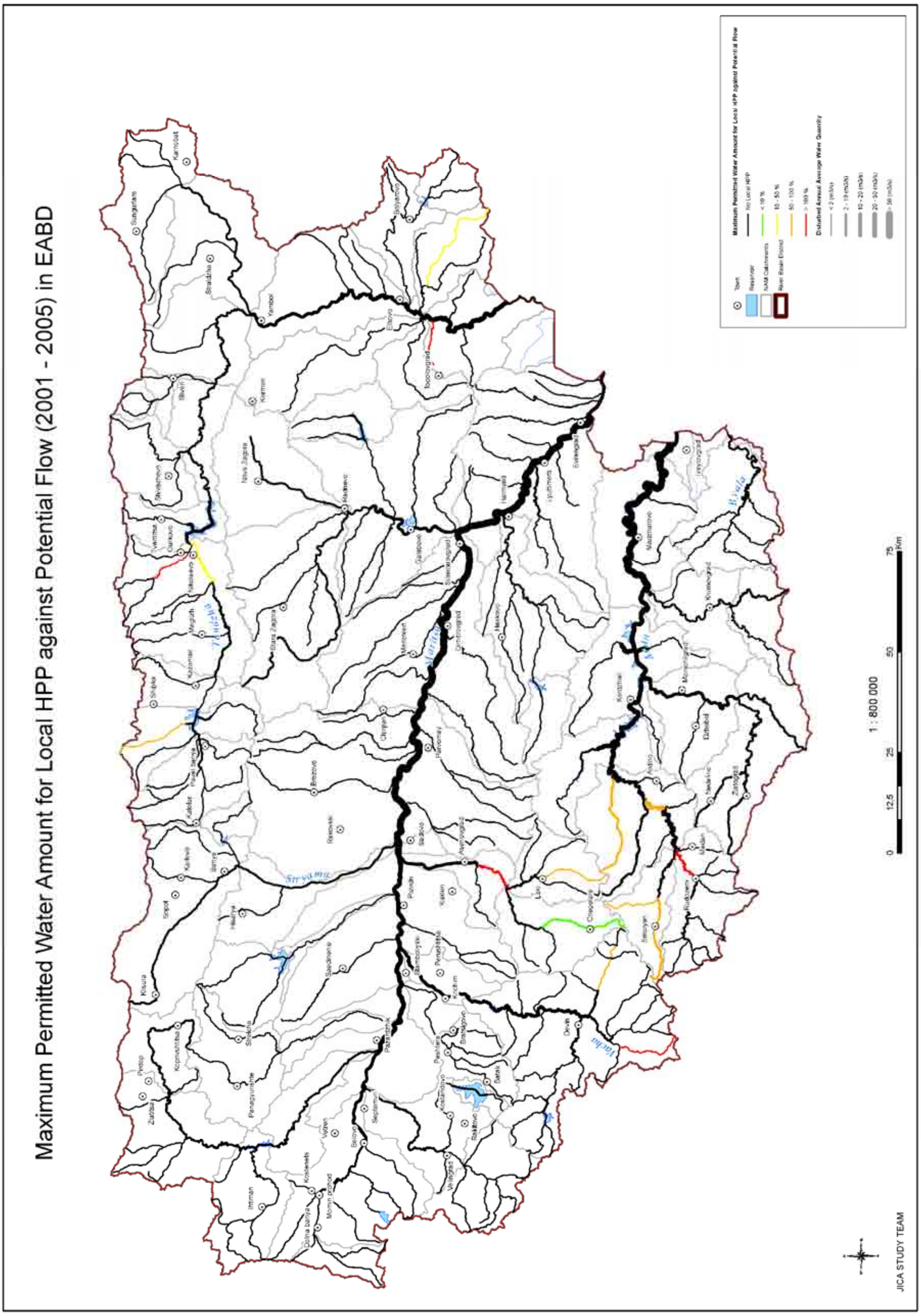


Figure B.4.10 Maximum Permitted Water Amount for Local HPP against Potential Flow in EABD (Average in 2001 –2005)

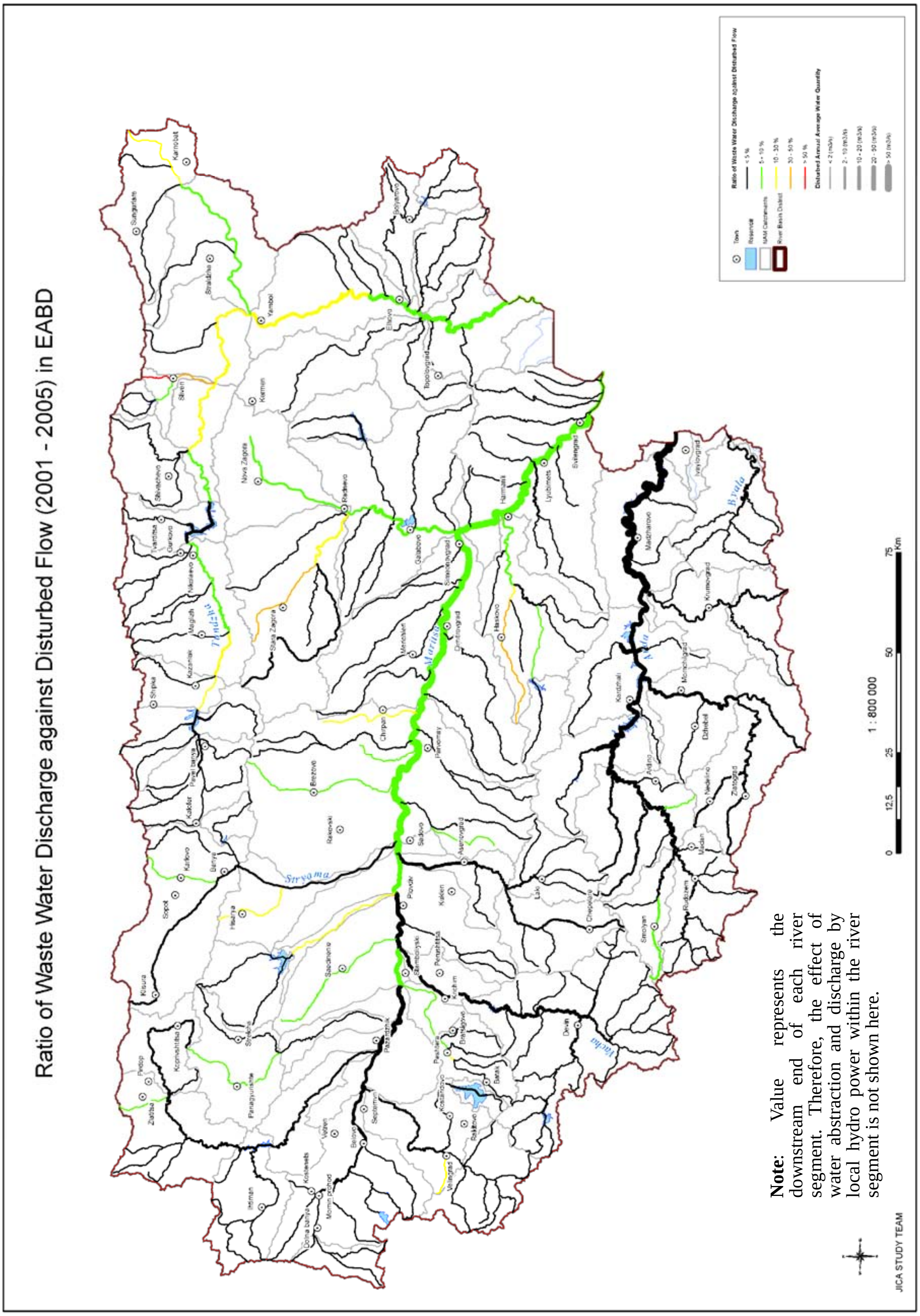


Figure B.4.11 Ratio of Waste Water Discharge against Disturbed Flow in EABD (Average in 2001 – 2005)

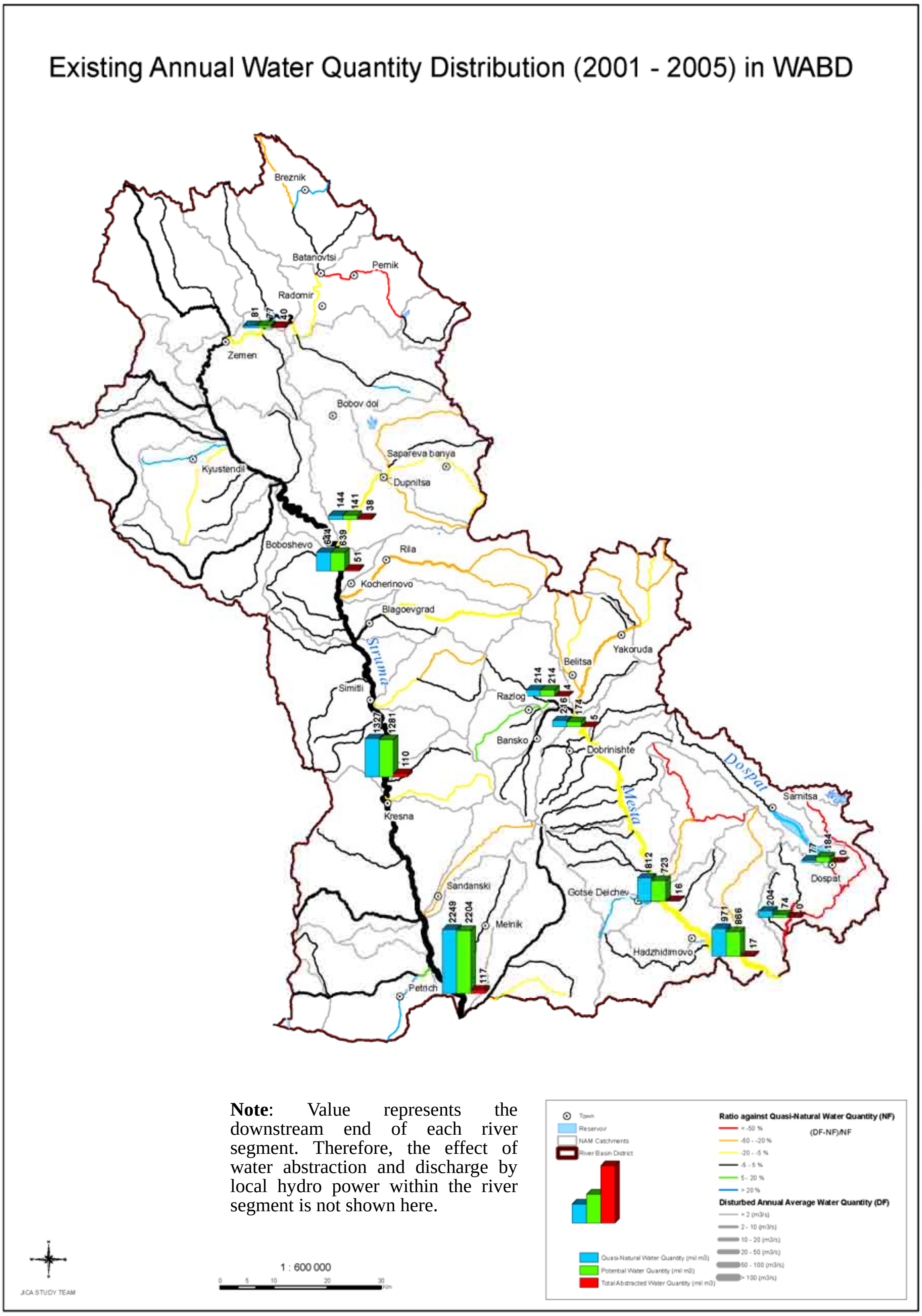


Figure B.4.12 Water Balance including Inter-Basin Water Transfer in WABD (Average in 2001 – 2005)

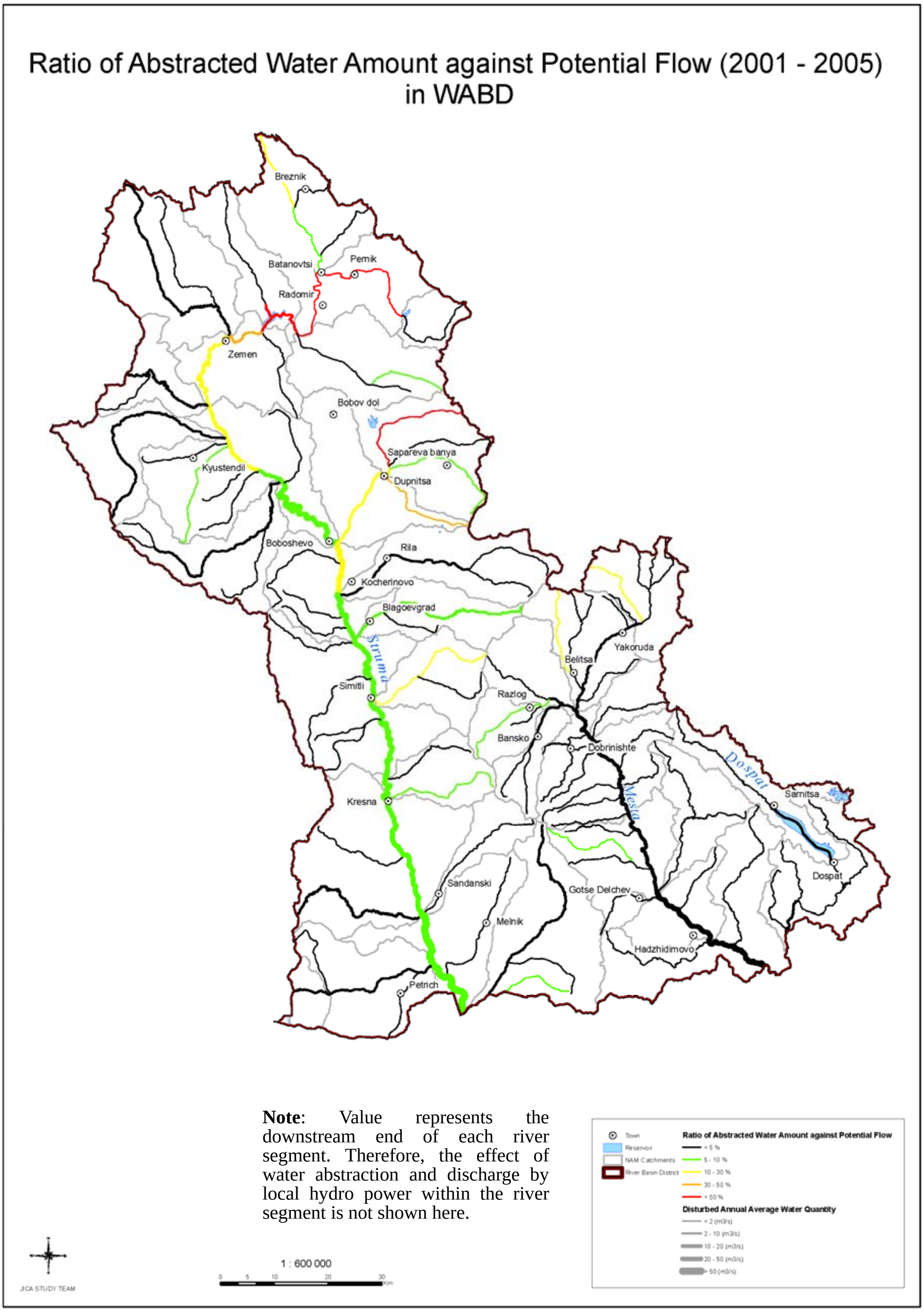


Figure B.4.13 Ratio of Abstracted Water Amount against Potential Flow in WABD (Average in 2001 – 2005)

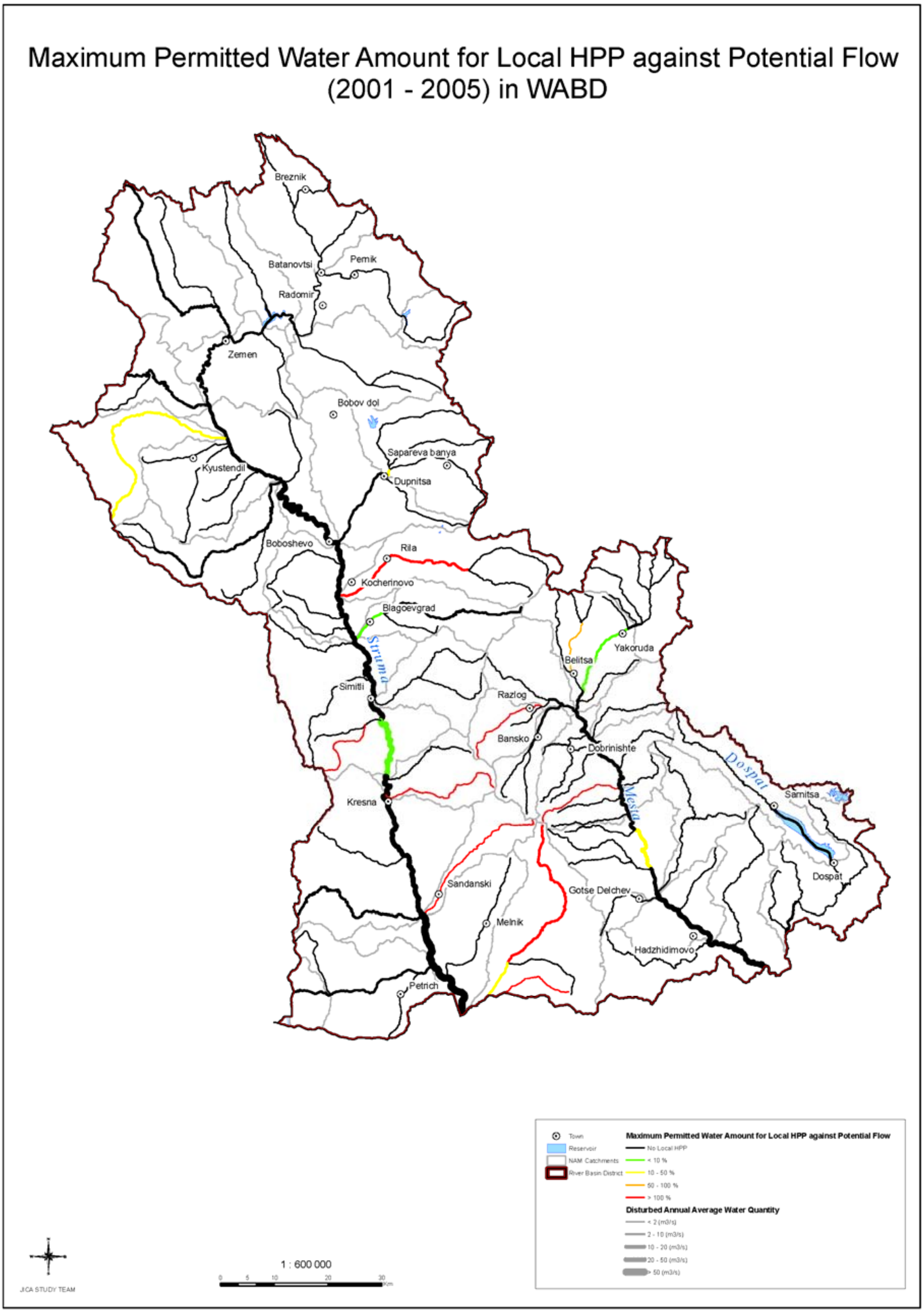


Figure B.4.14 Maximum Permitted Water Amount for Local HPP against Potential Flow in WABD (Average in 2001 – 2005)

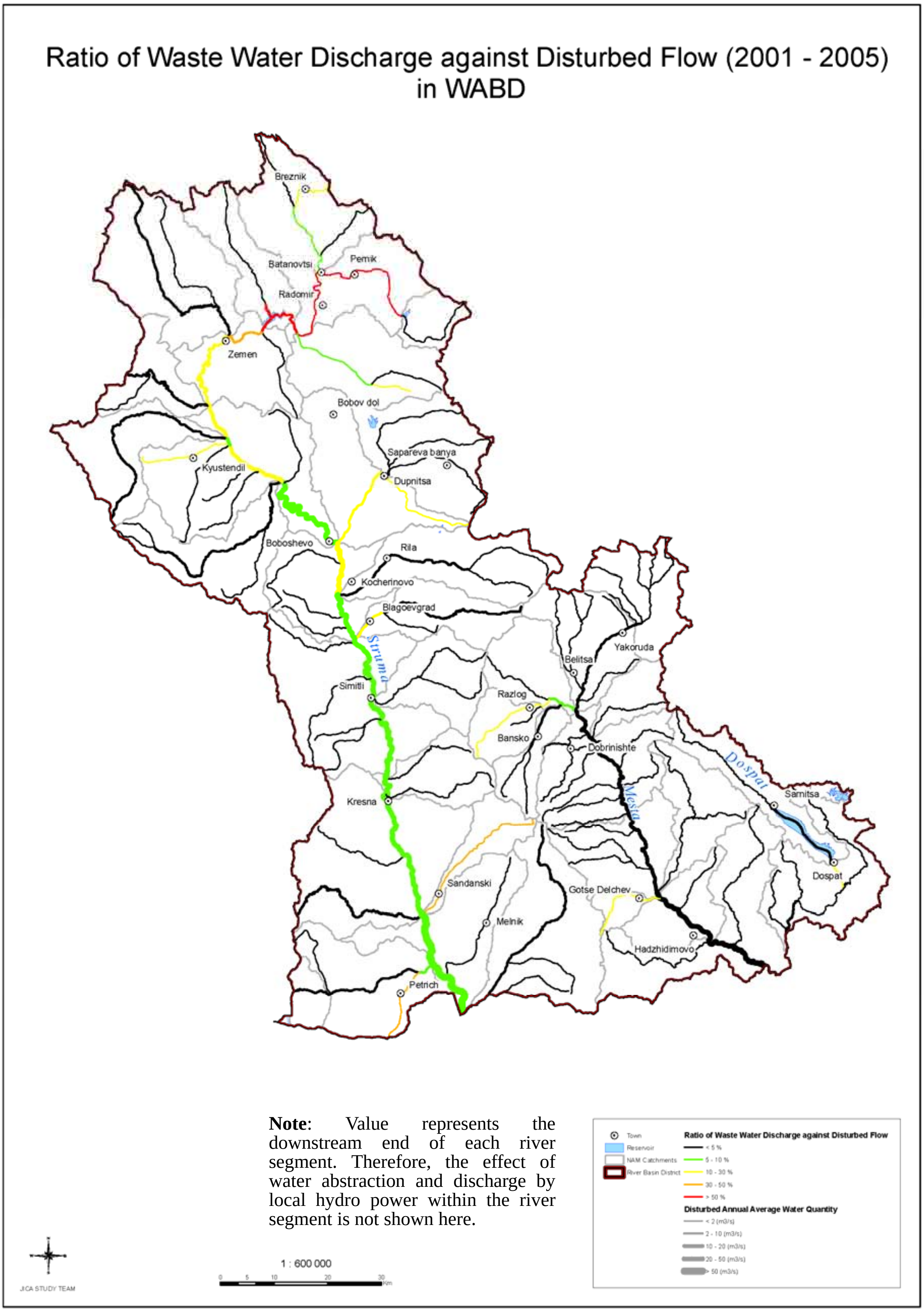
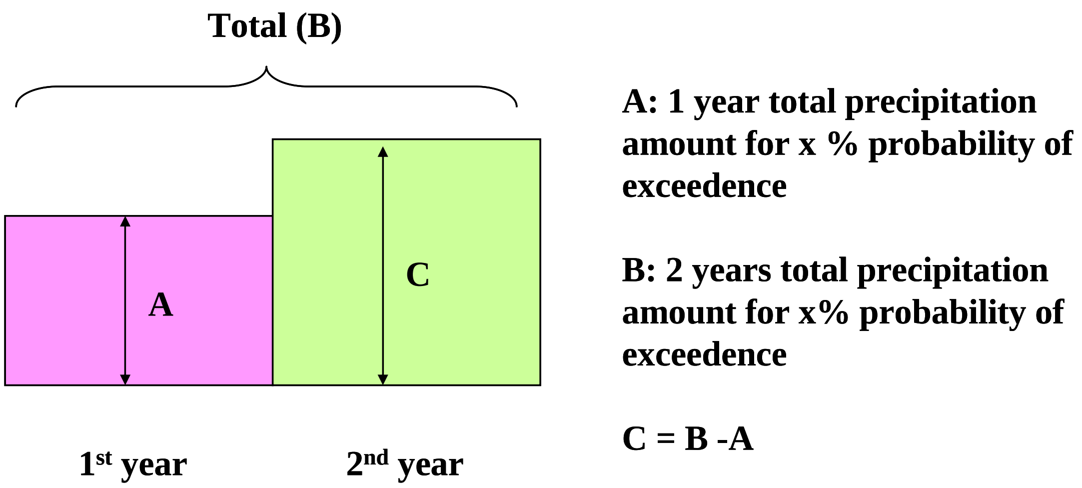
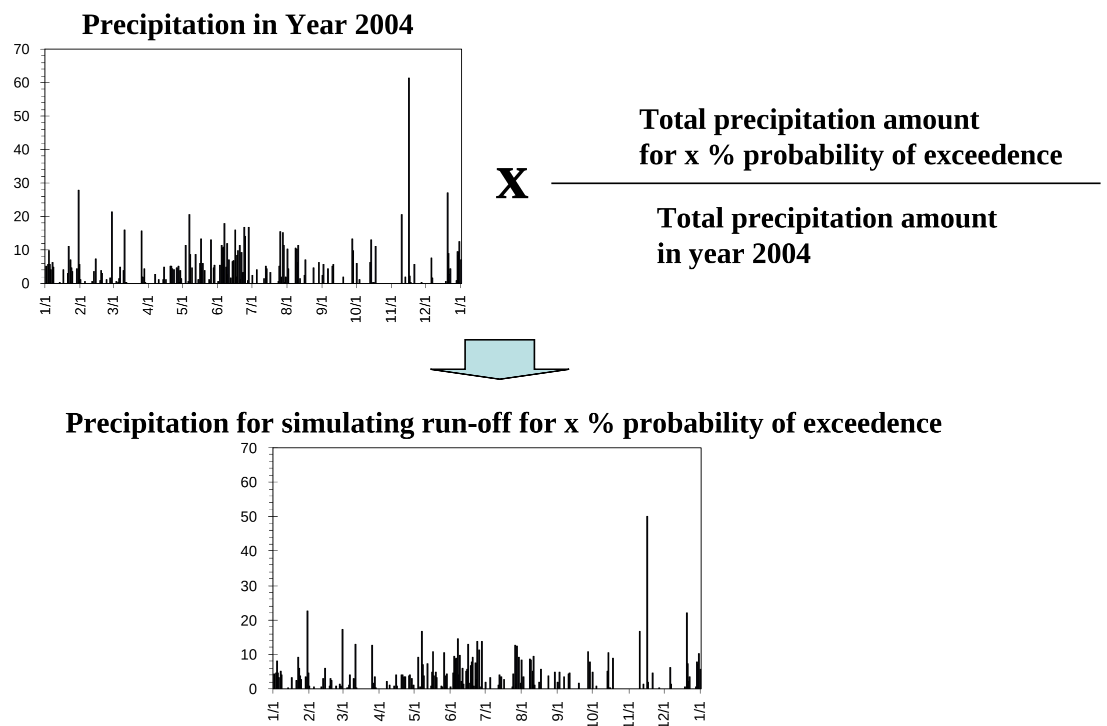


Figure B.4.15 Ratio of Waste Water Discharge against Disturbed Flow in WABD (Average in 2001 – 2005)



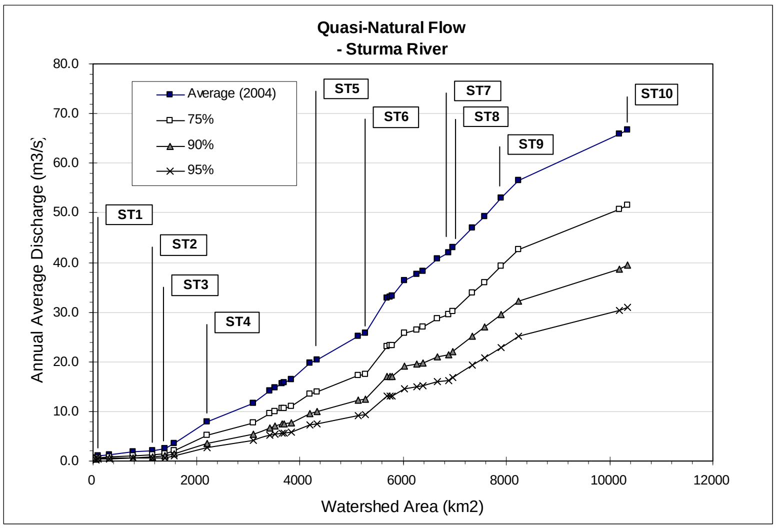
Source: JICA Study Team

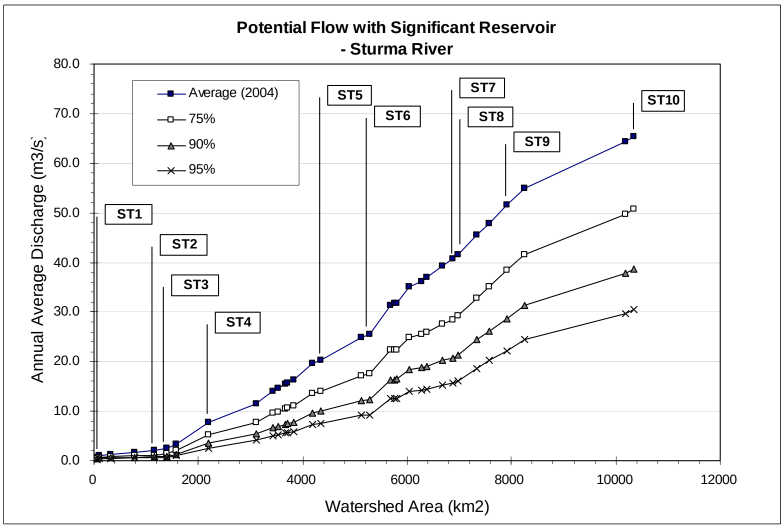
Figure B.6.1 Given Precipitation Amount in Continuous 2-year

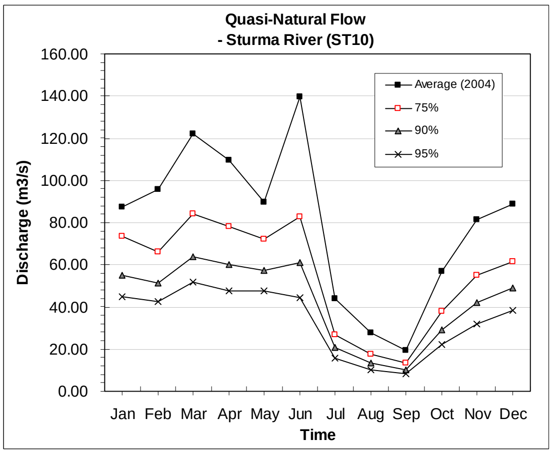


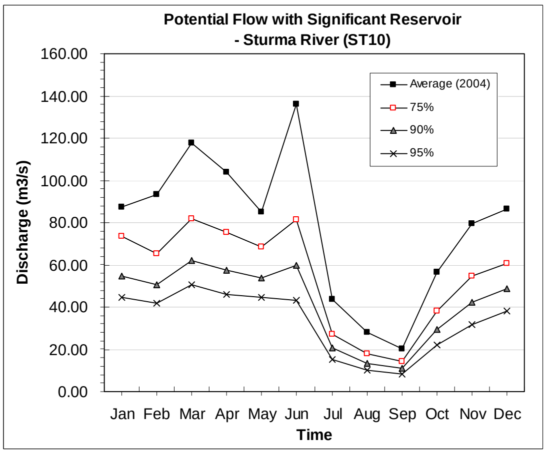
Source: JICA Study Team

Figure B.6.2 Precipitation Pattern for Rainfall-Runoff Simulation



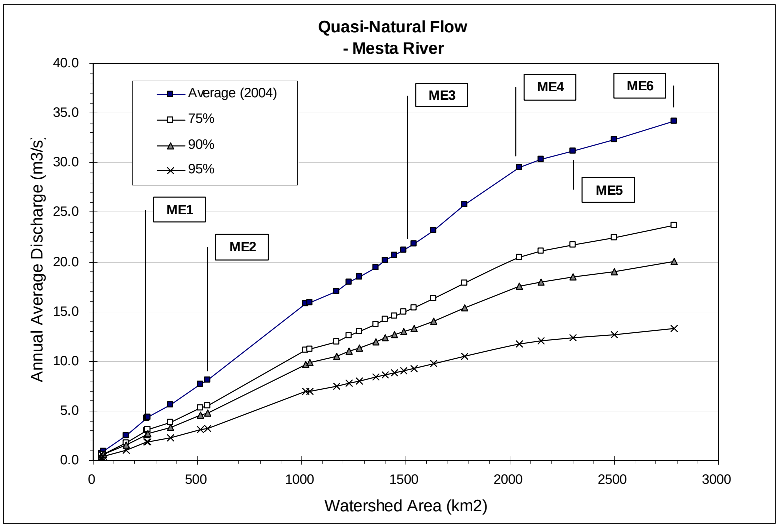


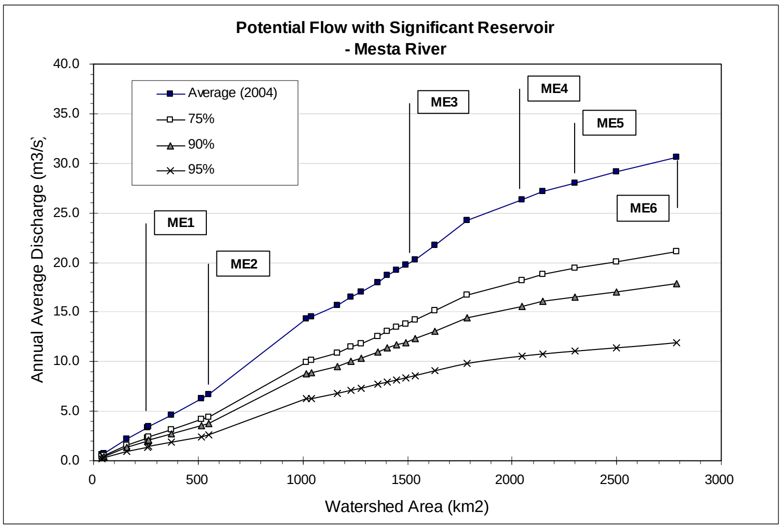


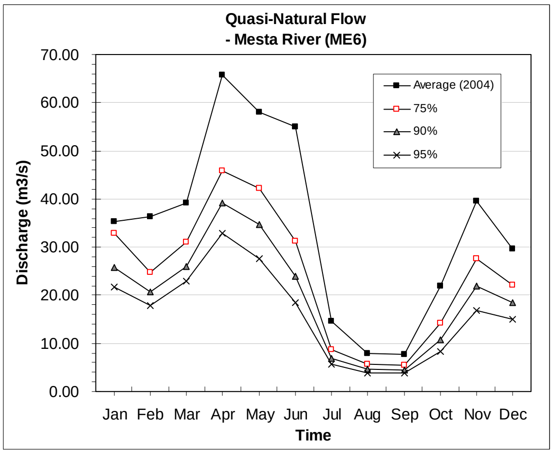


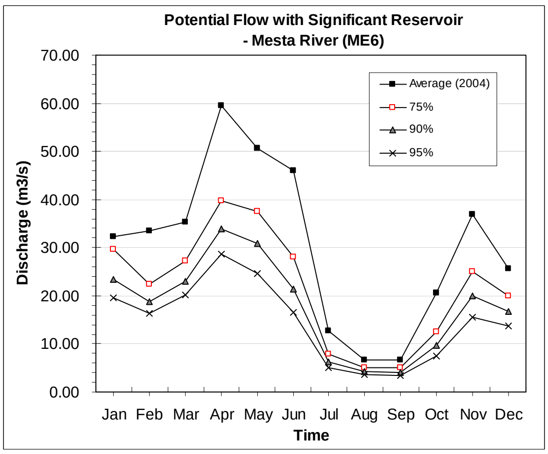
Source: JICA Study Team

Figure B.6.3 Probable Water Quantity in Struma River Basin



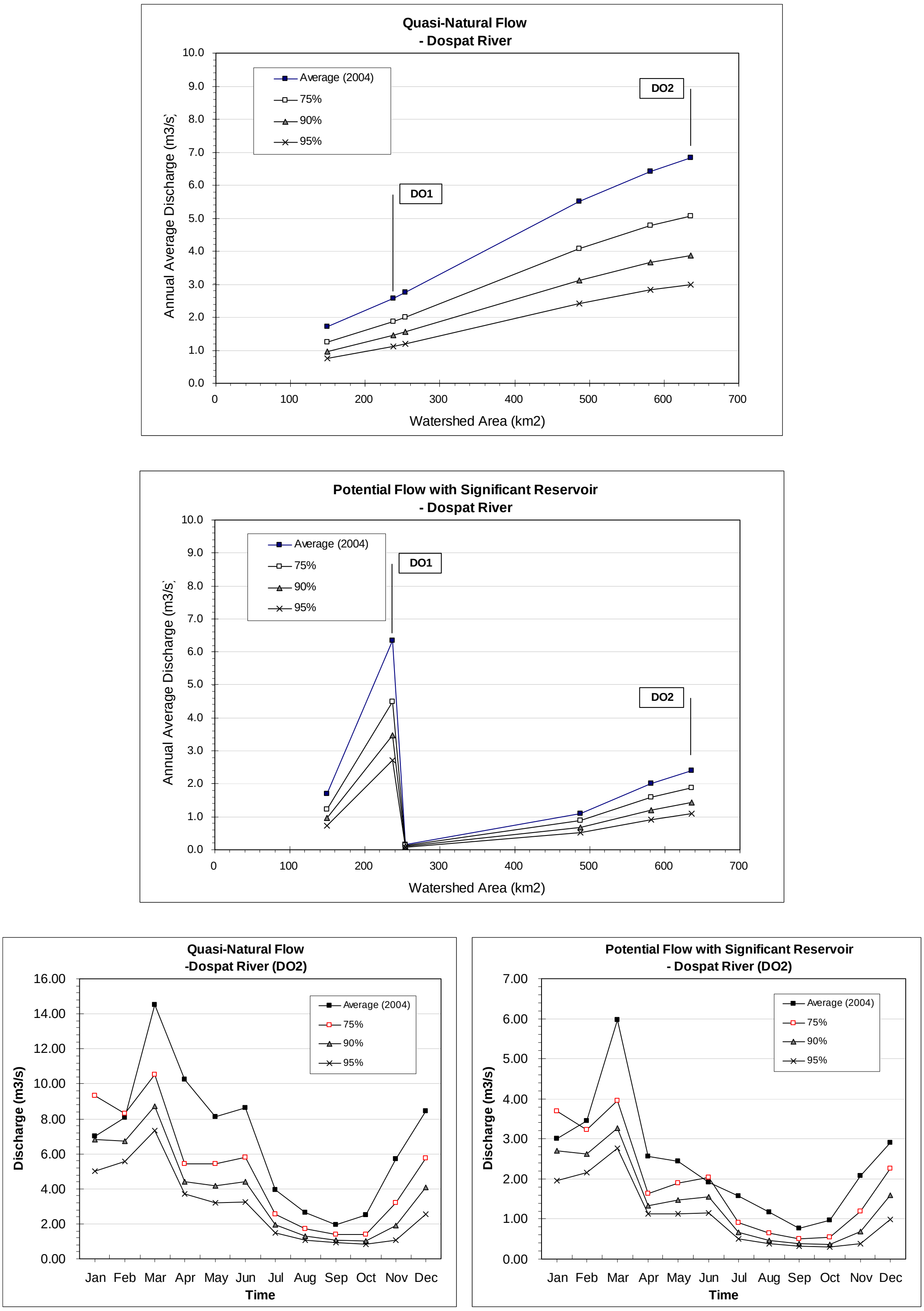






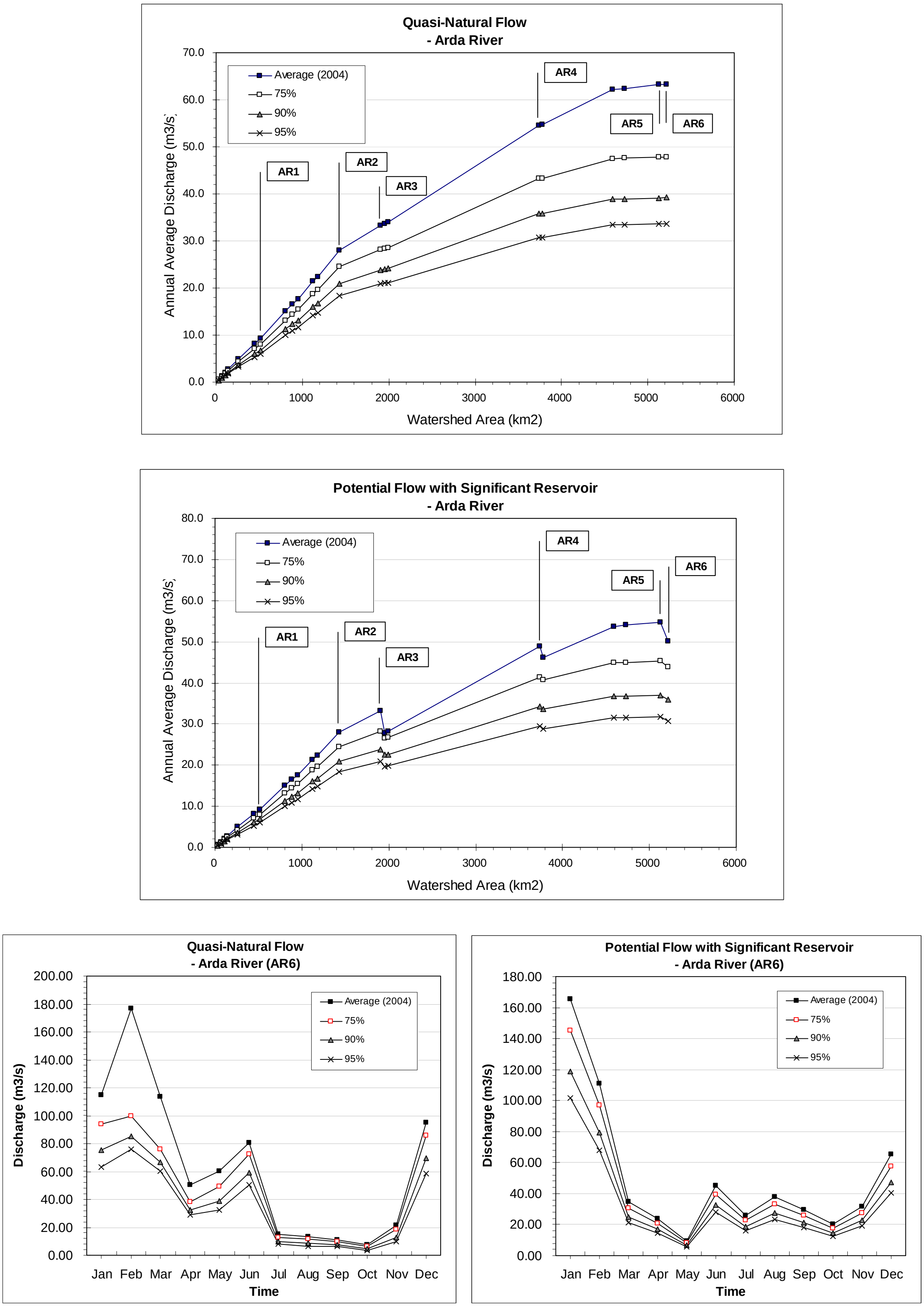
Source: JICA Study Team

Figure B.6.4 Probable Water Quantity in Mesta River Basin



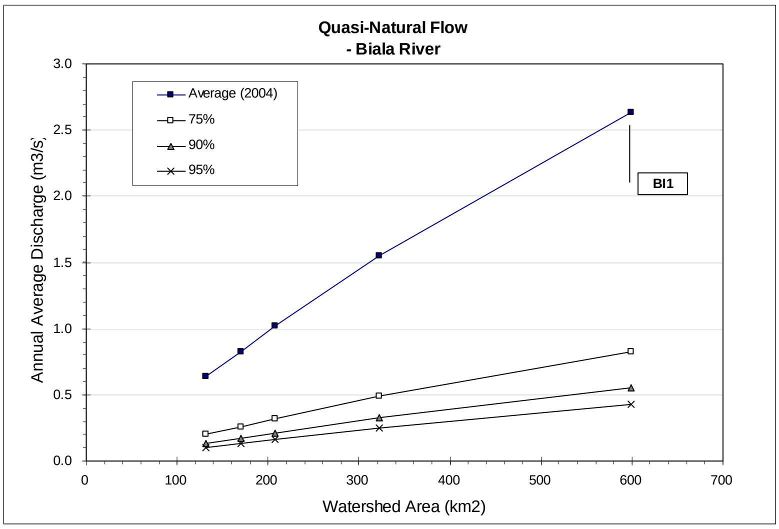
Source: JICA Study Team

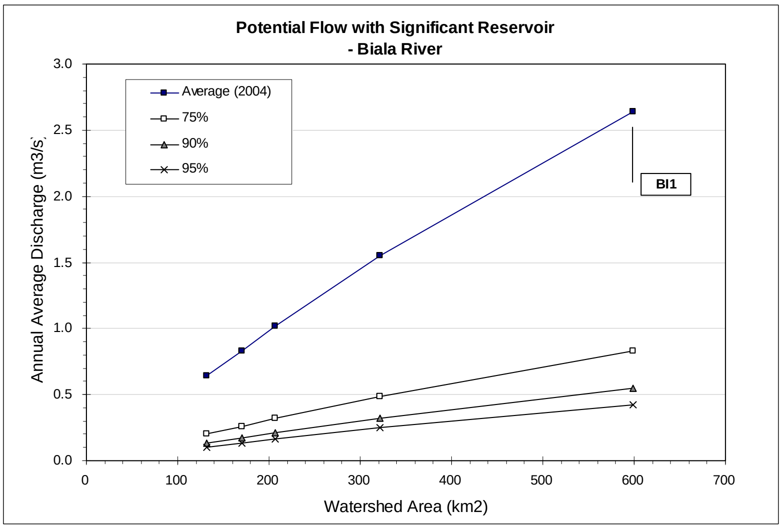
Figure B.6.5 Probable Water Quantity in Dospat River Basin

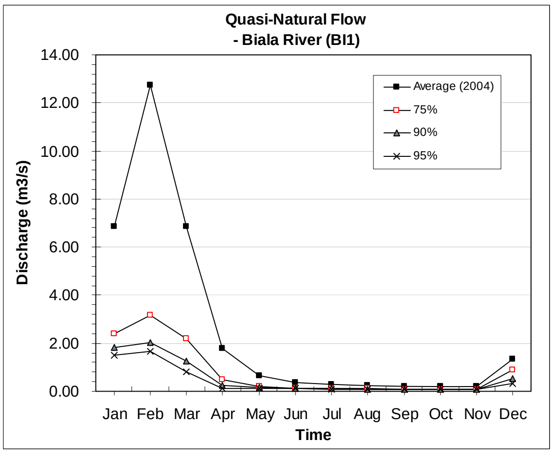


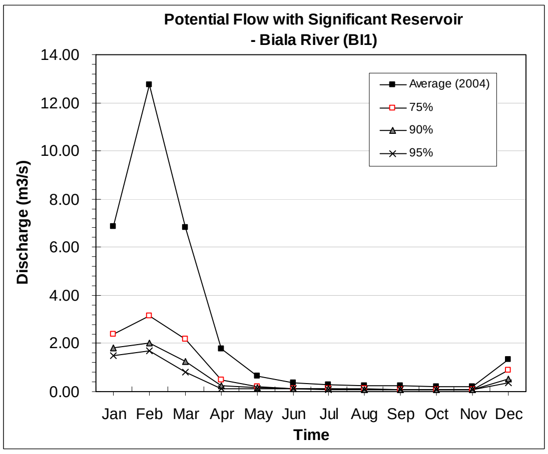
Source: JICA Study Team

Figure B.6.6 Probable Water Quantity in Arda River Basin



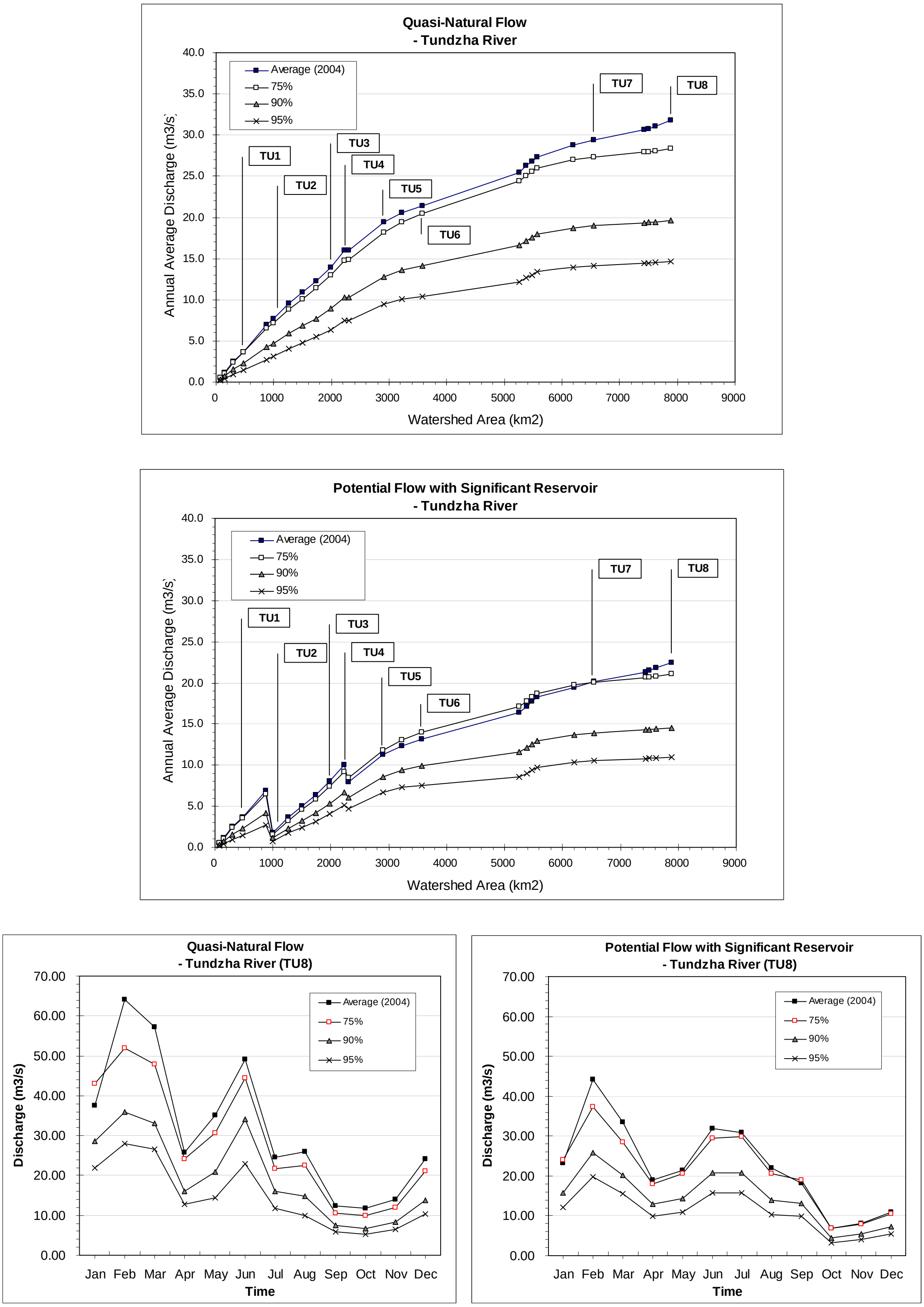






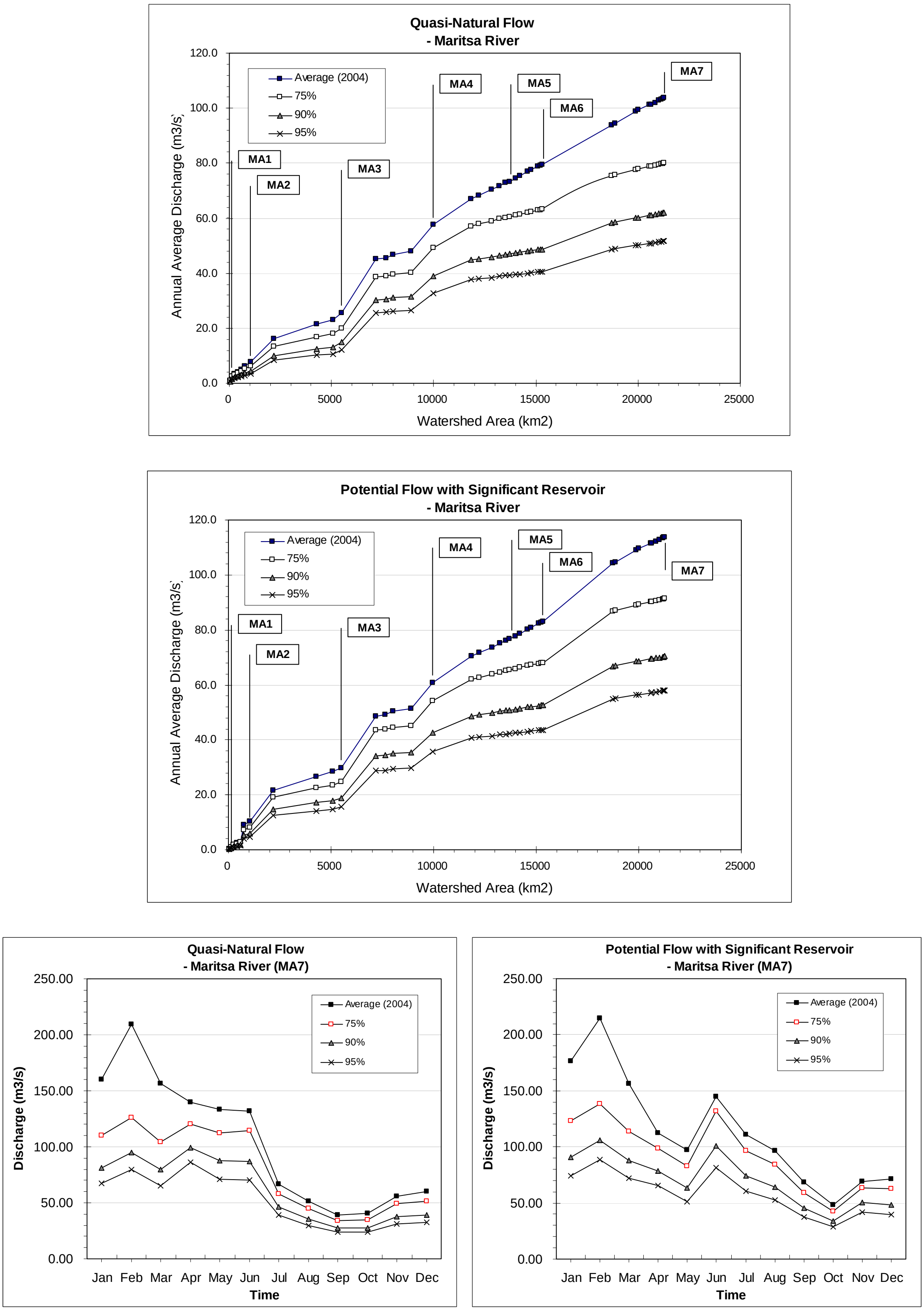
Source: JICA Study Team

Figure B.6.7 Probable Water Quantity in Biala River Basin



Source: JICA Study Team

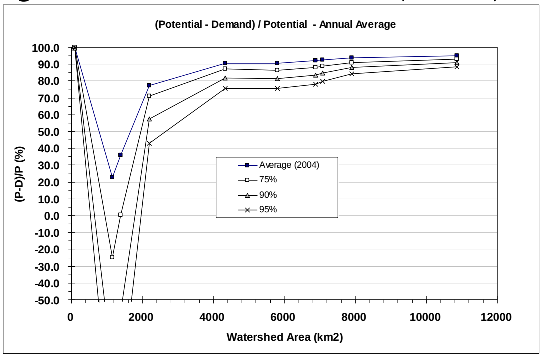
Figure B.6.8 Probable Water Quantity in Tundzha River Basin

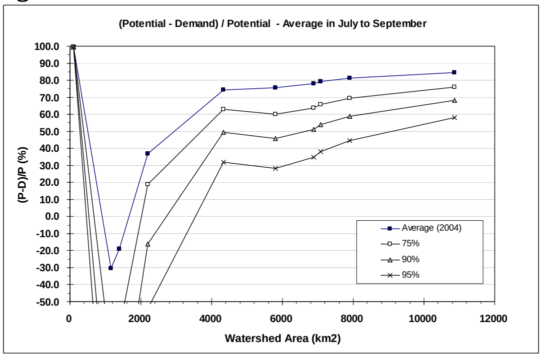


Source: JICA Study Team

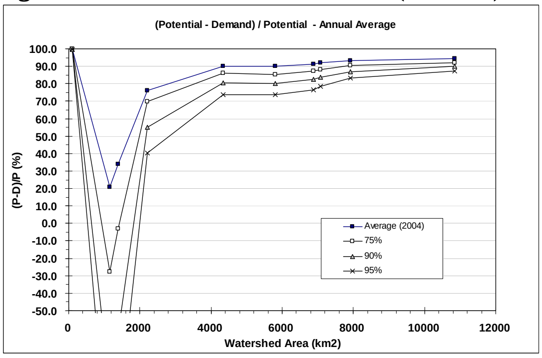
Figure B.6.9 Probable Water Quantity in Maritsa River Basin

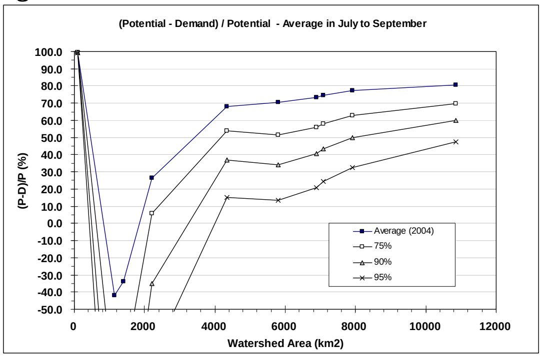
Irrigation Loss = Current Condition (48-74%): Irrigation Area = 5% of Potential Area



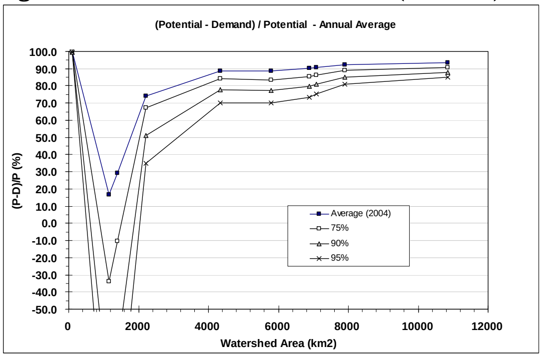


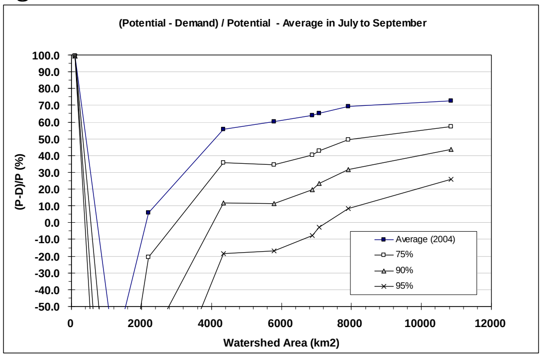
Irrigation Loss = Current Condition (48-74%): Irrigation Area =10% of Potential Area



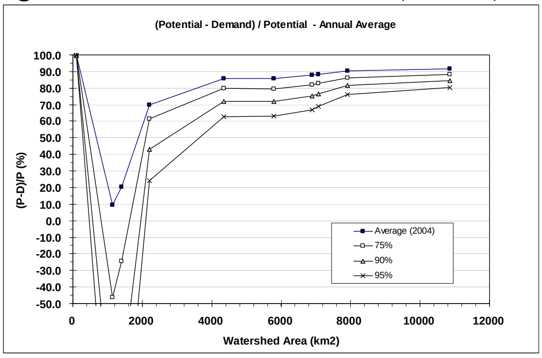


Irrigation Loss = Current Condition (48-74%): Irrigation Area =20% of Potential Area





Irrigation Loss = Current Condition (48-74%): Irrigation Area =40% of Potential Area



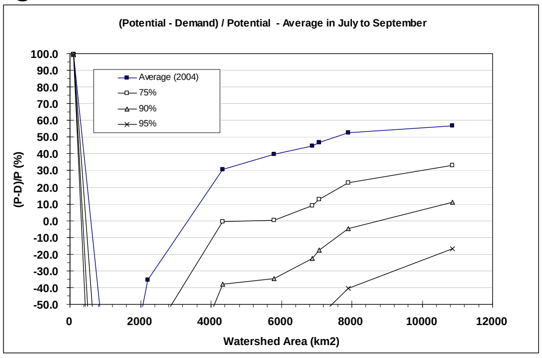
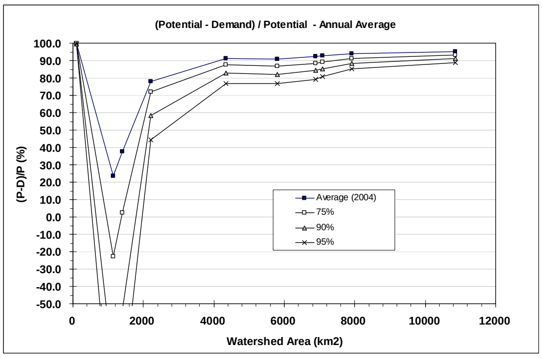
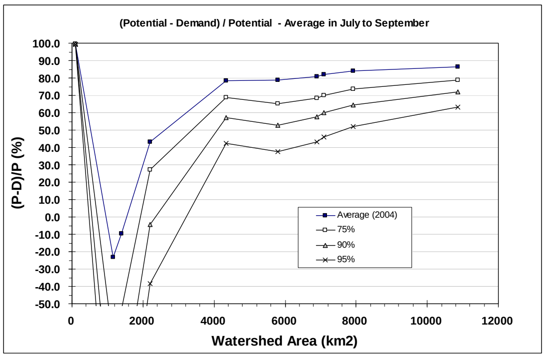


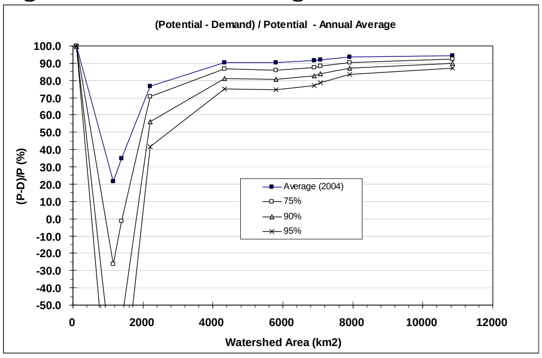
Figure B.7.1 Balance between Water Resources Potential and Water Demand along Main Stream of Struma River Basin (1/2)

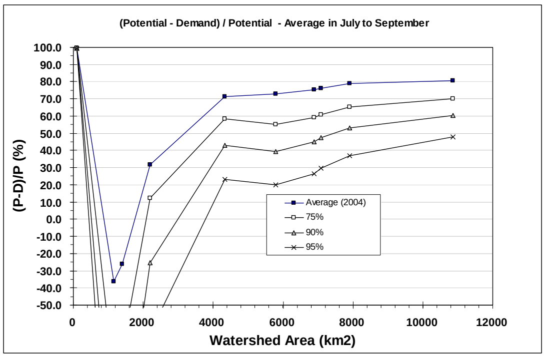
Irrigation Loss = 30%: Irrigation Area = 5% of Potential Area



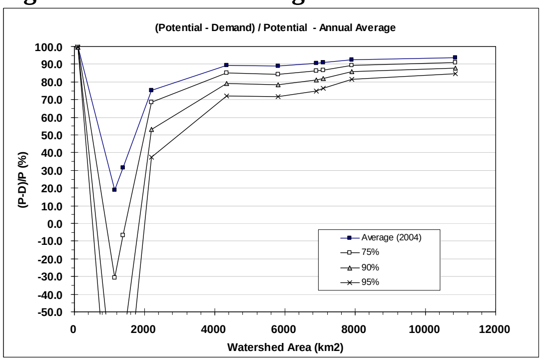


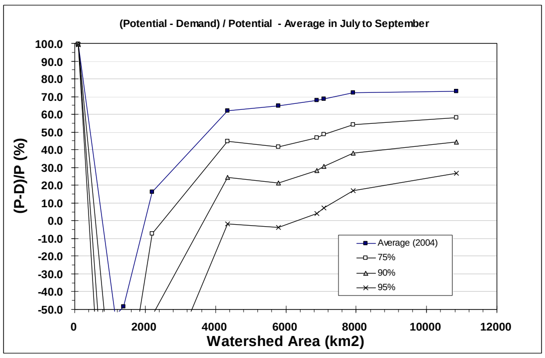
Irrigation Loss = 30%: Irrigation Area = 20% of Potential Area



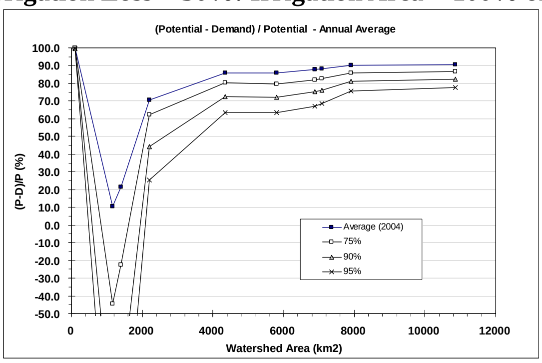


Irrigation Loss = 30%: Irrigation Area = 40% of Potential Area





Irrigation Loss = 30%: Irrigation Area = 100% of Potential Area



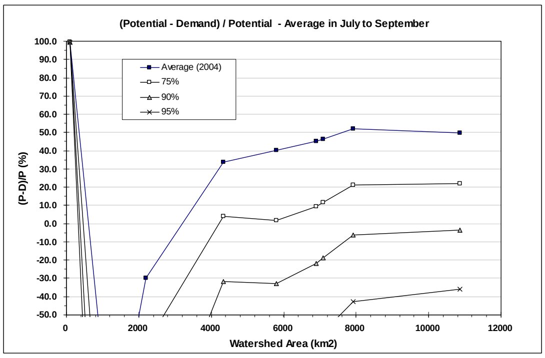
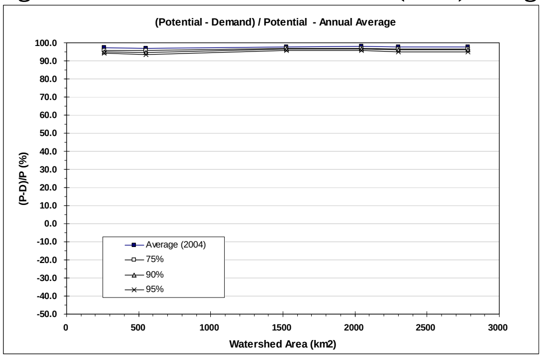
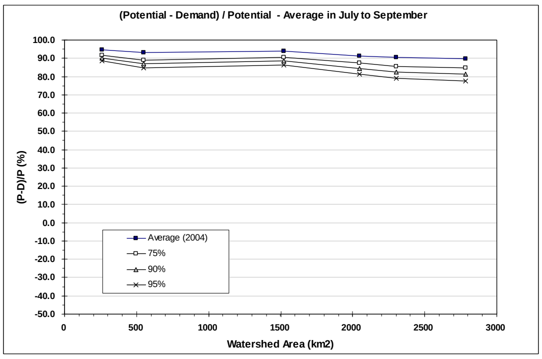


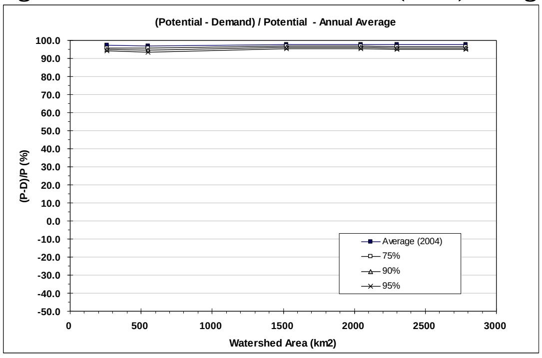
Figure B.7.2 Balance between Water Resources Potential and Water Demand along Main Stream of Struma River Basin (2/2)

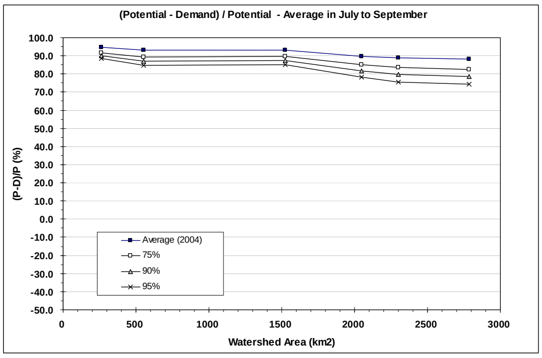
Irrigation Loss = Current Condition (64%): Irrigation Area = 15% of Potential Area



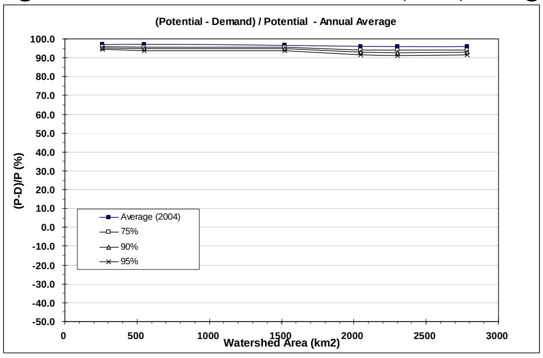


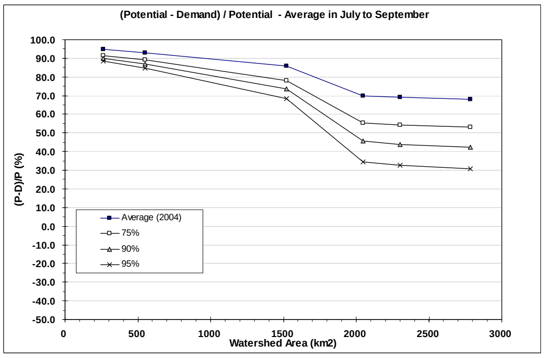
Irrigation Loss = Current Condition (64%): Irrigation Area =30% of Potential Area



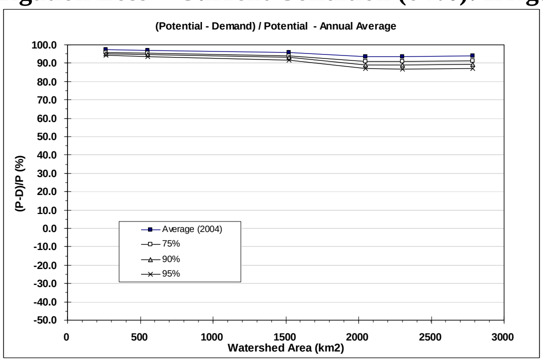


Irrigation Loss = Current Condition (64%): Irrigation Area =50% of Potential Area





Irrigation Loss = Current Condition (64%): Irrigation Area =100% of Potential Area



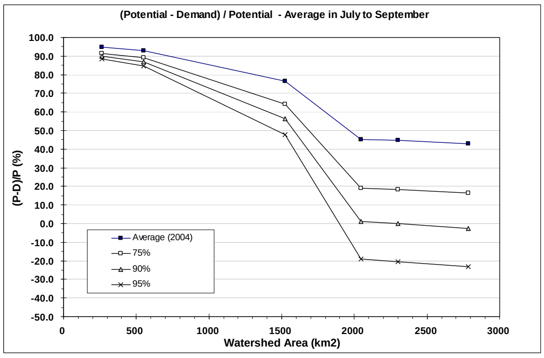
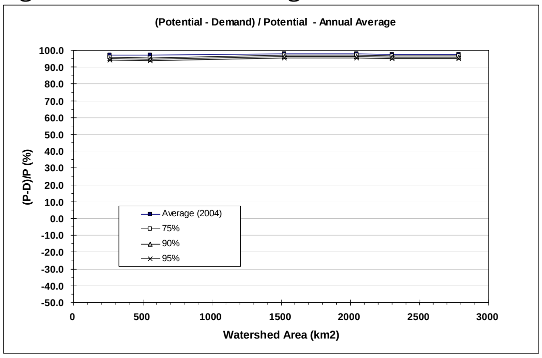
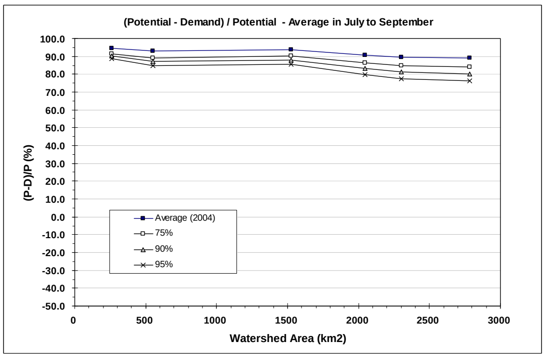


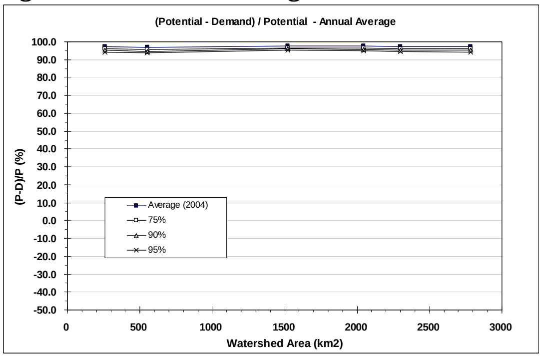
Figure B.7.3 Balance between Water Resources Potential and Water Demand along Main Stream of Mesta River Basin (1/2)

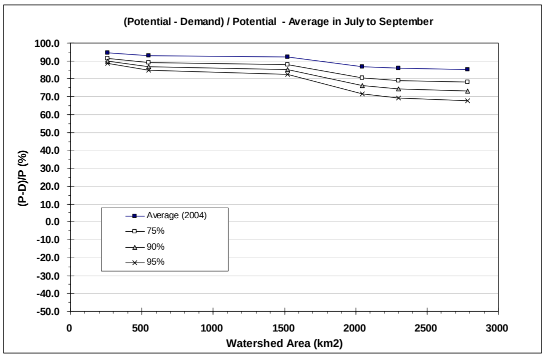
Irrigation Loss = 30%: Irrigation Area = 15% of Potential Area



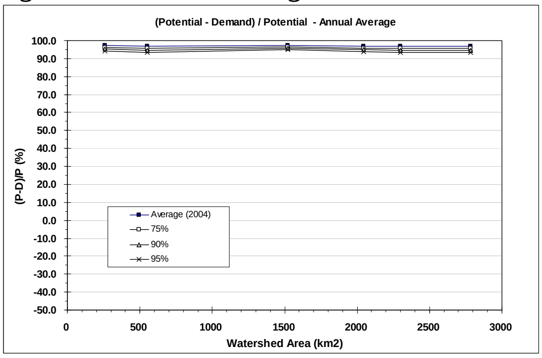


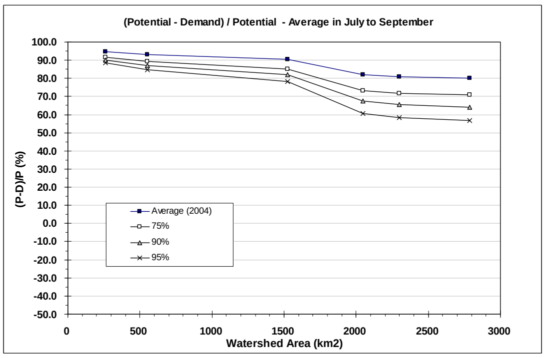
Irrigation Loss = 30%: Irrigation Area =30% of Potential Area



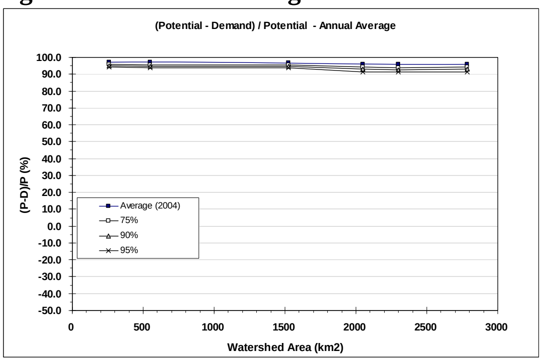


Irrigation Loss = 30%: Irrigation Area =50% of Potential Area





Irrigation Loss = 30%: Irrigation Area =100% of Potential Area



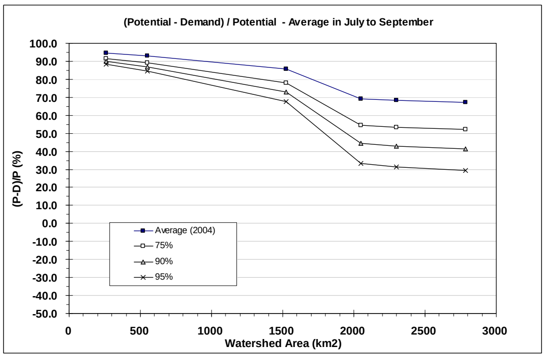
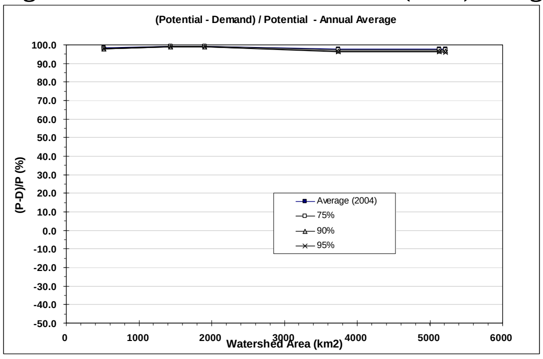
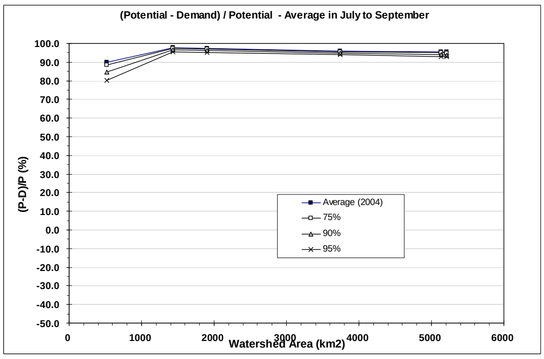


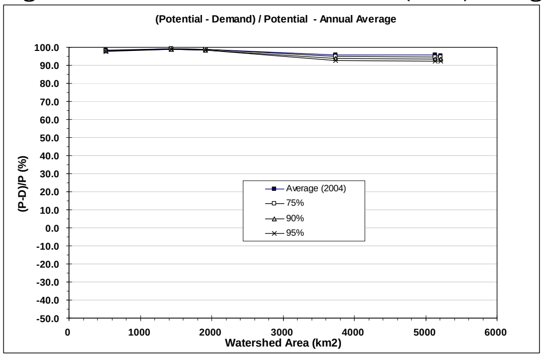
Figure B.7.4 Balance between Water Resources Potential and Water Demand along Main Stream of Mesta River Basin (2/2)

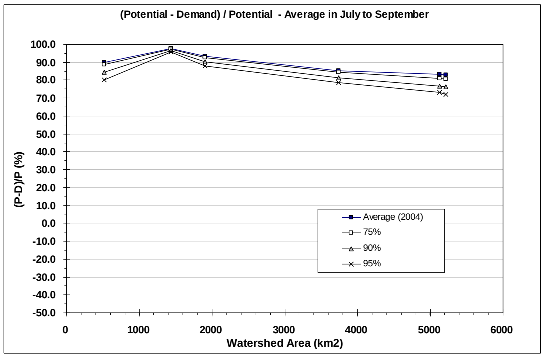
Irrigation Loss = Current Condition (73%): Irrigation Area = 5% of Potential Area



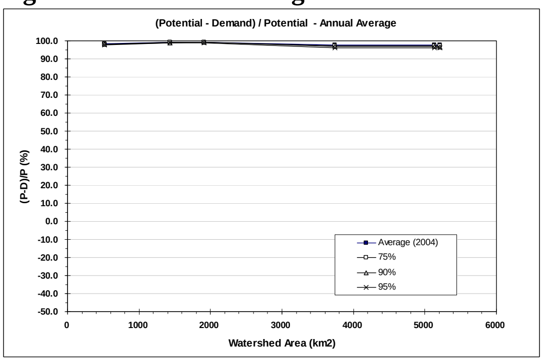


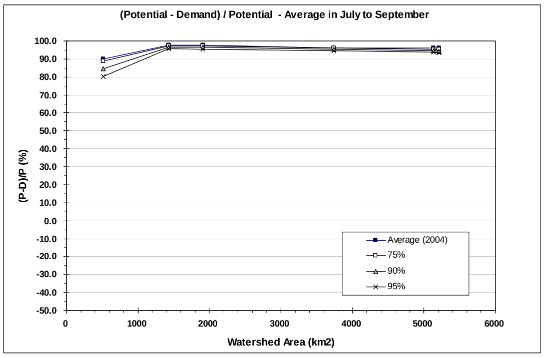
Irrigation Loss = Current Condition (73%): Irrigation Area =100% of Potential Area



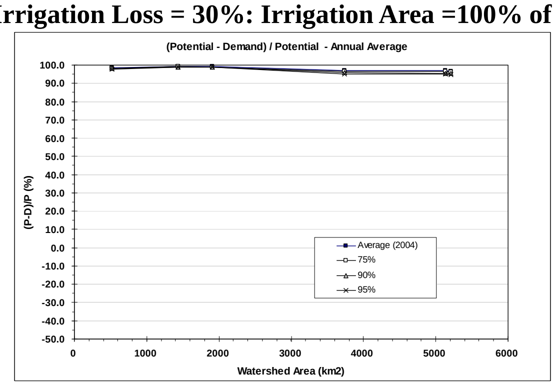


Irrigation Loss = 30%: Irrigation Area = 5% of Potential Area





Irrigation Loss = 30%: Irrigation Area =100% of Potential Area



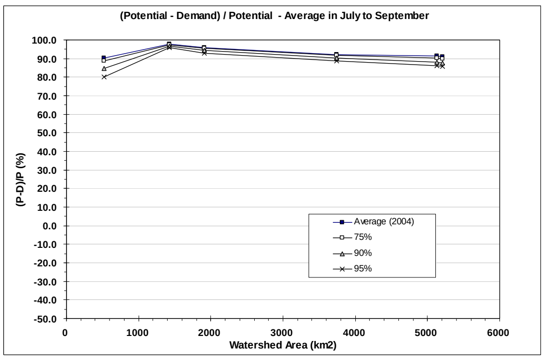
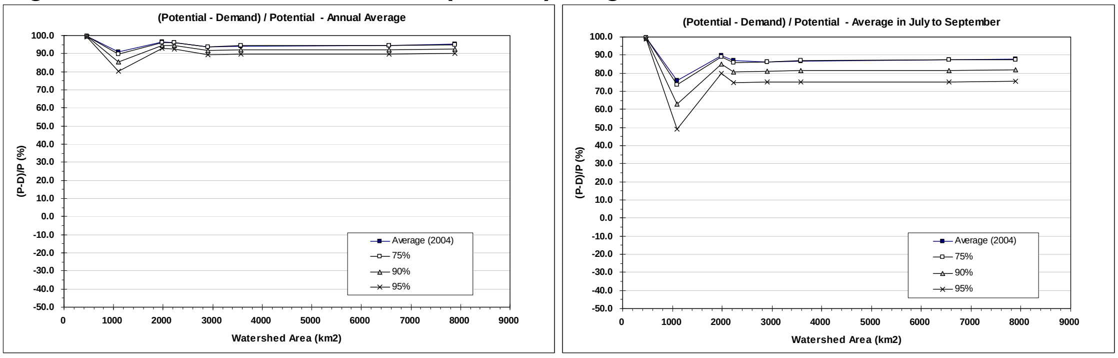
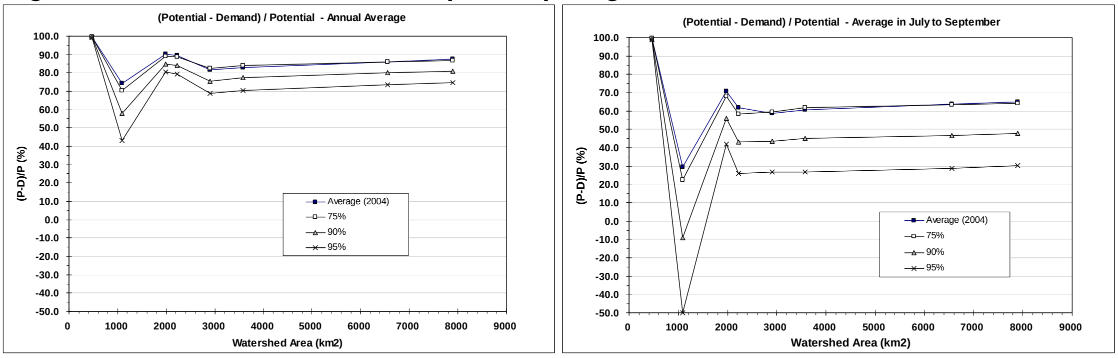


Figure B.7.5 Balance between Water Resources Potential and Water Demand along Main Stream of Arda River Basin

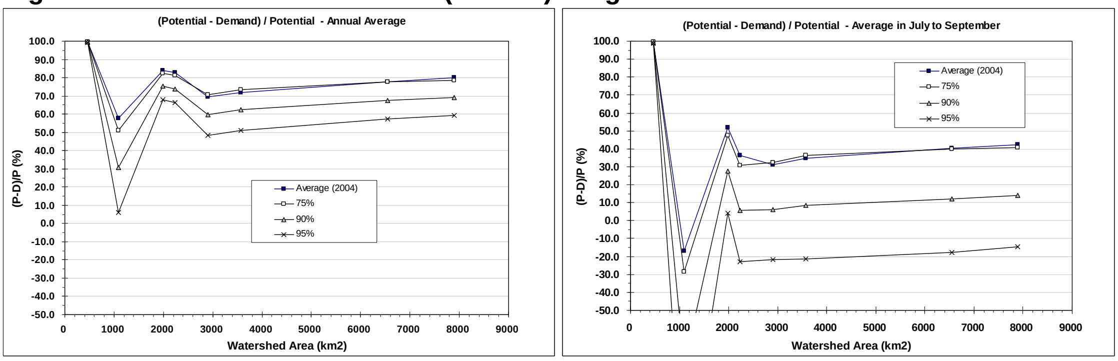
Irrigation Loss = Current Condition (61-84%): Irrigation Area = 5% of Potential Area



Irrigation Loss = Current Condition (61-84%): Irrigation Area =15% of Potential Area



Irrigation Loss = Current Condition (61-84%): Irrigation Area =25% of Potential Area



Irrigation Loss = Current Condition (61-84%): Irrigation Area =35% of Potential Area

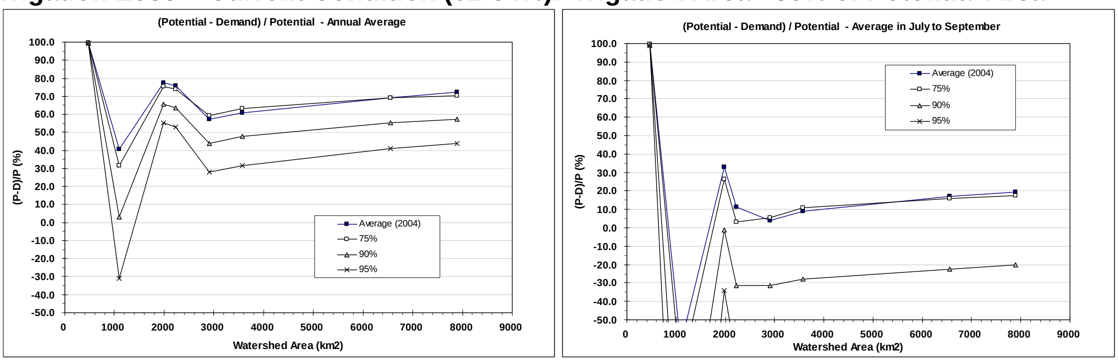
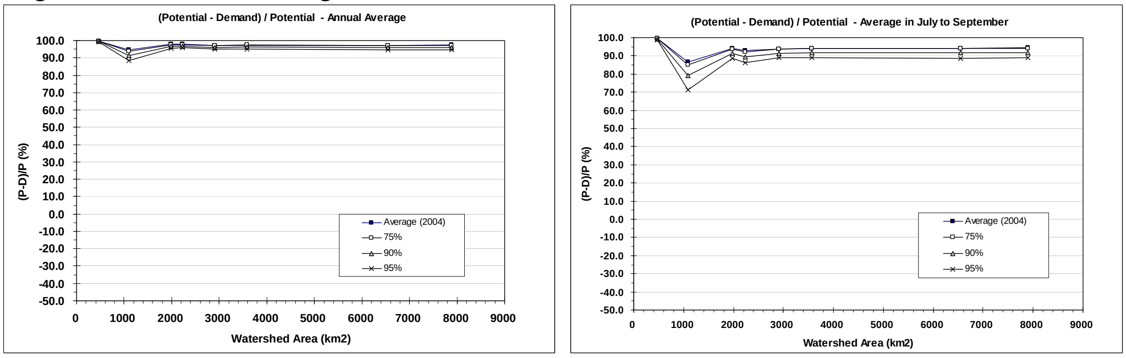
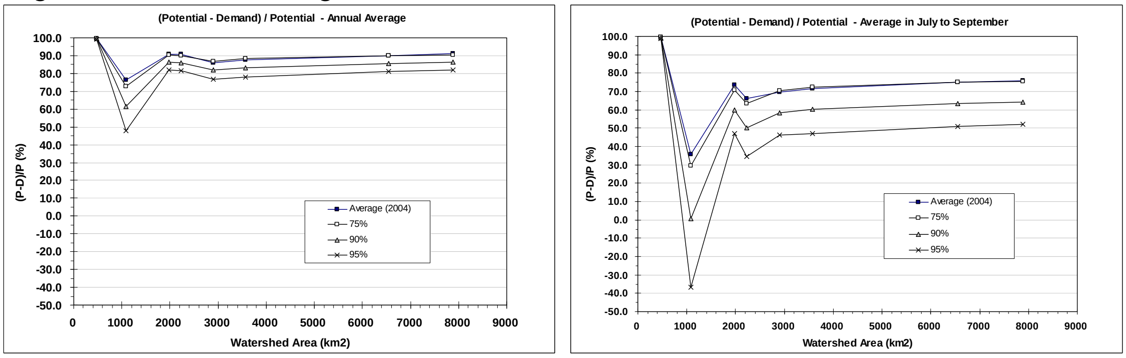


Figure B.7.6 Balance between Water Resources Potential and Water Demand along Main Stream of Tundzha River Basin (1/2)

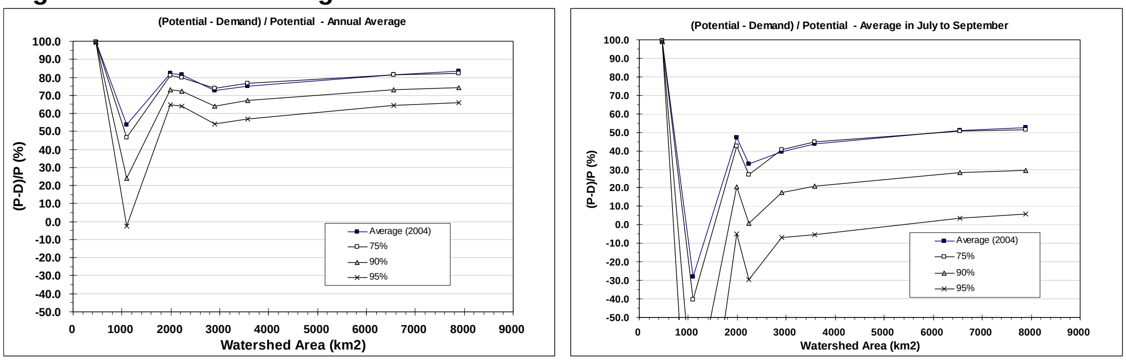
Irrigation Loss = 30%: Irrigation Area = 5% of Potential Area



Irrigation Loss = 30%: Irrigation Area = 25% of Potential Area



Irrigation Loss = 30%: Irrigation Area = 50% of Potential Area



Irrigation Loss = 30%: Irrigation Area =70% of Potential Area

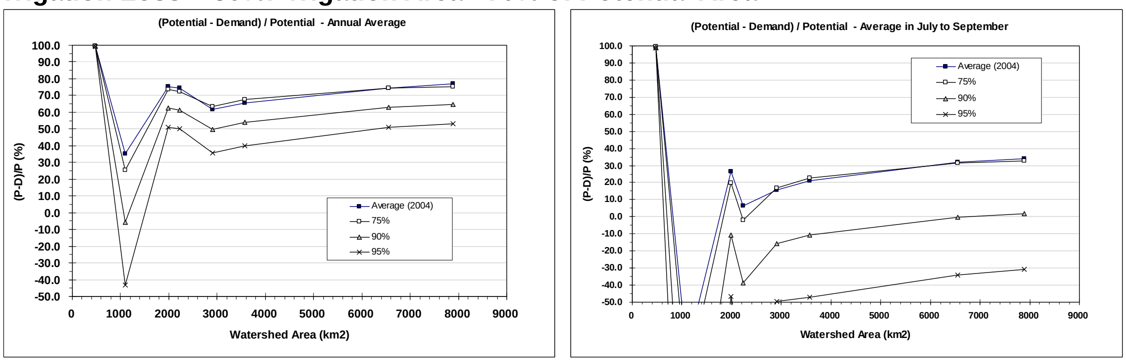
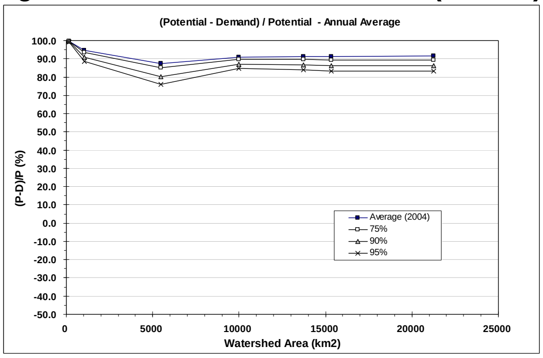
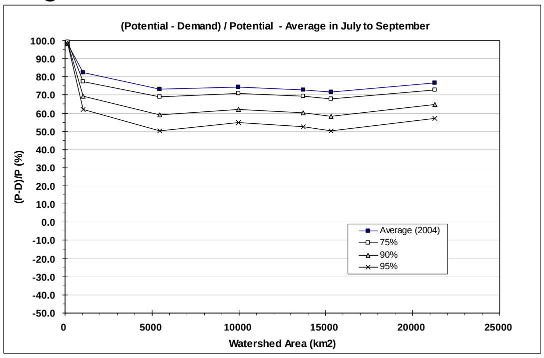


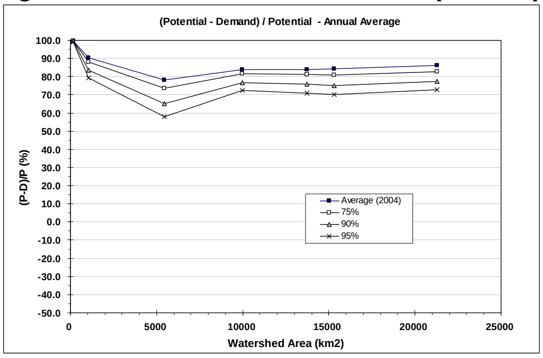
Figure B.7.7 Balance between Water Resources Potential and Water Demand along Main Stream of Tundzha River Basin (2/2)

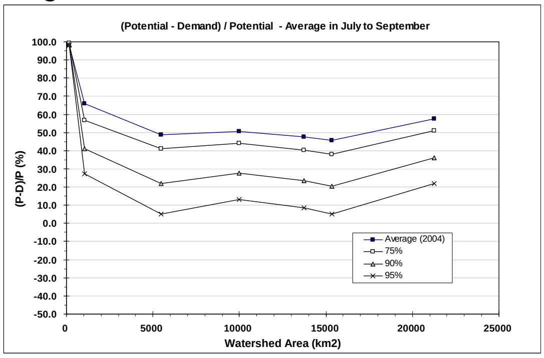
Irrigation Loss = Current Condition (60-74%): Irrigation Area = 5% of Potential Area



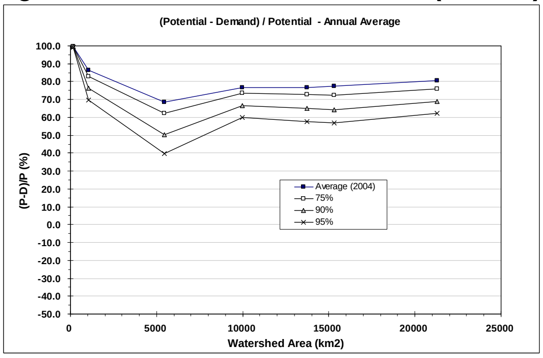


Irrigation Loss = Current Condition (60-74%): Irrigation Area = 10% of Potential Area





Irrigation Loss = Current Condition (60-74%): Irrigation Area =15% of Potential Area



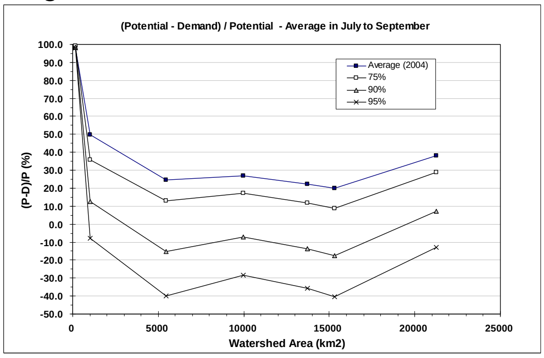


Figure B.7.8 Balance between Water Resources Potential and Water Demand along Main Stream of Maritsa River Basin (1/2)

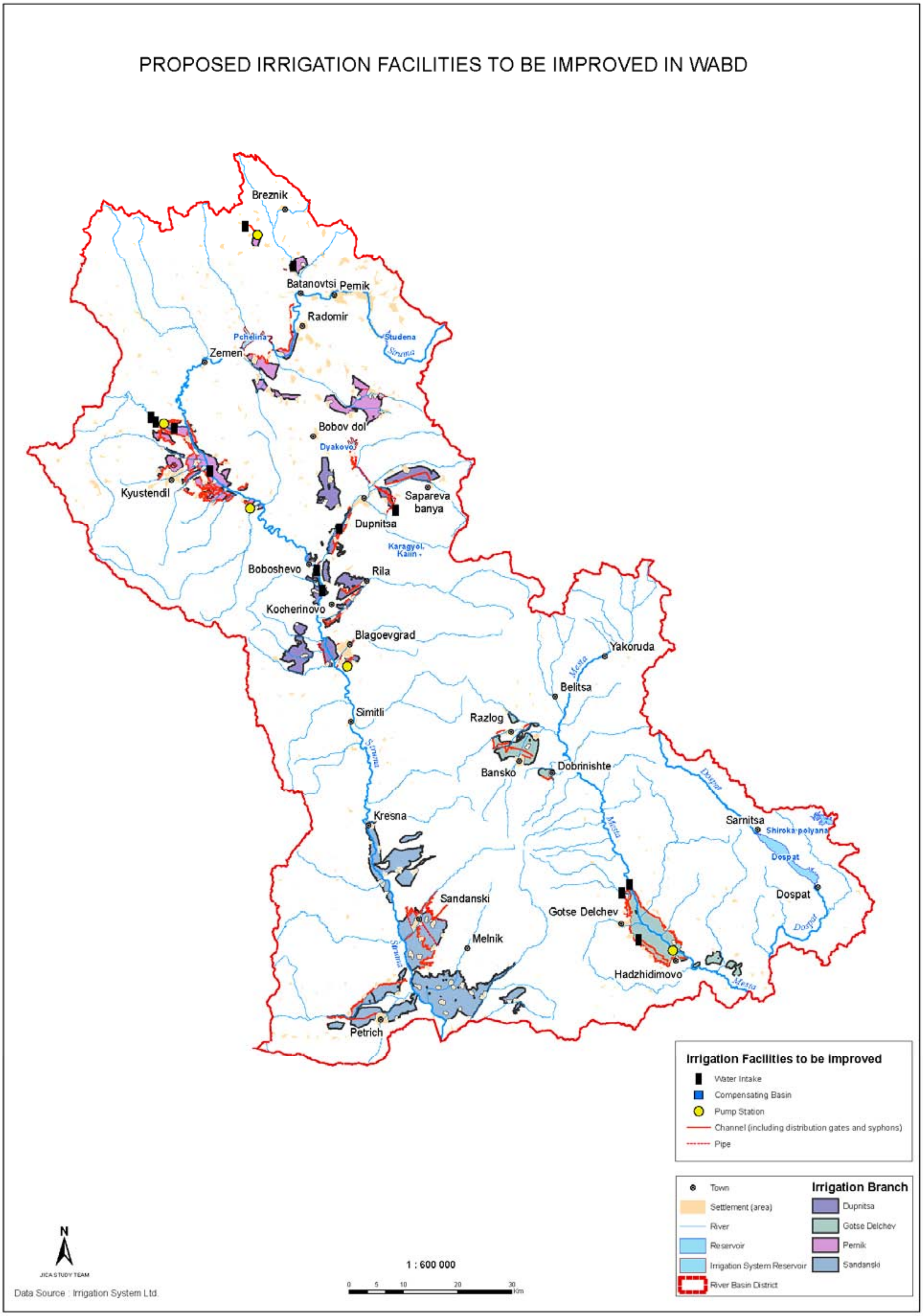
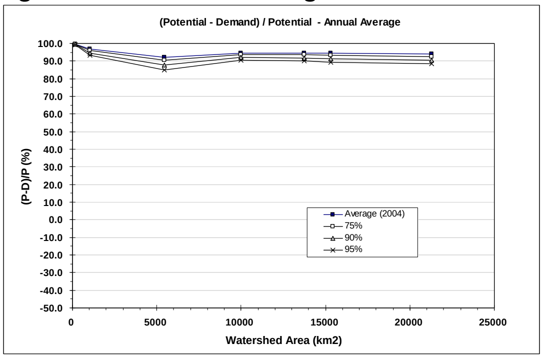
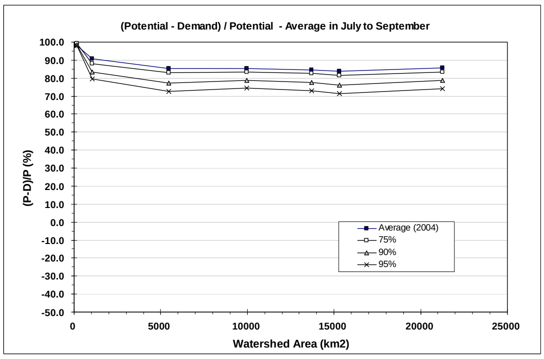


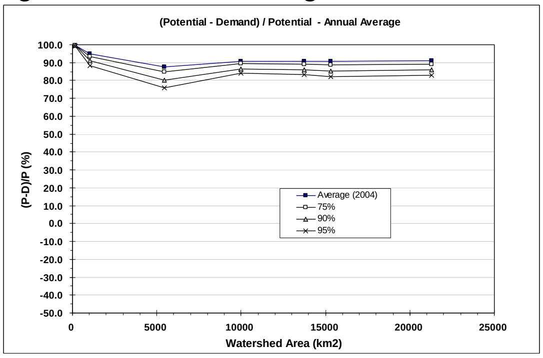
Figure B.8.2 Proposed Irrigation Facilities to be Improved (WABD)

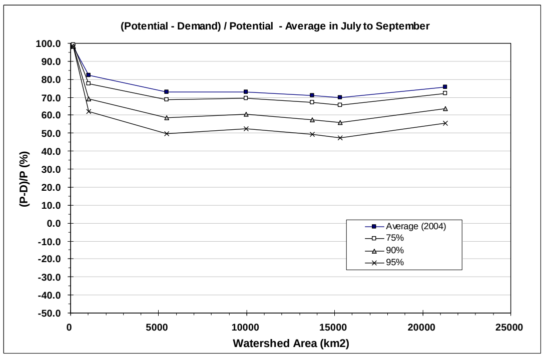
Irrigation Loss = 30%: Irrigation Area = 5% of Potential Area



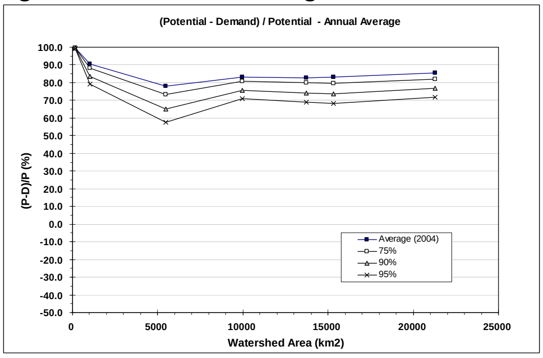


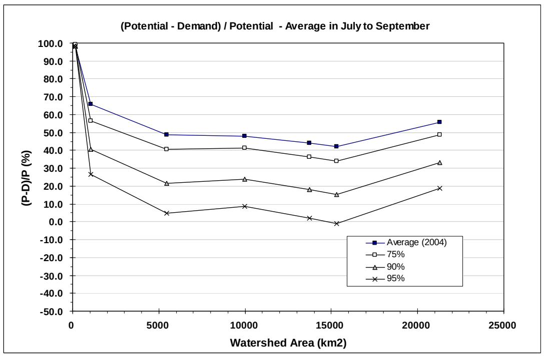
Irrigation Loss = 30%: Irrigation Area = 10% of Potential Area



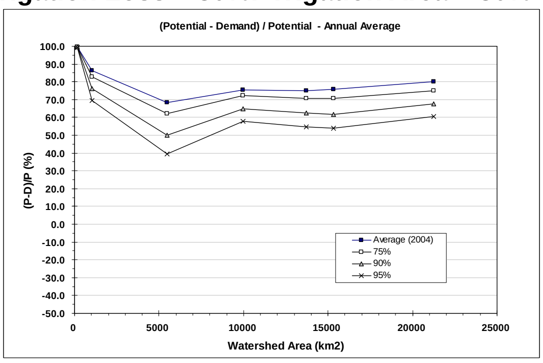


Irrigation Loss = 30%: Irrigation Area = 20% of Potential Area





Irrigation Loss = 30%: Irrigation Area = 30% of Potential Area



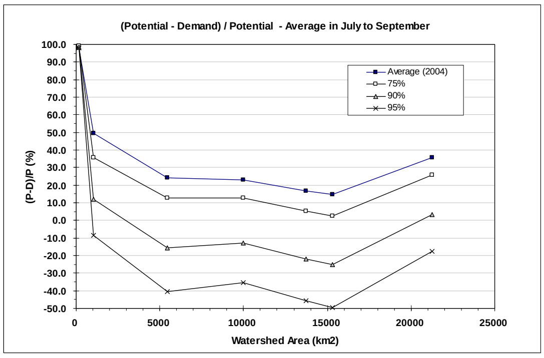


Figure B.7.9 Balance between Water Resources Potential and Water Demand along Main Stream of Maritsa River Basin (2/2)

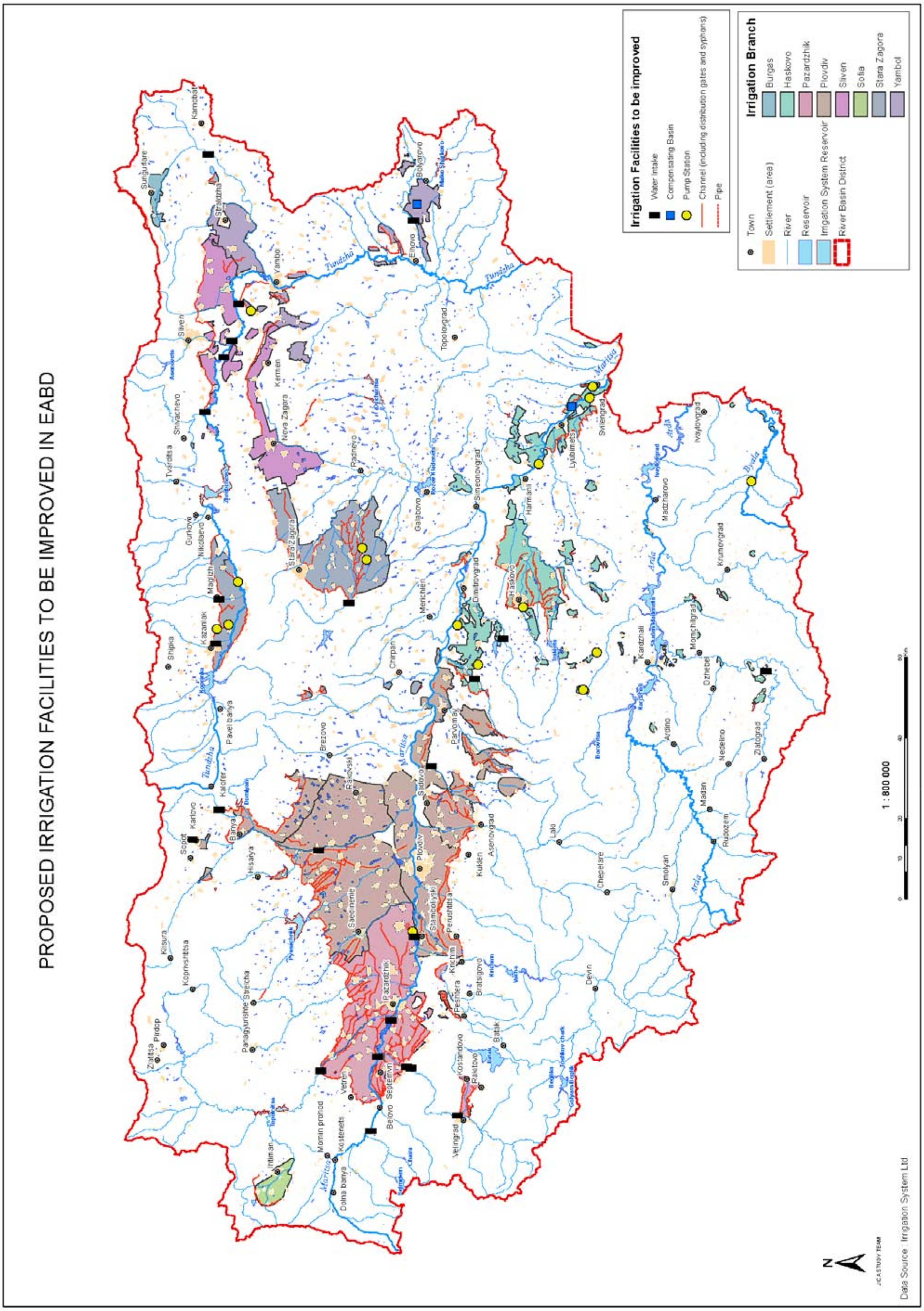


Figure B.8.1 Proposed Irrigation Facilities to be Improved (EABD)