JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF TRANSPORT AND COMMUNICATIONS
MINISTRY OF ENVIRONMENT AND PHYSICAL PLANNING
CITY OF SKOPJE
PUBLIC ENTERPRISE “WATER SUPPLY AND SEWERAGE” SKOPJE

THE STUDY
ON
WASTEWATER MANAGEMENT
IN
SKOPJE
IN
FORMER YUGOSLAV
REPUBLIC OF MACEDONIA

FINAL REPORT

MAIN REPORT

JUNE 2009

TOKYO ENGINEERING CONSULTANTS CO., LTD.
(TEC)
In Association with
CTI ENGINEERING INTERNATIONAL CO., LTD. (CTII)

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ON
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SKOPJE
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CONSTITUENT VOLUMES

SUMMARY

MAIN REPORT

APPENDIX (1)

APPENDIX (2)

APPENDIX (3)

PREFACE

In response to a request from the Government of Former Yugoslav Republic of Macedonia, the Government of Japan decided to conduct a study on Wastewater Management in Skopje in Former Yugoslav Republic of Macedonia and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched the Study Team headed by Mr. Kazufumi Momose of Tokyo Engineering Consultants Co., LTD. consisting of Tokyo Engineering Consultants Co., LTD. and CTI Engineering International Co., Ltd. between September 2007 and June 2009. In addition, JICA set up an advisory committee supported by Mr. Wataru Fukatani, Ministry of Land, Infrastructure, Transport and Tourism and Ms. Hiroko Kamata, Senior Advisor, JICA, which examined the Study from specialist and technical points of view.

The Team held discussions with the officials concerned of the Government of Former Yugoslav Republic of Macedonia and conducted field surveys in the study area. Upon returning to Japan, the Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between these two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Former Yugoslav Republic of Macedonia for their close cooperation extended to the Study.

June 2009

Ariyuki Matsumoto
Vice-President
Japan International Cooperation Agency

Mr. Ariyuki Matsumoto
Vice-President
Japan International Cooperation Agency

June 2009

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled “The Study on Wastewater Management in Skopje in Former Yugoslav Republic of Macedonia”. This report has been prepared by the Study Team in accordance with the contracts signed on 14th September 2007, between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. in association with CTI Engineering International Co., Ltd.

The report examines the existing conditions of sewerage system of the Skopje City and presents the basic plan and feasibility study on priority project selected from the basic plan.

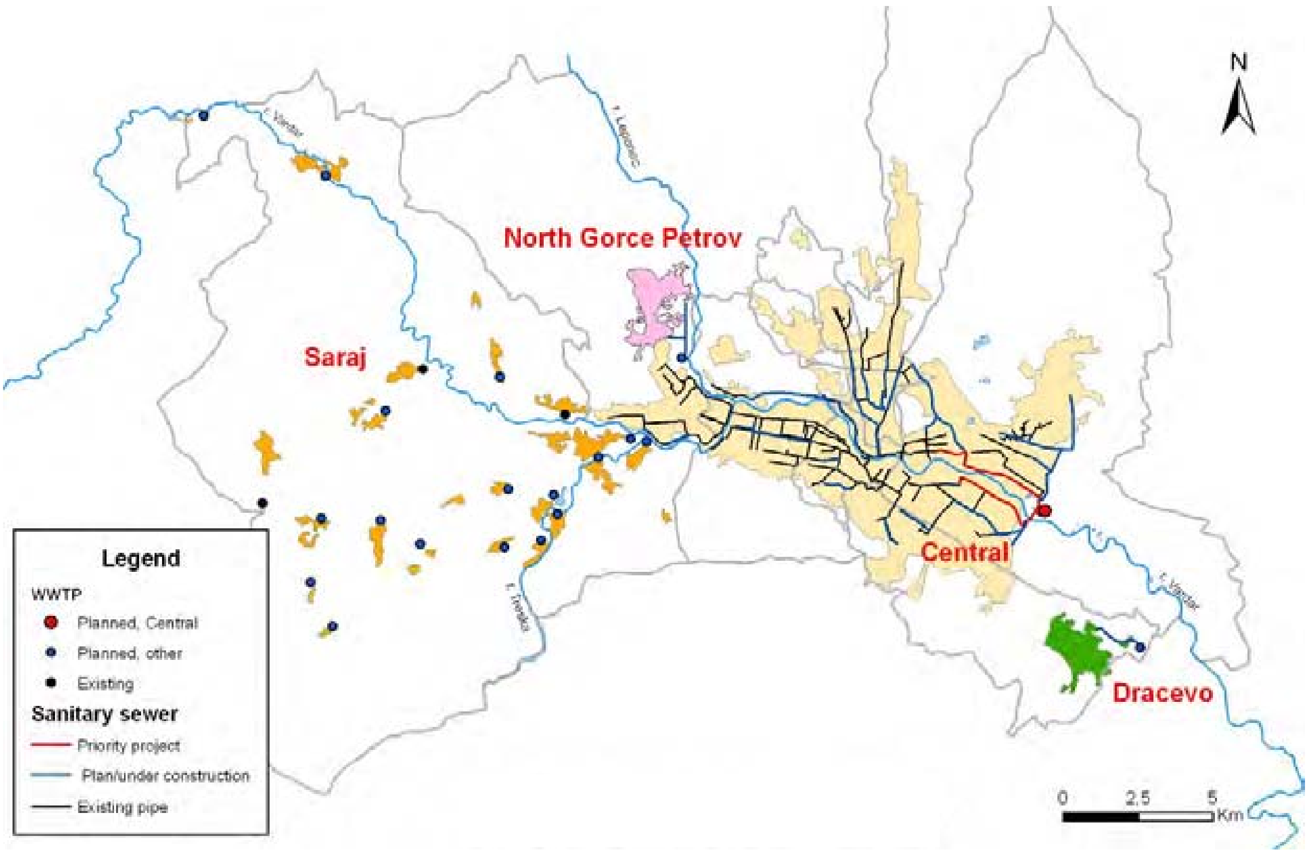
The Study aimed to improve the water quality of the Vardar River. The Study Team is sure that the recommendations made in the report shall contribute to improving the water quality of the Vardar River and the sewerage system in Skopje City.

All the members of the Study Team wish to acknowledge gratefully to the personnel of your Agency, Ministry of Foreign Affairs, JICA Balkan Office, and also to the officials and individuals of the Government of Former Yugoslav Republic of Macedonia for their assistance extended to the Study Team.

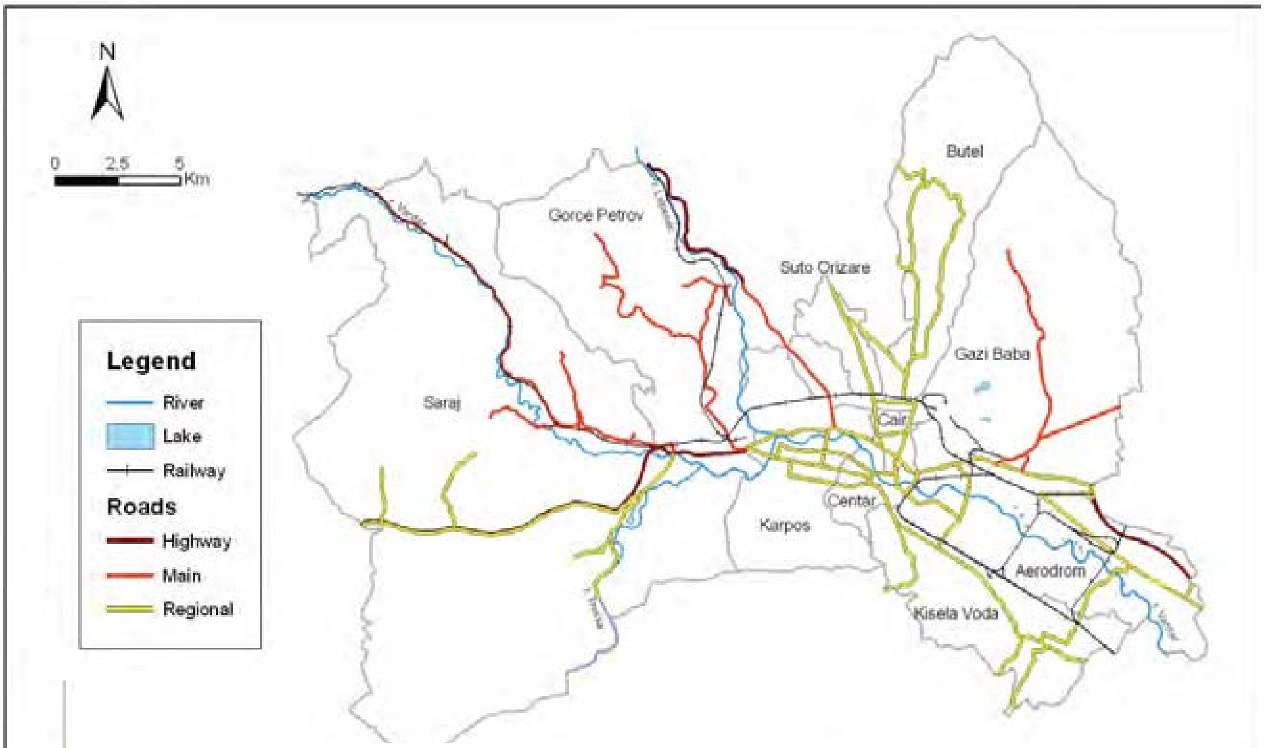
Yours faithfully,

Kazufumi MOMOSE
Team Leader

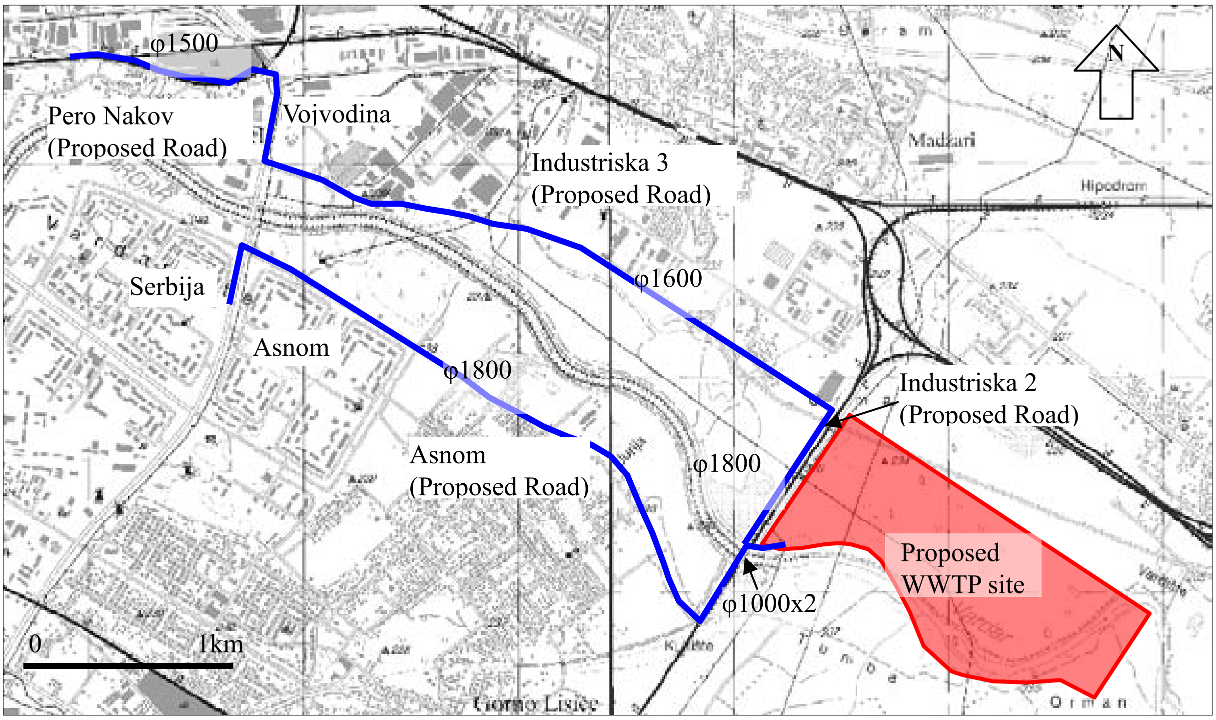
LOCATION MAP OF FORMER YUGOSLAV REPUBLIC OF MACEDONIA



BASIC PLAN FOR SEWERAGE DEVELOPMENT IN SKOPJE



General View of Study Area



Scope of Priority Project

The Study on Wastewater Management in Skopje
in Former Yugoslav Republic of Macedonia

FINAL REPORT
Main Report

Table of Contents

Part II FEASIBILITY STUDY

CHAPTER 5 COST ESTIMATION AND IMPLEMENTATION SCHEDULE .... Part II: 5-1

CHAPTER 6 ENVIRONMENTAL IMPACT ASSESSMENT (EIA) .... Part II: 6-1

Part III ACTION PLAN ON INSTITUTIONAL AND FINANCIAL CAPACITY

Part Ⅳ ACTION PLAN ON INDUSTRIAL WASTEWATER MANAGEMENT AND WATER QUALITY MONITOIRNG

List of Tables

Part I BASIC PLAN

Part II FEASIBILITY STUDY

Part III ACTION PLAN ON INSTITUTIONAL AND FINANCIAL CAPACITY

Part Ⅳ ACTION PLAN ON INDUSTRIAL WASTEWATER MANAGEMENT AND WATER QUALITY MONITOIRNG

List of Figures

Part I BASIC PLAN

Part II FEASIBILITY STUDY

Part III ACTION PLAN ON INSTITUTIONAL AND FINANCIAL CAPACITY

Part Ⅳ ACTION PLAN ON INDUSTRIAL WASTEWATER MANAGEMENT AND WATER QUALITY MONITOIRNG

Abbreviations

AA	Atomic absorption Analyzer
AP	Adjustment Plan
A/P	Action Plan
ASRT	Aerobic Solids Retention Time
BAT	Best Available Techniques
BOD	Bio-chemical Oxygen Demand
BREF	BAT Reference
B/P	Basic Plan
CA	Capacity Assessment
CARDS	Community Assistance for Reconstruction, Development and Stability in Balkans.
CASP	Conventional Activated Sludge Process
CD	Capacity Development
CHPI	City Health Protection Institute
COD	Chemical Oxygen Demand
CP	Cleaner Production
C/P	Counterpart
DB	Data Base
DF/R	Draft Final Report
DO	Dissolved Oxygen
D/D	Detail Design
EAP	Environmental Action Plan
EC	European Commission
EC	Electric Conductivity
EIA	Environmental Impact Assessment
EIB	European Investment Bank
EU	European Union
F.C.	Foreign Currency portion
F/R	Final Report
F/S	Feasibility Study
GC-mass	Gas Chromatography-mass spectrometry
GHG	Green House Gasses
GUP	General Urban Plan 2002 City of Skopje
g/c/d	Gram per capita per day
HRT	Hydraulic Retention Time
HMI	Hydro Meteorological Institute
ICP	Inductivity-Coupled Plasma
IC/R	Inception Report
IEE	Initial Environmental Examination
IEP	Integrated Environmental Permit
IPA	Instruments for Pre-Accession
ISIC	International Standard of Industrial Classification
IUCN	International Union for the Conservation of Nature and Natural Resources
IPPC	Integrated Pollution Prevention and Control
IT	Information Technology
IT/R	Interim Report
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
KfW	Kreditanstalt für Wiederaufbau
kg/d	Kilogram per Day
L.C.	local currency portion
lpcd	liter per capita per day
L.W.L.	Low Water Level
m^3	Cubic meter
MAFWE	Ministry of Agriculture, Forestry and Water Economy
Max	Maximum

MEPP	Ministry of Environment and Physical Planning
MF	Ministry of Finance
mg/l	Milligram per liter
Min	Minimum
MKD	Macedonian Denar
MOE	Ministry of Economy
MOH	Ministry of Health
MLSS	Mixed Liquor Suspended Solids
Sewerage M/P 99	Sewerage Master Plan prepared in 1999 by Kruger
MTC	Ministry of Transport and Communication
NACE	Nomenclature des Activities Economiques
NDP	National Development Plan
NEAP	National Environmental Action Plan
NGO	Non Governmental Organization
NRW	None-revenue Water
OJT	On the Job Training
O&M	Operation and Maintenance
PAPs	Project Affected Peoples
PE	Population Equivalent
PHARE	Poland and Hungary Assistance for Reconstruction of Economy.
PR/R	Progress Report
PV	Present Value
R.C.	Reinforced Concrete
SCADA	Supervisory Control and Data Acquisition
SME	Small and Medium sized Enterprise
SRT	Solids Retention Time
SS	Suspended Solids
S/W	Scope of Work
TDS	Total Dissolved Solids
TOC	Total Organic Carbon
TOR	Terms of Reference
USEPA	United States Environmental Protection Agency
VAT	Value Added Tax
Vodovod	Public Enterprise “Water Supply and Sewerage” Skopje
WB	World Bank
WWTP	Wastewater Treatment Plant

Part I

BASIC PLAN

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

After becoming independent in 1991, Former Yugoslav Republic of Macedonia ("Macedonia") decided to become a member of EU[1] as a part of its policy. Also EU has provided wide support to Middle Eastern European countries, which include Macedonia, in preparation for the EU participation and for promotion of democratization. Specifically, EU has been emphasizing support in the field of maintaining environment quality which is one of the required conditions for EU participation.

With the financial assistance of the EU as soft component, the Ministry of Environment and Physical Planning (MEPP) has been established / strengthened to handle environmental issues. EU has also supported institutional strengthening and formulation of legal system concerning environment. Also, financial assistance has been provided by the EU for the formulation of environmental laws and water laws, the formulation of EIA system, and the setting of environmental quality standards related to the rivers and lakes including establishment of environment-related ordinance. In addition, EU has provided financial assistance for activities such as construction of wastewater treatment plants in Struga city and Ohrid city near the Ohrid lake, which is designated as world heritage; providing water quality analysis equipment, and for establishment of water quality monitoring system.

Skopje is the capital and the largest city of Macedonia. The percentage of population covered by sewerage services has reached 80% and thus sanitary conditions of the living environment have improved. The Vardar River, which passes through the center of the city, has been polluted due to discharge of untreated wastewater from the entire city. Therefore, the support concerning improvement of sewerage services in Skopje was enforced in 1999, with the goal of improving water quality in the Vardar River. However, Feasibility study preparation and financial support for this purpose has not been realized yet.

In the past, Japan has undertaken the Project titled "The study on Integrated Water Resources Development and Management Master Plan, 1999". Of the proposed projects by this Study a few were implemented through Japanese cooperation. These projects include "Zletovica Basin Water Utilization Improvement Project" as a loan project, and "The project for Improvement of Water Supply in Skopje Outskirts" (completed in March 2005) as a grant aid project. Following the Study of The Ministry of Land, Infrastructure and Transport of Japan, Macedonia requested this project for wastewater treatment development in Skopje city in July 2005, with their expectation for the public finance support of the Government of Japan. Government of Japan adopted this project in November 2006. JICA conducted a preparatory study and concluded the S/W in March 2007.

1.2 Objectives of the Study

The main aim of the Study is water quality improvement in the Vardar River flowing through the center of Skopje city and to achieve this target, this Study is undertaken with the following objectives.

(1) To formulate a Basic Plan (B/P) in order to control pollution due to domestic and industrial wastewater.
(2) To conduct a Feasibility Study (F/S) on the sewerage projects selected from the B/P.
(3) To formulate an Action Plan (A/P) for improvement of organizational, institutional and financial aspects.
(4) To formulate an A/P pertaining to industrial wastewater management and water quality monitoring system.

[1] Candidate status was given in December 2005.

1.3 Study Flow and Report Contents

The study has commenced in September 2007 and is scheduled to complete in June 2009. It is implemented in two phases: Phase 1 for B/P has been completed in March 2008, and is followed by phase 2 study for F/S. Study schedule is presented in Figure 1.1.

It is emphasized here that a basic plan is conducted only for selection of the priority projects. The depth of study in a basic plan is different from a Master Plan study. Accordingly, the study in Saraj, North Gorce Petrov and Dracevo is not so comprehensive but limited only for selection of priority projects in Skopje city.

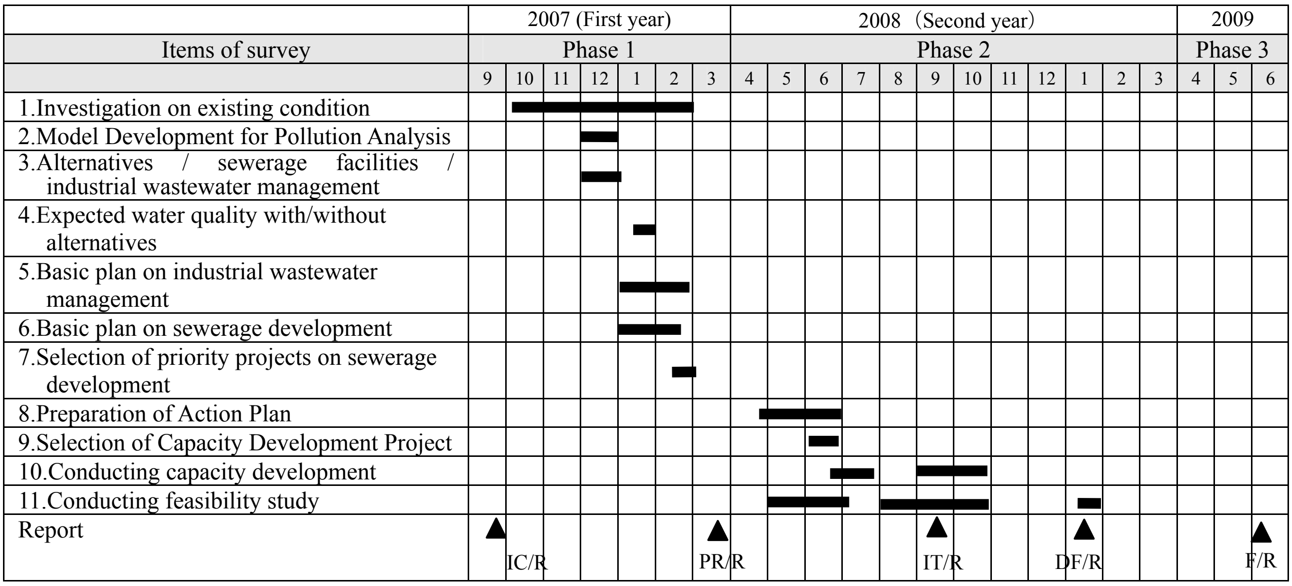


Figure 1.1 Study Schedule

1.4 Study Area

The study area covers entire Skopje city as indicated in the "General Urban Plan 2002 (Target year 2020) (hereinafter referred to as "GUP")". The study area is shown in Figure 1.2 while its size is shown in Table 1.1.

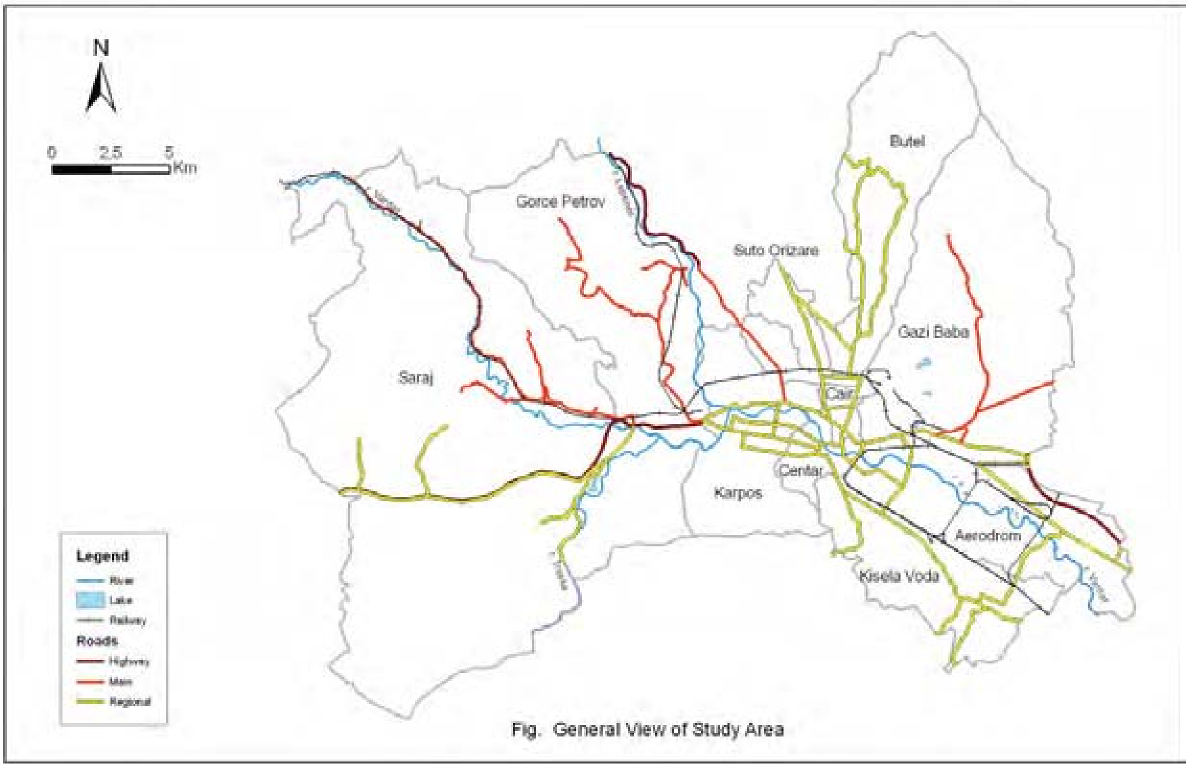


Figure 1.2 Study Area

Table 1.1 Size of Study Area

(km²)

Municipality	Size	Municipality	Size
Aerodrom	9.48	Kisela Voda	34.24
Butel	54.79	Center	7.52
Gazi Baba	110.86	Cair	3.52
Gorce Petrov	66.93	Suto Orizari	7.48
Karpos	35.21	Saraj	229.06
		Total	559.09

Source: JICA Study Team

1.5 Counterpart Agency in Macedonia

Counterpart agencies for the Project include:

(1) Ministry of Transport and Communications (MTC)
(2) Ministry of Environment and Physical Planning (MEPP)
(3) Skopje City
(4) Public Enterprise "Water Supply and Sewerage" Skopje (Vodovod)

The members of Steering Committee (S/C) are from above four agencies and Ministry of Agriculture, Forestry and Water Economy (MAFWE) (see Appendix Part I, 1.1). The responsibilities and functions of each agency are summarized in Table 1.2.

Table 1.2 Counterpart Agency in Macedonia

Name of Agencies	Responsibility / Function
MTC	・ Regulation on sewerage ・ Assisting City in sewerage project ・ Monitoring Vodovod ・ Laws on water, collection and treatment of sewage ・ Sewerage Tariff Guidelines
MEPP	・ Law on Environment ・ EIA Regulation ・ Industrial Wastewater Monitoring (Class A[2]) ・ Wastewater Monitoring ・ Proposed Law on Waters ・ Spatial Planning
Skopje City	・ Public services (including water supply and sewerage) ・ Founder and Controlling Body of Vodovod ・ Industrial Wastewater Monitoring (Class B)
Vodovod	・ Planning / Construction / Operation / Maintenance of Water Supply and Sewerage facilities
MAFWE	・ Law on Waters ・ Regulation on Water Quantity and Quality ・ Monitoring River Flow and Quality

(1) Ministry of Transport and Communications (MTC):
The MTC, among other activities, drafts and revises laws related to water supply and sewerage. As the government is responsible for the construction of water supply and sewerage facilities, the MTC appropriates national budget to finance projects in the water supply and sewerage sectors. The MTC commits the beneficiary city and municipalities to undertake the construction projects. The MTC is responsible for licensing water supply and sewerage projects applied by the city and municipalities. The project facilities are transferred to the respective municipalities on a grant basis after completion, and operated by them.

The MTC also acts as the recipient body of external assistance. The provision and enforcement of design criteria for water supply and sewerage facilities are also the responsibilities of the Ministry. It is a great strength of the MTC to have the right to draft laws related to the sector, and the power to allocate budget to the sector. However, it is a weakness of the MTC that it does not possess sufficient expert staff to evaluate the performance of the projects under its financing. Organization chart of the MTC is shown in Figure 1.3.

[2] Class A includes industries which emit large quantity of hazardous substances such as water, air and noise. Class B includes similar industries but with small quantity. List of A and B is shown in Appendix 3.5, Part I.

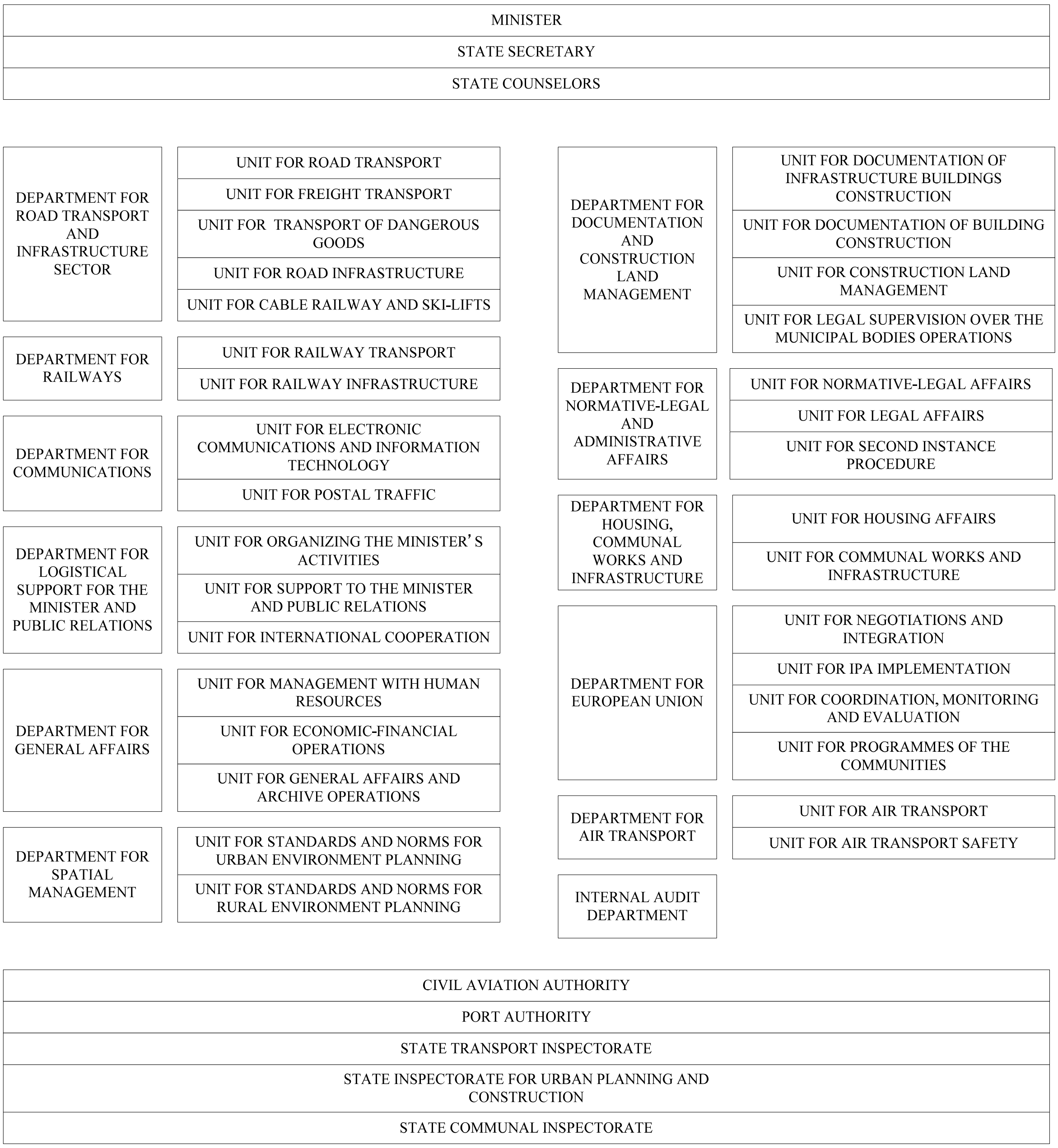


Figure 1.3 Organization Chart of MTC

(2) Ministry of Environment and Physical Planning (MEPP)

The MEPP assumes the authority of enacting laws not only on environment but also on water resources and their management. Starting from 2010 it administers, based on the revised Law on Waters, water rights on rivers and groundwater. The MEPP carries out the function of environmental inspection at the national level with the establishment of the Environmental Agency and the National Environment Inspectorate. The MEPP conducts surveillance of water quality of natural water bodies as well as urban and industrial wastewater. It has implemented the National Environmental Action Plan (NEAP) I (1996) and is carrying out the NEAP II with some revisions to its scope of work. Under the proposed Law on Waters, the MEPP's power has been strengthened since it can now manage not only the environment but also the water sector in a wide perspective since it will be entitled to control not only the activities on the prevention of pollution but also the uses of water sources.

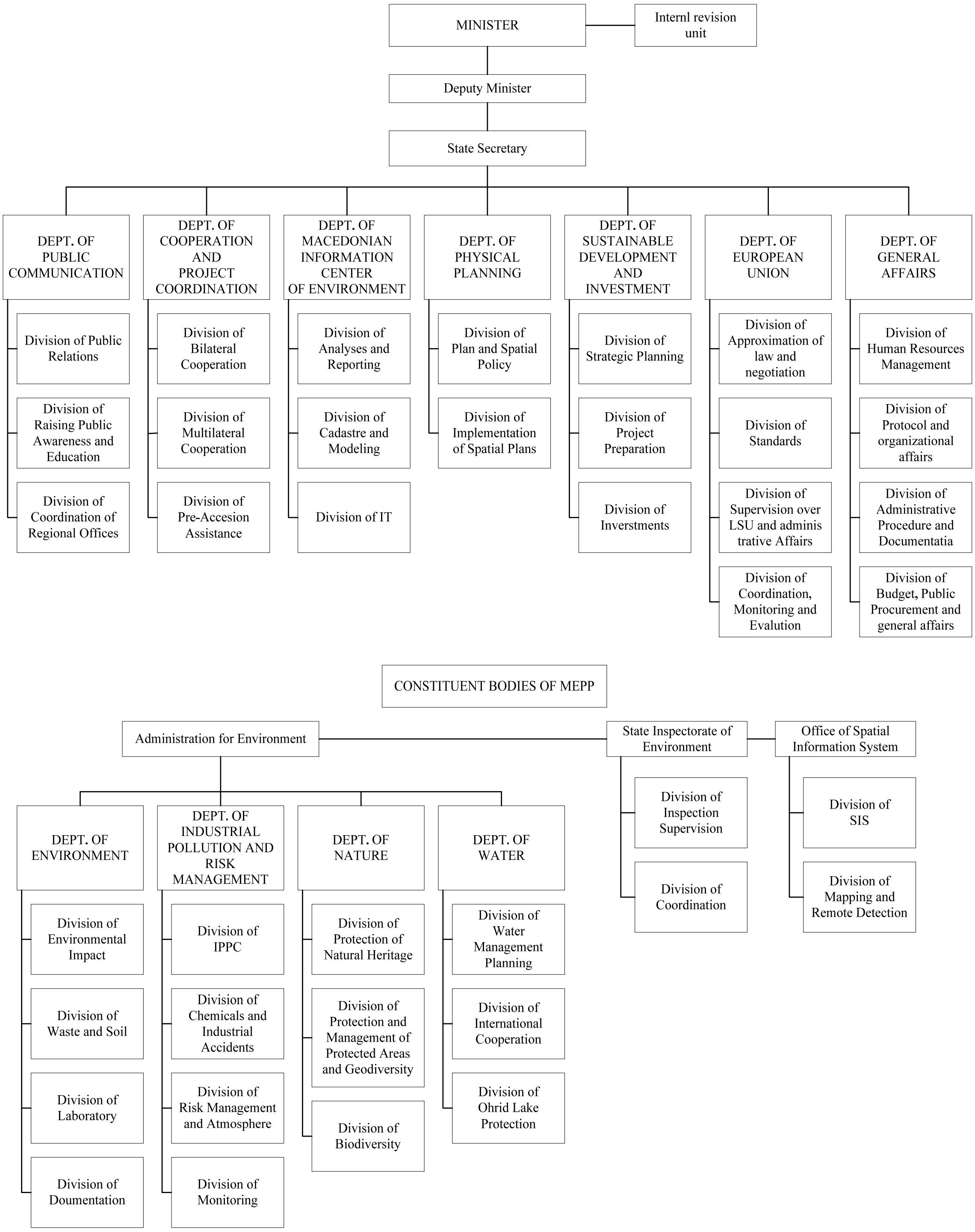


Figure 1.4 Organization Chart of MEPP

(3) Skopje City

Skopje city has 12 departments, 1 inspectorate and 1 fire brigade with 530 employees as of October 2008. Fire brigade has the largest employees of 223. In addition, the city has 6 public enterprises:

1) Street and roads – 182 employees
2) Public transport – 1,290 employees
3) Parks and green area – 404 employees
4) Solid waste – 1,050 employees
5) Water Supply and sewerage (Vodovod) – 1,150 employees
6) City parking – 140 employees

Skopje City's activities related to the water sector are the following:

1) Planning, design and construction of water supply and sewerage facilities
2) Supervision of Vodovod's operation activities of water supply and sewerage services
3) Approval of the revision of water and sewer services tariff

The City vests the Vodovod with the operation of water supply and sewerage facilities. The city of Skopje is entitled to plan, design and construct water and sewerage facilities within its own jurisdiction with financial assistance from the government or external sources. Organization of Skopje City is shown in Figure 1.5. The communal affairs department is responsible in the sewerage works.

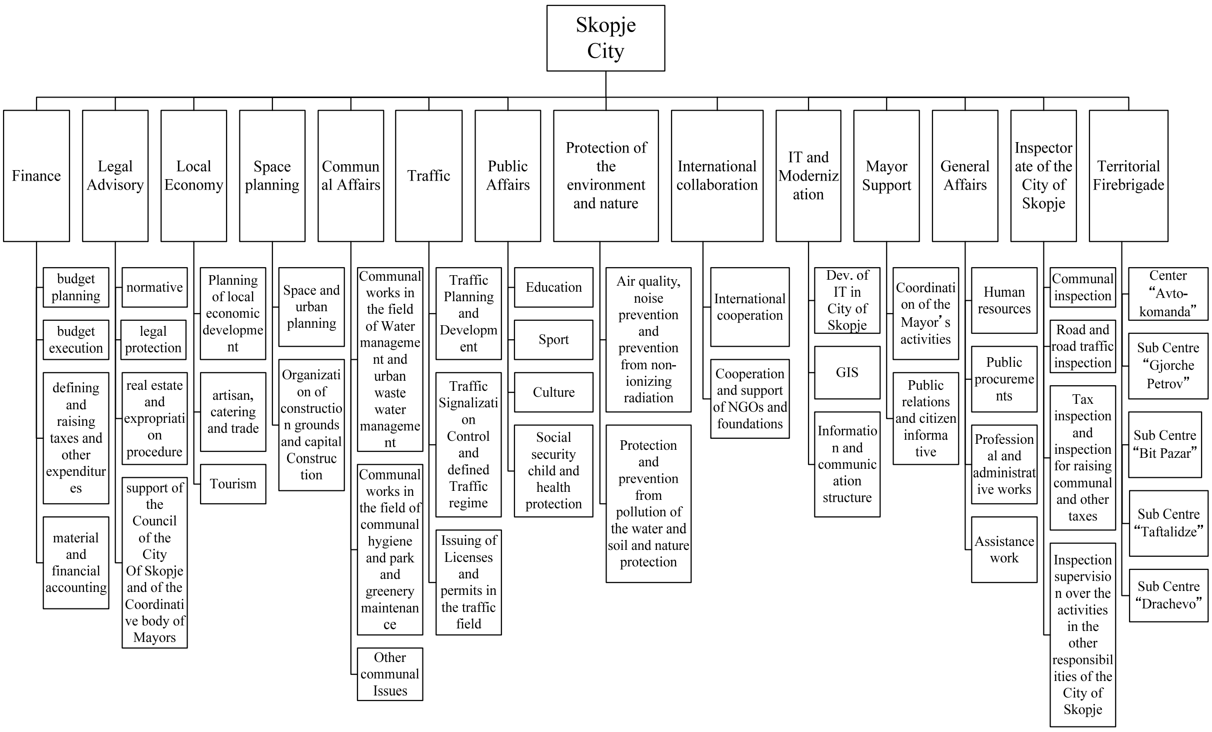


Figure 1.5 Organization Chart of Skopje City

(4) Municipalities of Skopje
In Skopje there are 10 municipalities. (There are 84 municipalities in Macedonia.) According to the Law on Local Self-Government (2005), municipalities are entitled to implement (plan, design and construct) water supply and sewerage projects by themselves, as well as receive external sources. Some municipalities are currently undertaking water supply and sewerage projects with external grant funds. Notwithstanding, the Ministry of Finance considers that the financial fundamentals of municipalities are not strong enough for these municipalities to be a borrower of an external loan.

(5) The Public Enterprise "Water Supply and Sewerage" – Skopje (Vodovod)
The Vodovod basically operates water supply and sewerage facilities which are owned by Skopje City. In other words, the Vodovod does not plan, design or construct major new or rehabilitation projects. Its functions are summarized as follows:

1) Operation and maintenance of water supply and sewerage facilities
2) Water and sewerage tariff collection
3) Planning, design and construction of minor facilities

Operating expenses including depreciation are met through the water supply and sewerage services sales to be collected by the Vodovod. In principle, no subsidies from the City can be expected. The Vodovod can propose the revision of water and sewer service charge, which is subject to the City council's decision. The tariff structure is as follows. The tariff is flat rate; there is no increase or decrease by water consumption. About 80% is actually collected against the invoiced charges.

Table 1.3 Water and Sewerage Tariff

(MKD/m^3)

	Domestic	Industrial
Water tariff	17.25	46.63
Sewerage tariff	12.12	19.17
Total	29.39	65.80

Source: Vodovod

Skopje City in coordination with municipalities plan, design and construct, among other things, new and major rehabilitation of water supply and sewerage facilities. However, before actual construction, the City and the municipalities have to consult and discuss with the Vodovod for the work, particularly for laying of water mains and main sewers in consideration of the capacity of the existing pipe network. On the other hand, the operation and maintenance including minor repair work of the facilities is the Vodovod's responsibility except for an independent area which is covered by an exclusive project.

The municipalities and the city of Skopje can legally obtain extrernal loans for construction of a wastewater treatment plant. However, local governments have never directly received external loans due to lack of financial capabilty and experience. Instead, the central government through MTC etc. borrows loans. Constructed facilities financed by external loans are granted to municipalities. It is not clear that, in future, constructed facilities financed by external loans are transfered to municipalities which, in turn, will pay back the loan amounts.

(6) Ministry of Agriculture, Forestry and Water Economy (MAFWE)

The MAFWE has authority to grant water rights on surface and groundwater for all purposes until the end of 2009 when MEPP will assume their responsibilities. As to water resource management, the MAFWE has been conducting flow measurements and monitoring of water quality of rivers.

In 1975 Water Management Plan was implemented by the MAFWE, which resulted in the establishment of the Water Fund. The Water Fund is expected to provide and implement a water sector development plan and its implementation schedule including the development and exploitation of water resoures; irrigation facilities; establishment of water user unions; and the construction of rural water supplies. In effect, however, it is said that only minor portion of such a plan has been realized.

(7) Ministry of Finance (MF)

The MF provides the national budget plan every year including capital investments to be administered by each ministry in charge. The MF allocates the budget to each ministry, and the ministries reallocate the investment budgets to respective sectors which need funding for implementation of required projects.

Macedonia will be the executing agency for EU funds including the IPA starting from 2008. Macedonia will be imposed stricter conditions for accessing the funds. In this connection, a new department namely "International Finance Department" was established in the MF, which handles contract-making related to the IPA funds, market survey and project management.

1.6 Assistance for the Project Realization

"Development and technical documentation for wastewater collection and treatment for Skopje" is listed among the projects for 2007 to 2008 in the National Development Plan (NDP) 2007 – 2009 which was formulated by the MF. In the list of 2009 projects, "Construction of the wastewater collection and treatment for Skopje" together with "Rehabilitation and water supply improvement" is included as well. NDP is to initiate program of investments that is consistent with the EU multi-annual programming practice and to support preparation of programming documents required for the use of EU pre-accession funds. Complying with the EU environmental Acquis would require huge investments in the establishment and development of environmental infrastructures (sometimes called communal infrastructure including water supply, wastewater and solid waste management).

In addition to the on-going projects in Krivogastani, Kumanovo[3], Berovo, and Gevgelija, new projects in Skopje, Cucer Sandevo[4], Caska, Prilep[5], Tetovo, Bitola, Veles, Strumica, Berovo, Debar are also listed in the NDP. The required investment costs are estimated as 104 million Euros for sewerage and water supply sector during 2007 and 2009, out of the total investment costs of 1,100 million Euros. The Second National Environmental Action Plan, on the other hand, says that the volume of required investment to comply with the EU Urban Waste Water Directive is 230 million Euros.

Considering a relatively small size of the capital expenditure of 1.43 million MKD (2.4 million Euro) in 2007 budget and 2.14 million MKD (3.6 million Euro) in 2008 budget compared with the required investment costs, as the National Environmental Action Plan points out, an external finance is indispensable. IPA (Instrument for Pre-Accession) fund is a possible promising external financial resource. IPA was introduced in 2007 after the earlier schemes of Phare（Poland and Hungary Assistance for Reconstruction of Economy） and CARDS Program（Community Assistance for Reconstruction, Development and Stability in the Balkans） was integrated into a Multi-annual Fund[6]. Under the CARDS, the Macedonia received 229 million Euros, and of this 6.3 million Euros was allocated to the environmental and nature protection sector. The Multi-annual Fund has expressed to allocate 8 to 12 million Euros for the year 2007 to 2009 which was allocated to the sewerage project in Prilep city. The second Fund starting the year 2010 will be allocated to a part of the Skopje sewerage project.

There are several potential international donor agencies of the capital required for the Project implementation. EIB[7] is a possible donor agency and the JICA with very low-interest rate and long-term repayment period is also one of the potential donor agencies.

Although request for JICA loan is usually made based on F/S results, assistance even during the study process to the counterparts to accelerate placement of JICA request is one of the items in the study. It is found out that the request can be made only after decision of the Government (Ministers), who can decide based on the results of F/S. Therefore, the earliest request can be made at the first quarter of 2009 when a substantial result will be available through the F/S report.

1.7 Investor

"Who can be an investor, as defined in the EIA procedure, on the Project" is the next issue. The city and all 84 municipalities (10 municipalities constitute the City of Skopje) are responsible, among others, for collection and treatment of wastewater according to the Law on local self-government, 2005. Based on this[8], the City of Skopje as an investor hosted stakeholder meetings on environmental and social issues.

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[3] Operation started in 2008.
[4] Operation started in 2008.
[5] Fund is applied to IPA-fund in 2008.
[6] Multi-Annual Indicative Financial Framework for the year 2007 – 2009 is 210.5million Euro; 40.5 million Euro is expressed for regional development. Further 20 to 30% is allocated to environmental sector. Thus, 8 to 12 million Euro is calculated.
[7] EIB plans to provide 8.7 billion Euros for 7 years covering 2007 to 2013 to Croatia, Turkey and the western Balkan countries.
[8] The city of Skopje also expressed to become an investor in the Steering Committee of this Study in November 2007.

On the other hand, their financial base is still not strong enough to finance the Project, although financial base has started strengthening. The Project can be financed either by the subsidy from the central government and/or through external loan. As mentioned already, in addition to the domestic budget, external loan is essential for the Project realization.

Direct external borrowing by a city or municipality became legitimate in June 2007. The government, however, shall not approve such borrowing to be practiced by a city or municipality unless it has realized a sound financial position with sufficient surplus for at least a couple of consecutive years. As of beginning of 2008, only 8 municipalities are observed to be financially sound local self-government unit and are allowed to borrow external loan by the MF. City of Skopje is not included among these 8 municipalities. Even if it is allowed to borrow, the municipality should be backed up by the government as guarantor.

Assuming that the project is financed by a loan from an external lending agency, the MTC shall be the executing agency as a tradition. Skopje City can also be the executing agency from legislative point of view. It is not yet clear, however, whether or not Skopje City could be the executing agency for the present project. The executing agency would be required to handle complex loan and project management procedures including the procurement through untied international competitive bidding, disbursement of loan proceeds, and amortization of the loan.

As a result, the government shall perform as the borrower. It is understood that the MTC (or the MEPP), guaranteed by the MF, has been borrower in past for such projects and could be a loan borrower, namely as an investor. However, the agency that will be assigned as borrower can be decided by the Government (Ministers) only when a loan is requested. In case of the Zletovica multi-purpose phase 1, a new law was formulated defining that the MAFWE be a borrower and the MF be a guarantor. If this case is applied to the wastewater treatment project in Skopje, the MTC or MEPP will be a borrower, guaranteed by the MF and the City of Skopje will be an investor and will pay back loan amounts. During the course of the Study, possibility of setting up of a P.E. by the central government is heard. However, it is not clear of the possibility.

1.8 Regulation on Environment and Water

Macedonia obtained the EU candidate status in December 2005. Even though it is stressed that significant efforts will be needed to ensure the implementation and enforcement of the legislation (EU Enlargement Strategy and Main Challenges 2006-2007), progress on approximation process to EC “acquis communautaire” has been made in the environmental and water sectors. Law on Environment has been enacted in 2005. Its bylaws are in preparation stage. The Law requires to have National Ecological Plan and Local Environmental Action Plans. The (second) National Environmental Action Plan was formulated in 2006.

1.8.1 EU Legislation on Environment and Water

EC made an effort to establish an environmental policy and unify pollution control measures towards EU integration. Table 1.4 shows the main legislations related to the Study. Early European water legislation began with standards for those of the rivers and lakes used for drinking water abstraction in 1975, and culminated in 1980 in setting quality targets of 48 chemical and microbiological parameters for drinking water.

Table 1.4 EU Water and Environmental-related Legislation

Field		Decision, Regulation and Directives
Water Pollution	Water Framework Directive	Directives[9] 2000/60/EC、Decision 2455/2001/EC
	Drinking Water Water for human consumption Surface water for drinking Drinking water measuring methods	 Directives 80/778/EEC (Directives81/858/EEC, Directives 90/656/EEC, Directives 91/692/EEC, Directives 98/83/EC, Regulation 1882/2003) Directives 75/440/EEC, Directives 79/869/EEC, Directives 90/656/EEC, Directives 91/692/EEC, integrated into Directives 2000/60/EC Directives 79/869/EEC, Directives 81/855/EEC, Directives 90/656/EEC, Directives 91/692/EEC, Regulation 807/2003, Directives 2000/60/EC
	Surface water for bathing	Directives 76/160/EEC, Directives 2006/7/EC
	International river	Decision 95/308/EC
Urban Wastewater	Urban wastewater treatment	Directives 91/271/EEC (Regulation 1882/2003)
	Fresh water for fish	Directives 78/659/EEC (Directives 90/656/EEC, Directives 91/692/EEC)
	Nitrates	Directives 91/676/EEC
	Dangerous substances Mercury Others : water environment	Directives 76/464/EEC（Directives 91/692/EEC, 2000/60/EC）The Council Directive 76/464/EEC will be integrated in the Water Framework Directive. Directives 82/176/EEC (Directives 90/656/EEC, Directives 91/692/EEC) Directives 76/464/EEC (Directives 90/656/EEC, Directives 91/692/EEC)
	Others: groundwater	Directives 80/68/EEC (Directives 90/656/EEC, Directives 91/692/EEC)
Industrial Wastewater	Integrated Pollution Prevention and Control	Directives 96/61/EU
Solid Waste	Landfill Directive	Directives 99/31/EC
	Sewage Sludge for Agriculture	Directives 86/278/EC

In late ‘80s the existing legislation were reviewed and it was concluded that a number of improvements could be made and gaps could be filled. This resulted, in 1991, in the adoption of:

- the Urban Wastewater Treatment Directive, providing for secondary (biological) wastewater treatment, and even more stringent treatment where necessary.
- the Nitrates Directive, addressing water pollution by nitrates from agriculture.

Other legislative results of these developments were Commission proposals for action on:

- a new Drinking Water Directive, reviewing the quality standards and, where necessary, making them more strict (adopted November 1998),
- a Directive for Integrated Pollution and Prevention Control (IPPC), adopted in 1996, addressing pollution from large industrial installations.

Whilst EU actions in the past, such as the Drinking Water Directive and the Urban Wastewater Directive, can duly be considered milestones, water policy and water management are to address problems in a coherent way. Responding to this, a Proposal for Water Framework Directive (2000/60/EC) was drafted with the following key aims:

- expanding the scope of water protection to all waters, surface waters and groundwater
- achieving "good status" for all waters by a set deadline
- water management based on river basins
- ”combined approach” of emission limit values and quality standards
- getting the prices right

[9] A directive shall be binding, as to the result to be achieved, upon each Member State to which it is addressed, but shall leave to the national authorities the choice of form and methods. A decision shall be binding in its entirety upon those to whom it is addressed.

- getting the citizen involved more closely
- streamlining legislation

One advantage of the framework directive approach, in its own way a significant one, is that it will rationalize the Community's water legislation by replacing seven of the "first wave" directives: those on surface water and its two related directives on measurement methods and sampling frequencies and exchanges of information on fresh water quality; the fish water, shellfish water, and groundwater directives; and the directive on dangerous substances discharges. The operative provisions of these directives will be taken over in the framework directive, allowing them to be repealed.

The key objectives, in respect of which the quality of water needs attention, are general protection of the aquatic ecology, specific protection of unique and valuable habitats, protection of drinking water resources, and protection of bathing water. For this reason, a general requirement for ecological protection, and a general minimum chemical standard, was introduced to cover all surface waters. These are the two elements "good ecological status" and "good chemical status[10]". All these objectives must be integrated for each river basin. Formulation of a river management plan and its updating every six years are required.

There are a number of measures taken at Community level to tackle particular pollution problems. Key examples are the Urban Wastewater Treatment Directive and the Nitrates Directive, which together tackle the problem of eutrophication (as well as health effects such as microbial pollution in bathing water areas and nitrates in drinking water); and the Integrated Pollution Prevention and Control Directive, which deals with chemical pollution.

The aim is to co-ordinate the application of these so as to meet the objectives established above. First of all, the objectives are established for the specific river basin. Then an analysis of human impact is conducted so as to determine how far from the objective each body of water is. At this point, the effect on the problems of each body of water of full implementation of all existing legislation is considered. If the existing legislation solves the problem, the objective of the framework Directive is attained. However, if it does not, the Member State must identify exactly why, and design whatever additional measures are needed to satisfy all the objectives established. These might include stricter controls on polluting emissions from industry and agriculture, or urban wastewater sources, and so on. This should ensure full co-ordination.

1.8.2 Macedonian Legislation on Environment and Water

(1) National Environmental Action Plan (NEAP)

In 2006, the second National Environmental Action Plan (NEAP) was formulated incorporating EU acquis communautaire. It is a basic guideline for six years to cover up to 2011. It says that approximation to EC acquis communautaire will end in 2007 with an adoption of new law on Waters. As per this Plan issues to be solved are financial sources on various environmental measures, capacity improvement on environmental issues, administrative restructuring and strengthening. It also says that required financial sources are huge and external grant and loan are to be sought.

Macedonia has signed an “Ohrid Framework Agreement” where a decentralization article is included. This decentralization process is also considered in the second NEAP. Sustainable development is also emphasized in the second NEAP.

(2) Law on Environment, Official Gazette No. 53/05, 81/05, 24/07

Law on Environment was enacted in June 2005 with twice revisions thereafter. It encompasses right and duty of the state, municipality, and individuals on environmental conservation. It incorporates EC acquis communautaire and includes an Integrated Pollution Prevention and Control, Environmental Impact Assessment, Public Access to Environmental Information, etc. It also defines

[10] "Good ecological status" and "good chemical status are defined in Appendix V, Water Framework Directive. To achieve the status, 32 priority substances were listed in 2001.

environmental standards, prohibition/ permission procedure on activities affecting environment, pollution prevention/ mitigation, environmental monitoring etc. Implementing agency is the MEPP.

(3) Law on Waters, Official Gazette No. 4/98, 19/00, 42/05, and Revised Law on Waters, No. 87/08
Law on Waters was enacted in 1998 with revisions twice in 2000 and 2005. It is administered by the MAFWE. This law defines conservation and control of water. It also defines water sources utilization and development, control of excess water use, prevention of water quality deterioration, financing and procedure of water resources activity, water right and control of international water. It also defines 1) creation of water fund to seek financial sources for water resources development, 2) measures of financial allocation, 3) creation of water supply authorities and, 4) creation of water users association. It further defines responsible organization of water use and wastewater discharge. However, no progress was made except creation of water fund.

A Water Management Plan was formulated in 1975. In 2004, it was revised based on a revised Law on Waters. It defines 1) formulation of short- and mid-term planning, 2) allocation of water resources to irrigation and hydro-power generation etc., 3) flood control and 4) rural development utilizing water resources.

The law on Waters is revised in August 2008. A comprehensive law of EU Water Framework Directives is incorporated fully into the revised law. It defines standard, principle, duty and right of the state, municipality, and (legal and natural) individuals. According to this, water is to be managed by 4 river basins of Vardar, Crn Drim, Strumica and Juzna Morava. It defines rational and effective water use, sustainable water resources development, action and procedures of water pollution prevention. Main implementation agency will be the MEPP. Effluent standard bylaws will be defined based on the proposed law. It emphasizes that water has economic value and, therefore users should pay water cost. However, this concept is not fully understood, for example, about 80% only can pay water and sewerage charges in Skopje.

(4) Urban Wastewater
Urban wastewater is currently regulated by the following laws:

- (Old) Law on Waters (Official Gazette No. 4/98, 19/00, 42/05), The MAFWE
- Law on Waters (Official Gazette No. 87/08), The MEPP
- Law on Water Supply, Drainage, Treatment and Discharge of Urban Wastewater (Official Gazette 03/00, 68/05, 28/06), The MTC
- Law on Communal Services (Official Gazette No. 08-2808/1 September 1997, No. 07-2540/1 April 1999, No. 07-1514/1 March 2004), The MTC
- Law on Local Self-Government (Official Gazette No.5/2002), The Ministry of Local Self-Government
- Law on City of Skopje (Official Gazette No. 07-3430/1 August 2004), The Ministry of Local Self-Government
- Law on Financing the Local Self-Government (Official Gazette No. 61/04, 96/04,67/07) , The Ministry of Local Self-Government
- Law on Environment (Official Gazette No. 53/05, 81/05, 24/07), The MEPP
- Law on Waste management (Official Gazette No. 68/04, 71/04), The MEPP

According to the revised law on Waters, settlements with over 2,000 population equivalent should provide collection and treatment of wastewater. The MEPP in agreement with the MTC should propose the government a wastewater plan, based on the decision of the council of the local self-government unit. Its implementation should vest on the government and the local self-government.

On the other hand, according to the law on the local self-government, local self-government units should construct, operate and maintain wastewater facilities. However, their financial base is not strong enough to do it. Their total budget was small, equal to only 3% of the state budget in 2007. It increased to 7% equivalent in 2008. Their own income sources are 3% of income tax and value added tax but their largest income is transfer from the central government. The capital grant from the MTC can be used for sewerage facility construction.

The local self-government can now borrow internal and external loans according to the new law. However, only a few financially-sound municipalities can borrow loan as of 2008, based on the clearance of some conditions imposed by the MF. City of Skopje has not cleared such condition yet and its local self-government is not permitted to obtain loan.

Ten municipalities which constitute the City of Skopje, have same legal status as some other municipalities in Macedonia and the City of Skopje according to the Law. Hence they can construct wastewater facilities on their own. Surrounding municipalities of Saraj, Gorce Petrov and Kisela Voda are planning or constructing wastewater facilities. On the other hand, communal works including wastewater facilities which can not be separated or divided are to be constructed and managed by the City of Skopje. However, there is no definition of “separation” or “division”.

Public enterprises established by the local self-government are controlled by the MTC which has a sector of the communal works.

Ordinances or sub-laws concerning wastewater quality standard on effluents from industries and urban wastewater is not established. Ordinances or sub-laws will be formulated based on the (new) Law on Waters. Effluent standard will be formulated complying with EU Directives 271/91/EEC. The law on waters defines that industrial effluent with more than p.e. 4,000, discharging to the rivers, lakes etc. must comply with the wastewater quality standard. The law also defines that MEPP with consent of the MTC and mayor of the municipality impose industry a pre-treatment facility if effluent is discharged into a sewerage system.

CHAPTER 2 PRESENT CONDITION OF THE VARDAR RIVER AND TASKS FOR WATER QUALITY IMPROVEMENT

2.1 Condition of the Vardar River

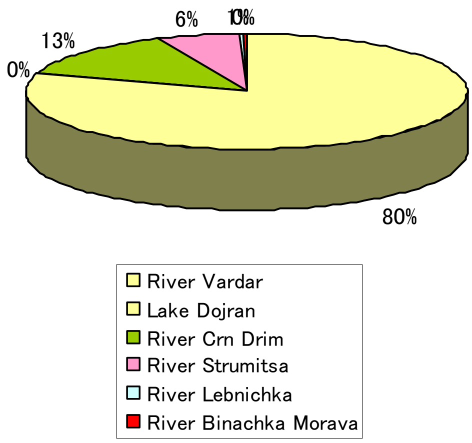
The Vardar River is the largest river in Macedonia in terms of its catchment area and length of water course. This is an international river which flows into Aegean Sea via Greece. Some of its tributaries are coming from Serbia and Kosovo, located north of Macedonia. The Lepenec River which joins the Vardar River within the study area also comes from Kosovo.

The catchment area of the Vardar River at the border city named Gevgeliga between Macedonia and Greece is 22,290 km^2, which nearly covers 80 % of the total land area (25,713 km^2) of Macedonia. Catchment area in Macedonia is shown in Figure 2.2 and distribution of catchment area of each river is shown in Figure 2.3. Average flow rate in rivers in Macedonia is presented in Table 2.1.

Figure 2.1 Vardar River

Source: Statistical Yearbook of the RM 2007

Figure 2.2 Catchment Area



Color of catchment area same as right figure

Figure 2.3 Distribution of Catchment Area

Table 2.1 Average Flow Rate in Rivers in Macedonia

	Surface Area (km^2)	Precipitation (mm/year)	Fallen Water (millions m^3/year)	Outflow and Inflow Water in (millions m^3)			Outflow Coefficient
				Outflow	Inflow	Total	
Basin of the River Vardar	20,535	707	14,603.0	4,835.0	604.0	5,439.0	0.33
Basin of Lake Dojran	120						
Basin of the River Crn Drim	3,350	933	3,125.6	1,687.8	487.2	2,175.0	0.54
Basin of the River Strumitsa	1,535	791	1,214.1	216.6	-	216.6	0.18
Basin of the River Lebnichka	129	890	114.8	34.4	-	34.4	0.30
Basin of the River Binachka Morava	44	700	30.8	9.2	-	9.2	0.30
Total	25,713	742	19,088.3	6,783.0	1,091.2	7,874.2	0.35

Source: Statistical Yearbook of the Republic of Macedonia, 2007

The Vardar River within the Study area is one tenth of the total length and located in the upper stretch. In order to figure out the dimension of the Vardar River and its tributaries, cross section survey has been conducted under the Study in November 2007. Five sections were surveyed (see Figure 2.4 for location).

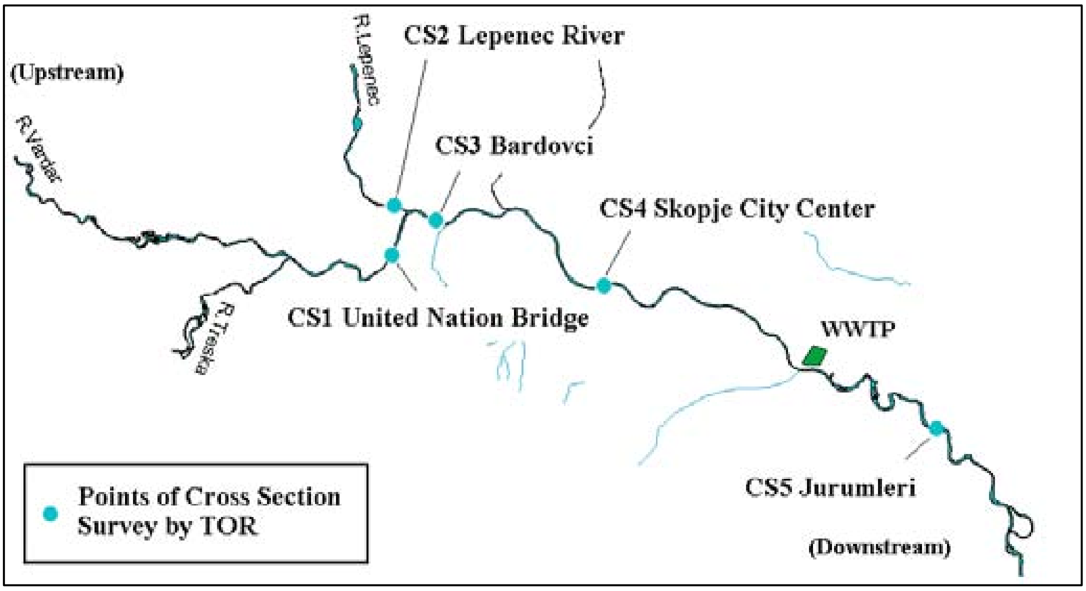


Figure 2.4 Cross Section Survey Point in This Study Area

The pictures below show that the river improvement with bank protection is done from CS1 to CS4 with low-water and flood channel. The slope consists of pebble, while the riverbed consists of sand and pebble, and grasses and bushes are seen in low-water channel. CS5 is a natural river without bank protection, where the slope and riverbed are covered by black soil and grasses and trees are seen growing on the banks.

Cross sections and water level observed through the survey in November 2007 are shown in the following figures. Additional information of the river slope is based on transversal section drawings of the Vardar River obtained from Vodovod.

CS1 is located on the mainstream of the Vardar River, before its confluence with the Lepenec River. At this location, width of wetted cross section at water surface is 53 m, maximum water depth is 1.1 m, and slope of the river bed is 2.46‰.

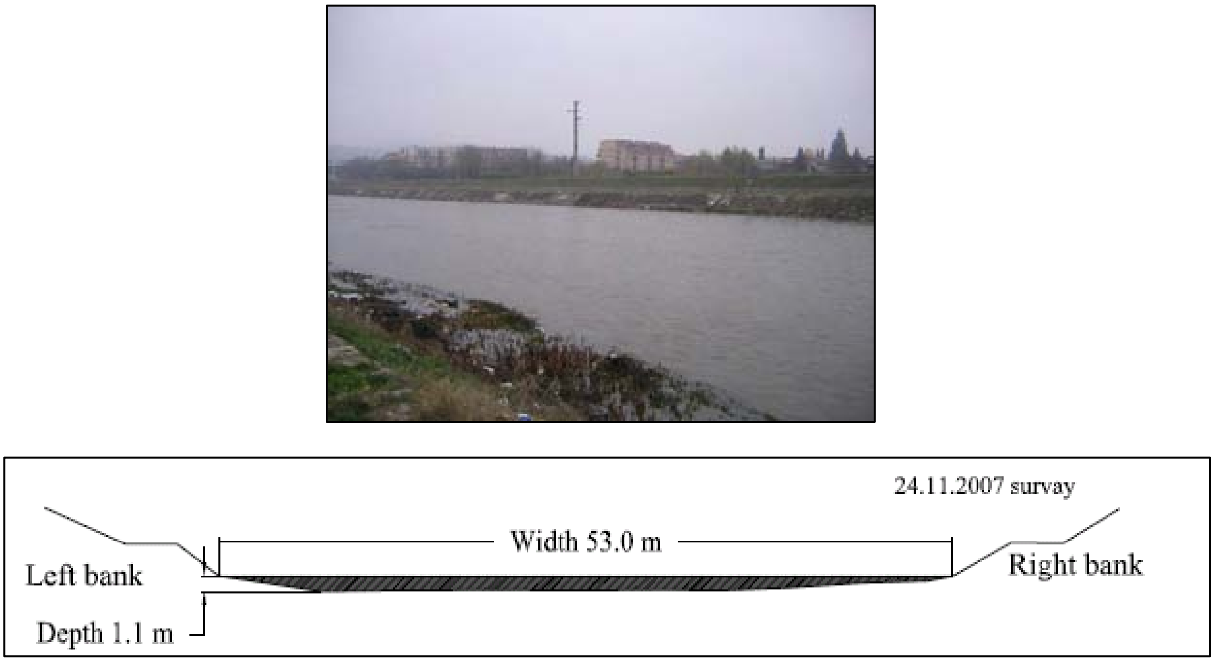


Figure 2.5 Cross Section at CS1 (UN Bridge)

CS2 is located at the end of the Lepenec River before its confluence with the Vardar River. At this location on this river, the width of water surface is 36.2m, and maximum water depth is 0.76 m. There is a weir just before this cross section, and the level of water varies before and after the weir. The water level in CS2 shows lower level after the weir.

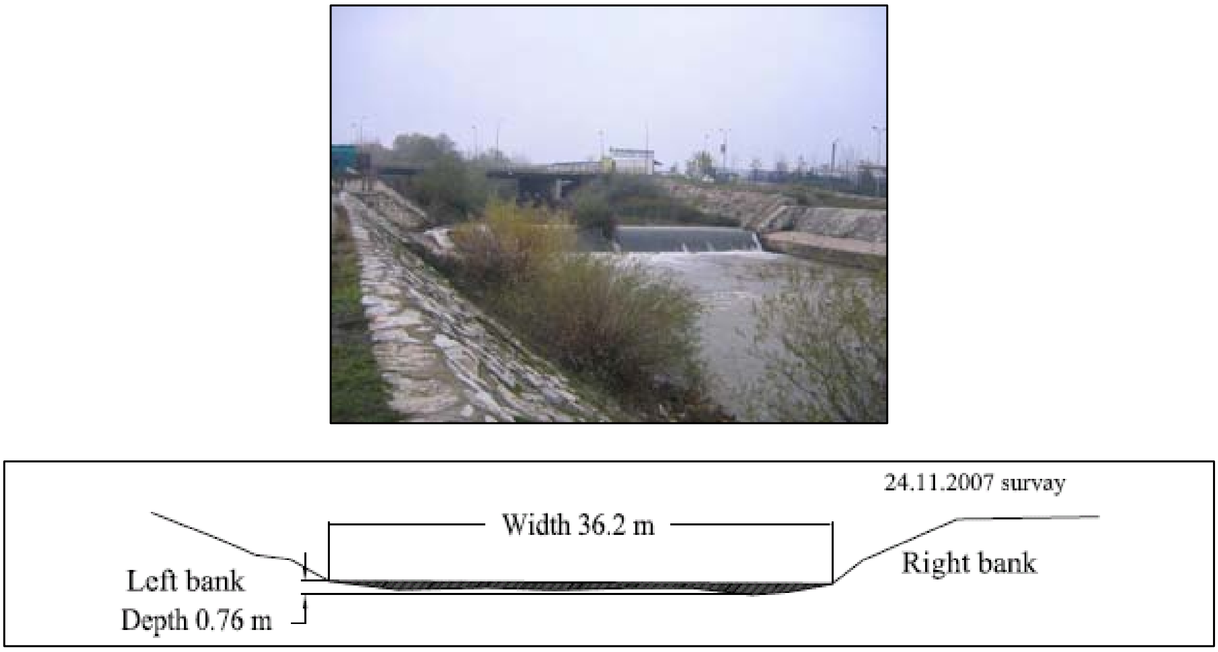


Figure 2.6 Cross Section at CS2

CS3 is located along the mainstream of the Vardar River, after confluence with the Lepenec River. At this location, width of water surface is observed as 48.3m, maximum water depth is 2.3 m, and slope of the river bed is 1.84‰

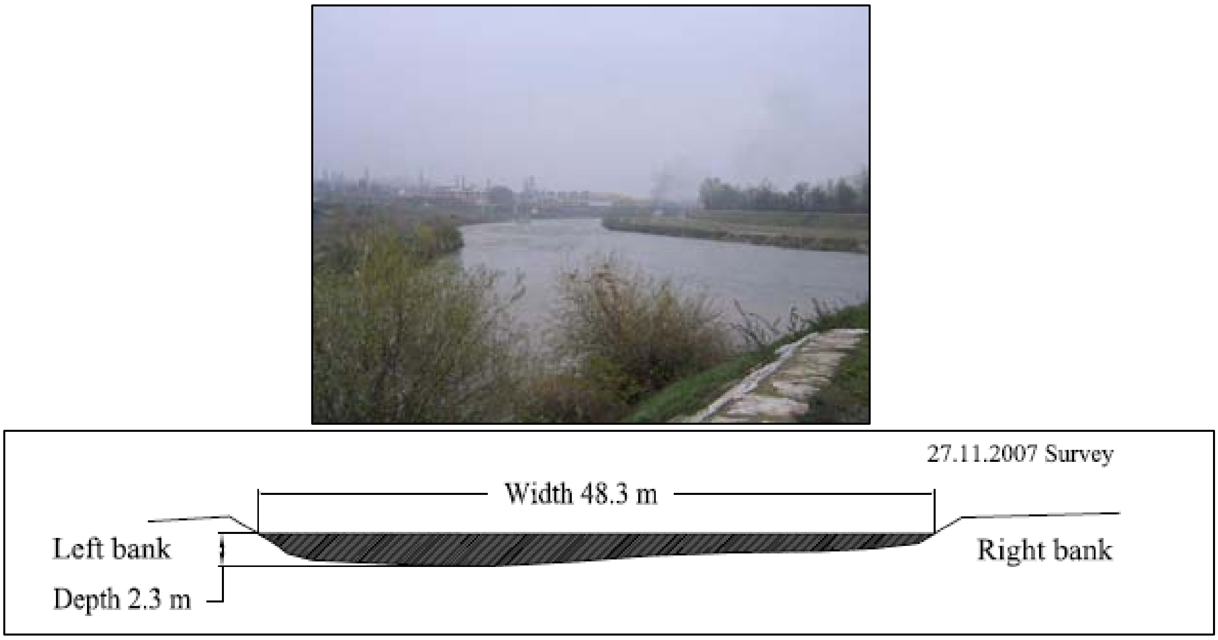


Figure 2.7 Cross Section at CS3 (Bardovci)

CS4 is located on the mainstream of the Vardar River, at the city center. At this location, the width of water surface is 48.9m, maximum water depth is 1.7 m, and slope of river bed is 1.48‰.

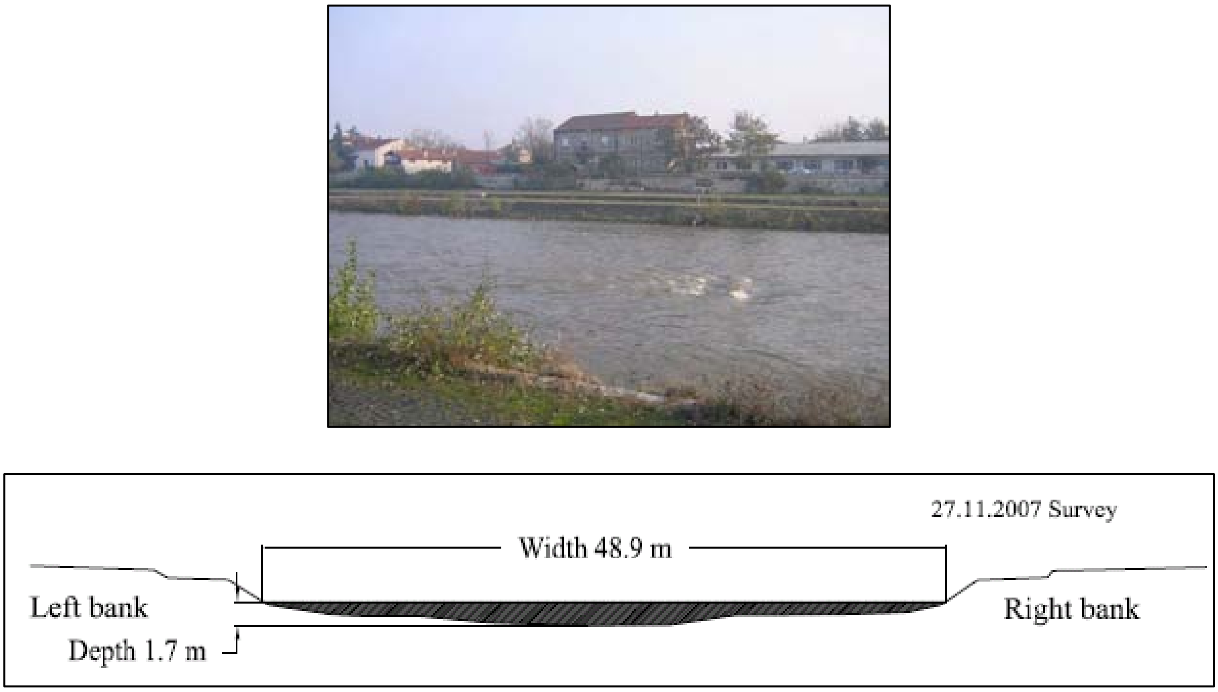


Figure 2.8 Cross Section at CS4 (Skopje City Center)

CS5 is located on the mainstream of the Vardar River, downstream of urbanized area. At this location, the width of water surface is relatively narrow, 36.2m, and maximum water depth is deeper than other locations, 3.9 m. Slope of river bed is 0.59‰, which is relatively moderate.

Figure 2.9 Cross Section at CS5 (Jurumleri)

2.2 Flow Rate of the Vardar River

2.2.1 Hydrological and Hydraulic Data

(1) Precipitation in Skopje City

In order to collect data on precipitation in Skopje City, a meeting with HMI was organized through which monthly precipitation data from 2002 to 2006 was obtained.

Normal Rain Gauge
Used in Skopje City

Precipitation is measured by HMI using the normal rain gauge shown in the photo on the right. Amount of precipitation is recorded manually once a day at a particular time. Previously, automatic rain gauge was used, but it was not used as of November 2007 due to some mechanical problem.

In the table 2.2, monthly precipitations are shown from 1980 to 2006. Data from 2002 are obtained from HMI, and data until 1996 are obtained from former JICA report "The Study on Integrated Water Resources Development and Management Master Plan in the Former Yugoslav Republic of Macedonia". Precipitation data are taken from station RST027 in Skopje. The Table below shows that the annual precipitation varies from 400 mm to 700 mm approximately and the average precipitation is 512 mm/year.

Table 2.2 Historical Amount of Monthly Precipitation in Skopje City

Year	Monthly Precipitation, in mm												Yearly (mm)
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
1980	58	21	22	19	107	25	13	12	30	94	31	63	494
1981	24	19	17	65	12	51	76	53	91	95	108	58	671
1982	5	38	44	51	36	5	48	41	17	49	55	36	425
1983	1	18	23	43	48	124	58	28	39	24	70	102	578
1984	31	90	47	37	39	29	24	45	21	7	38	37	445
1985	79	31	28	23	46	46	13	11	12	16	144	11	460
1986	82	-	35	21	42	60	51	6	12	35	22	23	390
1987	48	33	86	44	47	33	1	27	20	41	63	39	481
1988	11	34	37	20	32	49	14	-	20	30	87	46	380
1989	3	6	21	49	178	74	30	39	12	42	32	39	524
1990	2	16	12	69	24	19	24	17	12	10	13	158	375
1991	26	86	32	76	47	10	150	3	41	48	44	6	567
1992	14	7	18	162	35	110	42	2	16	35	63	74	579
1993	56	27	64	14	23	13	20	22	19	38	63	31	388
1994	57	33	1	43	41	24	50	17	12	32	8	70	388
1995	71	20	60	45	70	49	74	50	85	0	43	138	705
1996	63	61	36	38	51	21	8	19	135	13	34	57	536
2002	17	15	56	79	47	16	71	99	83	67	15	156	722
2003	113	16	2	32	93	62	2	12	21	91	26	27	497
2004	43	26	40	44	55	55	61	16	63	27	63	38	532
2005	44	23	39	23	72	38	37	73	34	50	39	102	575
2006	51	56	58	24	19	95	39	29	43	57	13	10	495
Average	40.9	32.0	35.4	46.3	52.9	45.9	41.2	29.6	38.0	41.0	48.8	60.1	512

Source: 1980~1996 form JICA Report "The Study on Integrated Water Resources Development and Management Master Plan in the Former Yugoslav Republic of Macedonia", 2002~2006 from HMI

Monthly variation in precipitation is shown in the Figure 2.10. The figure shows that the average precipitation is high in May and December, with 50 to 60 mm of monthly total precipitation. Average precipitation is low in February and August, with 30 mm of monthly precipitation approximately. As most of the monthly precipitation is under 40 mm/month, it seems that the occasional heavy rain pushes up the average precipitation.

During the stay of study team member in October to November 2007, it rained but the rainfall was so weak that the umbrella was not necessary. Sometimes it rains heavy and leads to increase in total precipitation. In January and February 2008, there was little rain; it rained only once a month.

Table 2.3 Frequency of Monthly Rainfall

Monthly Rainfall	No. of Occurrence	Percentile of Occurrence	
0 – 10 mm/month	22	8.4%	56.0%
11 – 20 mm/month	47	17.9%	
21 – 30 mm/month	37	14.1%	
31 – 40 mm/month	41	15.6%	
41 – 50 mm/month	37	14.1%	44.0%
51 – 60 mm/month	21	8.0%	
61 – 70 mm/month	17	6.5%	
71 – 80 mm/month	11	4.2%	
81 – 90 mm/month	7	2.7%	
91 –100 mm/month	7	2.7%	
101 – mm/month	15	5.8%	
No Data	2		
Total	264	100.0%	100.0%

Note: Based on data for 264 months shown in Table 2.2

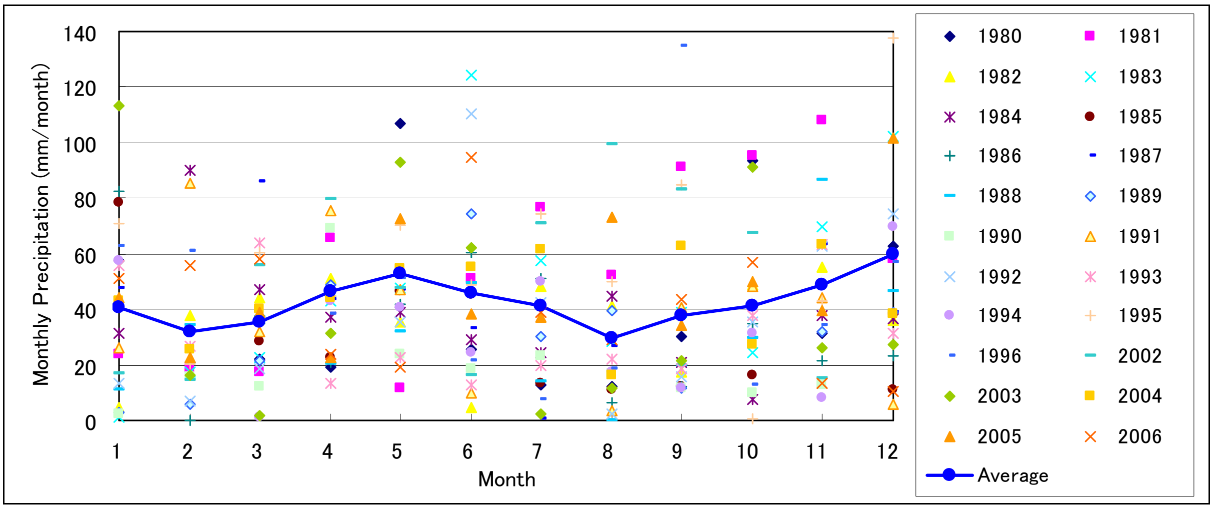


Figure 2.10 Variation of Monthly Precipitation in Skopje City

Table 2.4 Daily Precipitation in Skopje City (2007)

(mm)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Total
1					5.2		1.2		0.1		6.9	1.0	14.4
2					2.2				0.0		2.1		4.3
3	2.6										2.7		5.3
4			1.0		0.2	10.1						4.4	15.7
5		0.4		7.4	0.7	3.1		1.5			0.1	0.2	13.4
6	0.0				0.2	11.6		38.0	3.0				52.8
7					0.2	5.9		12.9	3.3	0.0			22.3
8					6.0				0.3	4.5			10.8
9									3.0	0.7		2.3	6.0
10		0.2						0.3		5.4	0.0	0.6	6.5
11		4.2								23.3	4.2	0.4	32.1
12										17.2	2.6	0.5	20.3
13	0.6	0.0				2.8			8.2	3.3	0.4	0.3	15.6
14		6.8								0.5	1.1	0.2	8.6
15												0.6	0.6
16											2.6	1.3	3.9
17		3.5				1.4					8.5		13.4
18					8.1						4.4	0.1	12.6
19		0.2	0.0		12.5						23.1		35.8
20		0.0			5.3					0.4	0.1		5.8
21			14.8		16.4				6.9	8.4			46.5
22			1.1							22.2			23.3
23		0.1	3.5							29.0			32.6
24	0.3		2.9		0.1								3.3
25	18.2			0.2	4.2								22.6
26	3.9	0.1	0.0		17.4							0.2	21.6
27	2.1	1.8	6.0	0.2					0.3	4.4	9.5	3.6	27.9
28	2.1	3.7	0.7		6.4				0.9				13.8
29			0.0		8.4				1.2	11.5			21.1
30	0.2									7.2	1.1		8.5
31			1.0		2.6					2.0			5.6
Total	30.0	21.0	31.0	7.8	96.1	34.9	1.2	52.7	27.2	140.0	69.4	15.7	527.0

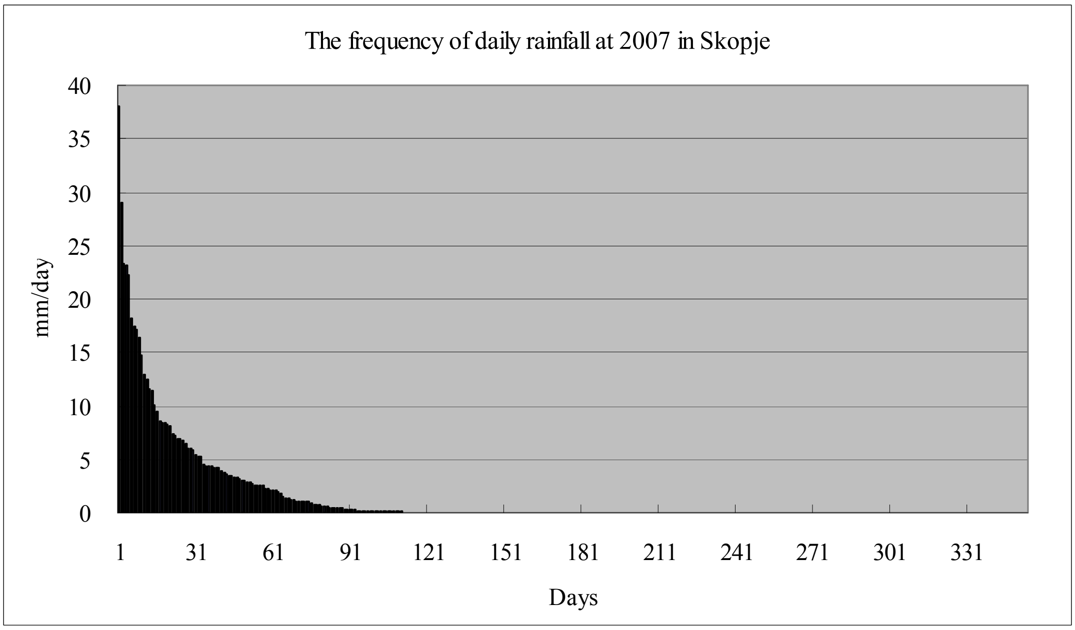


Figure 2.11 Frequency of Daily Rainfall (2007)

(2) Flow Rate in Rivers

In order to calculate the flow rate in the Vardar River, information on flow rate and water level were collected from HMI which measures and manages related data. Detailed flow data is presented in Appendix Part I, 2.1 and Appendix Part I, 2.2. Locations at which measurement of flow and water level is carried out by HMI are shown in Figure 2.12.

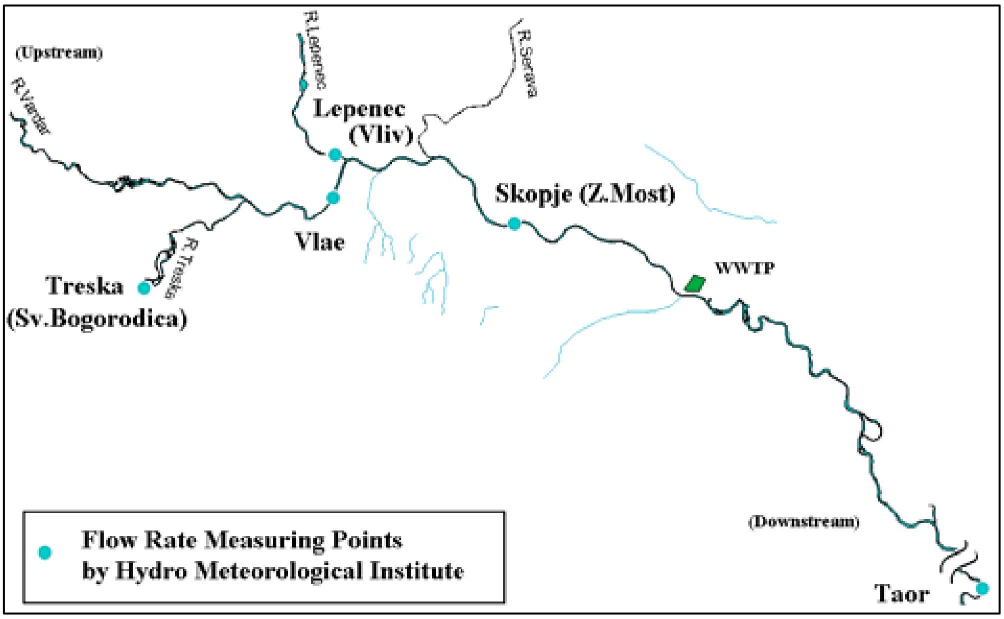


Figure 2.12 Flow Rate Measuring Points in Study Area

Tendency of flow rate from 1991 to 2005 at each station is shown in Figure 2.13 through Figure 2.17. Original flow rate data were provided by HMI. Tendency of flow rate is very similar to those of precipitation, which increases in May and December, and decreases in August.

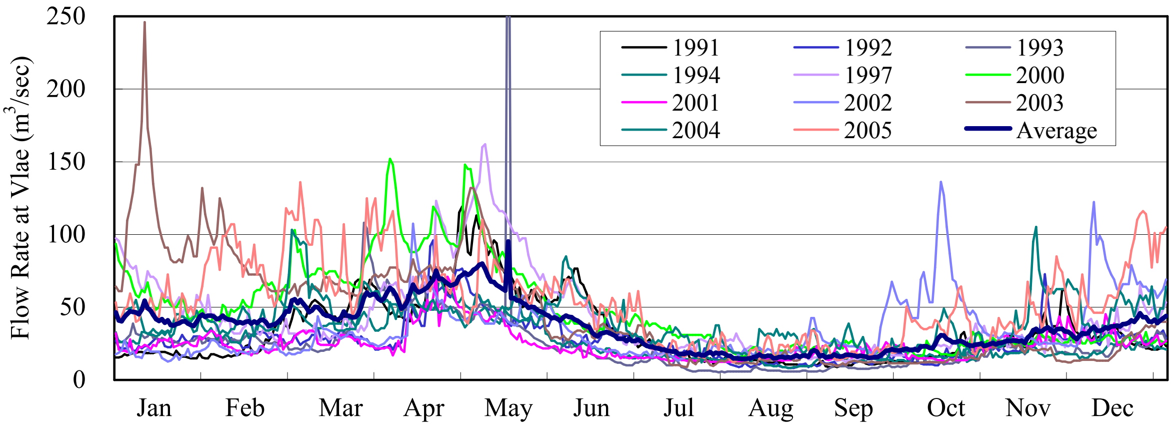


Figure 2.13 Flow Rate at Upstream of the Vardar River (Vlae)

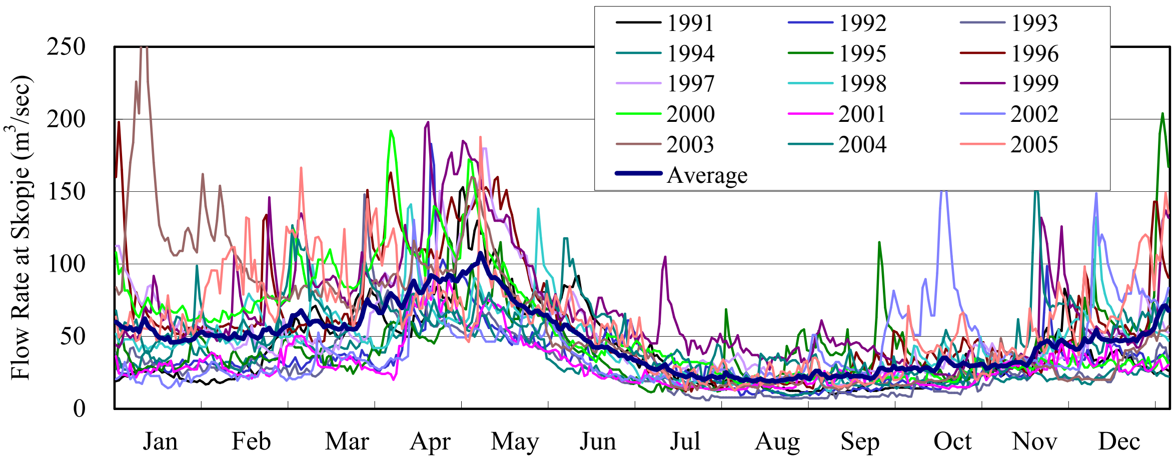


Figure 2.14 Flow Rate at Middle of the Vardar River (Skopje Z.Most)

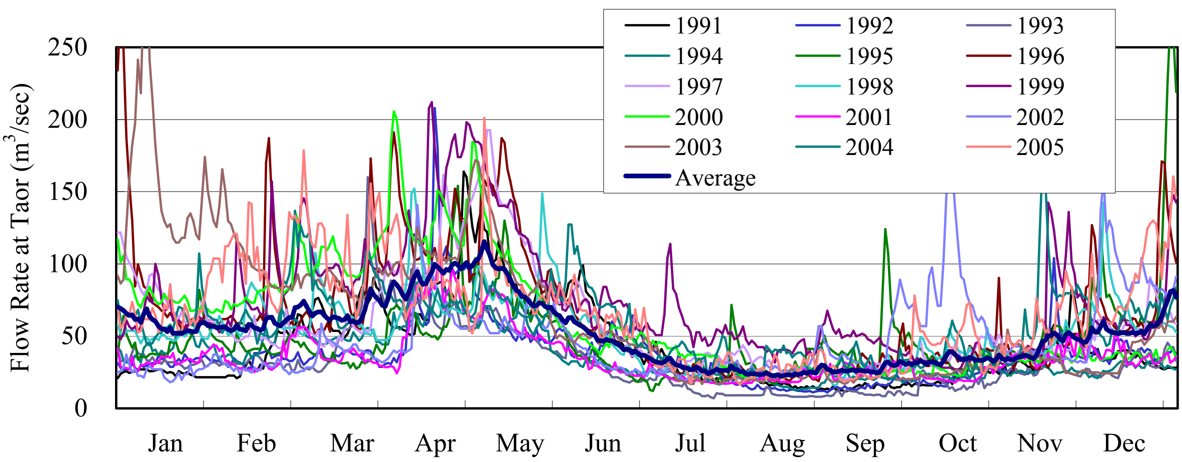


Figure 2.15 Flow Rate at Downstream of the Vardar River (Taor)

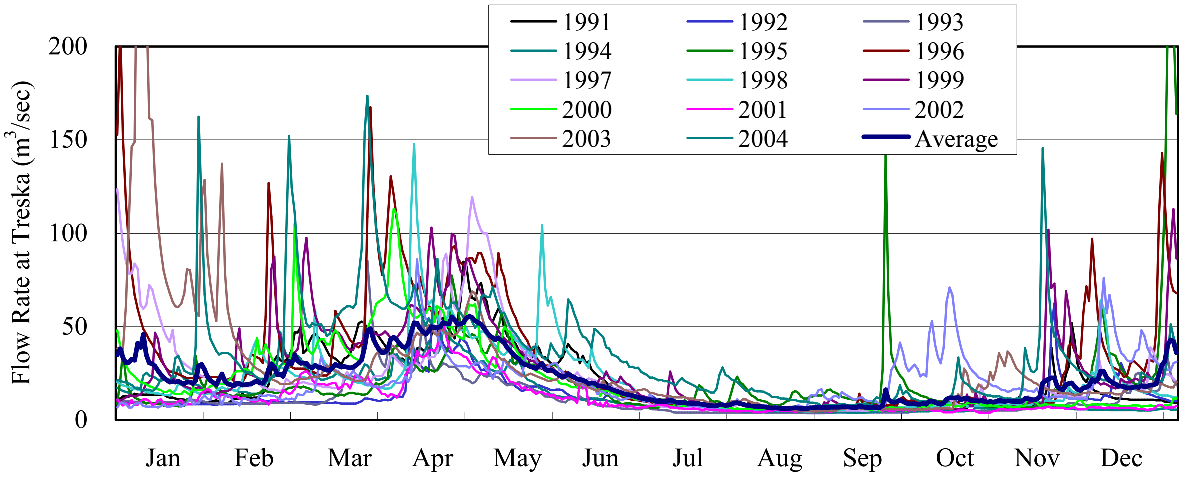


Figure 2.16 Flow Rate in Tributary of the Vardar River (Treska River at Sv.Bogorodica)

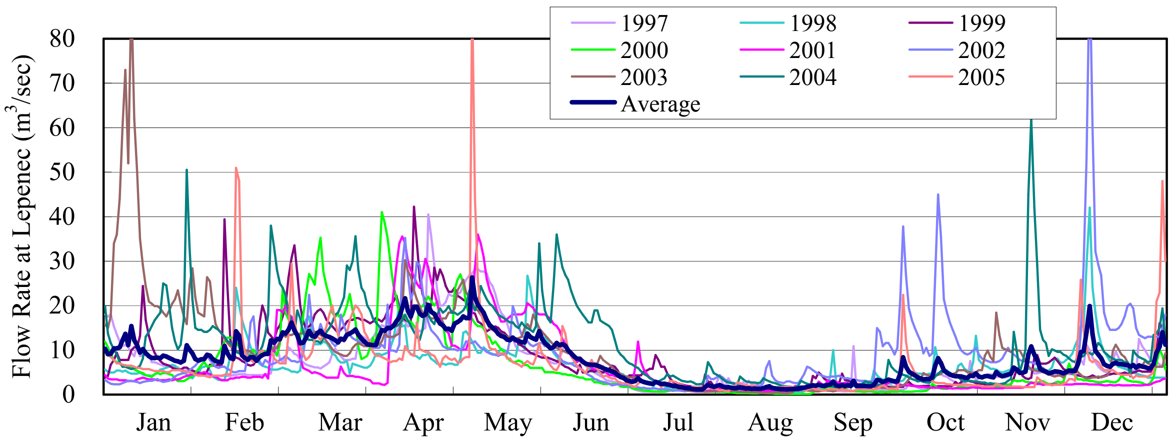


Figure 2.17 Flow Rate of Tributary of the Vardar River (Lepenec River at Vliv)

2.2.2 Calculation of Low-water Flow Rate

Using the above mentioned data from 1991 to 2005, high-water flow (95 days flow rate), average-water flow (185 days flow rate), low-water flow (275 days flow rate), and draught flow rate (355 days flow rate) have been calculated. First, high water, average water, low water and draught flow have been calculated for each year. Then, average value of these yearly values are calculated and presented below. Low water flow rate in the Vardar River is 19.6 m^3/s at the upstream, 25.7 m^3/s at the city center and 29.8 m^3/s at the downstream. Low water flow in tributaries of the Vardar River is 8.4 m^3/s in the Treska River and 2.5 m^3/s in the Lepenec River.

Table 2.5 Flow Rate in the Vardar River and Tributaries; High, Average, Low and Draught Water

	Vardar River			Treska River	Lepenec River
	Vlae	Skopje	Taor		
High-water (95-day) flow rate (m^3/s)	47.4	59.7	65.7	27.5	10.3
Average-water (185-day) flow rate (m^3/s)	30.0	39.2	43.8	14.6	5.6
Low water (275-day) flow rate (m^3/s)	19.6	25.7	29.8	8.4	2.5
Draught-water (355-day) flow rate (m^3/s)	12.1	15.1	18.9	5.5	0.9

Seeing from the water balance, the low water flow at the Lepenec River seems too small. The water balance (a) between Vlae and Skopje and (b) between Skopje and Taor, are 6.1 m^3/s and 4.1 m^3/s, respectively and the water balance of (a) is larger than that of (b).

In order to confirm the status, a JICA team member walked along the Vardar River and found that amount of inflow (a) between Vlae and Skopje was small except for the large inflow from the Lepenec River. One small river, the Serava River also joins the Vardar River before Skopje, but the amount of inflow was small. On the other hand, amount of sewer outlet (b) between Skopje and Taor was large; there were many pipes with the diameter larger than 1 m, where considerable volumes of water were running into the Vardar River.

Confluence of Vardar River and Lepenec River

At the confluence of the Vardar River and the Lepenec River (see right picture), it is observed that considerable amount of water flows in the Lepenec River with 35 m width. The amount seems much more than 10 % of main stream of the Vardar River. Considering the above situations, the low water flow at the Lepenec River is expected to be more than 2.5 m^3/s.

Then, in order to evaluate low water flow of the Lepenec River, the ratio of flow rate and catchment area (Q/A) is compared. The comparison shows that Q/A of the Lepenec River is the smallest of the Treska, Skopje and Lepenec. The land use of catchment area was confirmed by satellite photo. A large portion of Catchment area of the Treska is covered by forest, the catchment of Lepenec is covered by forest at upstream, and residential area and farmland at the downstream. Land use in catchment of Skopje is forest and farmland at the upstream, and highly urbanized area at the downstream. Since type of land use of the Lepenec is between those of the Treska and Skopje, Q/A value of the Lepenec is considered to be between those of the Treska and Skopje. So, low water flow of the Lepenec River has been calculated as 3.9 m^3/s using average value of Q/A_{Treska} and Q/A_{Skopje}. This value is reasonable considering the water balance.

Table 2.6 Comparison of Catchment Area and Low Water Flow

River (Location)	Catchment Area A (km^2)	Low Water Flow Rate Q (m^3/s)	Q/A (Low water)	Draught Water Flow Rate Q (m^3/s)	Q/A (Draught-water)
Treska (Sv.Bogorodica)	1,813	8.4	0.0046	5.5	0.0030
Lepenec (Vliv)	770	2.5	0.0032	0.9	0.0012
Skopje (Z.Most)	4,625	25.7	0.0056	15.1	0.0033

The results of low water flows for water quality simulation are shown in Figure 2.18.

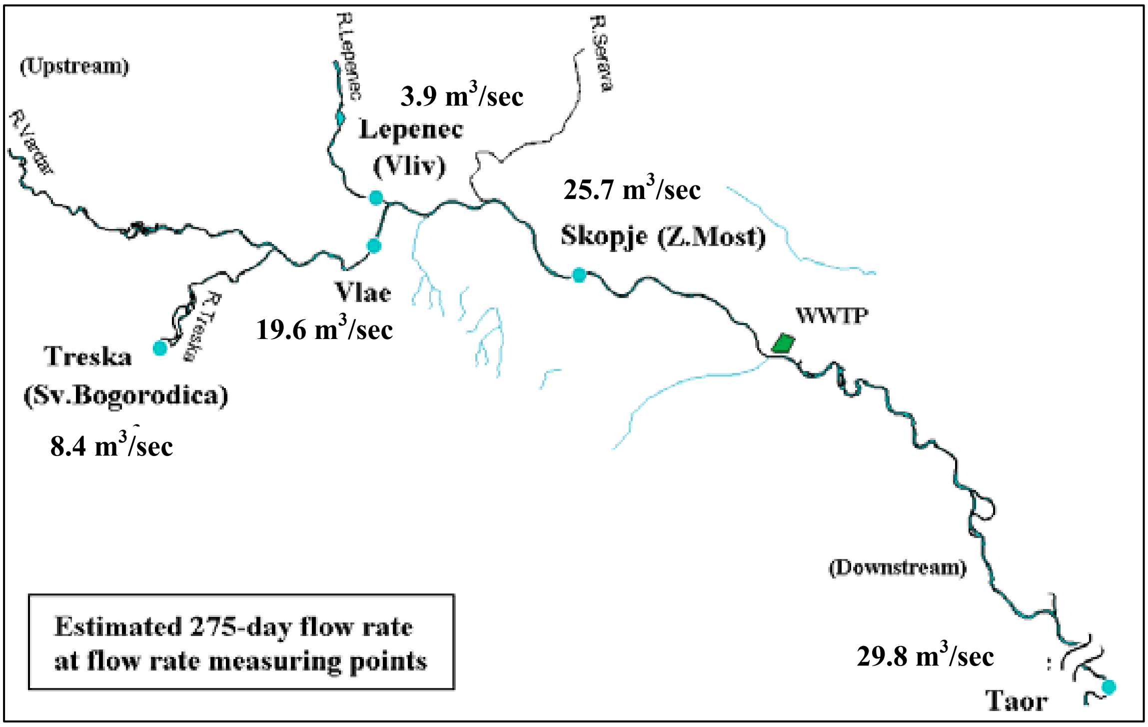


Figure 2.18 Low Water Flow for Water Quality Analysis

2.3 Water Quality in the Vardar River

2.3.1 Regulation for Classification of Water

By the environmental standard "Regulation for Classification of Water", water qualities of surface water, water courses, natural and artificial lakes and groundwater are classified into five categories.

Table 2.7 Regulation for Classification of Water

Class	Definition
I	This is very clean, oligotrophic water, which in its natural state or with possible disinfection can be used for drinking, production and processing of food product, and for breeding and raising of noble types of fish – salmonids.
II	This is very clean, mesotrophic water, which in its natural state can be used for bathing and recreation, water sports, production of other types of fish, or which can be used – after usual methods of purification / coagulation, filtration, disinfection etc./–for drinking and, production and processing of food products.
III	This class includes moderately eutrophic water, which in its natural state can be used for irrigation, and after usual purification methods (conditioning) for industries which do not need drinking water quality.
IV	This is strongly eutrophic, polluted water, which in its natural state can be used for other purposes only after certain process of treatment.
V	This is much polluted, hypertrophic water, which in its natural state can be used only for other purposes.

Source: Regulation for Classification of Water, Official Gazette No. 18/99

The indicators for the classification of water into classes are;

A: Organoleptic Indicators;
B: Indicator of Acidity;
C: Oxygen Regime Indicators;
D: Mineralization Indicators;
E: Eutrophication Indicators;
F: Microbiological Indicators;
G: Radioactivity, and;
H: Harmful and Dangerous Substances;

Main indicators are shown in Table 2.8 while each indicator is shown in Appendix 2.3, Part I.

Table 2.8 Water Quality Limits for Main Parameters

Class	pH	BOD	SS	DO
I	6.5 - 8.5	Less than 2.0 mg/l	Less than 10 mg/l	More than 8.0 mg/l
II	6.5 - 6.3	2.01- 4.00 mg/l	10 - 30 mg/l	7.99 - 6.00 mg/l
III	6.3 - 6.0	4.01- 7.00 mg/l	30 - 60 mg/l	5.99 - 4.00 mg/l
IV	6.0 - 5.3	7.01-15.00 mg/l	60 - 100 mg/l	3.99 - 2.00 mg/l
V	Less than 5.3	More than 15.00 mg/l	More than 100 mg/l	Less than 2.00 mg/l

Source: Regulation for Classification of Water (Official Gazette No. 18/99)

Generally, the entire Vardar River is classified as class II except downstream of the large cities like Skopje and Veles. Classes II and III are separated in Skopje in sewer outlet from the main right bank sewer, 20 m downstream of the Serbia Bridge. The Treska and Lepenec Rivers flowing into the Vardar River are also under the class II, similar to the upstream section of the Vardar River.

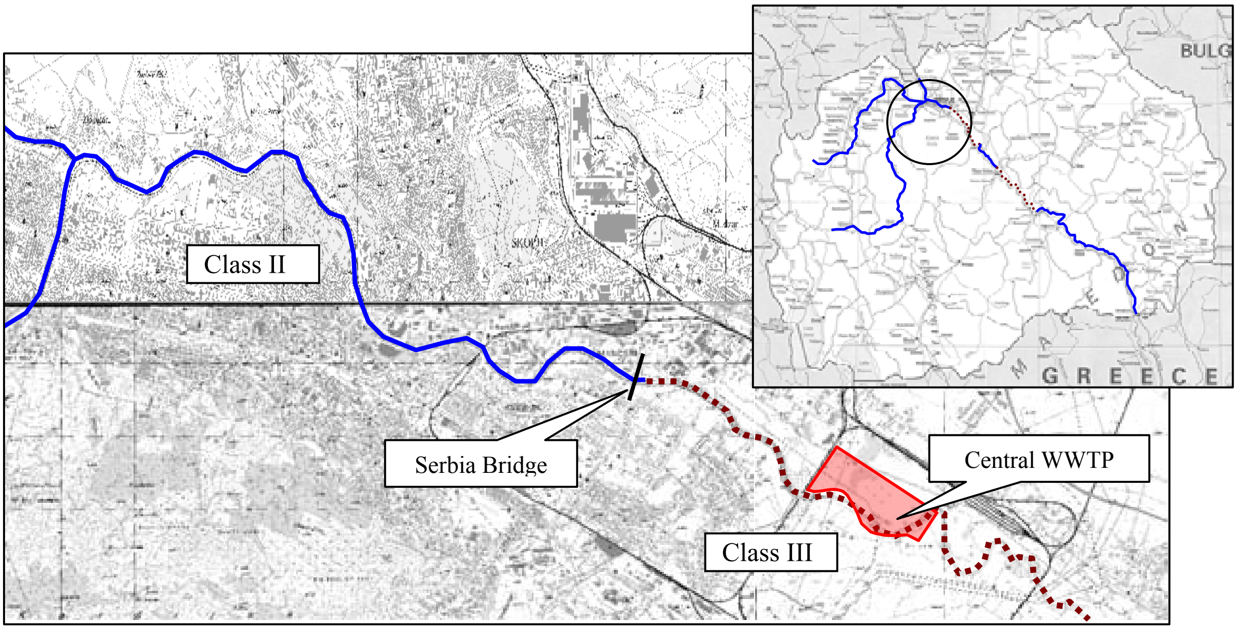


Figure 2.19 Water Quality Classification of the Vardar River

2.3.2 Water Quality of the Vardar River

Periodical water quality measuring and monitoring in rivers are carried out by the MEPP. Monitored locations along the main stream of the Vardar River are Radusa, Taor, Basino Selo, Nogaevci, Demir Kapija and Gevgelija. Monitoring locations near Skopje City are Radusa at the upstream, and Taor at the downstream, about 15 km from Skopje City. The classification is changed from Class II to Class III at the outlet of the Skopje municipal sewage canal (see Figure 2.19 and Appendix Part I, 2.4.3 for detail data).

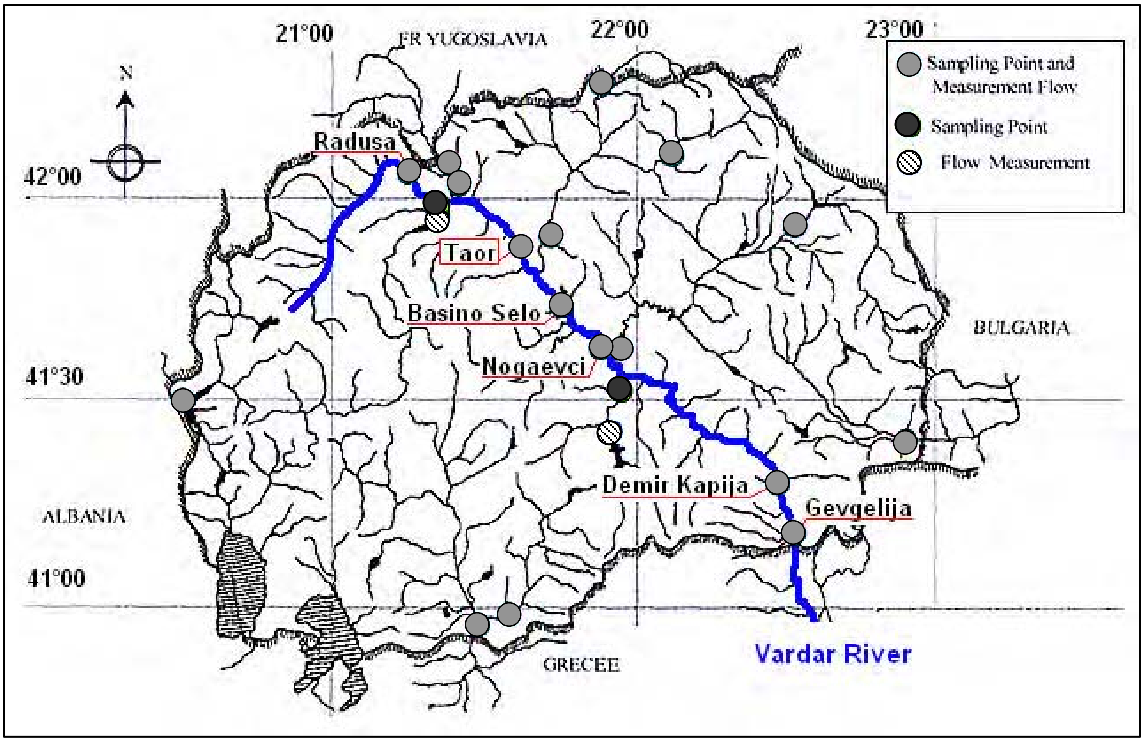


Figure 2.20 Water Quality Measuring Points in Macedonia (Source: HMI)

The data on water quality at locations mentioned above, from Taor to Gevgelija, have been received from MEPP. The level of BOD and SS at these locations in 2006, which are important factors for planning wastewater treatment plant, are presented in Table 2.9. Existing River water quality at all these five locations fall under Class III both in terms of BOD and SS, the BOD levels ranging from 6 to 7 mg/l and SS ranging from 35 to 55 mg/l.

Table 2.9 Water Quality in the Vardar River – BOD and SS

	Designated Class	BOD (mg/l)			SS (mg/l)		
		Average	Min	Max	Average	Min	Max
Taor	III	6.1	3.1	9.8	46.3	10.0	144.0
Basino Selo	II	6.9	4.7	9.0	42.1	8.0	180.0
Nogaevci	III	6.4	3.0	7.8	37.0	10.0	110.0
Demir Kapija	II	6.8	3.2	11.3	53.7	10.0	148.0
Gevgelija	II	6.6	3.4	10.4	50.1	8.0	120.0

Note: The figures are average from February to December 2006
Source: MEPP

Monthly trend of BOD is shown in the following graph.

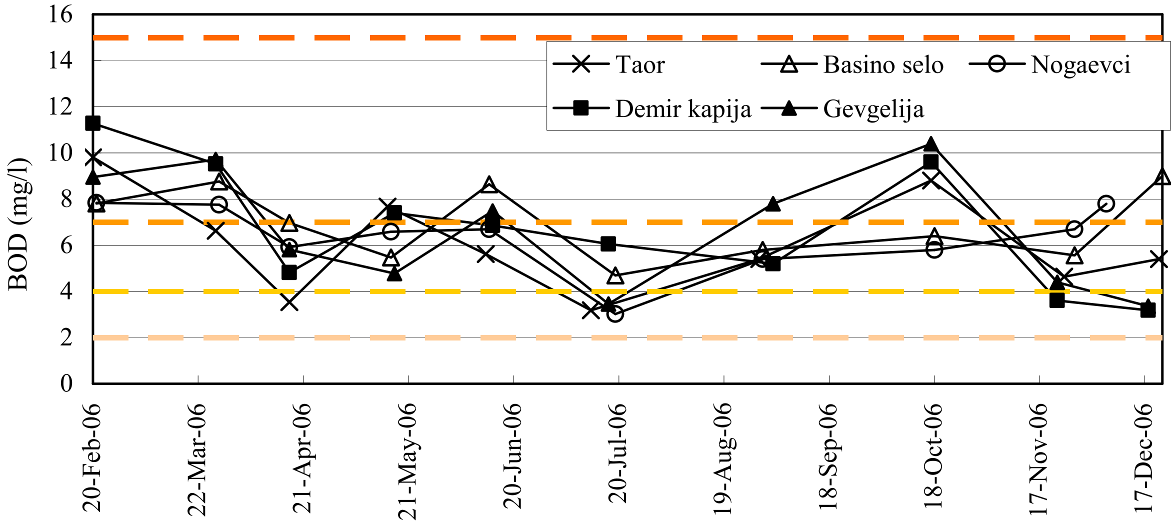


Figure 2.21 BOD in the Vardar River

It is observed in the graph of BOD that the water quality deteriorates to Class IV in the months of February, March and October. Average water quality, Class III, remains in the months of April to September, and November and December. There is no data for January.

Monthly trend of SS is shown in the following graph.

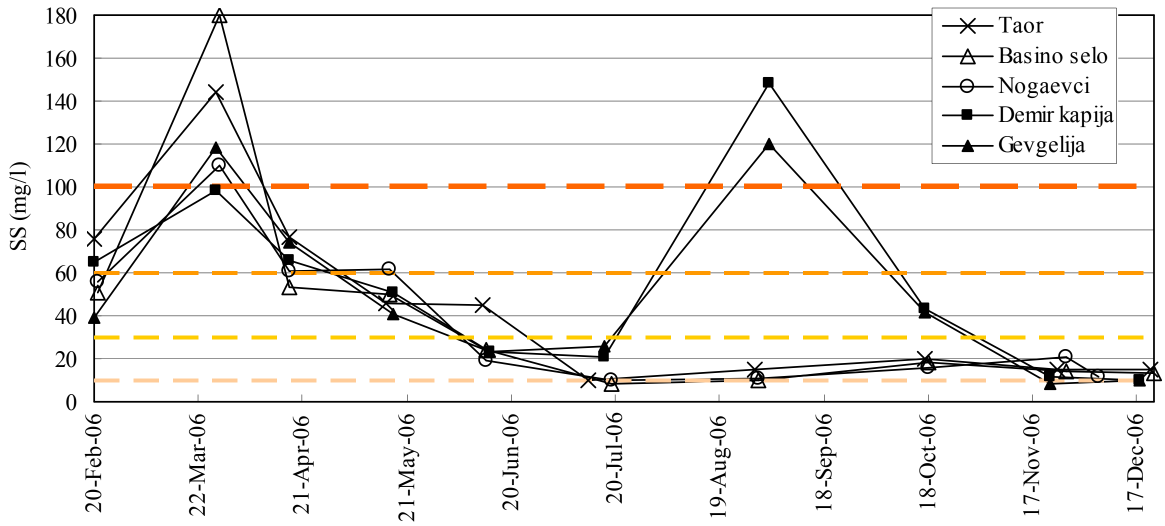


Figure 2.22 SS in the Vardar River

As is observed in the graph of SS, water quality deteriorates to Class V in March. At some monitoring locations, such as Demir kapija and Gevgelija located downstream, water quality is deteriorated to Class V even in September. Average level of water quality, Class III, is observed in the months of February, and April to June. Water quality is improved to Class II in the months of July to December except in case of downstream location in summer.

2.3.3 Water Quality in Study Area

There are three institutes which monitor and measure water quality in Skopje city.

- City Health Protection Institute (CHPI)
- Vodovod

- Hydro Meteorological Institute (HMI)

Of these institutes, HMI submits data to the MEPP. Therefore, data published by MEPP is measured by HMI.

Table 2.10 Water Quality Monitoring Institutes in Macedonia

	MEPP	HMI	CHPI	Vodovod
Function	Inspection of water quality in river and lakes in whole country, monitoring of water quality of sanitary sewer and industrial wastewater.	Control of surface water and ground water in its usage and water quality. Industrial water quality analysis on request only.	Subsidiary organization of Public Health Protection.	Monitoring of water quality in the Vardar River and its tributaries, wastewaters
No. of analysts	9 + 3 (part time) people	11 people	6 people	18 people
No. of Monitoring Locations	No direct-control of monitoring locations. Collection of data from HMI.	60 locations in entire country (at Skopje Center, 20 points in whole country, 3 points along the Vardar River and its tributaries around Skopje)	8 locations.	11 monitoring locations (3 locations along the Vardar River, 8 locations at outlet of sanitary sewer and industrial wastewater)
Frequency of analysis	Not regularly.	Once a month.	Once a month from April to September	Once a month.
Item of analysis	No regulation.	General (e.g. appearance, pH, EC), BOD, COD, 11 kinds of Metals, 8 kinds of anions; 37 items in total.	General (e.g. appearance, pH, EC), BOD, CODcr, SS, anion, N, P, Metals, Phenol, anionic surfactant; 37 items in total. E coli, Fecal coliforms.	General (e.g. temperature, pH, EC), N, P, BOD, $KMnO_4$ consumption, anion, oils, phenol, anionic surfactant; 24 items in total.
Analysis equipment possessed	ICP, AA, gas chromatography (FID, ECD, FOD), GC-mass, liquid chromatography, ultraviolet and visible light absorption spectrophotometer, fluorescent X-ray analysis, TOC analyzer, IR, 24-hour sampler, portable analyzer (e.g. temperature, pH, DO, turbidity, EC)	AA, gas chromatography (FID, ECD), ion chromatography, liquid chromatography, ultraviolet and visible light absorption spectrophotometer, TOC analyzer, portable analyzer (e.g. temperature, pH, DO, turbidity, EC)	ICP, ultraviolet and visible light absorption spectrophotometer, pH analyzer, EC analyzer, turbidity analyzer, DO analyzer	Turbidity analyzer, EC analyzer, pH analyzer, ultraviolet and visible light absorption spectrophotometer, AA (planned)
Pretreatment	Acid decomposition facility, distillation equipment (3 nos.)	Acid decomposition equipment	Acid decomposition equipment	Acid decomposition equipment, distillation equipment (1 nos.)

Water quality data were collected from the above monitoring institutes for the Study. Number of measuring points of river water and collected data are listed below.

Table 2.11 Location and Collected Number of River Water Monitoring Data

Monitoring Institutes	Vardar River	Treska River	Lepenec River	Collected Data	
	Location	Location	Location	Term	Sample No. (total)
CHPI	6	1	1	2003/4 - 2007/10	36
Vodovod	5	0	1	2003/4 - 2007/10	36
HMI	1 (Taor)	1	1		

Number of monitoring locations for wastewater and collected data are listed below.

Table 2.12 Location and Collected Number of Wastewater Monitoring

Investigation Body	Location	Term	Sample No.
Health Protection	9	2002/2 - 2006/12	52 times

Locations of monitoring and sampling stations are shown in Figure 2.23.

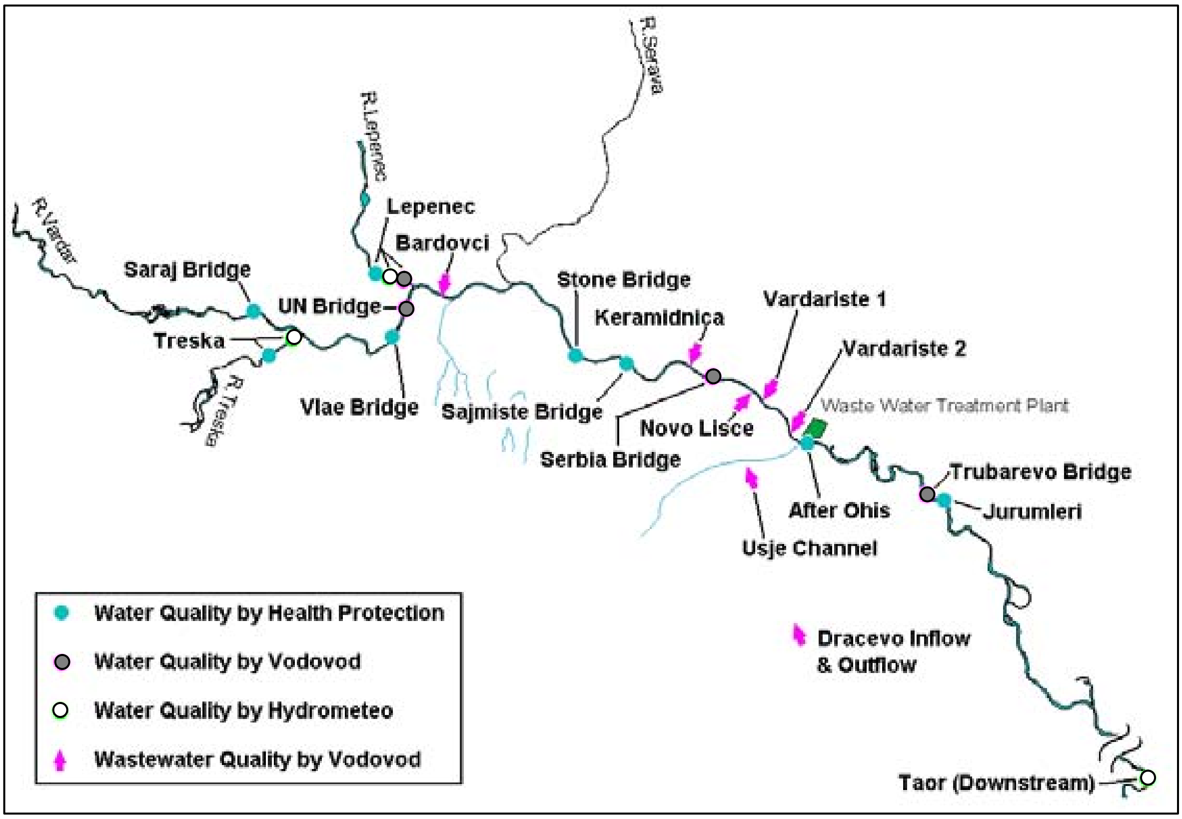


Figure 2.23 Locations of River Water and Wastewater Monitoring Station

2.3.4 River Water Quality – BOD

BOD in the Vardar River is measured by CHPI and Vodovod. Average value of water quality and classification of water are listed below. Data from HMI are not described here since these data are already mentioned above as in case of Taor. Also, the tendency of water quality in Treska River and Lepenec River measured by HMI are not included here because the values are almost same as in the case of CHPI and Vodovod.

Table 2.13 Mean Value of BOD in the Vardar River and Its Tributaries

(mg/l)

Location	Designated Class	by CHPI (from Apr. 2003 to Oct. 2007)	by Vodovod (from Apr. 2003 to Oct. 2007)
Vardar River			
Saraj Bridge	II (4.0)	2.5	-
Vlae Bridge		1.9	-
UN Bridge		-	2.3
Stone Bridge		2.1	-
Sajimiste Bridge		2.6	-
After Ohis	III (7.0)	4.3	-
Trubarevo Bridge		4.3	-
Jurumleri		-	3.4
Tributaries of the Vardar River			
Treska River	II (4.0)	2.3	-
Lepenec River		2.1	2.8

Monthly variation of BOD in the Vardar River along its upstream to middle reach within the study area is shown in Figure 2.24. Most of the values are about 2 mg/l, but it occasionally increases to 4 mg/l. The level of BOD on average is 2 mg/l.

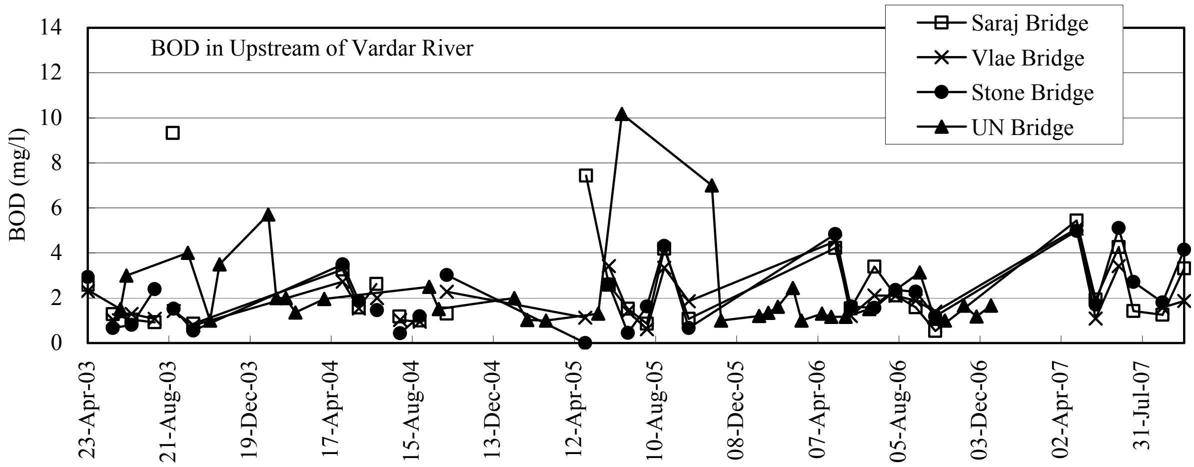


Figure 2.24 BOD in Upstream of the Vardar River

Monthly variation of BOD in the Vardar River along its middle to downstream reach within the study area is shown in Figure 2.25. Water quality is observed to deteriorate compared to upstream reaches because lots of houses and industry are located around the middle reach and often untreated wastewater is discharged to the Vardar River. Values of BOD along this stretch vary from 2 to 7 mg/l and existing water quality for this stretch falls in Class III on average.

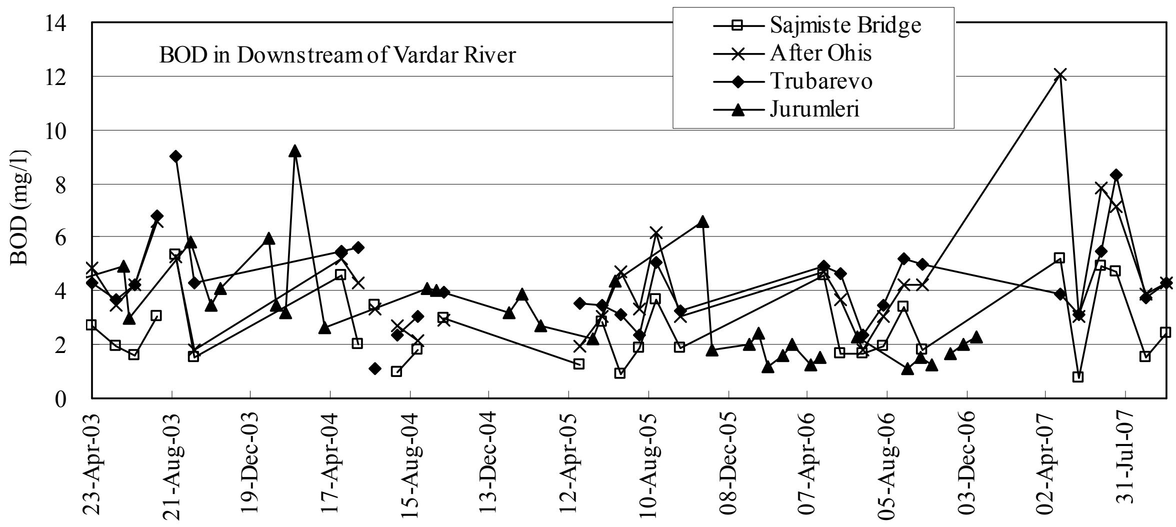


Figure 2.25 BOD in Downstream of the Vardar River

Monthly variation of BOD along tributaries of the Vardar River, i.e. Treska River and Lepenec River, is shown in Figure 2.26. Existing water quality is observed to be same as in case of upstream stretch of the Vardar River, which is about 2 mg/l and falls in Class II.

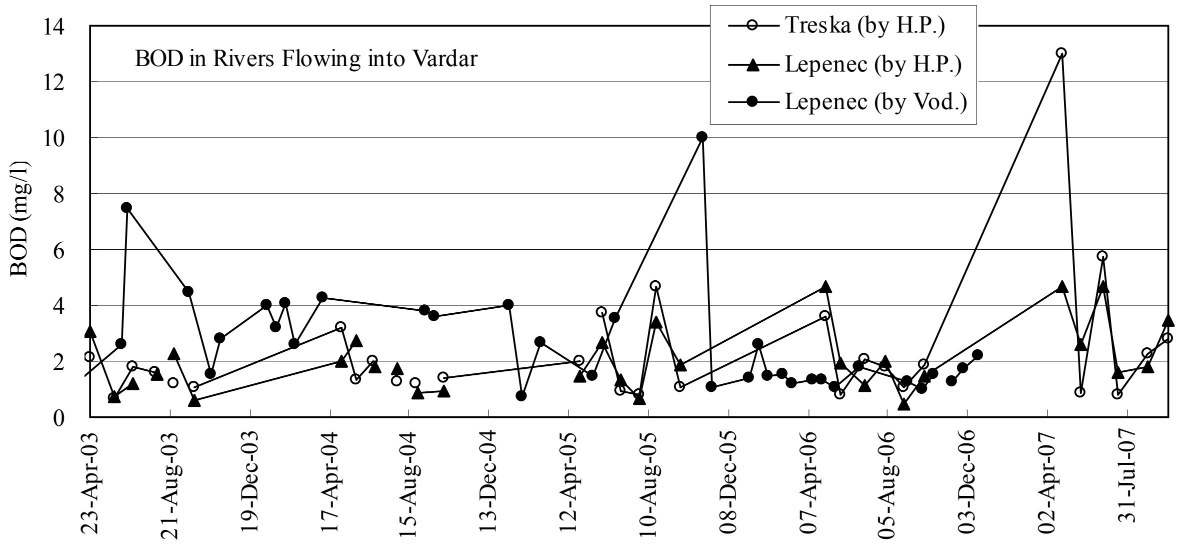


Figure 2.26 BOD in Tributaries of the Vardar River

2.3.5 River Water Quality – SS

River water quality of SS is measured by CHPI and Vodovod. But here, only results of CHPI are presented in Table 2.14 because SS values measured by Vodovod are twice as large as those specified for Class V water. That may be because some particles larger than 2 mm are included during test.

Table 2.14 Mean Value of SS in the Vardar River and Its Tributaries

(mg/l)

Location	Designated Class	by CHPI (from Apr. 2003 to Oct. 2007)	by Vodovod (from Apr. 2003 to Oct. 2007)
Vardar River-			
Saraj Bridge	II (30)	31.2	
Vlae Bridge		32.5	
UN Bridge		-	NA
Stone Bridge		31.2	
Sajimiste Bridge		33.0	
After Ohis	III (60)	36.6	
Trubarevo Bridge		42.2	
Jurumleri		-	NA
Tributaries of the Vardar River			
Treska River	II (30)	26.1	-
Lepenec River		50.0	NA

Monthly variation in SS along upstream stretch of the Vardar River within the study area is shown in Figure 2.27. SS value ranges from 20 to 60 mg/l, which is 30 mg/l in average, and hence falls in Class III. It was expected that turbid water from Lepenec River would influence the quality in the Vardar River, but there is no significant difference between SS value at Vlae Bridge and Stone Bridge which are located before and after the confluence, respectively.

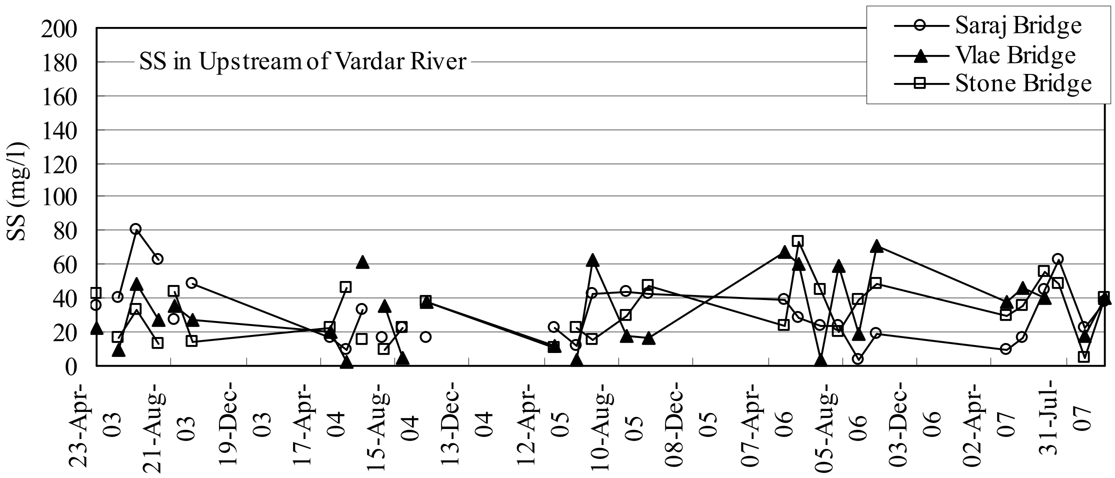


Figure 2.27 SS in Upstream of the Vardar River

Monthly variation in SS along the downstream stretch of the Vardar River within the study area is shown in Figure 2.28. In this case, the SS values range from 10 to 100 mg/l, and the average is 35 mg/l that could be said to fall in Class III. Large number of houses and industries are located in the middle of Skopje City and wastewaters from these houses and industries lead to deterioration of the water quality along the downstream of the Vardar River.

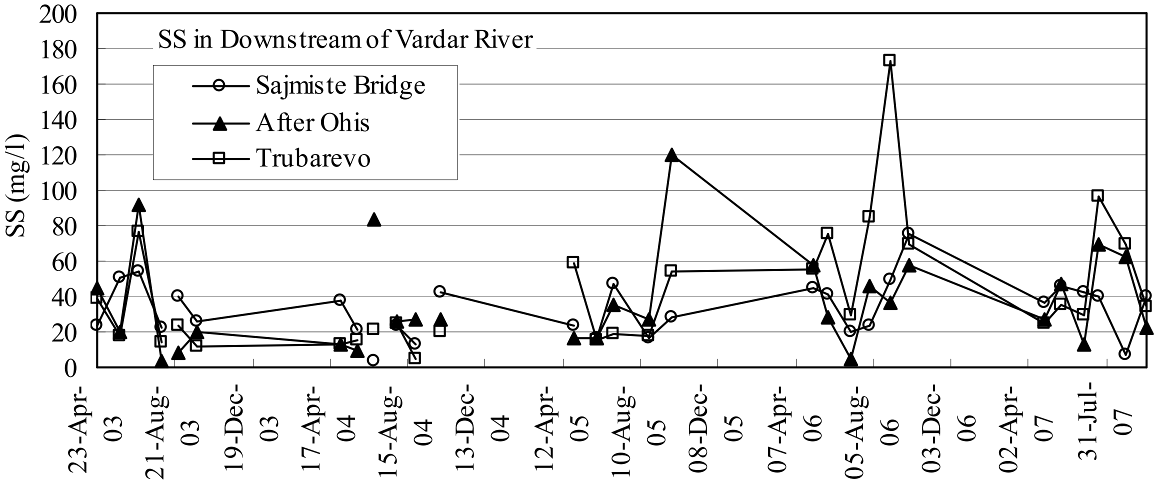


Figure 2.28 SS in Downstream of SS River

Monthly variation in SS along the tributaries of the Vardar River within the study area is shown in Figure 2.29. SS value in Treska River is mostly less than 30 mg/l and falls in Class II. Since water quality deteriorates occasionally, average existing water quality falls in Class III.

The level of SS in Lepenec River is normally worse, varying from 30 to 100 mg/l and water quality in terms of SS falls in Class III. This has also been confirmed by visual investigation of the Study Team.

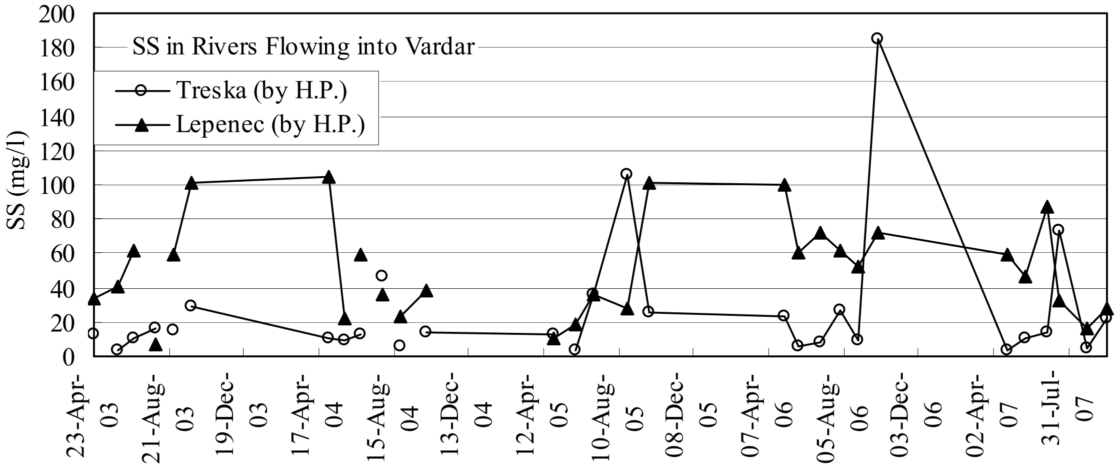


Figure 2.29 SS in Tributaries of the Vardar River

2.3.6 River Water Quality – Others

(1) Organoleptic Indicators

Visible wastes are not observed at all, and smells are not observed but for one day. In terms of color, the water quality falls under Class I in general, Class II in Lepenec River and downstream stretch of the Vardar River. In terms of the turbidity, river water falls in Class III in general, Class IV in Lepenec River and along downstream stretch of the Vardar River.

Table 2.15 Mean Value of Organoleptic Indicators in the Vardar River and Its Tributaries

Location (designated class)	Visible Waste	Smell at 25 Degrees	Color (Degree Pt-Co)	Turbidity (NTU)
Vardar River				
Saraj bridge (II)	0	0	12.5	1.6
Vlae bridge (II)	0	0	12.7	1.0
Stone bridge (II)	0	0	14.6	3.0
Sajmiste bridge (II)	0	0	14.4	2.7
After Ohis (III)	0	0	18.1	2.3
Trubarevo bridge (III)	0	0.5	18.4	3.6
Tributaries of the Vardar River				
River Treska (II)	0	0	10.4	1.1
River Lepenec (II)	0	0	22.5	5.4
Limit value: Class I	None	None	<15.0	<0.5
Class II	None	None	15.1-26.0	0.5-1.0
Class III	None	Hardly notable	26.1-40.0	1.1-3.0
Class IV	None	Notable	>40.1	>3.0

Note: The water quality data is the average from April 2003 to October 2007
Darkened columns indicate exceeding environmental water quality standard
Source: City Health Protection Institute

(2) Indicators of Acidity

In terms of pH, river water quality falls under Class I in the entire study area, which is weak alkali. Considering alkalinity, river water quality falls in Class II in the stretch along the study area.

Table 2.16 Mean Value of Indicators of Acidity in the Vardar River and Its Tributaries

Location (designated class)	pH	Alkalinity (mg/l $CaCO_3$)
Vardar River		
Saraj bridge (II)	8.2	160.7
Vlae bridge (II)	8.2	167.2
Stone bridge (II)	8.2	177.1
Sajmiste bridge (II)	8.2	179.7
After Ohis(III)	8.2	190.8
Trubarevo bridge(III)	8.2	191.0
Tributaries of the Vardar River		

Location (designated class)	pH	Alkalinity (mg/l $CaCO_3$)
River Treska (II)	8.2	200.0
River Lepenec (II)	8.1	174.9
Limit value: Class I	6.5-8.5	>200.0
Class II	6.5-6.3	200.0-100.0
Class III	6.3-6.0	100.0-20.0

Note: The water quality data is the average from April 2003 to October 2007
Source: City Health Protection Institute

(3) Oxygen Regime Indicators

Dissolved oxygen along the river stretches falls under Class I in Study area. Saturation of oxygen is under Class I or II due to supersaturation. Tendency in BOD has been already described earlier. In this analysis result, value of COD is often observed to be lower than those of BOD, which is quite a rare case. This rarity is observed at most of the locations in the study area. Monitoring of COD might not have been carried out very well resulting into possible error.

Table 2.17 Mean Value of Oxygen Regime Indicators in the Vardar River and Its Tributaries

Location (designated class)	Dissolved Oxygen (mg/l)	Saturation of Oxygen (%)	BOD (mg/l)	COD (mg/l)
Vardar River				
Saraj bridge (II)	10.6	109.9	2.5	2.1
Vlae bridge (II)	10.5	109.4	1.9	1.9
Stone bridge (II)	10.4	104.7	2.1	1.9
Sajmiste bridge (II)	10.4	105.6	2.6	1.9
After Ohis (III)	9.8	99.5	4.3	2.2
Trubarevo bridge (III)	9.8	99.1	4.3	2.0
Tributaries of the Vardar River				
River Treska (II)	11.0	113.2	2.3	2.6
River Lepenec (II)	10.2	105.2	2.1	1.9
Limit value: Class I	>8.0	<105.0	<2.0	<2.5
Class II	7.9-6.0	105-115	2.0-4.0	2.5- 5.0
Class III	5.9-4.0	115-125	4.0-7.0	5.0-10.0

Note: The water quality data is the average from April 2003 to October 2007
Source: City Health Protection Institute

(4) Mineralization Indicators

Compared to the high SS values, values of dry matters under filters (Total Dissolved Solid) are relatively small (Class I).

Table 2.18 Mean Value of Mineralization Indicators in the Vardar River and Its Tributaries

	Suspended particles (SS) (mg/l)	Dry matters under filter (TDS) (mg/l)
Vardar River		
Saraj bridge (II)	31.2	200
Vlae bridge (II)	32.5	199
Stone bridge (II)	31.2	214
Sajmiste bridge (II)	33.0	218
After Ohis (III)	36.6	220
Trubarevo bridge (III)	42.2	227
Tributaries of the Vardar River		
River Treska (II)	26.1	241
River Lepenec (II)	50.0	268
Limit value: Class II	10-30	500
Class III	30-60	1000

Note: The water quality data is the average from April 2003 to October 2007
Darkened columns indicate exceeding environmental water quality standard
Source: City Health Protection Institute

(5) Eutrophication Indicators

Values of total nitrogen (T-N) and total phosphorous (T-P) in the study area could not be obtained. Values of nitrogen and phosphorus are listed here instead of T-N and T-P.

Table 2.19 Mean Value of Eutrophication Indicators in the Vardar River and its Tributaries

Location (designated class)	Phosphates – ortho (μg/l)	Ammonia as Nitrogen (μg/l)
Vardar River		
Saraj bridge (II)	15.0	132.4
Vlae bridge (II)	7.8	137.7
Stone bridge (II)	22.4	246.9
Sajmiste bridge (II)	34.0	224.3
After Ohis	74.4	472.6
Trubarevo bridge	82.1	486.2
Tributaries of the Vardar River		
River Treska (II)	6.6	163.3
River Lepenec (II)	67.6	211.2

Note: The water quality data is the average from April 2003 to October 2007
Source: City Health Protection Institute

(6) Microbiological Pollution Indicators

It is observed from the available test results that there were only two values of MPN of bacteria (in one liter), i.e., 0 or 200,000, in samples. For the reference, number of days on which bacteria were detected in samples out of total days is presented in the right column.

Table 2.20 Mean Value of Microbiological Pollution Indicators in the Vardar River and Its Tributaries

Location (designated class)	Most Probable Number of Coliform Bacteria (MPN/100ml)	Number of Day Detected/ Number of Days Tested
Vardar River		
Saraj bridge (II)	1.9E+05	24/30
Vlae bridge (II)	2.0E+05	24/29
Stone bridge (II)	2.1E+05	26/30
Sajmiste bridge (II)	2.1E+05	26/30
After Ohis	1.9E+05	24/30
Trubarevo bridge	1.9E+05	24/30
Tributaries of the Vardar River		
River Treska (II)	1.8E+05	23/30
River Lepenec (II)	1.9E+05	23/30
Limit value: Class II Class III	5-50 50-500	-

Note: The water quality data is the average from April 2003 to October 2007
Source: City Health Protection Institute

(7) Harmful and Dangerous Substances

Based on the presence of Cyanide and Nitrites as Nitrogen, river water quality falls in Class III or IV in the entire study area, and in terms of Chromium $^{6+}$ and Phenols categorization could be made as Class III or IV along some part of the Vardar River within the study area. In terms of other parameters, river water quality falls in Class I or II in the entire study area.

It is to be noted that in terms of harmful and dangerous substances, limit values in case of Class I and II are the same, as in Class III and IV. Therefore, water quality is described as “Class I or II”, or “Class III or IV”.

Table 2.21 Mean Value of Harmful and Dangerous Substances in the Vardar River and Its Tributaries

(µg/l)

Location (designated class)	Aluminum	Cadmium	Chromium 6+	Total Chromium	Cyanide	Copper
Vardar River						
Saraj bridge (II)	62.15	0.02	10.01	6.31	1.23	1.39
Vlae bridge (II)	43.40	0.01	9.17	5.68	1.12	1.43
Stone bridge (II)	62.32	0.01	8.26	5.15	1.28	1.26
Sajmiste bridge (II)	50.21	0.02	8.02	5.26	1.89	1.83
After Ohis (III)	39.20	0.01	9.37	3.56	1.88	2.08
Trubarevo bridge (III)	41.19	0.02	9.62	3.88	2.44	2.10
Tributaries of the Vardar River						
River Treska (II)	29.87	0.03	3.29	3.77	1.14	1.32
River Lepenec (II)	125.51	0.02	9.34	3.73	2.44	1.89
Limit value: Class I-II	1500.00	0.10	10.00	50.00	1.00	10.00
Class III-IV	1500.00	10.00	50.00	100.00	100.00	50.00

Note: The water quality data is the average from April 2003 to October 2007
Darkened columns indicate exceeding environmental water quality standard
Source: City Health Protection Institute

Location (designated class)	Phenols	Iron	Lead	Zinc	Nitrates as Nitrogen	Nitrites as Nitrogen
Vardar River						
Saraj bridge (II)	0.000	41.43	2.86	6.90	1,175.7	28.5
Vlae bridge (II)	0.000	33.10	3.71	5.86	1,006.7	26.3
Stone bridge (II)	0.000	60.97	2.62	10.18	1,137.4	32.7
Sajmiste bridge (II)	1.135	67.13	2.65	8.28	1,221.9	35.7
After Ohis (III)	0.000	99.56	3.31	9.74	1,268.6	47.4
Trubarevo bridge (III)	0.697	88.60	3.29	8.33	1,303.9	48.0
Tributaries of the Vardar River						
River Treska (II)	0.112	35.52	2.44	5.79	841.0	12.3
River Lepenec (II)	0.680	88.53	4.24	11.45	1,375.9	41.9
Limit value: Class I-II	1.000	300.00	10.00	100.00	10,000.0	10.0
Class III-IV	50.000	1000.00	30.00	200.00	15,000.0	500.0

Note: The water quality data is the average from April 2003 to October 2007
Darkened columns indicate exceeding environmental water quality standard
Source: City Health Protection Institute

2.3.7 Citizen's Recognition on Water Quality

Inhabitants' survey is conducted from November to December 2008. The interviews total to 400 households in number and cover 10 municipalities in the Skopje city. Among the questionnaire, understanding for water quality on the Vardar River is included.

As many as 98% or 391 households say that the Vardar River is polluted. Against the question "since when it has been polluted", 339 households say since more than 10 years ago, 46 households say since 5 years ago and the 7 households say since 3 years ago.

Similar interviews were also conducted for 50 business organizations. Twenty-one organizations say since 20 years ago while the almost same number of 20 organizations says since 10 years ago (see details in Social Survey Report, Appendix 10.1).

Solid waste dumping is the largest causes of water pollution, followed by the discharge of untreated wastewater. It is pointed out that citizens feel at least aesthetical worsening of the river.

2.4 Existing Condition on Waterworks

In Skopje, the population served by water supply is as high as 96% of the total population and 84% of the population is satisfied with the current water supply system[1]. Sixteen percent is not satisfied with the system: 8% complains about inadequate water volume and the same 8% complains about inadequate water quality like smell and turbidity. Complaints about inadequate water volume are small in the central municipalities but large in the peripheral municipalities. About two-thirds complaints are in the municipalities of Aerodrom, Gazi Baba, Kisela Voda, Suto Orizari and Gorce Petrov. The ratio of revenue water is as low as 42%. Skopje City recognizes large amount of leakage, which results in a high ratio of non-revenue water. In addition, Vodovod estimates illegally-used water to be at 15 - 20 %. Figure 2.30 indicates volume of water distributed and revenue water as well as the ratio of revenue water. After year 2000, the supplied water volume has increased by 10%. On the other hand, the ratio of revenue water has been decreasing, which is acknowledged as a severe issue on waterworks in Skopje. People without connection to the Vodovod utilize wells and/or springs. However, no information is available regarding this matter.

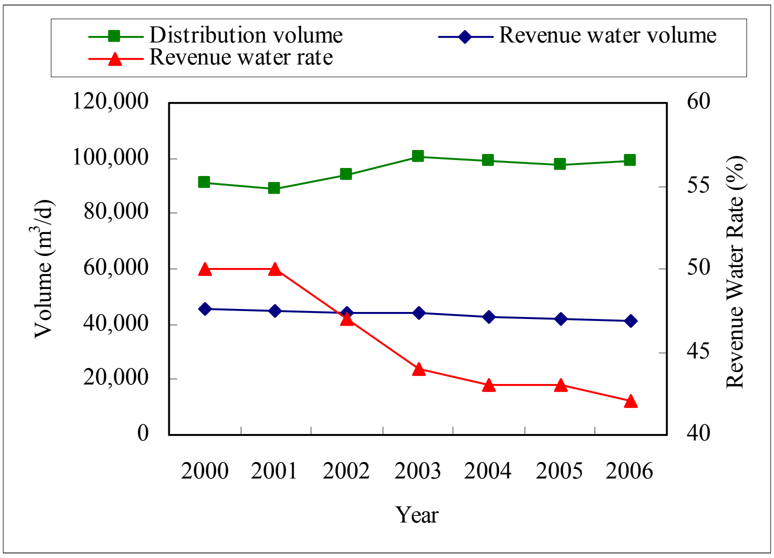


Figure 2.30 Supplied Water Volume and Accounted-for Water Volume

2.5 Existing Condition on Sewerage Facilities

2.5.1 Existing Condition of Sanitary Sewerage Facilities

The sewerage system in Skopje was started as a separate system. Construction of sanitary sewer was started in the first half of 1960s followed by construction of storm sewer in the second half of 1960s. The service population is estimated to be more or less 80%[2] with 20% population of septic tanks usage. The social survey indicates satisfaction ratio of the population with the sewerage system at 62%, which is lower than the water supply system (83.7%). The highest dissatisfaction is on overflow of the pipe followed by untreated sewerage. It seems to result from incomplete storm sewer network: service area is low, stormwater pipe is not connected with the river but connected with sanitary sewer pipes. Forty-four percent of the population is willing to pay for an improved system while 56% is not. Additional willingness to pay of the 44% respondents is MKD 300 per month. It is difficult to judge this amount as high or low. For reference, MKD 500 to 2,000 are spent for health sector under the same survey.

Collected sewage is mostly discharged into the Vardar River through two main outlets; one each in the left and right banks of the Vardar River. Many industrial wastewater is also discharged into the Vardar River without treatment or inappropriate treatment. There are two small WWTPs in Saraj municipality. Their capacity is relatively small and they have never been operated. One plant was malfunctioned due to inflow of large quantity of soil sediments while the other one was severely

[1] Refer to Social Survey Report in 2007 (Appendix 10.1 of Part I (B/P)
[2] According to the Social Survey conducted during October 2007 - January 2008 by JICA Study Team.

damaged during the conflict. The plants have not been rehabilitated. As of February 2008, a new plant is being financed in Saraj by EU. There is a small WWTP in Dracevo, constructed in 1965 but has not been operated for a long period. Replacement of several parts is required for the operation.

The outline of existing sewerage facilities is described in the Table 2.22 and Table 2.23. In addition, Figure 2.31 shows the pipe networks together with pumping stations.

Table 2.22 Outline of Existing Sewerage Facilities

		Amount
Sanitary Sewerage Service Area		6,074 ha
Sewer	Sanitary	539,900 m
	Stormwater	206,700 m
	Total	746,600 m
Constructed Year	Before Year 1966 (Old)	294,500 m
	Year 2002-2006 (New)	34,200 m
	Others (1967-2001)	417,900 m
Number of Pump Station		11
	Sanitary	8
	Stormwater	3
Number of WWTP		3 (2 in Saraj, 1 in Dracevo)

Source: Vodovod

Table 2.23 Specification of Pumping Stations for Sanitary Sewer

Name of Pumping Stations	Capacity (l/s)		Specification of Pumps			
	Max Capacity on Actual Condition	Capacity of Installed Pumps	Each Capacity (l/s)	Nos.	Capacity (l/s)	Head (m)
1. SPS Madzari 1 (Sin|elic- Cento)	460	460	90 250 120	1 1 1	90 250 120	10.0 8.0 8.0
2. SPS Madzari 2 (curch)	180	180	90	2	180	10.0
3. SPS Madzari 2a (sahta)	150	240	150 90	1 1	150 90	10.0 10.0
4. SPS Makosped/Industrija	180	270	90 90	1 2	90 180	10.0 10.0
5. SPS Staro Lisice	80	160	80	2	160	13.5
6. SPS Novo Lisice	660	860	400 130 200	1 2 1	400 260 200	10.1 13.0 13.0
7. SPS Dracevo	140	140	90 70	1 2	90 140	10.0 14.0
8. SPS "11 Oktomvri"	170	170	170	1	170	10.0

Source: Vodovod

2.5.2 Existing Condition of Stormwater Drainage Facilities

Stormwater in Skopje City is drained to the Vardar River through storm sewers or canals. The storm sewer network is shown in Figure 2.32. The existing storm sewers, shown in green color, are laid in the city area, and canals are mainly dug on the hillside. Existing storm sewers were installed after the huge earthquake in 1961. Currently, the storm sewers cover 25% of Skopje City, i.e., more than 50% of the residential area. In order to extend the coverage, a D/D on the storm sewer network development plan under GUP has been completed. As soon as the budget is prepared, the project will be commenced. After the project is completed, storm sewer network will cover almost all the residential area in Skopje.

As mentioned above, the design concept of the drainage system is to utilize only storm sewers for conveying stormwater to rivers. However, some parts of storm sewers are connected to sanitary sewers, and stormwater is discharged to the Vardar River through the sanitary sewers. The areas where storm sewers are connected to the sanitary sewers are located on the left bank of the Vardar River, encircled by red line in Figure 2.32. Moreover, rainwater from individual houses is drained through sanitary sewers by illegal connections.

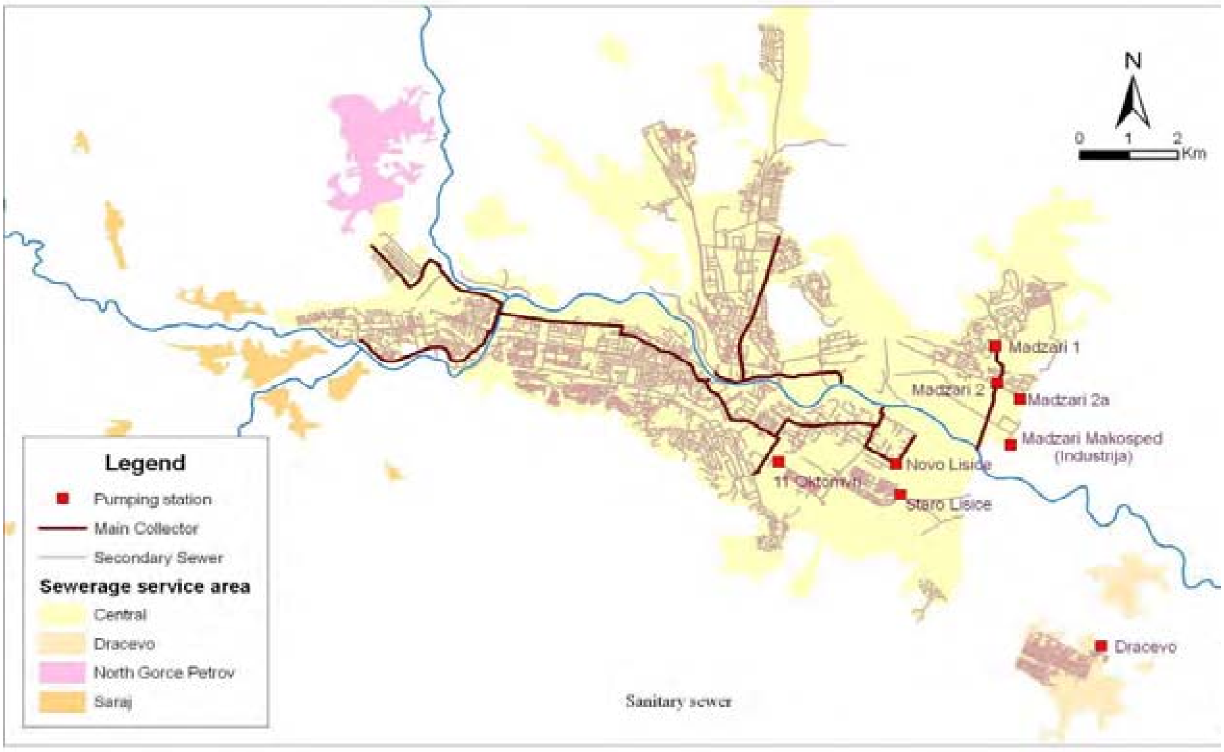


Figure 2.31 Sanitary Sewer

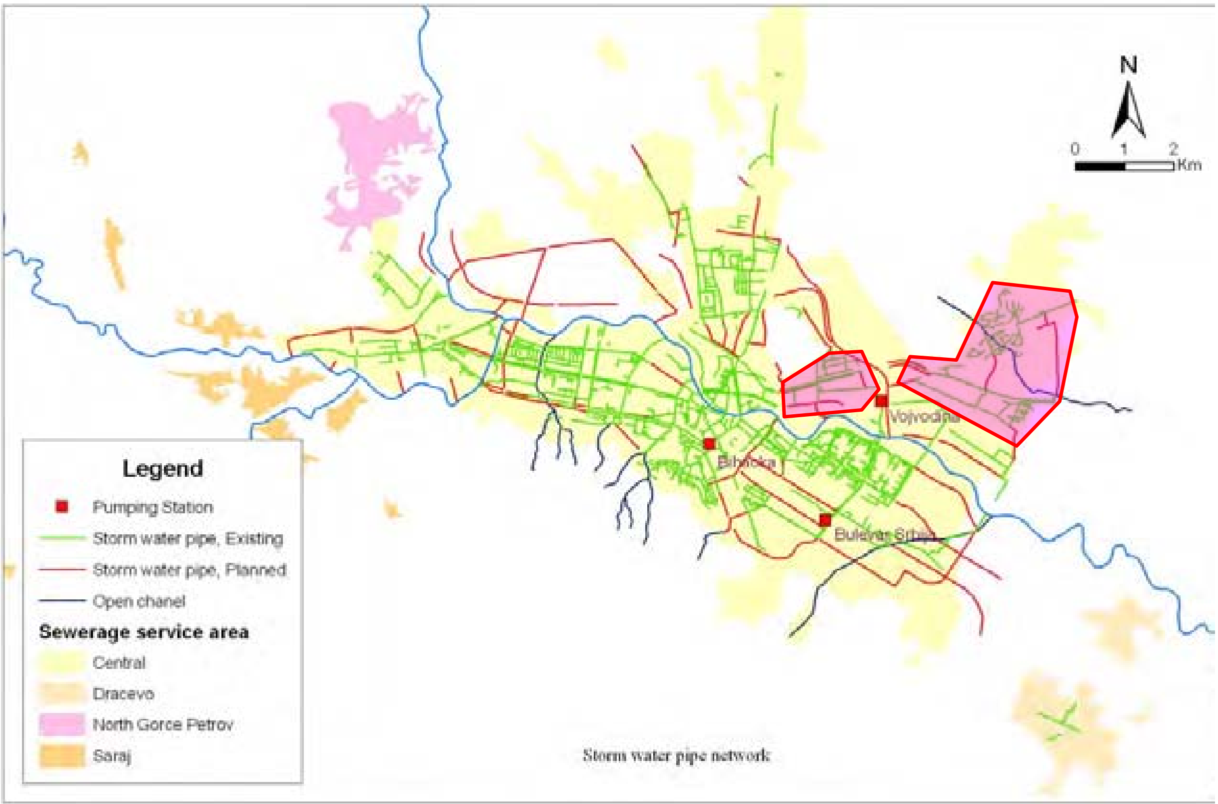


Figure 2.32 Existing and Planned Stormwater Sewer Network and Location of Pumping Stations

There are three stormwater pump stations in the study area (see Figure 2.32). In order to keep them in "ready to operate" condition, pumps and relevant equipment are maintained regularly.

Table 2.24 Specification of Pumping Stations for Stormwater

Name of Pumping Stations	Capacity (l/s)		Specification of Pumps			
	Max Capacity on Actual Condition	Capacity of Installed Pumps	Each Capacity (l/s)	Nos.	Capacity (l/s)	Head (m)
1. PS Vojvodina	90	90	45	2	90	10
2. PS Bulevar Srbija	60	120	60	2	120	15
3. PS Podvoznik (Bihacka)	160	160	80	2	160	8

Source: Vodovod

2.6 Status Quo and Capacity Assessment of Vodovod

Vodovod operates a water supply system with spring water and groundwater (stand-by) sources (4,000 l/s and 1,450 l/s respectively) and 924 km of water mains, and a sewerage system with 540 km and 207 km of sanitary sewers and storm sewers respectively to serve about 503,000 residents (130,000 households). Water service is provided on a 24-hour basis with a water quality satisfactory to customers. Although the sewer network covers most parts of the city, some sections are damaged or clogged; and collector sewers are insufficient. There is no sewage treatment pant, so all the urban sewage and industrial wastewater are discharged to the Vardar River with no treatment. Insufficient stormwater drainage facilities are another issue since various parts of the city get inundated at the time of heavy rain. (Refer Chapter 1 for legislative provisions.)

2.6.1 Financial Status of Vodovod

For the years of 2002 to 2004 the balance of operating revenue and expenses resulted in surplus ranging from 10.0 million MKD to 67.7 million MKD. In 2005 and 2006 large deficits of 138 million MKD and 173 million MKD occurred due to sizeable write-offs of long-overdue accounts receivables. For 2002 to 2006 the revenue totaled 699 million MKD to 821 million MKD whereas the total expenditure amounted to 715 million MKD to 887 million MKD. Vodovod states that such deficits were met with accumulated retained earnings from the previous years. As shown in the income statement, the balance turned into surplus in 2007 owing to a large (98%) rate hike made early in 2007. For 2007, the total revenue amounted to 1,219 million MKD and the expenditure totaled 1,144 million MKD, resulting in 75.8 million MKD of surplus (31.9 million MKD after tax). From 2002 to 2007, 93% of the revenue on average was generated from water and sewer service sales. The largest expenditure item was salaries and wages, which averaged 330 million or 39.6% of the total expenditure. For preparation of financial tables, no separation is made between water supply and sewerage operations (See Table 2.25). The 2006 sales revenue declined 5.6 % compared with the 2002-2005 average. The cause for the decrease is unknown. The meter reading was 6.5 % lower than the average.

The balance sheet of the Vodovod shows that the total assets, which equal to the total equity and liabilities, were 4.33 billion MKD in 2005. The assets consisted of 2.61 billion MKD of the net fixed assets, and 1.72 billion MKD of the total current assets, which are composed of work in progress, cash and bank deposits, accounts receivable and inventories. The amount of accounts receivables was markedly large: 1.57 billion MKD. The total equity was 3.48 billion MKD consisting of the equity (2.28 billion MKD), contribution (1.10 billion MKD), revaluation surplus (0.24 billion MKD), and operational deficits (-0.14 billion MKD). The total current liabilities amounted to 0.85 billion MKD consisting of prepayment (0.01 billion MKD) and current maturities (0.84 billion MKD). There is neither long- nor short-term debt. Accounts payable is negligibly small. The total current liabilities equal to the total liability since there is no short-term debt. For 2006, the distribution of the assets among above items is very similar to those for 2005. (Total assets 3.86 [billion MKD, do for the rest], net fixed assets 2.47, total current assets 1.39 [including accounts receivables 1.26], total equity 3.30 [including equity 2.28, contribution 9.6, revaluation surplus 2.4 and operational deficits -1.7], total liabilities 55.9 [total including current liabilities 5.6 consisting of current maturities 5.5 and prepayment 0.1]) (See Figure 2.33). For 2007, the contents of the balance sheet are closely identical to those for 2005 and 2006.

Vodovod recently employed an internationally standardized accounting method for recording its financial activities. They prepare income statements, cash flow statements and balance sheets. However, the Study Team experienced difficulty to find sources and uses of funds since the style of the cash flow statements are considerably different from the internationally standardized one. As Vodovod purchased various durable goods, Vodovod explains that the cost of such purchases was met with disbursements directly from the current account. Such concept is not compatible with the internationally standardized method of accounting. It is stated that they keep a large book which record all the transactions including not only operating expenses but also capital investments. Likewise, both operating expenditures and capital outlays are stated in a single table of budget request from each Sector. No separation is made between them. The budget plan for 2008, which was presented to the Study Team, only shows capital revenue and investment plans for a total of 724 million MKD and 690 million MKD respectively with an estimated surplus of 34 million MKD to be distributed to each Sector. Its resources are depreciation, co-financing, self-reserve funds, accounts receivable and retained earnings. Vodovod has been preparing financial tables in hand-written forms for reporting to the City council, which appears to be a tedious work and may make chances for errors. It can be easily improved by the use of a spread-sheet software.

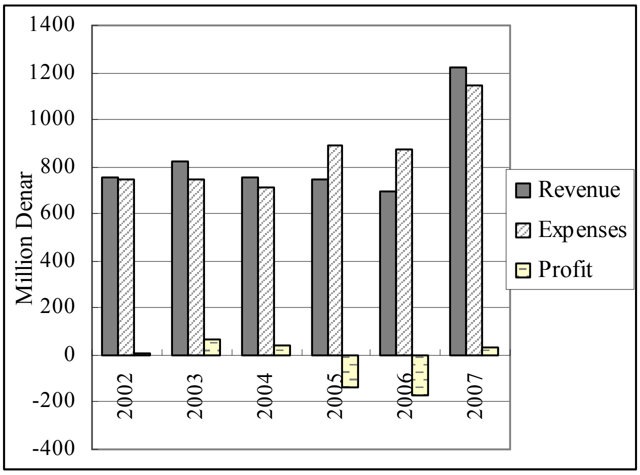
Although the Vodovod collects water and sewer charges, 22.5% of its water sales revenue is automatically transferred to the Public Enterprise for Parks and Public Area Maintenance of the City.

Table 2.25 Income Statements of Vodovod

(thousand MKD)

		2002	2003	2004	2005	2006	2007
1	Total Income	753,652	821,241	758,482	748,943	698,718	1,219,396
1.1	Revenue from Selling Services	**696,980**	**733,504**	**696,997**	**681,876**	**663,448**	**1,179,577**
1.2	Revenue from Financing	215	1,228	1,967	58,841	29,785	34,037
1.3	Other Income	56,456	86,509	59,518	8,227	5,484	5,781
2	Total Expenses	741,934	743,865	715,211	887,165	871,970	1,143,632
2.1	Total Tangible Expenses	**131,570**	**111,759**	**111,445**	**108,798**	**115,394**	**133,476**
2.2	Depreciation	144,779	157,981	154,959	169,805	168,046	168,485
2.3	Intangible Expenses	106,855	116,128	107,971	161,244	129,955	159,384
2.4	Gross Payment of Salaries	339,757	335,340	327,657	329,962	339,127	346,955
2.5	Dismissal of Uncollectible Receivable Accounts (Non-paid Bills)	2,371	15,777	6,545	116,975	118,699	334,332
2.6	Expenses from Interest Rates	16,602	6,879	6,633	379	748	1,000
Gross Income		11,718	77,377	43,271	-138,222	-173,252	75,764
Tax		1,741	9,669	4,802			43,857
Income after Tax		9,977	67,708	38,469			31,907
Loss					138,222	173,252	

Source: Vodovod



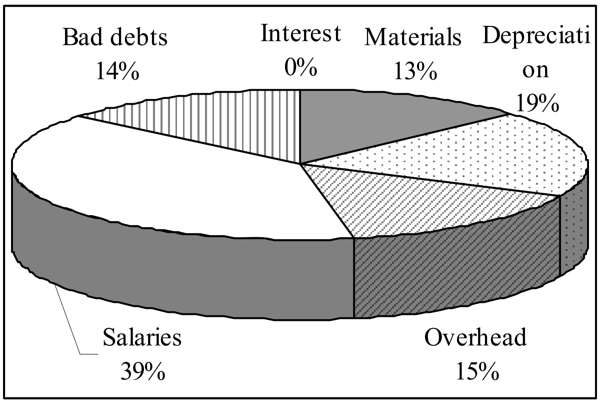


Figure 2.33 Financial Conditions of Vodovod and Its Detailed Expenditures

Table 2.26 Balance Sheets of Vodovod

(thousand MKD)

ASETTS				EQUITY AND LIABILITIES			
	2005	2006	2007		2005	2006	2007
Fixed Assets in Operation		5,886,040	5,901,972				
Minus Accumulated Depreciation		3,417,626	3,582,816	Equity	2,275,374	2,275,374	2,276,193
				Contributions	1,097,779	959,768	786,516
Net Fixed Assets	2,605,973	2,468,414	2,319,156	Revaluation Surplus	241,439	241,439	241,439
				Operational Surplus	-138,222	-173,252	31,907
Work in Progress	5,547	6,695	6,620				
Cash and Bank Deposits	50,022	19,419	327,146	Total Equity	3,476,370	3,303,329	3,336,055
Accounts Receivables	1,573,610	1,259,460	1,355,816				
Inventories	92,594	108,144	114,527	Long Term Debt (Net)	0	0	0
				Accounts Payables	671	1,442	62,641
Total Current Assets	1,721,773	1,393,718	1,804,109	Prepayment	7,680	11,071	10,949
				Current Maturities	843,025	546,290	713,621
Total	**4,327,746**	**3,862,132**	**4,123,265**	Total Current Liabilities	851,376	558,803	787,211
				Short Term Debt	0	0	0
				Total Liabilities	851,376	558,803	787,211
				Total Equity-Liabilities	**4,327,746**	**3,862,132**	**4,123,266**

Source: Vodovod

Table 2.27 Financial Status of Vodovod

No.	Indicator	Vodovod 2006	Vodovod 2007	Nagoya City	Akita City
1	Operating Ratio	76.8	103.7	118.0	129.0
2	Current Ratio	80.8	106.3	102.0	104.0
3	Salary-Water Sales Revenue Ratio	51.1	29.4	33.1	24.4
4	Depreciation - Water Sales Revenue Ratio	25.3	14.3	26.1	29.2
5	Unit Water Price (MKD/m^3)	16.0	29.6	171.0	189.0
6	Unit Water Cost (MKD/m^3)	21.1	28.7	179.0	190.0
7	Revenue Water Ratio	66.6		92.6	88.2
8	Liquid (Acid) Ratio	190.7	228.9	209.0	439.0
9	Owned Capital Ratio	80.3	85.5	53.4	47.3
10	Fixed Asset Ratio	71.0	74.7	162.0	202.0
11	Turn Over of Fixed Assets	0.26	0.47	0.20	0.11
12	Technical Staff Ratio		62.5	67.7	58.1
13	Number of Meters per Staff	144	152	438	750

Source：Vodovod and JICA Study Team

2.6.2 Institutional Status of Vodovod

(The Management)

A General Director heads up Vodovod with a Deputy General Director to assist him. For decision-making the Director consults with a Management Board and a Control (Audit) Board. The Deputy General Director directs four assistants, namely, an Assistant General Director for Technical Affairs, an Assistant General Director for Legal & Economic Affairs, a Personal Assistant and a Consultant. There are eight Sectors and two centers, which handle day-to-day activities of Vodovod (See Figure 2.34).

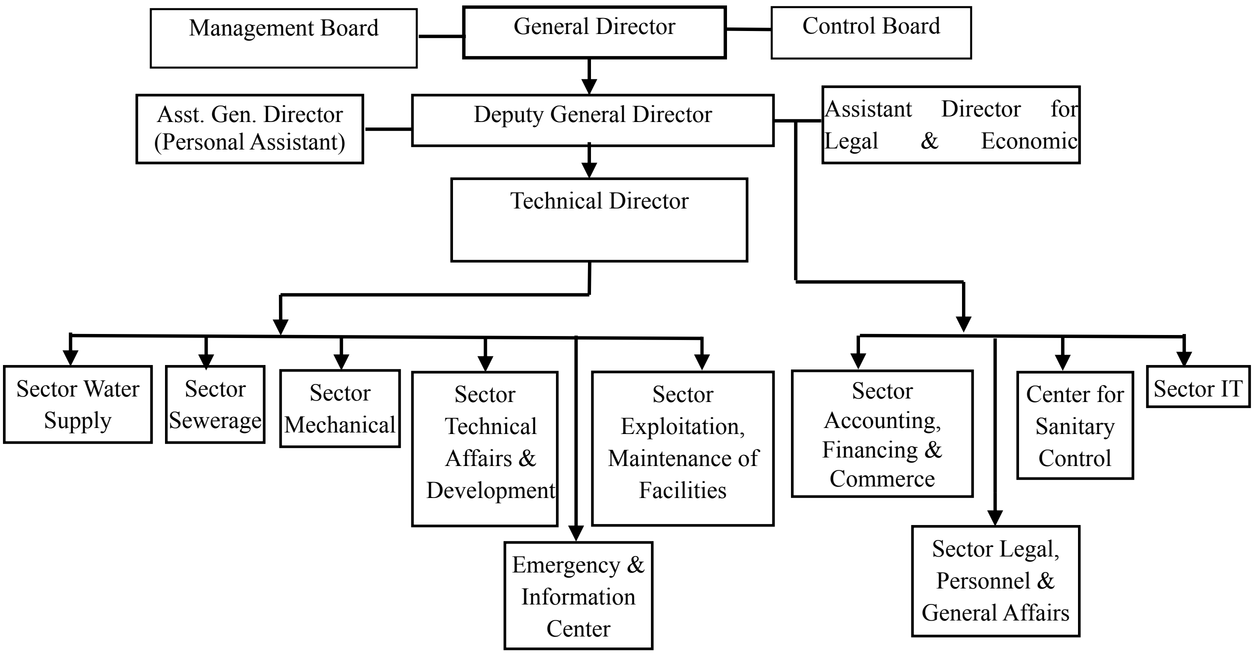


Figure 2.34 Organization Chart of Vodovod

(The Sectors) [Total No. of staff members of Vodovod: 1,120as of March 2008]

(1) Sector Water Supply: (Total No. of staff members: 181)

(Scope of work)

- Planning and replacement of water mains
- Maintenance of water transmission and distribution mains
- Repair of leakage*
- Installation of water services (domestic and industrial)
- Operation of meter repair shop (laboratory)

*The information on the locations of services to be installed is brought from Sector Technical Affairs and Development.

Budget request for the next year is submitted to the management (General Director) by December each year. (This applies to all the Sectors.) Expenditure items are water pipe, valves, hydrants, water meters and other supplies.

(Issues and weaknesses of the Sector)

- Major weakness of the Sector rests on the physical condition of the facilities. Water mains, and mechanical and electrical facilities are too old and deteriorated. Although no significant survey of physical loss of water has been made, it is broadly estimated to exceed one third of the production. Such situation, however, is expected to improve since the Vodovod's financial position has been improved due to the rate hike of 2007; and it can now use more money for upkeep of facilities.

- Another weakness is related to the function of the Sector: When Skopje City plans and designs distribution water mains, Vodovod gives guidelines on planning and design thereof and reviews the design work. However, it does not participate in the actual planning and design work.

(2) Sector Sewerage: (Total No. of staff members: 122)

(Scope of work)
- Maintenance of sanitary and storm sewers
- Repair of sewers
- Installation of services (connections) for new customers

(Issues and weaknesses of the Sector)
- When Skopje City plans and designs sewerage facilities such as sewer network, Vodovod gives guidelines on planning and design thereof and reviews the design work. However, it does not participate in the actual planning and design work.
- Solid waste and garbage are thrown in the sewer causing clogging of sewers and pollution of the river.
- A number of sewers are illegally installed by residents and private business enterprises.
- The municipalities sometimes construct new sewer network, and connect to the existing sewer networks without prior consent of Vodovod.
- Shortage in mechanical equipment including sewer monitoring instrument, e.g., robot cameras, small trucks, etc.
- The experience of the Sector staff is in general unsatisfactory.

(3) Sector Mechanical: (Total No. of staff members: 111)

(Scope of work)
- Storage, maintenance and deployment of heavy construction and transportation machinery.*
- Major cleaning of sewers by machines
- Procurement of major machinery and vehicles. Procurement of such articles is requested to Vodovod's management. The purchase is made through competitive bidding.
  *Vodovod owns such heavy machinery as an old sewer cleaning vehicle, power-shovel, and trailers.

(Major problems with the Sector)
- Lack of construction machinery such as trenchers, back-hoes, advanced sewer cleaning machines, vacuum machines and a multi-function earthwork machines.
- Shortage of experienced personnel (10 employees are retiring, but their replacement is not easy.)
- All the machineries are too old, and maintenance is difficult.
- Spare parts are available in the domestic market, but delivery is very slow.

(4) Sector Technical Affairs and Development: (Total No. of staff members: 40)

(Scope of work)
- Planning and design of minor facilities is carried out by staff of the Sector.
- Installation of customer services (connections)
- Cost estimates of works to be contracted out.
- Preparation of budget plans with a list of construction schemes for the next year for Management's approval and submission to the City council.

(Activities in 2006)
- The Sector carried out about 115 planning and design schemes in 2006.

(Major merits and demerits of the Sector)
- There is no shortage of qualified technical staff for surveillance and monitoring of works

undertaken by contractors.
- There is no problem of the drain of human resources since employment opportunities are gravely limited in Macedonia.
- Slow development and utilization of mains (pipe) database

(5) Sector Operation and Maintenance of Facilities: (Total No. of staff members: 282)

(Scope of work)
- Operation and maintenance (O&M) of water intake facilities and water treatment (chlorination) plant, and water and sewage pumping stations
- O&M of the wastewater treatment plant (after the completion of the Project)
- Maintenance of electrical and mechanical facilities
- Maintenance of structures, buildings and offices
- Development of SCADA and related communication network; and their utilization.
- Horticulture upkeep work
- Security and fire protection services

(Issues and weaknesses of the Sector)
- There is an urgent need to replace some superannuated pumps. Purchase of spare parts is difficult by financial reasons (This situation is being improved due to the Vodovod's financial position due to the rate hike made in 2007). New pumps can be purchased from Europe, e.g., Germany.
- Instrument for flow measurement, etc. is needed to be purchased.
- Low level of automation
- Serious shortage in experienced personnel for development and O&M of the SCADA; and means of data generation and communication are underdeveloped.
- Electrical and mechanical equipment is depreciated at the rate of 5% p.a.
- Lack of the complete O&M manuals of facilities

(6) Sector Accounting, Financing & Commerce: (Total No. of staff members: 246)

(Scope of work)
- General accounting
- Budgeting and disbursement monitoring
- Billing and collection of water and sewerage charges
- Asset Management
- Banking
- Processing of accounts receivable and payable
- Processing of commercial papers and bank drafts

(Activities in 2006)
- Preparation of the annual report of accounting
- Preparation of the budget plan for each fiscal year

(Procedure of rate revision)

(i) Trial setting of a new rate, (ii) Financial analysis with consideration to the future capital expenditure, (iii) Adjustment to the rate and its test through repetition of financial analyses, (iv) Submission of the rate proposal to the City council for approval.

*No approval of the MTC to the new rate is needed. However, the performance of Vodovod is checked by the government and City's communal inspectors.

(Issues of the Sector)
- The financial tables are prepared. However, their style is somewhat different from the international standard.
- Balance sheets for the purpose of reporting to the City council are provided by means of filling

out a table in hand-writing; no spread sheet software is used (due to the too high cost of the software according to the chief of the accounting division).
- Not all accounting and asset management routines are computerized.

(7) Sector Legal, Personnel and General Affairs: (Total No. of staff members: 64)

(Scope of work)
- Prosecution for non-paying customers*
- Prosecution for illegal connections
- Personnel management including recruitment, discharge or promotion (demotion) of staff.
- Clerical work management
- Workplace management

* The connection to default users is disconnected after 6 to 12 months of warning.

(Main concerns of the Sector)
- In cases of court solution, Vodovod has to pay certain amount (400 MKD or so) of charges to the court. However, the resources of Vodovod are not sufficient to do so.
- Vodovod does not practice a system of performance evaluation of its personnel. However, promotion and demotion are decided by Sector Heads.

(8) Sector IT: (Total No. of staff members: 26)

(Scope of work)
- Acquisition of operational and asset-related information
- Processing of data and preparation of a database
- Printing of bills for water and sewer service charges
- Development and installation of communications networks
- Setting-up of common use environment of the database

(Issues of the Sector)

Sector IT at present only collect (1) personnel data from Sector Legal, Personnel and General Affairs, and (2) meter reading and billing data from Sector Accounting, Finance and Commerce. The system of data collection and compiling is not firmly established in terms of hardware as well as software. No data and information is gathered from the management and other sectors than the Personnel Division and the Customer Division. Thus the contents of the database are rather limited. The database is not broadly accessible to staff. Nonetheless, this condition is expected to be improved since there is a plan to upgrade the database and communication systems.

(9) Emergency and Information Center: (Total No. of staff members: 26)

(Scope of work)
- Water leakage detection
- Emergency information services
- Emergency repair work mainly for services

(Issues of the Center)

Weak relationship with Sector IT, especially to access its database through the communication network. Both Sector IT and Sector Operation and Maintenance of Facilities will have communication network. It is not clear whether or not both of them construct the communication system part by part, or either one of them constructs all the communication system.

(10) Center for Sanitary Control: (Total No. of staff members: 17)

(Scope of work)
- Sanitary control of drinking water
- Surveillance of sewage quality

(Issues of the Center)
Modern analytical instruments are available. However, there is a shortage in fully experienced staff, which affects the efficiency of the work and reliability of the obtained data.

2.7 Current Industrial Wastewater Management and Issues

Industrial wastewater is regulated by an IPPC system. It controls the specific industries which are most probably discharge toxic substances. Industrial effluent standard is decided by the monitoring institution referring BAT Reference. The decided standard is considered for the monitoring institutions in evaluating and approving "Environmental Plan" submitted by the specific industries. This practice has already started with transitional period by 2015. By 2015, Adjustment (environmental) plan is practiced which is also subject to approval of the monitoring institutions. By 2015, necessary investments are made towards full implementation of environmental plan.

2.7.1 Status of Industrial Wastewater Management and Issues

Table 2.28 shows the current industrial wastewater management system in the surveyed installations. Details are shown in Appendix Part I ,3.18 "Current Situation of Industrial Wastewater Management".

Table 2.28 Current Industrial Wastewater Management System except Industrial Wastewater Quality and Generation

Items	Breakdown			Remarks
Wastewater Treatment Plant including Simple Oil Separator	Yes：9	No：35	No reply：6	
Hope of Where to Discharge in the Future	Sewer：44	Vardar River：2	No reply：4	Number in Industrial Survey：27,29
Willingness to Pay for Sewerage Services	Yes：28	No：13	No reply：9	
Pollution Controller Arrangement	Yes：10	No：29	No reply：11	
Water Quality Analysis	Self：14	Out-sourcing：16	No reply：20	Self means self-laboratory with outsourcing
Acquisition of ISO 9000 or 14000, Other	Yes：21	No：22	No reply：4	Other qualification：HACCP：2,ISO22000：1
Water Recycle, Reuse	Yes：13	No：37	No reply：0	
Quantity Measurement of Water Supply	Meter：45	Other：4	No reply：1	
Quantity Measurement of Wastewater		No：50		

From Table 2.28, the followings will be pointed out.

- Only nine (9) industries have their treatment plants including simple oil separator, of the fifty (50) surveyed industries. Other industries do not have any treatment facilities. Most of them discharge their wastewater to existing public sewerage system and few discharges directly to the Vardar River. Among the installations which answer to have treatment plants, installations with sedimentation, oil separator, biological treatment plant and cyimide oxidation facilities are six, (6), four (4), one (1) and one(1), respectively.
- Among 50 surveyed industries, only 20 % installations arrange pollution controller. Of twenty one (21) factories that have ISO 9000 or 14000, more than half of them do not have arrangement of pollution controller.

- Only 26 % of the surveyed factories recycle or reuse water. Remaining 74 % of the installations do not practice recycling of water.
- The surveyed installations responded that they grasp the water consumption by meter or bill. However, they do not measure generated amount of wastewater.
- Although, in principle, self-monitoring of industrial wastewater is essential, only less than 30 % of surveyed installations practice it.
- Among the installations that want to discharge their effluent to public sewerage system in future, less than 50 % of them show willingness to pay for sewerage services. (no reply is counted negative)

Pollution Controller

There is no direct expression of pollution controller as in Japan: however, there is a sentence to suggest the pollution controller in (5), the Article 23, Law on Environment that in order to acquire accreditation for assessment of technology, the technological line, product, semi-finished product or raw material, legal entities and natural persons should have at least one employee with a University degree in the area of technology, metallurgy, chemistry or environment and with minimum of three years of professional experience in the relevant field, as well as appropriate technical conditions and devices, equipment and premises. The employee stated in this article has lots of responsibilities to prevent various kinds of pollution and risks.
Furthermore, the enterprises is required to have the environmental management system as the organization as described in 5.4.1 to get the permission of IEP. From these facts, it is observed that similar system will be necessary as pollution controller system in Japan,

2.7.2 IPPC System and Implementation

Basic laws related to environment including industrial wastewater management have been prepared by EU's assistance. Related sub-laws and regulations are under preparation one after another. Application of operation permit under IPPC (Integrated pollution prevention control) system which is deeply related to industrial wastewater management has been started and the first permission was issued in early 2008. The next challenge is how to secure proper implementation and technical improvement.

Relating to sewerage, there is a regulation on discharge in "Law on Water Supply, Drainage, Treatment and Discharge of Urban Wastewater". However, there is no description of discharge criteria in the above mentioned law. As for the industrial wastewater, there are no laws and regulations as of now and discharge criteria to water body and to sewer have not been defined yet. At present, the discussion about it is based on the environmental criteria.

The Law on Water was revised in 2008, and to be enforced in 2010. Discharge criteria to water body or public sewerage system will be regulated by MEPP in the law or sub-law or regulations. It will be decided by each industry based on BAT reference under IPPC system and the existing condition of water body.

It is clearly described in Chapter XII. INTEGRATED ENVIRONMENTAL PERMITS FOR OPERATION OF INSTALLATIONS WITH AN ENVIRONMENTAL IMPACT of Law on Environment which was enacted in 2005 that operation of installation is required the permit based on IPPC system with EIA (Environmental Impact Assessment). The industrial units which discharge toxic substance to environment require the introduction of EU's IPPC Directive (Council Directive 96/61/EC). According to the Directive, large scale or highly toxic substances handling industrial units are recognized as A classification and are supervised by MEPP. Other middle to small sized and less toxic handling factories are recognized as B classification and are supervised by the municipality.

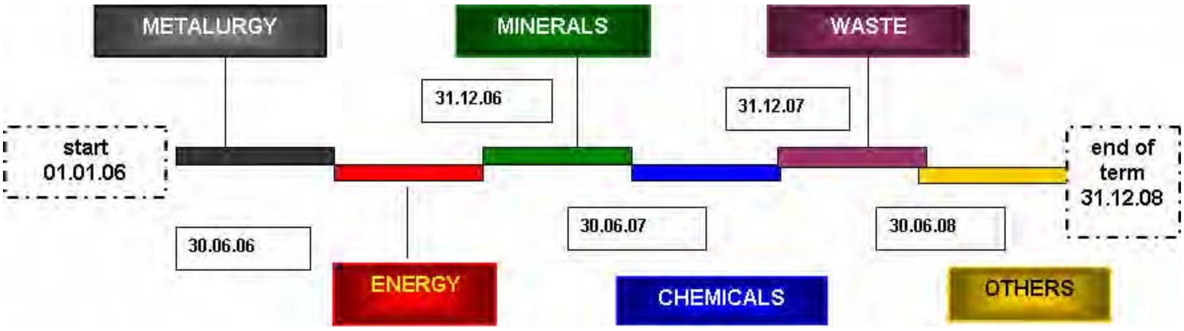
Although the complete introduction of IPPC system in Macedonia was scheduled to 2007, it was extended to 2014 due to the following considerations:

1. It would be appropriate in Macedonian industrial situation if it can have enforcement,
2. It would also be good to know how many staff is necessary to supervise, availability of industrial technical resources in Macedonia,

3. It would take time to gain close cooperation with factories.
4. Similarly, it required to think about what to do with provisional standard to the existing facilities.

IPPC system is introduced as a comprehensive environmental prevention in water, air pollution and soil pollution. The operation permit application for any new installation is evaluated based on the concept of BAT (Best available techniques) in EIA stage. As for existing facilities, reasonable plan for its improvement is required. The application of A classified industries has started according to types of industries. Seventy one (71) factories have already finished the applications so far and the first approval was permitted in early 2008. B classified industries are expected to submit the application to Skopje City by the beginning of 2009. Then IEP (Integrated Environmental Permission) will be issued one by one to these industries or enterprises.

Figure 2.35 shows the application procedure of class A industries or enterprises.



Source: "Application form for an A environmental integrated permit/ adjustment permit with an adjustment plan", MEPP

Figure 2.35 Application Procedure of Class A

The followings are required to be described in the application form.

- Information about the Operator
  - General information about the company (operator), Ownership of the land, Ownership of the facilities, Type of Application,
  - Information about the installation: Boundaries, coordinates given on a location maps, category of activity
  - Information about the Authorized Contact Person for the permit (and its deputies)
  - Changes in the permit

- Description of the Installation
  - The technical units, methods, processes, environment protection systems, development and history of the activities and the location, copies of plans,
  - Drawings: maps, reports, support documentation,
  - List of operations and their location plans: Technological scheme for each technological process, additional relevant information

- Management and Control
  - Description of the management with organizational scheme
  - Description of the management structure concerning the environmental protection systems
  - Procedures for maintaining and calibrations of equipment and instruments
  - Review of the waste control systems
  - Quality control
  - Environmental policy and environmental management
  - Annexes: Environmental management program, copy of the environmental policy and environmental statement

- Raw Materials, Auxiliary Materials, Energy
  - List of: raw materials, auxiliary materials, products, other materials (chemicals), fuels, energies
  - Average stored amounts (stocks)
  - Explanations: special attention should be paid to the materials containing dangerous substances, materials which are not affecting the environment are not taken into consideration. When raw material consists of many substances, only those which can have negative influence on the environment are presented

- Materials Handling
  - Raw materials, fuels, intermediates, products,
  - Locations and descriptions of units and installations for: storage (cold storage warehouses, closed units), separation, transport of solid and liquid materials (pipes, tracks, vehicles), testing of bounded structures, tanks and pipelines,
  - Waste management: categorized as defined in the waste management-European waste catalog, generating source, storage, amounts of generated waste, conversion factors, dynamics of generating
  - Option assessment for decreasing, reuse and recycling of waste
  - Waste disposal arrangements
  - In the case of waste disposal site: transport / transporter, further treatment, location and method of final disposal, Export of waste- Basel convention
  - Waste disposal by land filling: in the case of waste disposed by landfill on-site, the proposed landfill operational plan must be supplied in full.

- Emissions
  - Point emissions (controlled emissions): list of all point emissions such as boiler emissions, major (main) emissions, minor emissions, potential emissions
  - Emitters Reference numbers must be identical with those of the installation plan and the submitted map (it is suggested that reference numbers are unified on the state level for example A01, A02...)
  - Fugitive and potential emissions
  - Emissions to Surface Waters: list of emission points (maps drawings and other documentations), details of substances present in all emissions, positioning according to national coordinate system, name and type of the recipient
  - Emissions to Sewers: summary list of all emissions maps drawings and other documentations), details of substances present in all emissions, information for the sewer – receptor, including systems for reduction and wastewater treatment which are not described
  - Emissions to Ground: treatment and pollution prevention systems for underground waters
  - Land spreading: details of the waste (agricultural and non-agricultural waste , ash , sludge etc.) that will be land spread, amounts, rates, mode of application
  - Noise: noise sources, and related details (location, frequency, intensity, duration, impact area)
  - Vibration
  - Ionization and non ionization radiation
  - The emissions with significant breach of the BREF associated values are matter of improvement program or adjustment plan
  - Unusual condition emissions: start up (burners, electrostatic filters, discontinuous work.) and shut down (burners, catalytic and absorption processes)

- Site Condition and Impact of the Activity
  - Details for site condition (study, elaborate with measurement results)
  - Air emission assessment: dispersion model, odor detection
  - Surface water impact assessment: sewer
  - Ground and ground water: hydrogeology

- Land spreading of agricultural and non agricultural waste: land spreading in case the operator is owner of the land – proper preconditions should be accomplished (ex. 70 sources per 1 ha), land spreading in case the operator is not owner of the land – the agreement should be set with the land owner regarding the same conditions as the previous example, The land spreading frames should be regulated in proper ordinance (soil analysis, land spreading near streams/surface water, seasonal, concentrations, waste analysis…).

- Description of the Technologies and Other Techniques for Prevention/Abatement of the Pollutant Emissions
    - Description of the process integrated prevention measures: abatement of the raw material toxicity, usage of recoverable sources, cleaner production program etc
    - Abatement of the raw material toxicity
    - Usage of recoverable sources
    - Cleaner production program etc.

- "End of Pipe" Solutions
    - Table should be completed for all abatement systems. Systems that are not responsibility of the applicant shouldn't be included.
    - Process scheme for abatement system should be supplied
    - Attention should be paid to the control parameters
    - The monitoring equipment for the system consists of flow, pressure, temperature, concentration, acidity (which is also a result of the concentration) etc. measuring devices.

- Description of Other Planned Preventive Measures.
    - Accident prevention and emergency response : SEVESO[3], accidents management plan, Details of storage of all raw materials, products and wastes, details of spill or emergency containment measures and structures, details of sealing, surface treatment, collection systems – refer to any horizontal guidance
    - Drawings with invert levels of all process wastewater drains, pipelines, private sewers and ancillary manholes and appurtenant structures.
    - Information on possible contamination of ground, groundwater, or surface water from fire water run-off in the event of a fire on-site etc.
    - Transport of material within the site, solid, liquid or sludge transported by pipe, vehicle or conveyor etc.,
    - Potential points of contamination/areas most at risk.

- Remediation, Decommissioning, Restoration & Aftercare
    - The Residuals Management Plan: based on risk assessment, bringing the site to a satisfactory condition, the control of residual materials on site, the planned clearance and cleaning of buildings and technical facilities, the scope of demolitions, the management of construction/demolition waste, the remediation of contaminated ground and the maintenance and review of the plan during the operating life of the installation.

- Nontechnical Summary
    - Review of all chapters from the application form without going into technical details
    - Identification of all impacts

[3] The "Seveso" accident happened in 1976 at a chemical plant in Seveso, Italy, manufacturing pesticides and herbicides. A dense vapor cloud containing tetrachlorodibenzoparadioxin (TCDD) was released from a reactor, used for the production of trichloropenol. Commonly known as dioxin, this was a poisonous and carcinogenic by-product of an uncontrolled exothermic reaction. Although no immediate fatalities were reported, kilogram quantities of the substance lethal to man even in microgram doses were widely dispersed which resulted in an immediate contamination of some ten square miles of land and vegetation. More than 600 people had to be evacuated from their homes and as many as 2000 were treated for dioxin poisoning. SEVESO means the prevention of major accidents which involve dangerous substances and the limitation of their consequences for man and the environment, with a view to ensuring high levels of protection throughout the Community in a consistent and effective manner.

  - Description of all mitigation measures
  - Additional information required

- Declaration
  - The application form with the declaration is a part of the application
  - The declaration is signed by a executive (general) manager

To get the permission about six (6) months are needed. During the period, announcement of the application is made by newspaper and internet and public hearing. The permission is reviewed every seven (7) years.

The emissions with significant breach of the BREF associated values are matter of improvement program or adjustment plan (AP). This is like a temporary permission for existing installations until 1st of April 2014.

In case of emission not based on BREF, the followings are required.

- Strong justification that the improvement benefits would not be adequate to the investments made.
- Improvement plan
  - Operators applying for an environmental integrated permit submit a draft improvement plan for improving the environmental performance and protection of the environment
- Adjustment plan
  - The operators of the existing installations submit an application for an adjustment permit with an adjustment plan

An Adjustment plan is;

- The procedure for negotiation and achieving agreement on the content of the AP. The deadline for its realization is determined in the Ordinance of the procedure for issuing an adjustment permit with an adjustment plan, Official gazette 4/06.
- The individual negotiations should be carried out in discretion, so a condition can be developed for real (actual) negotiations.
- The results of the negotiations will be open for the public.
- Commencement of the negotiations – decision of the minister.
- Commission for adjustment plans.
- The decision contains list of issues and a scope of their negotiation, especially regarding:
  - BAT adjustment,
  - Financial plan of realization of AP., and
  - Time schedule for realization.

Content of AP includes the followings measures, phase-specific solutions and deadlines for achieving the:

- conditions for obtaining integrated environmental permit;
- conditions for the operation of the installation;
- schedule of implementation of the plan by specific phases (one phase – max.12 months)
- monitoring and manner of reporting;
- summary financial resources required for the implementation of each of
- the phases of the adjustment plan, and summary of the total financial
- resources required for the implementation of the plan;
- emission values during the implementation of specific phases of the plan
- indicators of usage of raw materials, energy, natural resources, water and other materials by specific phases of the plan; and
- other issues stipulated in the special laws on individual environmental media and areas protection

To get AP permit, it needs about six (6) months. Deadline of realization of AP is planned not later than 1st of April 2014.

2.7.3 Issues of IPPC System

Although IPPC system is ideal to cope with comprehensive environmental problems, the followings should be discussed to implement it.

(1) Measures to alternatives

BAT(Best Available Technique) is defined as the most effective and advanced stage in the development of activities and methods of operation which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission limit values designed to prevent and, where that is not practicable, to reduce emissions and the negative impact on the environment. And "available" means "viable use, technically and finically".

EU has been preparing BAT guidance or BAT reference by industry to promote this system. BAT regulated for each industry is described in BAT Reference Document (BREF Note).

BREF shows the indicator regarding appropriate permit conditions based on BAT but it does not show unified discharge limits. The discharge limit of each industrial unit is entrusted to the legal authorities of each country among EU; however, it is obligation to consider the standard based on BREF in establishment of permit condition by EU members and relevant authorities of the country in question, on the other hand.

BREF includes expected discharge guidelines and remodeling of process facilities to achieve the guidelines; however, BREF and IPPC themselves do not cover all types of industries. Appendix 5.12 shows the industries for which BREF exist at present (31 types of industries). In addition, there is an opposition from EU industrial fields, saying that BREF itself is too severe, which has led to delay of implementation and has started reviewing the BREF.

Furthermore, BAT is not compulsion and there is a possibility to change and is a room to establish more lax discharge limits than the guidelines by each member of EU.

In permitting installation operation, EIA is necessary as a principle. EIA shall be evaluated, based on BAT and setting up BAT committee is obligated in order to evaluate the proposed BAT. However, it is said that the committee was never organized and has never acted until now. For a different technical proposal from BREF or the type of industry not included in IPPC system, the issue of how the discharge criteria shall be decided is expected. To evaluate the case will need considerable labor resources with competence; which will need more time to give the permission. At present there are only eight (8) MEPP staffs in charge of evaluation of application and permission of A category. Considering the lack of personnel resources and non-existence of BAT committee, the evaluation of alternative BAT proposal will be very difficult.

As for some of the industries out of IPPC system, EIA is necessary to be prepared and approved, based on Macedonian EIA standard where target type of industry and size are defined. However, it is also said that the experience of EIA itself is poor.

(2) Financial assistance

In order to promote IPPC and BAT system based on EU directive, cleaner production (CP) facilities, improvement of process facility, installation of wastewater and air pollution prevention plant, etc. are required. However, financial assistance system for enterprise is not established. As the financial resources, accumulated fund by fines to the enterprises which violate law and donor assistance are expected. However, how legal violator could be identified without clear definition of discharge criteria still remains a question.

During the survey, when the installations were asked why they did not install treatment facilities for their own effluents, some of the installations responded that there is no definition of discharge criteria and also there is lack of fund. If severe discharge criteria are forced without financial assistance, it would result in only a burden for enterprises and an obstacle for their existence and economic development for Macedonia itself.

(3) Evaluation and Supervision System

There are eight (8) MEPP staff members and two (2) staff members of Departure of Environment and Nature Protection in the City of Skopje to evaluate the permission and issue operation permission under IPPC system for category A and B, respectively. The number of inspectors who supervise the implementation of IPPC system has been increasing every year. There are fourteen (14) state inspectors among which five (5) are in charge of installations of category A in the City of Skopje and four (4) city inspectors of department of environment and nature protection are in charge of installations of category B in February 2008. However, the personnel resources is still lacking and capacity strengthening of the inspectors is urgently required.

2.8 Tasks on Water Quality Improvement

2.8.1 Current Water Quality

The Vardar River is classified as class II in the upstream of the Skopje city and as class III in its downstream. The class II is defined as "a very clean, mesotrophic water, which in its natural state can be used for bathing and recreation, water sports, production of other types of fish / ciprinides /, or which can be used – after usual methods of purification / coagulation, filtration, disinfection etc./–for drinking and production and processing of food products". The class III is as "moderately eutrophic water, which in its natural state can be used for irrigation, and after usual purification methods (conditioning) for industries which do not need drinking water quality. Buffering capacity of the water is low, bat it maintains the / pH value / acidity at a level still suitable for most fish".

In the upstream, BOD is mostly 2 mg/l, falling under the class II, however occasionally exceeding the upper limit value of 4 mg/l for class II. SS ranges from 20 to 60 mg/l, averaging 30 mg/l which equals to the upper limit value. Harmful and dangerous substances such as cyanide, nitrate as nitrogen, chromium 6+, phenol etc. exceeds the upper limit value and the river falls practically under the class III category. Fecal-coliform also exceeds the upper limit value.

In the downstream, after the right bank main sewer outlet, BOD ranges from 2 to 7 mg/l, which is below the upper limit value of 7 mg/l, however occasionally exceeds it. SS ranges from 10 to 100mg/l with average of 35 mg/l upper limit value of which is 35 mg/l. Concentrations of harmful and dangerous substances such as cyanide, nitrate, chromium 6+, phenol etc. fall under the class III category. Fecal-coliform exceeds the upper limit value.

2.8.2 Wastewater Treatment Plant and Industrial Wastewater Management

To meet the BOD value for the current situation and future worsened situation, with the classes II or III, biological wastewater treatment plant is effective. It will biologically treat the wastewater and reduce BOD value. However, biological treatment cannot remove harmful and dangerous substances. Therefore, in parallel with wastewater treatment, industrial wastewater management through IPPC system enforcement is required. IPPC system has started its operation with provisional adjustment plan being enforced until the beginning of the year 2014. After that, IPPC system is planned to be fully implemented. The Study Team understands that such full implementation is very important to improve the Vardar River. It is also noted that harmful and dangerous substances seem not only generated inside the Skopje city but also upstream of the Skopje city like Tetovo city, considering that they are detected far upstream of the Skopje city. Industrial wastewater management is further discussed in Part IV.

CHAPTER 3 FRAMEWORK OF THE STUDY

3.1 Objective of Sewerage B/P and Target Year

3.1.1 Objective of Sewerage B/P

(1) Water quality standard in the Vardar River
The objective of the Sewerage B/P is to improve the water quality in the Vardar River that flows through Skopje City. The pollution of the river, as it became clear through the social survey, is not a recent but has been an old problem. The water quality in Skopje, upstream stretch of the Vardar River is in rather good condition with BOD level ranging 2 - 3 mg/l, which falls in the designated Environmental Standard Class II. River water quality gradually deteriorates along the stretch in downstream and is recorded as 4 mg/l. It still falls under the designated Class III. However, situation in the Vardar River will become worse and BOD will exceed the designated water quality category, if the domestic and industrial wastewaters continue to be discharged into the river without treatment and without control. BOD level is expected to be over 15 mg/l, Class V, according to the analysis of river water pollution.

(2) Effluent standard of wastewater treatment plant
According to the EU Directives on Urban Wastewater Treatment, for the agglomeration at the scale of population like Skopje (more than 20,000 PE), secondary treatment (biological process) is required. Macedonia as an EU candidate status needs to fulfill this EU Directives in the near future.

Accordingly, the objective of the B/P is 1) to develop public sewer systems in the non-served area and 2) to treat collected wastewater by a biological process.

3.1.2 Target Year

Target year is already agreed upon between the JICA and the Macedonian side to be 2020 which is the same as the Sewerage M/P 99 (established in 1999) and GUP (established in 2002). However, the Study Team proposes the target year of 2020 for WWTP and 2030 for trunk sewers. WWTP can be extended after year 2020 rather easily in the reserved site for this purpose. Around 80% of urban areas are already sewered and it is expected that by 2020 major portion of wastewater generated in Skopje can be collected and conveyed to the new WWTP. Thus, the target year of 2020 for the WWTP is justifiable under the situation mentioned above together with avoiding unnecessary initial investments.

On the other hand, in general, a staged construction of trunk sewers would be not easy, especially in urbanized areas. In addition to the trunk sewers accommodating the year 2020 flow, other trunk sewers to cover the difference between 2020 flow and 2030 flow have to be laid under the same road as the previous ones. It is rather unreasonable and uneconomical to lay two trunk sewers within a short time frame. Hence, it is recommended to have the target year of 2030 for trunk sewers.

In conclusion, the Study Team proposes the following target year scenarios:

- Target Years of 2020 for WWTP and 2030 for trunk sewers

3.1.3 Area of Sewerage B/P

Area of sewerage B/P has been determined based on discussion with Vodovod considering the Sewerage M/P and GUP. Based on the M/P, four sewerage districts, Central, Saraj, Gorce Petrov and Kisela Voda are set up; however, their combination or separation is discussed in Chapter 5. (Refer Table 3.2).

Table 3.1 B/P Sewerage District Area

Name	Size (km^2)	Municipality
Central	72.8	Aerodrom, Butel, Gazi Baba, Gorce Petrov, Karpos, Kisela Voda, Centar, Cair, Suto Orizari Plus out of Skopje city
Saraj	7.5	Saraj
North Gorge Petrov	3.2	Gorce Petrov
Dracevo	4.0	Aerodrom, Kisela Voda, Plus out of Skopje city
Total	87.5	

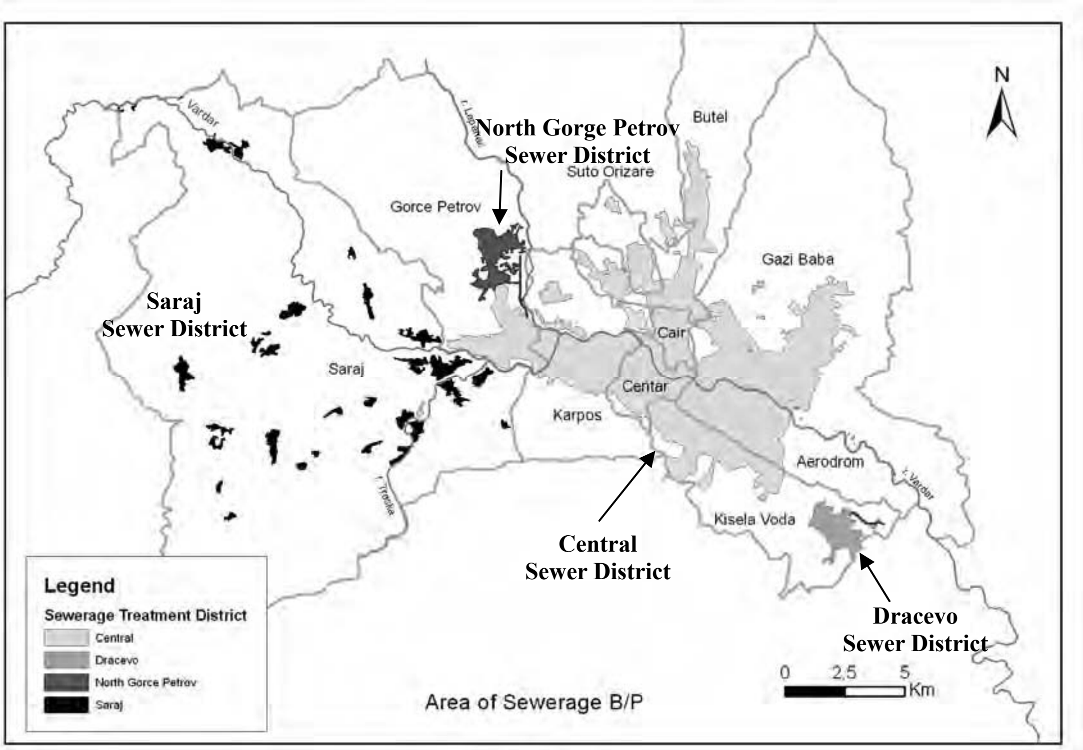


Figure 3.1 Area of Sewerage B/P

3.1.4 Type of Collection System

Sanitary sewers and stormwater sewers have been developed as separate systems since the start of the sewerage system. However, supposedly due to financial constraints, priority has been put on the sanitary sewers development, reaching about 80% service ratio. On the other hand, despite the high development in the central areas, stormwater service ratio is about only 30% as a whole. The City has intention to keep developing the stormwater sewers onwards. However, its drastic development is not expected.

Another reason for slow development of the stormwater sewers is small quantity of rainfall in Skopje. Average rainfall amount is about 500mm in a year and rainfall intensity is not so strong. Therefore, severe inundation has not taken place. As a result, large portion of stormwater is discharged, intentionally or unintentionally, through the sanitary sewers. They have relatively large capacity and can convey stormwater partly because they were designed and constructed previously based on large population, large per capita discharge amount and large number of factories.

The trunk sewers transport, in principle, domestic and industrial wastewater, and overflowing stormwater into the Vardar River at their starting point. On the other hand, EU directives 91/271/EEC says in the Article 3 (2) that “the design of the collection systems shall be undertaken in accordance with the best technical knowledge not entailing excessive costs, notably regarding limitation of pollution of receiving waters due to stormwater overflows”. The footnote (1) to Annex I.A states that ”given that it is not possible to construct collecting systems and treatment plants in a way such that all wastewater can be treated during situations such as unusual heavy rain, Member

States shall decide upon the measures to limit pollution from stormwater overflows. Such measures should be based on dilution rates or capacity in relation to dry weather flow, or could specify a certain acceptable number of overflows per year".

So the Study Team proposes that certain amount of stormwater be treated in order not to pollute the Vardar River to a large extent not entailing excessive costs. Certain amount is defined as the first flush which contains heavy pollutants load. The amount is decided as 31,000 m^3/day, which is equivalent to about 25% of domestic and industrial wastewater generation. Its calculation basis is explained in the section 3.2.3, Part I.

3.1.5 Industrial Wastewater Treatment

Industrial wastewater generation has decreased due to stagnant economic activities. There are lots of discussions whether industrial wastewater is treated by industries themselves or discharged to a sewerage system and treated in a sewerage system. In both cases, however, impact on the river water quality is the same because it is treated based on the same effluent standard which are applied to both a wastewater treatment plant in the sewerage system and an individual industrial wastewater treatment plant In case of treatment in the sewerage system, pre-treatment is required in the industrial effluent before discharging to a sewerage system because wastewater treatment plant cannot treat heavy metals.

Many industrial wastewater is connected the sewerage system. If industrial wastewater is treated by industry itself, each industry needs to construct its own discharge pipe. Further, its pipe needs to extend to the Vardar River due to few drainage channel or river nearby. This is not practical so that industrial wastewater is generally discharged to and treated in the wastewater treatment plant.

There are exceptions. Steel-related factories (former steel complex) are such examples. They are treating their large amount of industrial wastewater (equal to domestic wastewater generation in Skopje) and discharging it through their exclusive pipe. The Study Team recommends their continuation. Organic chemical factory "OHIS" is in the same situation as the steel-related factories and the Study Team recommends the same. Other factories proposing to treat their own wastewater are the beer and drinking food factories because their pollutant loads are very high and might induce adverse effect on the Central treatment plant.

Other industrial wastewater except the above 6 factories are proposed to be discharged into, and treated in, the wastewater treatment plant. Not only the 6 factories but also many factories discharging to the sewerage system have already submitted their "adjustment plan" to MEPP for their approval according to the IPPC system. In such a case, pre-treatment level will form an important factor in the adjustment plan. The pre-treatment standard based on the (new) Law on Waters is to be formulated by the MEPP in near future. Separately, the level is issued by Vodovod, however, it is a little old standard and cannot always be applied to. Therefore, for the reference, Japanese examples are shown in Appendix Part I, 3.16.

Another issue is to give inspection authority to Vodovod. MEPP has the authority to inspect water quality. Their purpose is protection of the environment, river, groundwater etc. Vodovod will function for keeping the environment safe. Vodovod needs to monitor their effluent within the discharge limits. To do so, treatment process should be kept in a good condition. In addition, heavy metals cannot be treated in the wastewater treatment plant. They should be pre-treated in the factories themselves. Therefore, frequent monitoring is required by Vodovod side and Vodovod should also have the inspection authority besides the MEPP.

There have been several problems in industrial wastewater treatment by individual factories in case of Japan. Pre-treatment was not adhered to the regulations due to financial constraints particularly in small to medium sizes factories. Therefore, in parallel to inspection and monitoring, other measures like soft loan provision and tax incentive to them must be introduced at the same time. These issues are dealt separately in Part IV.

3.1.6 Treatment Level

Secondary treatment is required for an agglomeration of more than 2,000 P.E. by Law on Waters incorporating the EU Directives. Its effluent standard is 25mg/l of BOD, 125mg/l of COD and 35 mg/l of SS. Treatment is also regulated to reflect seasonal changes and to treat against "weekly maximum average". In addition, stormwater needs to be treated as mentioned before.

More stringent measures are required according to the Law on Waters if the river sections are designated as sensitive area. Designation is determined in the future by the "river basin management plan". It will be formulated at the earliest in the year 2011. Its purpose is clear; to prevent eutrophication and to regulate nitrogen and phosphorous. Its article 103 states that "*a water body must be identified as a sensitive area in relation to urban waste water discharge if it shows one of following criteria*;"

1. *surface waters which are found to be eutrophic or which are susceptible to become eutrophic in the near future, if no protective measures are undertaken;*
2. *areas of water bodies intended for the abstraction of drinking water which contain a concentration of more than 50 mg/l of nitrate or which are susceptible reach such a concentration in the near future;*
3. *the receiving water body of discharged waste waters from agglomerations of more than 2000 equivalent population where further than secondary (biological) treatment of the municipal waste waster is required.*

There are neither lakes nor fresh water bodies which are found eutrophic or which in near future may become eutrophic in the stretch mentioned above. The Municipalities along the downstream of Skopje do not abstract the River's surface water for drinking purpose, but they rely on ground water or streams nearby which are the distributaries of the Vardar. There is an agriculture plant "Lozar" at 50 km downstream of Skopje. The Lozar utilizes water from Vales Lake, which is also a source of water for Babun and Yop Ika Rivers. However, when water volume of the lake is not sufficient in dry weather season, the Lozar abstracts water from the Vardar River without any discernable pollution problems so far.

The concentration of nitrate at Bashino which is located downstream of Taor, is less than 2mg/l. Accordingly, it can be said that all three requirements mentioned above are met so far. Therefore it is not required to remove nitrogen and phosphorus at the present stage.

However, it might be designated as a sensitive area based on the river basin management plan. It is because the Vardar River is an international River shared with the Greece and to protect the Aegean Sea from eutrophication. Another reason is that this project is expected to be partly financed by EU through IPA-fund and that more advanced measures might be required. Recently constructed plants in Macedonia by EU member countries of Austria and Switzerland have advanced treatment process. Therefore, if more advanced measures are required, additional facilities for nitrogen and phosphorous removal are set aside as a second stage.

3.1.7 Reuse of Treated Water and Sludge

(1) Reuse of treated water

The reuse of treated water contributes to the reduction of BOD load etc for receiving water body and to effective utilization of water resources. The necessity of reuse of treated water is stated in Article 117 of "Law on Waters" as follows:

"*The treated municipal waste water shall be re-used whenever appropriate, provided that any adverse effects on the environment is reduced to the lowest possible level, and after prior permit issued by the state administrative body competent for environment.*"

The treated water has been utilized inside treatment plant site for the purpose of machine cleaning, cooling water, cleaning tank and watering plants etc. The treated water can also be used for general purposes as shown in Table 3.2.

Table 3.2 Application Examples of Reuse of Treated Water

Use for Treatment Facilities	Other
Water seal of Various Pumps	Water for Miscellaneous Use (flush toilet, green zone, car wash)
Cleaning Water of Machine Facilities of Grit Chamber	Water for Landscape Use such as Pond, Stream
Water for Deforming Device of Aeration Tank	Water for Agricultural Use
Water Supply for Disinfection Facility	Water for Fire Prevention
Washing Water of Sludge Dewatering Facilities	Water for Heat Source of Air Conditioning
Dissolution Water of Chemicals	Water for River Maintenance Flow
Water for Odor Removal Facilities	
Water of Secondary Cooling of Diesel Engine	

The demand for reuse of treated water outside treatment plants is so little because the areas in the vicinity of treatment plant have plenty of water. There is no irrigated farmland around and not within a considerable distance. Therefore, the reuse of treated water would not be expected now but may be in the days ahead.

If treated wastewater is utilized, water quality should be paid to attention. Industrial wastewater is estimated to constitute about 25% of the total amount. Heavy metals contents should be monitored carefully based on the pre-treatment standard, which will be established in the near future. In the law on waters as well as EU Directives, there is no indication about the water quality standard for reuse. Table 3.3 shows required water quality standard in Japan for reference[1]. In accordance with water quality requirement, the treatment methods have to be selected. The advance treatment might be required if a treated water is utilized for landscaping and recreation. In this study, however, the secondary treatment is applied due to their low possibility for landscaping and recreation. A treated wastewater after the secondary treatment can be used for flushing toilet and watering plants.

Table 3.3 Main Utilization and Required Water Quality

Water Quality Item	Flushing Toilet(1)	Watering Plant(1)	For Landscaping(2)	Water for Recreation(2)
Appearance	not unpleasant	not unpleasant	-	-
Number of Coliform(n/ml)	＜10	not detected	＜10	＜0.5
BOD(mg/l)			＜10	＜3
pH	5.8~8.6	5.8~8.6	5.8~8.6	5.8~8.6
Turbidity (degree)			＜10	＜5
Odor	not unpleasant	not unpleasant	not unpleasant	not unpleasant
Color (degree)			＜40	＜10
Residual Chlorine (combined) (mg/l)	retained	0.4＜	-	-

Source:
(1) "Guidelines for Reuse of Treated Wastewater", Ministry of Construction of Japan
(2) "Guidelines for Reuse of Treated Wastewater for landscape and Recreation", Ministry of Construction of Japan

(2) Reuse of sludge

The sludge contains nitrogen, phosphorous and other useful inorganic materials so that the sewage sludge can be used in agriculture. In the Struga and Ohrid treatment plant operating more than 10 years, sludge has partly been used as a fertilizer.

The necessity of reuse of sludge is stated in Article 118 of "Law on Waters" as follows:

"*The sludge resulting from the treatment of the municipal waste water shall be re-used whenever appropriate, subject to prior permit and provided that any adverse effects on the environment is reduced to the lowest possible level.*"

---

1 This standard was effective until 2005 in Japan.

In this law, however there is no indication about the quality standard for reuse. There is EU standard (Directives 86/278/EEC on the protection of the environment, and in particular of soil, when sewage sludge is used in agriculture) that define the sludge use for agriculture as shown in Table 3.4.

Table 3.4 Limit Values of Sludge for Various Uses

Parameter	for Concentrations of Heavy Metals in Soil	for Heavy-Metal Concentrations in Sludge for Use in Agriculture	for Amounts of Heavy Metals Which May Be Added Annually to Agricultural Land, Based on a 10 Year Average
Unit	dry basis mg/kg in a representative sample	dry basis mg/kg	kg/ha/y
Cadmium	1 ~ 3	20 ~ 40	0.15
Copper	50 ~ 140	1,000 ~ 1,750	12
Nickel	30 ~ 75	300 ~ 400	3
Lead	50 ~ 300	750 ~ 1,200	15
Zinc	150 ~ 300	2,500 ~ 4,000	30
Mercury	1 ~ 1.5	16 ~ 25	0.1
Chromium	-	-	-

Source: EU Directives 86/278/EEC

The reuse of sludge generated through treatment process is possible for agriculture use, if the heavy-metal concentration standard is cleared. If all sludge cannot be consumed as a fertilizer, it will be dumped into the Drisla site. The sludge needs to clear the heavy metal concentration standard if it is treated as a non-hazardous material. Accordingly, similar to the reuse of treated wastewater, pre-treatment for heavy metals is important. Table 3.5 shows the maximum concentrations of various substances, stipulated in EU Directive (1999/31/EC), to be regarded as non hazardous wastes to be allowed at disposal site.

If the sludge contains hazardous substances exceeding the standard, it should be disposed of at the "hazardous waste dump site". It is planned to be completed in 2014 as stated in the "waste strategic plan". Article 80 of the Law on Waste states that the construction and operation of the hazardous waste dump site is the responsibility of the State.

Table 3.5 Maximum Concentrations Regarded as Non Hazardous

	Leaching test		Co (mg/l)
	L/S = 2 l/kg (dry basis mg/kg)	L/S = 10 l/kg (dry basis mg/kg)	
Arsenic	0.4	2	0.3
Barium	30	100	20
Cadmium	0.6	1	0.3
Chromium (Total)	4	10	2.5
Copper	25	50	30
Mercury	0.05	0.2	0.03
Molybdenum	5	10	3.5
Nickel	5	10	3
Lead	5	10	3
Sb	0.2	0.7	0.13
Sc	0.3	0.5	0.2
Zn	25	50	15
Chlorides	10,000	15,000	8,500
Fluorides	60	150	40
Sulfates	10,000	20,000	7,000
Dissolved organic carbon (DOC)	380	800	250
Total dissolved substances (TDS)	40,000	60,000	-

Note: L/S shows the condition of leaching test.
Source: EU directive 1999/31/EC

3.1.8 Monitoring of Influent, Effluent and Sludge

Monitoring on effluent of the wastewater treatment plant is essential to improve the water quality of the River and for the people. Also important is monitoring on influent of the wastewater treatment plant. This is essential for proper operation of the plant. This is further required to prevent inflow of hazardous heavy metals. These cannot be treated in the plant and are accumulated mostly in the sludge and partly discharged into the River. Identification of factories which discharge higher heavy metals concentration than the established standard and order of remedial measures to them should also be vested on the Vodovod in addition to the MEPP.

3.2 Wastewater Generation

3.2.1 Domestic Wastewater

(1) Current Population

Population in Skopje City was 442,606 in 1981 which increased to 475,902 in 1994 and 502,665 in 2002 (by national census) (see Table 3.6). Population growth rate was 0.56% from 1981 to 1994, and 0.69 % from 1994 to 2002, which seems to be stable. Populations in each municipality are detailed in Appendix Part I, 3.1.

Boundary of Skopje City has been modified in 2005, and population within the new boundary has been announced by the Ministry of Local Self-Government as 506,926 in 2005. This value is calculated by re-distribution of population, 502,665 in 2002 national census along with new city boundary. Population in development area, 4,261 is also added. Therefore, population in 2005 is practically the same as in 2002 except for development area. Population in new boundary of Skopje City has been announced by State Statistical Office as 522,187 in 2006.

Table 3.6 Population in Skopje City

	National Census			Ministry of Local Self -Government	State Statistical Office
Year	1981	1994	2002	2005	2006
Population (persons)	442,606	475,902	502,665	506,926	522,187
Annual Growth Rate (%)		0.56	0.69	-	0.74

Note: Population by State Statistical Office is calculated based on population in 2002 with 0.73% of growth rate and people in development area as mentioned above.

As described later, B/P area consists of four sewer districts of Central, Saraj, North Gorce Petrove and Dracevo. Table 3.7 shows the breakdown of population of 522,187 in 2006 on municipality and sewer district basis.

Table 3.7 Population Breakdown on Municipality and Sewer District Basis in 2006

(Estimated by Statistics Bureau)

(Persons)

Name of Municipality	Sewer Districts					Other	Total
	Central	Saraj	NGP	Dracevo	Sub-total		
Skopje City							
Aerodrom	72,198	0	0	2,519	74,717	0	74,717
Butel	37,577	0	0	0	37,577	0	37,577
Gazi Baba	60,752	0	0	0	60,752	14,102	74,854
Gorce Petrov	34,097	0	6,987	0	41,084	0	41,084
Karpos	60,089	0	0	0	60,089	0	60,089
Kisela Voda	39,620	0	0	19,869	59,489	0	59,489
Center	47,200	0	0	0	47,200	0	47,200
Cair	67,321	0	0	0	67,321	0	67,321
Suto Orizari	22,883	0	0	0	22,883	0	22,883
Saraj	0	36,973	0	0	36,973	0	36,973
Sub-total	441,737	36,973	6,987	22,388	508,085	14,102	522,187

Name of Municipality	Sewer Districts					Other	Total
	Central	Saraj	NGP	Dracevo	Sub-total		
Out of Skopje City							
Sopiste	5,498	0	0	0	5,498		
Soncev Grad	0	0	0	0	0		
Studenicani	0	0	0	5,974	5,974		
Morani	0	0	0	1,771	1,771		
Batinci	0	0	0	5,537	5,537		
Sub-total	5,498	0	0	13,282	18,780		
Total	447,235	36,973	6,987	35,670	526,865		

Note: NGP for North Gorce Petrov

According to Table 3.7, the population of North Gorcev Petrov sewer district is 6,987 and that in Saraj district is 36,973, respectively. As described in detail in Chapter 5, municipalities of Saraj and North Gorce Petrov have their populations in respective sewer districts as shown in Table 3.8. B/P adopts these figures and alters the population distribution of these two municipalities as shown in Table 3.9.

Table 3.8 Service Population of Saraj and North Gorce Petrov Sewer Districts

(Persons)

	2006	2020	2030
Saraj Sewer District	38,628	52,500	62,820
North Gorce Petrov Sewer District	9,800	13,200	16,100

Source: Feasibility Report of each municipality

Table 3.9 Difference of Service Population of Saraj and North Gorce Petrov Sewer Districts (2006)

(Persons)

Municipality	North Gorce Petrov Sewer District		Saraj Sewer District		Difference between Two
	State Statistical Office	F/S of Gorce Petrov	State Statistical Office	F/S of Saraj	
Saraj			36,972	38,628	+1,656
Gorce Petrov	6,987	9,800			+2,813
Total					+4,469

B/P sets the population of Skopje City in 2006 as 526,656 that is 4,469 more than the figure of Statistics Bureau.

(2) Population Projection

Future population of Skopje City is projected by Sewerage M/P 99 and GUP (2002). It should be noted that these two plans were made before 2002 census and hence do not incorporate the result of the census and do not take the alteration of city boundary done in 2005. Table 3.10 shows the future population projected in Sewerage M/P 99 and GUP. Refer to Appendix Part I, 3.1 for the details of population projection.

Table 3.10 Population Projection in Each Plan

	Sewerage M/P 99		GUP		
	1998	2020	1994	2010	2020
Population (persons)	401,000	469,000	394,997	433,045	458,897
Annual Growth Rate (%/ year)		0.80		0.58	0.58

While annual population growth rate in GUP shown in Table 3.10 is as low as 0.58% per year, the rate by Statistics Bureau shown in Table 3.6 is 0.75% per year. Sewerage M/P 99 applies 0.75% per year which is approved by Statistics Bureau. National Comprehensive Water Resource Master Plan established in 1999 by JICA also adopts 0.8% per year for annual population growth rate.

From above discussions, B/P applies the same rate of 0.8% as population growth rate. However, the future populations of Saraj and North Gorce Petrov sewer districts are projected based on the figures applied in respective feasibility studies. Kisela Voda municipality has its own development area and the future population in the area is projected based on the development plan. Table 3.11 shows population projection based on respective plans.

Table 3.11 Population Projection in Each Plan

Municipality	2006	2020	2030	Growth Rate or Source
Aerodrom	74,717	83,500	90,400	0.8%/year
Butel	37,577	42,000	45,500	0.8%/year
Gazi Baba	74,854	83,700	90,600	0.8%/year
Gorce Petrov				
NGP Sewer District	9,800	13,200	16,100	Based on F/S
Other	34,097	38,100	41,300	0.8%/year
Sib-total	43,897	51,300	57,400	
Karpos	60,089	67,200	72,800	0.8%/year
Kisela Voda				
Urbanized Area	59,489	66,500	72,000	0.8%/year
Newly Developed Area	0	6,200	6,700	Based on F/S
Sub-total	59,489	72,700	78,700	
Center	47,200	52,800	57,200	0.8%/year
Cair	67,321	75,300	81,500	0.8%/year
Suto Orizari	22,883	25,600	27,700	0.8%/year
Saraj	38,628	52,500	62,800	Based on F/S
Total	526,655	606,600	664,600	

Note: NGP for North Gorce Petrov

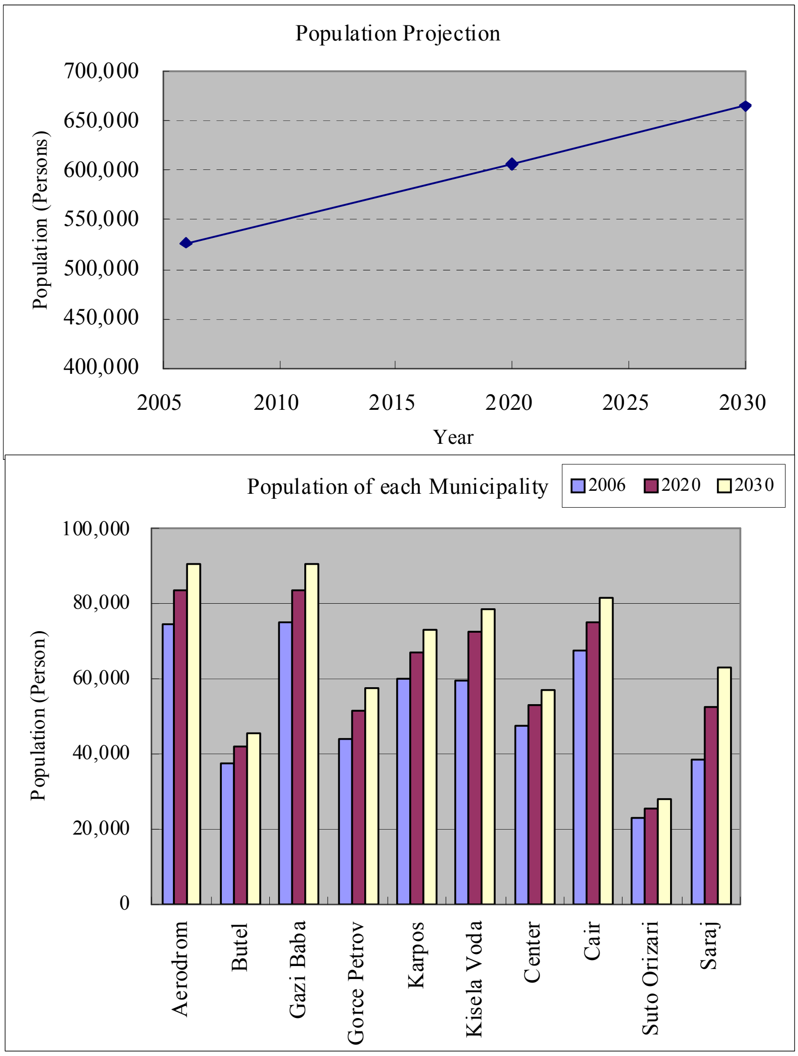


Figure 3.2 Expected Population in Skopje City

(3) Design Population in Treatment Districts

B/P area consists of the whole Skopje city and its adjacent communities outside the city forming four sewer districts of Central, Saraj, North Gorce Petrov and Dracevo. Boundaries of four districts in the B/P are to be the same as those determined in the Sewerage M/P 99. A part of Gazi Baba municipality is not included in the B/P area because of its remoteness from the urbanized area though the municipality constitutes Skopje city. On the other hand, central and Dracevo sewer districts are supposed to receive the wastewater generated in the neighboring communities outside the city. Table 3.12 shows the design population by sewer districts and municipalities in 2006 and 2020. Out of Skopje city's population of 606,600, the population within sewer districts is 590,800 and that outside the sewer districts is 15,800. Sewered population outside the city is 28,370. Hence, the total sewered population is 619,170.

Table 3.12 Design Population in Treatment District

(Persons)

(i) Year 2006

	Sewer Districts					Other	Total
	Central	Saraj	NGP	Dracevo	Sub-total		
Skopje City							
Aerodrom	72,198	0	0	2,519	74,717	0	74,717
Butel	37,577	0	0	0	37,577	0	37,577
Gazi Baba	60,752	0	0	0	60,752	14,102	74,854
Gorce Petrov	34,097	0	9,800	0	43,897	0	43,897
Karpos	60,089	0	0	0	60,089	0	60,089
Kisela Voda	39,620	0	0	19,869	59,489	0	59,489
Center	47,200	0	0	0	47,200	0	47,200
Cair	67,321	0	0	0	67,321	0	67,321
Suto Orizari	22,883	0	0	0	22,883	0	22,883
Saraj	0	38,628	0	0	38,628	0	38,628
Sub-total	441,737	38,628	9,800	22,388	512,553	14,102	526,655
Out of Skopje City							
Sopiste	5,498	0	0	0	5,498		
Soncev Grad	0	0	0	0	0		
Studenicani	0	0	0	5,974	5,974		
Morani	0	0	0	1,771	1,771		
Batinci	0	0	0	5,537	5,537		
Sub-total	5,498	0	0	13,282	18,780		
Total	447,235	38,628	9,800	35,670	531,333		

Note: NGP: North Gorce Petrov

(ii) Year 2020

	Sewer Districts					Other	Total
	Central	Saraj	NGP	Dracevo	Sub-total		
Skopje City							
Aerodrom	80,670	0	0	2,830	83,500	0	83,500
Butel	42,000	0	0	0	42,000	0	42,000
Gazi Baba	67,900	0	0	0	67,900	15,800	83,700
Gorce Petrov	38,100	0	13,200	0	51,300	0	51,300
Karpos	67,200	0	0	0	67,200	0	67,200
Kisela Voda	50,480	0	0	22,220	72,700	0	72,700
Center	52,800	0	0	0	52,800	0	52,800
Cair	75,300	0	0	0	75,300	0	75,300
Suto Orizari	25,600	0	0	0	25,600	0	25,600
Saraj	0	52,500	0	0	52,500	0	52,500
Sub-total	500,050	52,500	13,200	25,050	590,800	15,800	606,600
Out of Skopje City							
Sopiste	7,520	0	0	0	7,520		
Soncev Grad	6,000	0	0	0	6,000		
Studenicani	0	0	0	6,680	6,680		
Morani	0	0	0	1,980	1,980		
Batinci	0	0	0	6,190	6,190		
Sub-total	13,520	0	0	14,850	28,370		
Total	513,570	52,500	13,200	39,900	619,170		

Note: NGP: North Gorce Petrov

(iii) Year 2030

	Sewer Districts					Other	Total
	Central	Saraj	NGP	Dracevo	Sub-total		
Skopje City							
Aerodrom	87,350	0	0	3,050	90,400	0	90,400
Butel	45,500	0	0	0	45,500	0	45,500
Gazi Baba	73,500	0	0	0	73,500	17,100	90,600
Gorce Petrov	41,300	0	16,100	0	57,400	0	57,400
Karpos	72,800	0	0	0	72,800	0	72,800
Kisela Voda	54,640	0	0	24,060	78,700	0	78,700
Center	57,200	0	0	0	57,200	0	57,200
Cair	81,500	0	0	0	81,500	0	81,500
Suto Orizari	27,700	0	0	0	27,700	0	27,700
Saraj	0	62,800	0	0	62,800	0	62,800
Sub-total	541,490	62,800	16,100	27,110	647,500	17,100	664,600
Out of Skopje City							
Sopiste	8,160	0	0	0	8,160		
Soncev Grad	6,000	0	0	0	6,000		
Studenicani	0	0	0	7,240	7,240		
Morani	0	0	0	2,140	2,140		
Batinci	0	0	0	6,710	6,710		
Sub-total	14,160	0	0	16,090	30,250		
Total	555,650	62,800	16,100	43,200	677,750		

Note: NGP: North Gorce Petrov

(4) Per Capita Domestic Wastewater Quantity

1) Water Consumption Quantity by Type of Usage

Per capita per day domestic wastewater is estimated based on water consumption. Since no data on water consumption itself is available, water supply by use whose data is available in Vodovod's annual report (Table 3.13) is supposed to be the same as water consumption. Water consumption tends to decrease in these five years. Water supply by use shows that the supply for public and industrial uses has decreased by more than 20% while the supply for domestic and commercial uses has remained nearly the same. The supply through illegal connection which is not shown in the table has to be added. Vodovod assumes the supply by illegal connection would be 15 to 20% of water supply for domestic use.

Table 3.13 Water Consumption by Use

(m^3/d)

	2002	2003	2004	2005	2006
(1) Non Industrial					
Domestic	76,172	78,710	76,917	75,378	75,857
Commercial	3,472	4,079	3,682	3,341	3,471
Public	7,291	7,196	7,047	6,207	5,621
Sub-total	86,935	89,985	87,646	84,926	84,949
(2) Industrial					
Industrial	34,279	31,357	29,188	27,269	26,283
Total	121,214	121,342	116,834	112,195	111,232

Source: Vodovod Annual Report

2) Estimation of Quantity of Domestic Wastewater

Table 3.14 shows estimated per capita domestic (domestic, commercial and public) wastewater generation supposing the additional consumption by illegal connection of 17.5% and the actual water supply ratio of 96% being the same until 2006. The population served by water supply is estimated for every year using the supply ratio of 96%. Per capita water consumption is estimated by dividing the total water consumption by the served population. Refer to Appendix Part I, 3.2 for the water supply ratio and its amount in 2020.

Domestic wastewater is estimated supposing the return factor of 0.9 and the groundwater infiltration ration of 0.1, whose result is to be overall domestic wastewater.

Table 3.14 Estimation of Per Capita Domestic Wastewater Generation

	2002	2003	2004	2005	2006
Domestic Water Consumption (m^3/d)	86,935	89,985	87,646	84,926	84,949
Domestic Water Consumption - Illegal(m^3/d)	15,214	15,747	15,338	14,862	14,866
Estimated Total Water Consumption (m^3/d)	102,149	105,732	102,984	99,788	99,815
Population	506,926	511,858	516,791	521,723	526,655
Service Ratio	0.96	0.96	0.96	0.96	0.96
Population Served	486,307	491,384	496,119	500,854	505,589
Per Capita Water Consumption (lpcd)	210	215	208	199	197
Return Factor for Water Consumption	0.9	0.9	0.9	0.9	0.9
Allowance for Groundwater Infiltration	0.1	0.1	0.1	0.1	0.1
Per capita Sewage Generation (lpcd)	208	213	206	197	195

Note:
1) Domestic water consumptions contains commercial use and public use
2) Amount of illegal water consumption is assumed to be 17.5% of amount of legal consumption
3) Service ratio of 0.96 is of year 2002
4) Per capita sewage generation is 195 lpcd in year 2006, say 200 lpcd

Per capita wastewater generation in 2006 is calculated at 195 lpcd. Although it had almost decreased since 2002, it is assumed in the Study it will be constant at 200 lpcd during the planning period.

Table 3.15 Per Capita Domestic Wastewater Generation (2006 to 2030)

	2006 – 2030
Per Capita Domestic Wastewater Generation	200 lpcd

(5) Domestic Wastewater Generation

Table 3.16 shows domestic wastewater generation by sewer district which is obtained by multiplying per capita wastewater by the population in each sewer district.

Table 3.16 Domestic Wastewater Generation by Sewer District (including Groundwater Infiltration)

	Unit	2006	2020	2025	2030
Central Sewer District					
Population in the District	person	447,235	513,570	534,610	555,650
Sewage Generation	m^3/d	89,450	102,710	106,920	111,130
Saraj Sewer District					
Population in the District	person	38,628	52,500	57,650	62,800
Sewage Generation	m^3/d	7,730	10,500	11,530	12,560
North Gorce Petrov Sewer district					
Population in the District	person	9,800	13,200	14,650	16,100
Sewage Generation	m^3/d	1,960	2,640	2,930	3,220
Dracevo Sewer District					
Population in the District	person	35,670	39,900	41,550	43,200
Sewage Generation	m^3/d	7,130	7,980	8,310	8,640
Total Sewage Generation	m^3/d	106,270	123,830	129,690	135,550

Source: Industrial Survey and JICA Study Team

3.2.2 Industrial Wastewater

(1) Current Generation

The factories located in B/P area are supposed to be located within Central sewer districts except for a part of small scale ones. Hence, no industrial wastewater is included in Saraj, North Gorce Petrove and Dracevo sewer districts. In Central sewer district, on the other hand, all the industrial wastewaters except for those from six large scale factories that will implement their own treatment facilities will be collected and treated by public sewerage system.

Industrial wastewaters in Central sewer district shown in
Table 3.17 are estimated based on the industrial wastewater survey on 50 factories located there (shown in Figure 3.3). The target of the survey, 50 factories, is selected based on the flowing criteria.

- The target of factories survey in Sewerage M/P 99
- The factories listed in Cadastre of Polluters prepared by MEPP
- The factories which discharge larger amount of wastewater and pollutants under IPPC（Integrated Pollution Prevention Control）

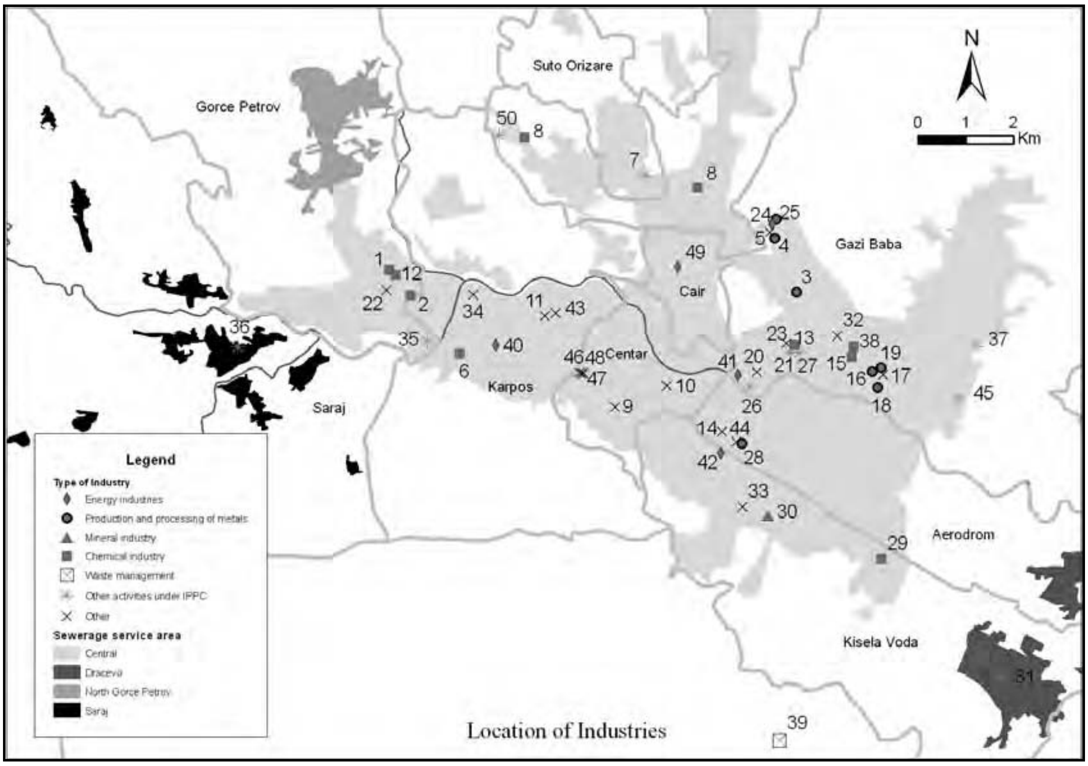


Figure 3.3 50 Factories of Industrial Survey

Table 3.17 Industrial Wastewater Quantity (2007)

	Type of Industry	Nos.	Wastewater Generation (m^3/d)			Remarks
			Own Treatment	Discharged to sewerage system	Total	
For 50 Factories	Energy Industries	5	0	380	380	
	Production and Processing of Metals	7	15,626	573	16,199	
	Mineral Industry	1	0	1,008	1,008	
	Chemical Industry	9	2,442	1,602	4,044	
	Waste Management	1	0	94	94	
	Other Activities under IPPC (Food, Paper Industry)	10	1,427	2,324	3,751	
	Other (Services)	17	0	2,975	2,975	
	Total	50	19,495	8,969	28,464	65% of Total
For Other Factories			-	-	15,327	35% of Total
Total			19,495	24,296	43,791	

Source: Industrial Survey and JICA Study Team

As shown in Table 3.17, the total amount of industrial wastewater from 50 factories is estimated to be 28,464 m^3/d. The amount is supposed to be about 65%[2] of all the industrial wastewaters including the ones excluded in the survey. The total industrial wastewaters including the ones or 15,327 m^3/d (35%) out of the survey scope is estimated to be 43,791 m^3/d. Refer to Appendix I, 3.3 for the detail

[2] Wastewater from hospitals, restaurants, laboratories etc. which were the subjects in the industrial survey is regarded as a part of industrial wastewater in the Study.

of industrial wastewaters.

Six factories listed in Table 3.18 will implement their own wastewater treatment plants and hence their wastewaters will not be handled by public sewerage system. As shown in Table 3.17, 24,296 m^3/d of industrial wastewater, the difference between the total amount of 43,791 m^3/d and 19,495 m^3/d to be separately handled, is to be covered by public sewerage system in 2007.

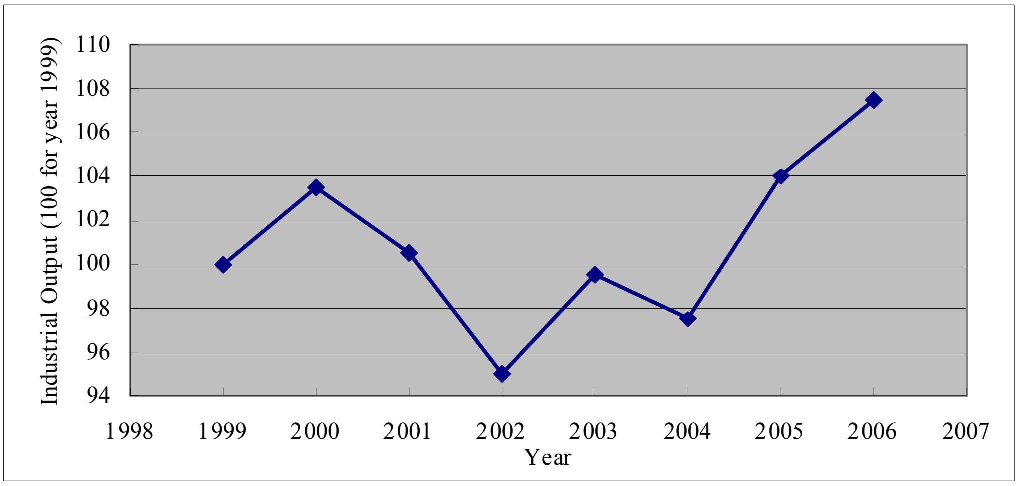
Table 3.18 Industrial Wastewater Quantity not Connecting Sewerage System (2007)

Factory Name	Wastewater Generation (m^3/d)	Remarks
(1) ArceloMittal Steel (Steel-related)	5,714	Possess their own plants already Much amount of wastewater but low BOD concentration
(2) Makstil (Steel-related)	4,174	
(3) Energetika – ELEM (Steel-related)	172	
(4) Skopski Leguri (Steel-related)	5,566	
(5) Pivara (Food)	1,427	Possess their own plants already
(6) Ohis AD (Chemical)	2,442	
Total	19,495	

(2) Generation Projection

Future industrial wastewater has to be projected taking industrial growth rate into account. Though the rate has not been officially estimated, Program of the Government for 2006 – 2010 by the Prime Minister's Office assumes the annual growth of as high as 6 to 8%. National Development Plan 2007 – 2009, three year investment plan by MOF, does not mention industrial growth rate, but describes "The recession began after the independence. The economy began to recover since 1996 but the growth rate remained very low. The economic growth was accelerated since 2004 and the growth rates in 2004 and 2005 were around 4%."

As shown in Figure 3.4 based on the data by Statistics Bureau, the industrial output was the smallest in 2002 and it showed 13% of growth during four years of 2002 through 2006 (average annual rate of 3.25%).



Source: Statistical Review: Industry and Energy, Industry 2001-2006, Republic of Macedonia State Statistics Office, June 2007

Figure 3.4 Industrial Output by Year

Considering these points, the Study Team assumed the annual industrial growth rate of 3.5 % until year 2020 and the same rate of increase was considered for increase of industrial wastewater generation. It is also assumed that the industrial wastewaters would be reduced by the introduction of "cleaner production." Future industrial wastewaters generation is forecast as shown in Table 3.19.

Table 3.19 Estimation of Industrial Wastewater Quantity

	2006	2007	2020	2030	Remarks
Growth Ratio of Industrial Wastewater Generation (1.0 for year 2007)	0.965	1.000	1.564	2.206	Growth rate = 3.5%/year
Industrial Wastewater Generation (m^3/d)	23,446	24,296	38,000	53,600	
Reduction Ratio with Cleaner Production	-	-	15%	35%	
Industrial Wastewater Generation with CP (m^3/d)	23,450	24,300	32,300	34,840	

3.2.3 Stormwater Generation

City of Skopje has implemented sewers targeting separate system. However, 70 % of the planned area has not been sewered with storm sewer mainly due to financial constraints.

(1) Rainfall pattern

Table 3.20 shows the percentage of each rainfall to total calculated from 218 events of rainfall in Skopje in the period between 2003 and 2007. Rainfall of less than 1 mm accounts for 30 % and that of less than 5 mm accounts for 63 % of the total, respectively. Table 3.21 outlines duration of rainfall according to which duration of less than 1 hour accounts for 30 % and duration of les than five hours accounts for 80% of the total, respectively.

Table 3.20 Frequency of Each Rainfall Category to Total (Year 2003 to2007)

Intensity	Number of Rainfall	Frequency	
Less than 1 mm	65	30%	63%
1～2 mm	33	15%	
2～5 mm	39	18%	
5～10 mm	39	18%	37%
More than 10 mm	42	19%	
Total	218	100%	

Table 3.21 Frequency of Duration of Rainfall (Year 2003 to 2007)

Duration	Number of Rainfall	Frequency	
Less than 1 hour	65	30%	81%
1～2 hours	41	19%	
2～3 hours	26	12%	
3～4 hours	24	11%	
4～5 hours	20	9%	
5～10 hours	28	13%	19%
More than 10 hours	14	6%	
Total	218	100%	

Rainfall events of rather long duration in 2007 were selected and the ratios of rainfall to time elapse are calculated, whose results are shown in Figure 3.5. Most rainfall events have no specific peak and rainfall of similar pattern continues.

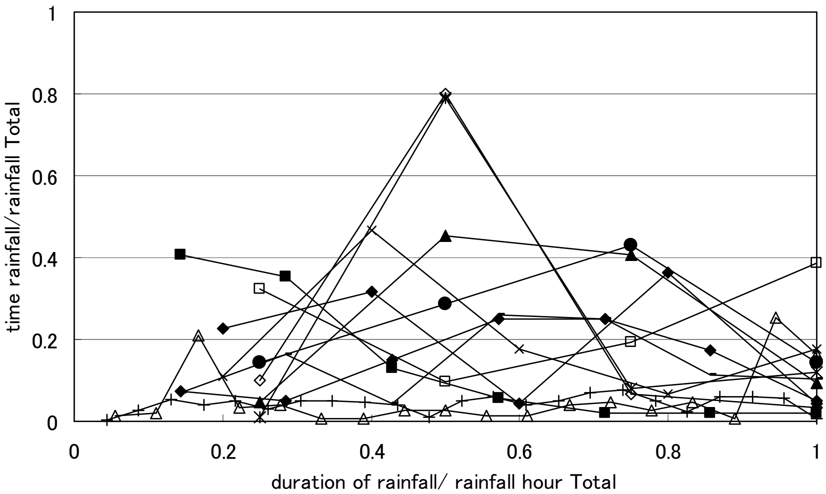


Figure 3.5 Frequency of Rainfall in Relation with Time Elapse

It is judged from above discussion that the rainfall in Skopje is mostly small rainfall intensity with longer duration. Refer to Appendix Part I, 3.16 for the detail of rainfall data.

(2) Calculation of storm water

Though Skopje City has implemented sewers targeting separate system, most rainfall in Central sewer district of 7,287 ha flows into sanitary sewers due to the insufficient implementation of storm sewers. Hence, Central WWTP is to treat certain amount of stormwater as tentative measures until storm sewers are implemented in the whole sewer district. It is not viable, however, to treat all the stormwater and it is proposed to treat a part of stormwater that is regarded as first flush with higher loadings. The rainfall in an hour is supposed to be the first flush and is calculated as follows. It is desirable to implement bypass channel to convey primary effluent to chlorination tank exceeding the plant secondary level capacity in an emergency.

The rainfall flowing to WWTP is estimated according to rational formula.

$Q = (1/360) \times C \times I \times A$

Where, C is Runoff coefficient: (0.6 for highly dense urbanized area),
I is average of rainfall intensity (mm/hr) and
A is catchment area (ha)

Average rainfall intensity is supposed to be 1.0 mm/hr that is median value of 218 rainfall data in Skopje obtained in 2003 through 2007.

Though the whole area of Central sewer district is 7.28 km^2, its 30 % is deducted because storm sewers have already been implemented there. Thus, the area from which stormwater flows into WWTP is calculated as follows.

$7.28\ km^2 \times 10{,}000 \times 0.7 = 5{,}096$ ha

The amount of stormwater flowing into WWTP is then calculated;

$Q = (1/360) \times C \times I \times A = (1/360) \times 0.6 \times 1.0$ mm/hr $\times 5{,}096$ ha $= 8.49\ m^3/s$

Runoff in an hour is;

$8.49\ m^3/s \times 3{,}600\ s = 30{,}600\ m^3$ (rounded up to 31,000 m^3)

3.2.4 District-wise Wastewater Generation

District-wise wastewater generation is shown in Table 3.22.

Table 3.22 District-wise Wastewater Generation

(m^3/d)

	2006	2020	2030
Central Sewer District			
Domestic	89,450	102,720	111,130
Industrial	23,450	32,300	34,840
Stormwater	31,000	31,000	31,000
Total	143,900	166,020	176,970
Saraj Sewer District			
Domestic	7,730	10,500	12,560
Total	7,730	10,500	12,560
North Gorce Petrov Sewer District			
Domestic	1,960	2,640	3,220
Total	1,960	2,640	3,220
Dracevo Sewer District			
Domestic	7,130	7,980	8,640
Total	7,130	7,980	8,640

3.3 Wastewater Quantity and Load

3.3.1 Domestic Wastewater

(1) Per Capita Load

Regarding pollution load, EU Directives on Urban Wastewater Treatment is applied for BOD load as 60 g/c/d. "If a different value other than 60 is used, EU member states should provide the EU commission with information on the approach/method. The Commission will assess whether its approach and/or its verification is appropriate. In case of doubts it may request further information."[3] On the other hand, no regulation on SS is found.

Domestic wastewater in Skopje City is discharged to the Vardar River through a number of discharge points and it is not appropriate to estimate unit domestic pollution load since it is mixed with industrial wastewaters in many cases. Dracevo district is far from housing and industrial areas in the central part of the city and is judged appropriate to estimate domestic pollution load since it is housing area whose wastewater is little affected by industrial wastewater with agricultural land between the district and the central part of the city.

Wastewater quality in Dracevo district is surveyed to know the present unit domestic pollution load. Table 3.23 shows unit domestic pollution load estimated using water qualities in the district measured by Vodovod and per capita domestic wastewater of 200 l/c/d estimated in 3.2.

Table 3.23 Per Capita Load of Dracevo Sewer District

	2002	2003	2004	2005	2006
(1) BOD					
Water Quality (mg/l)	129	123	176	157	157
Per Capita Sewage Generation (lpcd)			200		
Per Capita Load (g/d/d)	26	25	35	31	31
(2) SS					
Water Quality (mg/l)	204	198	180	241	188
Per Capita Sewage Generation (lpcd)			200		
Per Capita Load (g/d/d)	41	40	36	48	38

Source: Vodovod

Table 3.23 shows the average per capita BOD loading in the past five years of 2002 through 2006 was30 g/c/d and the average SS loading was 41 g/c/d, respectively. These values are the half the values stated in EU Directives. However, the data is not enough to explain why the Study does not apply the BOD of 60 g/c/d stipulated in EU Directives since it is not clear how the water qualities were

3 "Terms and definitions of the Urban Waste Water Treatment Directive (91/271/EEC), Agreed on December 2006 on UWWTD-REP working group.

measured at the frequency of as small as once every month.

The influent quality data at a WWTP in Kumanovo, a local city with the population of 110,000, shows per capita BOD loading in August 2008 was 40 g/c/d on an average and 60 g/c/d at its maximum fro late July through early August, which is close to the value in EU Directives. Joint WWTPs in Struga and Ohrid shows BOD loading of more than 60 g/c/d. From these performance data, per capita BOD loading is set to be 60 g/c/d, the value in EI Directives, and per capita SS loading is set to be 45 g/c/d supposing that the average value of 41 g/c/d in the past five years will not greatly increase. Table 3.24 shows per capita BOD and SS loadings for domestic wastewater.

Table 3.24 Pollutant Load for Domestic Sewerage

(g/person/day)

	2006	2020	2030
Per Capita BOD Load	30	60	60
Per Capita SS Load	41	45	45

(2) Load by Domestic Wastewater

Domestic wastewater loads are presented in Table 3.25 by 4 sewer districts.

Table 3.25 Domestic Pollutants Load by Sewer District

	2006	2020	2030
(1) Central Sewer District			
Population (Persons)	447,235	513,570	555,650
BOD Load (kg/d)	13,417	30,814	33,339
SS Load (kg/d)	18,337	23,111	25,004
(2) Saraj Sewer District			
Population (Persons)	38,628	52,500	62,800
BOD Load (kg/d)	1,159	3,150	3,768
SS Load (kg/d)	1,584	2,363	2,826
(3) North Gorce Petrov Sewer District			
Population (Persons)	9,800	13,200	16,100
BOD Load (kg/d)	294	792	966
SS Load (kg/d)	402	594	725
(4) Dracevo Sewer District			
Population (Persons)	35,670	39,900	43,200
BOD Load (kg/d)	1,070	2,394	2,592
SS Load (kg/d)	1,462	1,796	1,944

3.3.2 Industrial Wastewater

(1) Quantity and quality of industrial wastewater in 2007

Table 3.26 shows pollutant loading generated at 50 factories in the B/P area which was estimated for 50 factories described in Table 3.17.

Table 3.26 Load from Industrial Wastewater (Year 2007)

	Generation (m^3/d)	Water Quality (mg/l)		Load (kg/d)	
		BOD	SS	BOD	SS
For 50 factories	28,464	142	262	4,039	7,447

Loads from 6 factories which are not connected to the sewerage system are estimated as shown in Table 3.27. Refer to Appendix Part I, 3.3 for detail.

Table 3.27 Pollutants Load from Industry, not Connected with Sewerage System (2007)

	Generation (m^3/d)	Water Quality (mg/l)		Load (kg/d)	
		BOD	SS	BOD	SS
(1) ArceloMittal Steel (Steel)	5,714	60	500	343	2,857
(2) Makstil (Steel)	4,174	60	150	250	626
(3) Energetika – ELEM(Steel)	172	20	50	3	9
(4) Skopski Leguri (Steel)	5,566	20	70	111	390
(5) Pivara (Food)	1,427	850	130	1,213	186
(6) Ohis AD (Chemical)	2,442	100	80	244	195
Total or Average	19,495	111	219	2,165	4,263

Accordingly, generation and load from industrial wastewater connected with the sewerage system is estimated as BOD 209mg/l and SS 355mg/l as shown in Table 3.28.

Table 3.28 Pollutants Load from Industry Discharging to Sewerage System (2007)

	Generation (m^3/d)	Water Quality (mg/l)		Load (kg/d)	
		BOD	SS	BOD	SS
50 Factories from the Industrial Survey	28,464	142	262	4,039	7,447
6 Factories, not connected with Sewerage System	19,495	111	219	2,165	4,263
Factories Discharging to Sewerage System	8,969	209	355	1,875	3,184

(2) Future quantity, quality and pollutants from industrial wastewater

Future quality of industrial wastewater is expected to be improved through the execution of CP (Cleaner Production) by 20% in 2020 and by 35% in 2030 compared with present BOD of 209 mg/l and SS of 355 mg/l, respectively. Table 3.29 shows future water quality and pollutants of industrial wastewater. Water quality of 2006 is assumed to be same as that of 2007.

Table 3.29 Wastewater Quantity and Quality (Central District)

	2006	2007	2020	2030
(1) Industrial Wastewater Generation (m^3/d)	23,450	24,300	32,300	34,840
(2) BOD Load				
BOD Load Reduction with Cleaner Production	0%	0%	20%	35%
BOD Concentration with Cleaner Production (mg/l)	209	209	167	136
BOD Load (kg/d)	4,901	5,079	5,399	4,732
(3) SS Load				
SS Load Reduction with Cleaner Production	0%	0%	20%	35%
SS Concentration with Cleaner Production (mg/l)	355	355	284	231
SS Load (kg/d)	8,325	8,623	9,175	8,041

3.3.3 Stormwater

The quality of stormwater flowing into sewers is determined as shown in Table 3.30 referring to the "Guidelines for Measures against Combined Sewer Overflows, Japan Sewage Works Association".

Table 3.30 Quality and Load of Stormwater

	Quantity	Quality	Load
BOD	31,000 m^3/d	110 mg/l	3,410 kg/d
SS		400 mg/l	12,400 kg/d

Note: BOD and SS values are those during an first flushing.

3.3.4 Quantity and Quality of Overall Wastewater Flowing into Wastewater Treatment Plant.

Table 3.31 shows quantity and quality of total wastewater.

Table 3.31 Quantity, Load and Quality of Sewerage Influent

(1) Central Sewer District

	2006	2020	2030
Total Flow (m^3/d)	143,900	166,020	176,970
BOD Load			
Domestic (kg/d)	13,417	30,814	33,339
Industrial (kg/d)	4,901	5,399	4,732
Stormwater (kg/d)	3,410	3,410	3,410
Total Load (kg/d)	21,728	39,623	41,481
BOD Concentration (mg/l)	151	239	234
SS Load			
Domestic (kg/d)	18,337	23,111	25,004
Industrial (kg/d)	8,325	9,170	8,046
Stormwater (kg/d)	12,400	12,400	12,400
Total Load (kg/d)	39,062	44,681	45,450
SS Concentration (mg/l)	271	269	257

(2) Saraj Sewer district

	2006	2020	2030
Total Flow (m^3/d)	7,730	10,500	12,560
BOD Load (kg/d)	1,159	3,150	3,768
BOD Concentration (mg/l))	150	225	225
SS Load (kg/d)	1,584	2,363	2,826
SS Concentration (mg/l)	205	225	225

(3) North Gorce Petrov Sewer District

	2006	2020	2030
Total Flow (m^3/d)	1,960	2,640	3,220
BOD Load (kg/d)	294	792	966
BOD Concentration (mg/l))	150	225	225
SS Load (kg/d)	402	594	725
SS Concentration (mg/l)	205	225	225

(4) Dracevo Sewer District

	2006	2020	2030
Total Flow (m^3/d)	7,140	7,980	8,640
BOD Load (kg/d)	1,070	2,394	2,592
BOD Concentration (mg/l))	150	225	225
SS Load (kg/d)	1,462	1,796	1,944
SS Concentration (mg/l)	205	225	225

CHAPTER 4 WATER QUALITY ESTIMATION

Overall goal of the Study is to improve water quality of the Vardar River flowing through the central part of Skopje City. To reach the overall goal, important indicators include the implementation of trunk sewers, operation and maintenance of wastewater treatment plant(s) and control of industrial wastewaters. Water quality estimation is conducted to evaluate how the water quality of the Vardar River will be improved by the implementation of these measures shown as the indicators. Future water quality of the Vardar River is estimated by assuming the sewerage implementation in 2020, the extent to which industrial wastewaters are controlled and some levels at which wastewater is treated.

4.1 Vardar River

4.1.1 Flow Rate

Water quality is estimated for low water flow which is observed in July and August as shown in the flow data in Chapter 2, 2.2. Two photos below show the conditions of the Vardar River at Stone Bridge at low water flow and high water flow. Refer to Appendix Part I, 2.1 for the detail.

Vardar River (Summer)

Vardar River (Winter)

Table 4.1 shows low water flow and draught water flow.

Table 4.1 Flow Rate in the Vardar River and Tributaries; Low and Draught Water

(m^3/s)

	Vardar River			Treska River	Lepenec River
	Vlae	Skopje	Taor		
Low-water (275-day) Flow Rate (m^3/s)	19.6	25.7	29.8	8.4	3.9
Draught-water (355-day) Flow[1] Rate (m^3/s)	12.1	15.1	18.9	5.5	2.4

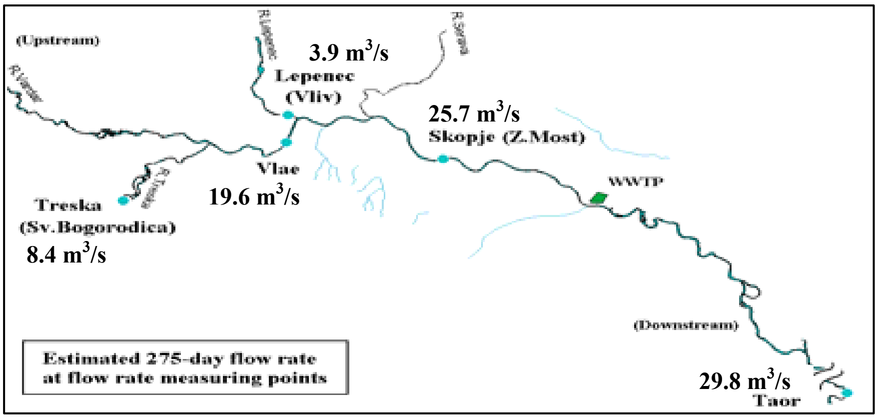


Figure 4.1 Flow Rate in the Vardar River and Tributaries; Low Water

[1] 355-day flow is defined that at least this flow runs in a river for 355 days in a year.

Water quality estimation uses the flows of the Vardar River (Rasce), Treska River and Lepenec River as boundary conditions. The flow at the most upstream of the estimation target (Rasce of the Vardar River) is to be the difference between the flow at Vlae right after Treska River joins the Vardar River and the flow of Treska River. Table 4.2 shows the flows of the Vardar River (at Rasce), Treska River and Lepenec River as boundary conditions.

Table 4.2 Flow Rate of the Vardar River and Its Tributaries (Boundary Condition)

(m^3/s)

River	Point	Low-water (275-day) Flow Rate	Draught-water (355-day) Flow Rate	Note
Vardar	Rasce	11.2	6.6	(Flow rate at Vlae) – (Flow rate in Treska River) Low-water: 19.6 – 8.4 = 11.2 Draught-water: 12.1 – 5.5 = 6.6
Treska	Upstream	8.4	5.5	
Lepenec	Upstream	3.9	2.4	

4.1.2 Water Quality of the Rivers and BOD Load

Water qualities of the Vardar River are discussed in Chapter 2, 2.2. It is necessary to know water qualities of the Vardar River, Treska River and the upstream part of Lepenec River as boundary conditions in pollution estimation. Measured water qualities are used for the estimation of current conditions, whereas water qualities stipulated in the environmental water quality standard (BOD of 4 mg/l) are used for the estimation in the target year of 2020 supposing the water quality would meet the standard assuming some pollution abatement measures would be taken at the upstream of the river. Table 4.3 shows water quality boundary conditions.

Table 4.3 Water Quality and BOD Load of the Vardar River and Its Tributaries (Boundary Condition)

River	Point	Low water flow (m^3/s)	BOD (mg/l)		BOD Load (kg/d)	
			Current (2006)	Target Year (2020)	Current (2006)	Target Year (2020)
Vardar	Rasce	11.2	2.5	4.0	2,419	3,871
Treska	Upstream	8.4	2.3	4.0	1,669	2,903
Lepenec	Upstream	3.9	2.1	4.0	708	1,348

4.2 BOD Load Generation from Skopje City

Pollution sources can be divided into point and non point sources. Most of the city area of Skopje City is already sewered, but collected domestic and industrial wastewaters are discharged to the Vardar River with no treatment; domestic wastewater and industrial wastewater from smaller scale factories to the river through two major and other smaller outlets and industrial wastewaters of large scale factories to the river through their own outlets. Hence, point sources are categorized as follows.

(i) Municipal wastewater discharged into rivers from sewerage system
(ii) Industrial wastewater discharged into rivers either directly or through sewerage system
(iii) Industrial wastewater discharged into rivers directly from individual use pipe.

Non point sources include domestic pollutants generated in non sewered areas and natural pollutants. No irrigation has been practiced within the city planning area of Skopje City and upland cropping is done only in limited areas. Hence, no agricultural pollutant is taken into account in pollutant estimation. Irrigation is done at the upstream and downstream areas outside the city planning area.

(i) Natural from lands (agricultural land, pasture and shrub/forest, livestock).
(ii) Wastewater from households (not covered by the sewerage system)

4.2.1 Point Source BOD Load Generation

(1) Locations of point sources in the survey area

There are some 50 wastewater and stormwater outlets on the both sides of the Vardar River including large and small and unused ones (Refer to Appendix Part I, 2.7 for the detail), many of which are concentrated in central part of the city of points A through E as shown in Figure 4.2. One existing trunk sewer is located at the left bank side of the river and the other at the right bank side of the river with their outlets at points C and D, respectively. The outlet at the right bank side discharges the largest amount of wastewater of 31,000 m^3/d in summer. The outlets from four steel related factories including Arcelomittal Steel and Makstil are located at the point E, the left bank side, discharge 80,700 m^3/d of wastewater that is the largest in the study area.

Pollution analysis model that will be described later regards two outlets from trunk sewers, the outlets exclusively for steel related factories and the WWTP to be constructed in the future as point sources, and other medium to small outlets as point sources continuously distributed in the central part to the city.

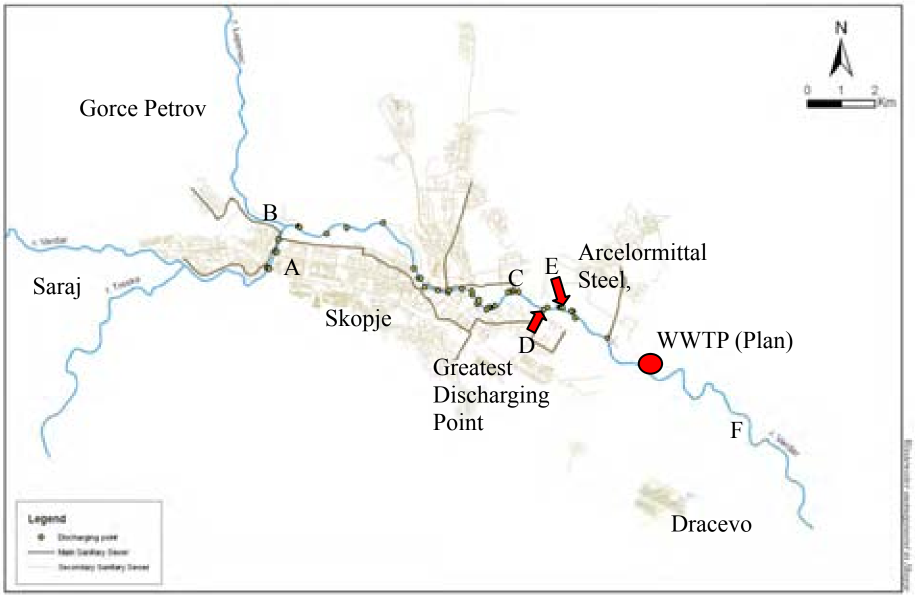


Figure 4.2 Outlet of Domestic Wastewater and Industry Wastewater

Point (A) UN Bridge (Vardar River)

Point (B) Lepenec River

Point (C) Keramidnica
(Outlet of Sewerage, Left Bank)

Point (D) Blvd Serbia, Bridge
(Outlet of Sewerage, Right Bank)

Point (E) Outlet of Industry
(Steel Industry)

Point (F) Taor
(Downstream Monitoring Point)

(2) Current conditions of point sources
The HMI and CHPI are periodically monitoring the flow rate and water quality of the Vardar River in Skopje City. Vodovod has carried out only water quality monitoring of each domestic wastewater and industrial wastewater outlet. Figure 4.3 shows the monitoring points by each institute. For the detail on water quality data of the Vardar River, see Appendix Part I, 2.4.

Table 4.4 shows average daily wastewater and BOD loading estimated using wastewater flow and BOD concentration provided by Vodovod and through site survey in November/December 2007. The survey shows that 183,623 m^3/d of domestic and industrial wastewaters is currently discharged to the Vardar River. Out of 183,623 m^3/d, the industrial wastewater from steel related factories including Arcelomittal Steel, Makstil accounts for 44% of the total wastewater or 80,784 m^3/d.

Amount of water supplied shown in Table 4.5 is nearly the same as measured amount of wastewater discharged to the Vardar River. Taking spraying water, groundwater infiltration and evaporation into account, the wastewater flow of 183,623 m^3/d is judged to be reasonable.

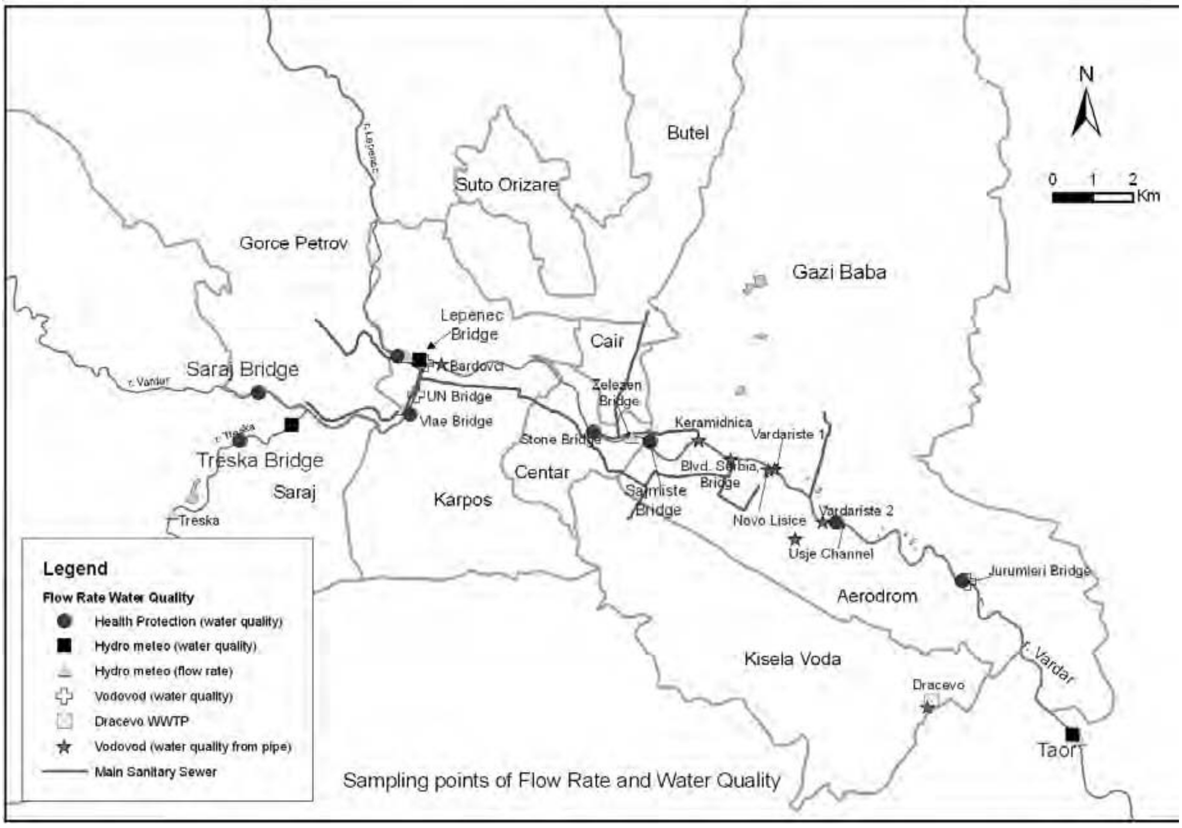


Figure 4.3 Measuring and Sampling Point

Table 4.4 Sewage and Generated BOD Load of the Vardar River

	Average Daily Wastewater	Generated BOD Load
Sewage (Mix of Domestic/Industry)	102,839 m^3/d	9,322 kg/d
Industrial Wastewater (Steel Industry)	80,784 m^3/d	4,847 kg/d
Total	183,623 m^3/d	14,169 kg/d

Note: Average daily wastewater is estimated based on the measured flows in major outlets (refer to Appendix I.10.2). It does not include flows in many small outlets (refer to Appendix I.2.7).

Table 4.5 Average Water Supply by Vodovod (2006)

	Average Daily Water Supply	Note
Municipal Water Supply	111,000 m^3/d	Total amount of water supply
Industry Water Supply	78,000 m^3/d	Steel related industry
Total	189,000 m^3/d	

Source: Vodovod Annual Report

4.2.2 Non-Point Source BOD Load Generation

There are 2 types of evaluation of the Non-point source pollution load, one is for the rivers and the other is for the closed water area. For water quality simulation of the rivers, the natural pollution load is anticipated as BOD 0.5~1.0 kg/d/km^2 concerning the whole river basin. But, water quality simulation of the closed water area should be calculated considering all parameters (farmland, household, mountains, forests and rainfall).

The objective of water quality simulation is estimation of water quality when the flow rate is low in the Vardar River. Therefore, wet weather effluent load is out of scope.

When the Non-point source pollution load is calculated on the basis of "Guidelines for Comprehensive Sewerage Implementation Plan for Individual River Basin (in Japan)", the value of natural BOD load becomes 0.45 kg/d/km^2. Standard value of natural pollution load is BOD 0.5~1.0 kg/d/km^2. Because actual value and guideline value are approximate, water quality simulation uses guideline value of BOD as 0.5 kg/d/km^2.

Table 4.6 Non-Point Source BOD Load (Land) of Vardar River Basin

Basin Area (km^2)	Average Flow (m^3/s)	Specific Run-off (l/s/km^2)	Unit Load (kg/d/km^2)	Note
20,655	135.96	6.58	0.45	$L=0.0702\times q^{0.9671}$ L: Unit (kg/d/km^2) q: Specific run-off (l/s/km^2)

Source: Statistical Yearbook of the Republic of Macedonia, 2007

(2) Pollutant load by domestic wastewater outside sewer district
Though most of the city area is included in sewer district, some areas such as a part of Gazi Baba municipality is outside the sewer district. Pollutant from domestic wastewater generated in these areas is regarded as non point source.

4.3 Outline of Simulation Model

4.3.1 Outline of Simulation Model

Water quality is simulated to estimate the effects of industrial wastewater control and the construction of wastewater treatment plant to be executed to reduce the pollutants to be discharged to the Vardar River. The stretch of the river between Rasce and Taor, water quality observation point at the downstream, with the length of 40.6 km is the target of simulation to project water qualities in and around Skopje City. Table 4.7 outlines the simulation model.

Table 4.7 Salient Features of Water Quality Simulation Model

Item	Explanation
Water Quality Parameter	BOD
Water Quality Model	QUAL2K（USEPA）
Used Equation	The pollution load runoff to the Vardar River (i.e., pollution load entering the Vardar River) is naturally purified while it flows down the Vardar River. BOD concentration decreases as explained below according to the Streeter-Phelps Equation Decreasing Reduction Rate of BOD: $dC/dt=-k \times C$ where: C=BOD concentration (mg/l) t=time (day) *k*=self-purification coefficient (l/day)
Purification Coefficient	Estimation of the self-purification coefficient *k* of the Vardar River through the Skopje City is rather difficult due to large number of outlets (about 50), scattered load inflow and relatively short time duration of the river flow (6 hours from Vlae Bridge to Taor). Though based on BOD mass balance, *k*=1.74 for the upstream section and *k*=1.18 for the downstream section were calculated. Average value of *k*=1.46 is applied to the simulation model. See Appendix Part I, 4.1 for the detail.
Stretch Analyzed	Vardar River The stretch between two monitoring points that correspond to sewer district of Skopje City. Upstream point: Rasce Downstream point: Taor Length of stretch: 40.6 km
Analysis Year	Year 2006 (Current) and Year 2020 (Target year of WWTP)
Pollution Load	Load from upstream boundary (Vardar River, Treska River and Lepenec River) Load from domestic wastewater Load from industrial wastewaters Load from WWTP Load from non point source (natural Load, domestic wastewater outside sewer district)

Item	Explanation
Analysis Scenario (Assessment of the Proposed Measures)	Industrial wastewater management Wastewater Treatment Plant Central Saraj, North Gorce Petrov and Dracevo Treatment Level (Primary or secondary)

4.3.2 River Model

The river model shown in Figure 4.4 is prepared incorporating the conditions of Treska River and Lepenec River, the outlets of domestic and industrial wastewaters to rivers and the location of WWTP to be constructed in the future. Table 4.8 lists domestic wastewater, industrial wastewater, WWTP and non point sources.

Table 4.8 Pollutant Loads List

	Pollution Source		Distance from Taor (km)	Remarks
1	River	Vardar River	40.60	Rasce where pollutants flow in from outside of the target area
2 a	River	Treska River	32.99	Pollutants flow in from outside of the target area
2 b	Point	Saraj Sewer District		Discharging into Treska River, tributary of Vardar
3		Central Sewer District Right-1	32.99～18.93	Small outlets of both bank sides of Vardar
4 a	River	Lepenec River	28.46	Pollutants flow in from outside of the target area
4 b	Point	North Gorce Petrov Sewer District		Discharged into Lepenec River, tributary of Vardar
5		Central Sewer District Left	19.89	Largest discharge at left bank
6		Factory (Pivara)		Industrial wastewaters directly discharged into Vardar
7		Central Sewer District Right-2	18.93	Largest discharge at right bank
8		Large Steel Factories	18.47	Industrial wastewaters directly discharged into Vardar
9		Factory (Ohis)	15.86	Industrial wastewaters directly discharged into Vardar
10		Central WWTP	15.51	WWTP for Central Sewer District (future)
11		Dracevo Sewer District	5.64	Discharged to Vardar through a channel
12	Non Point	Non Point Source (Domestic)	40.60～0.00	Distributed to the whole stretch
13		Non Point Source (Natural)	40.60～0.00	Distributed to the whole stretch

Note: Numbers in the table correspond to those in Figure 4.4.

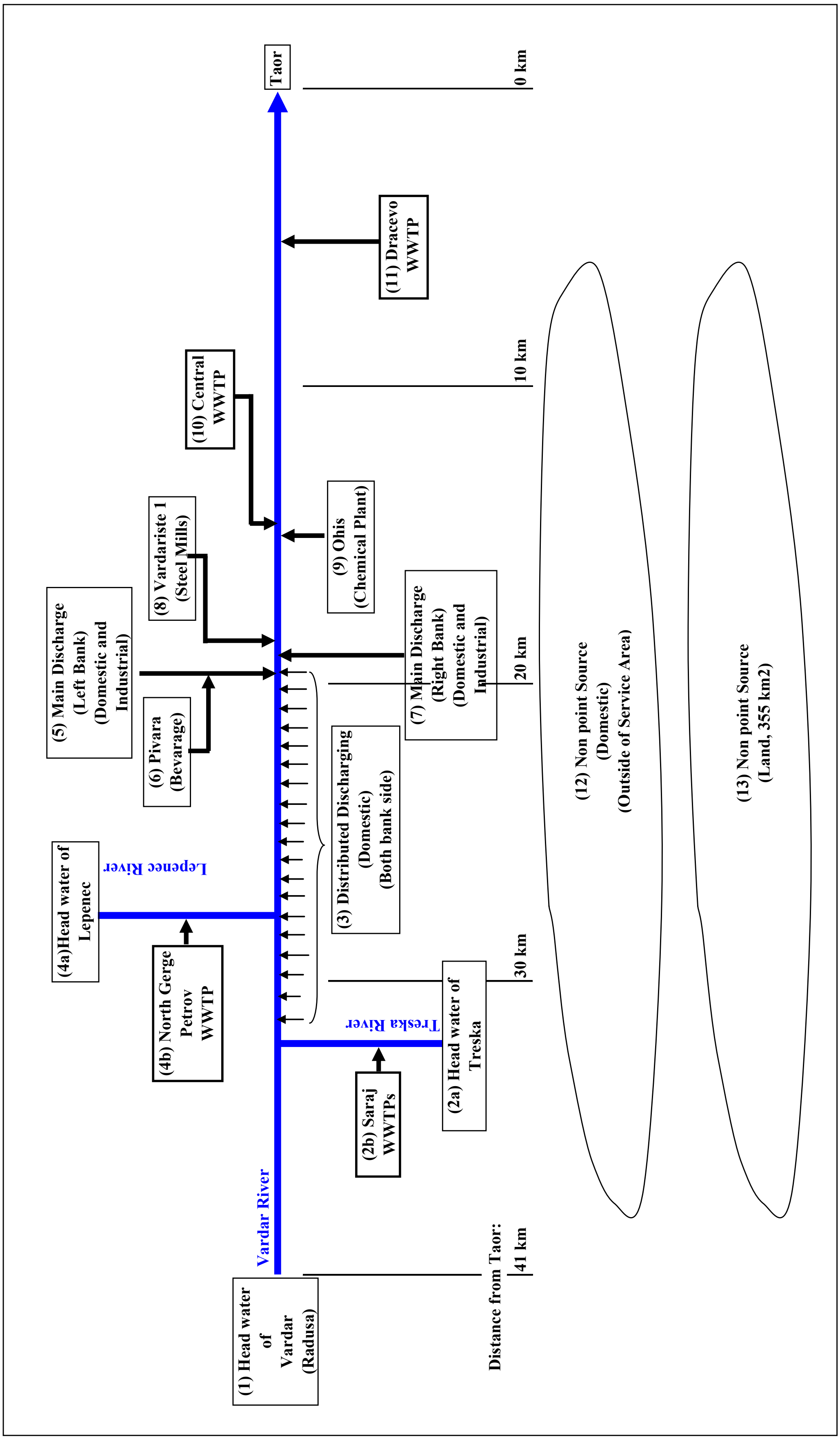


Figure 4.4 Water Quality Simulation Model

4.4 BOD Load Generation in the Target Year

4.4.1 Water Quality Improvement Scenarios for the Target Year

Water quality simulation is conducted for the current situation and 5 cases in the target year as shown in Table 4.9 in order to assess the proposed mitigation measures. The case-1 in the target year represents "without project" case while the case-2 to case-5 represent various "with the project" cases in the target year.

Table 4.9 Scenarios of Water Quality Improvement for the Target Year

	Title	Industrial Wastewater Management	Wastewater Treatment Plant		Explanation
			Central	Other 3	
Current (2006)		Without	Without	Without	
Target Year of WWTP (2020)					
Case-1	No measures	Without	Without	Without	
Case-2	Industrial Wastewater Management	With	Without	Without	1. No Wastewater Treatment Plant 2. Industrial Wastewater Management to all factories
Case-3	Primary Treatment at the Central WWTP	With	Primary	Without	1. Primary Treatment at Central WWTP 2. Industrial Wastewaters from all but 6 factories are discharged to WWTP 3. Industrial Wastewater Management for 6 factories
Case-4	Secondary Treatment at the Central WWTP	With	Secondary	Without	1. Secondary Treatment at Central WWTP 2. Industrial Wastewaters from all but 6 factories are discharged to WWTP 3. Industrial Wastewater Management for 6 factories
Case-5	Secondary Treatment in All 4	With	Secondary	Secondary	1. Secondary Treatment at Central and other WWTPs 2. Industrial Wastewaters from all but 6 factories are discharged to WWTP 3. Industrial Wastewater Management for 6 factories

Note:
(1) Other 3 are Saraj, North Gorce Petrov and Dracevo
(2) BOD effluent is BOD 25mg/l in case of industrial wastewater management
(3) BOD effluent in primary treatment is 143 mg/l =239 × (1 - 0.4), assuming 40% removal rate.
(4) BOD effluent in secondary treatment is 25mg/l, upper limit of EU Directives.

4.4.2 Estimation of Generated BOD Load

Generated BOD load is estimated according to the methods as shown in Table 4.10.

(1) Domestic generated BOD load = Population × Per capita load
(2) Industrial generated BOD load = amount of industrial wastewater × water quality
(3) Non-point source (domestic) generated BOD load = population ×Per capita load
(4) Non-point source (natural) generated BOD load = area × unit load of natural non-point source

Table 4.10 Estimation Methods of Generated BOD Load in the Target Year

Item				Estimation Method		
				Present (2006)	Target Year of WWTP (2020)	
Point Source	Domestic	Population		Refer to Table 3.12		
		Per Capita Generation		200 lpcd	200 lpcd	
		Per Capita Load		30 g/c/d	60 g/c/d	
	Industrial				Without Industrial Wastewater Management	With Industrial Wastewater Management
		Steel-related Large Factories (Discharged into Vardar)	Generation	Outlet Survey	Same as present generation due to unavailability of additional water supply	15% reduction due to CP
			Water Quality	Factory Survey	Same as present quality	BOD 25 mg/l
		Other Factories	Generation	Factory Survey	Annual growth rate of 3.5%	Annual growth rate of 3.5% with CP (15% reduction)
			Water Quality	Factory Survey	Same as present quality	In case of "without sewerage": BOD 25 mg/l (discharged into Vardar)
						In case of "with sewerage": 20% reduction due to CP
Non-point Source	Domestic (Out of Service Area)			Same as domestic point source		
	Natural			Unit Load of natural non-point source: 0.50 kg/d/km^2 Basin area: 355 km^2		

Note: Unit load is figures of year 2006
Factory survey is conducted in year 2007

4.4.3 Effluent BOD Load

Effluent BOD load is the load which is discharged after the septic tanks of household or industrial pretreatment facilities. Some households located out of the sewerage service area have the septic tanks, however the situation of operation and maintenance is not clear. Thus in this study, the effluent BOD load is equal to the generated BOD load.

Table 4.11 Estimation Methods of Effluent BOD Load in the Target Year

		Item		Effluent BOD Load	Explanation
Point Source	Domestic	Service area		-	To the WWTP
		Out of service area		Same with the wastewater generation	
	Industrial	Factories (discharge into the Vardar River)	With industrial wastewater management	Same with the wastewater generation	
			Without industrial wastewater management	Wastewater amount × regulated wastewater quality	Regulated wastewater quality: BOD: 25 mg/l
		Factories (discharged into the sewer)		-	To the WWTP
Non-point Source	Domestic (Out of Service Area)			Same with the wastewater generation	
	Natural			Same with the wastewater generation	

4.4.4 Run-off BOD Load

The effluent BOD load reaches to the Vardar River through channel, stream and sewers. The run-off BOD load is the generated load which reaches to the Vardar River. The run-off BOD load is smaller than the effluent BOD load because of the sedimentation, oxidation or filtration to the groundwater in the channel and stream. The ratio of run-off BOD load to effluent BOD load (run-off BOD load/ effluent BOD load) is run-off ratio. The run-off ratio is different from the development situation of the city or the conditions of the channel or stream. The survey related to the run-off rate in Skopje is not conducted, thus the run-off ratio for the water quality simulation is calculated based on the standard run-off rate shown in Table 4.12. The calculated run-off ratio for the simulation is shown in Table 4.13.

Table 4.12 Standard Run-off Ratio

Item		Run-off Ratio
Rural Area		0.0 – 0.2
Urban Area	Surrounding Area	0.1 – 0.6
	Center Area	0.6 – 1.0
Sewerage Service Area		1.0

Reference: Guidelines for Comprehensive Sewerage Improvement Plan for Individual River Basin (2008), Japan Sewage Works association

Table 4.13 Run-off Ratio which is used in the Simulation

				Run-off Ratio	Explanation
Point Source	Domestic	Central WWTP	Out of Service Area	0.3	Intermediate value of surrounding area of urban area in Table 4.12
			Service Area (Present)	0.8	Intermediate value of center area of urban area in Table 4.12
			Service Area (Future)	1.0	Sewerage service area in Table 4.12
		Other WWTP	Sewerage Area (Present)	0.3	Intermediate value of surrounding area of urban area in Table 4.12
			Sewerage Area (Future)	1.0	Sewerage service area in Table 4.12
	Industrial	Six Factories discharge into the River		1.0	Discharged into the River by private drain
		Other Factories	Present	0.8	Intermediate value of center area of urban area in Table 4.12
			Connected to Sewer (future)	1.0	Sewerage service area in Table 4.12
Non-point Source	Domestic (Out of Service Area)			0.1	Intermediate value of rural area in Table 4.12
	Natural			1.0	

4.4.5 Estimated BOD Load

(1) BOD Load Generation in Current Condition (Year 2006)

Table 4.14 shows the BOD load in 2006. All the wastewaters are discharged into the Vardar River without treatment. Domestic wastewater and industrial wastewater except 6 large industries which have their own discharge pipe are transported through the sewerage system to the main outlets and discharged to the Vardar River. Similarly large industrial wastewater is discharged to the Vardar River through their own pipes. Wastewater from Saraj, North Gorce Petrov and Dracevo is also discharged into the Vardar River without treatment.

Effluent BOD load is calculated as 27,695 kg/d; 27,094kg/d originated from the point-source, 601 kg/d from the non-point-source, and the run-off BOD load to the Vardar River is 20,543 kg/d.

Figure 4.5 indicates discharge points and their effluent BOD load.

Table 4.14 BOD Load (Year 2006)

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b	38,628	7,726	150	1,159	0.30	348
(2) North Gorce Petrov	4b	9,800	1,960	150	294	0.30	88
(3) Central	3,5,7	447,235	89,447	150	13,416	0.70	9,391
(4) Dracevo	11	35,670	7,134	150	1,070	0.30	321
Sub-total		531,333	106,267		15,939		10,148
2. Industry							
(1) Pivara	6		1,377	850	1,170	1.00	1,170
(2) Steel-related 4 Factories	8		80,784	60	4,847	1.00	4,847
(3) Ohis	9		2,357	100	236	1.00	236
(4) Others	5,7		23,450	209	4,902	0.80	3,922
Sub-total			107,968		11,155		10,175
3. Wastewater Treatment Plant							
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	10						
(4) Dracevo	11						
Sub-total							
Total (Point source)		531,333	214,235		27,094		20,323
B. Non-point Source							
1. Domestic	12	14,102	2,820	150	423	0.10	42
2. natural	13	0.5×355 km^2			178	1.00	178
Total (Non-point)		14,102	2,820		601		220
Total		545,435	217,055		27,695		20,543

Note:

(1) Pollutant source location numbers correspond with these in Figure 4.5.

(2) BOD load of domestic wastewater in Central Sewer District is allocated into No.3 (25%) of medium and small discharges, No.5 (37.5%) of outlet of left bank side trunk sewer and No.7 (37.5%) of outlet of right bank side trunk sewer.

(3) BOD load of industrial wastewater (others) in Central Sewer District is allocated into No.5 (50%) of left bank side trunk sewer and No.7 (50%) of right bank side trunk sewer.

(4) Run-off ratio of domestic wastewater in central district (weighted average efficiency) is 0.7 and the calculation is show in the table below.

	Run-off Ratio	% of theAarea	Weighted Average Efficiency
Out of Service Area	0.3	20%	$0.3 \times 20\% + 0.8 \times 80\% = 0.70$
Service Area (Present)	0.8	80%	

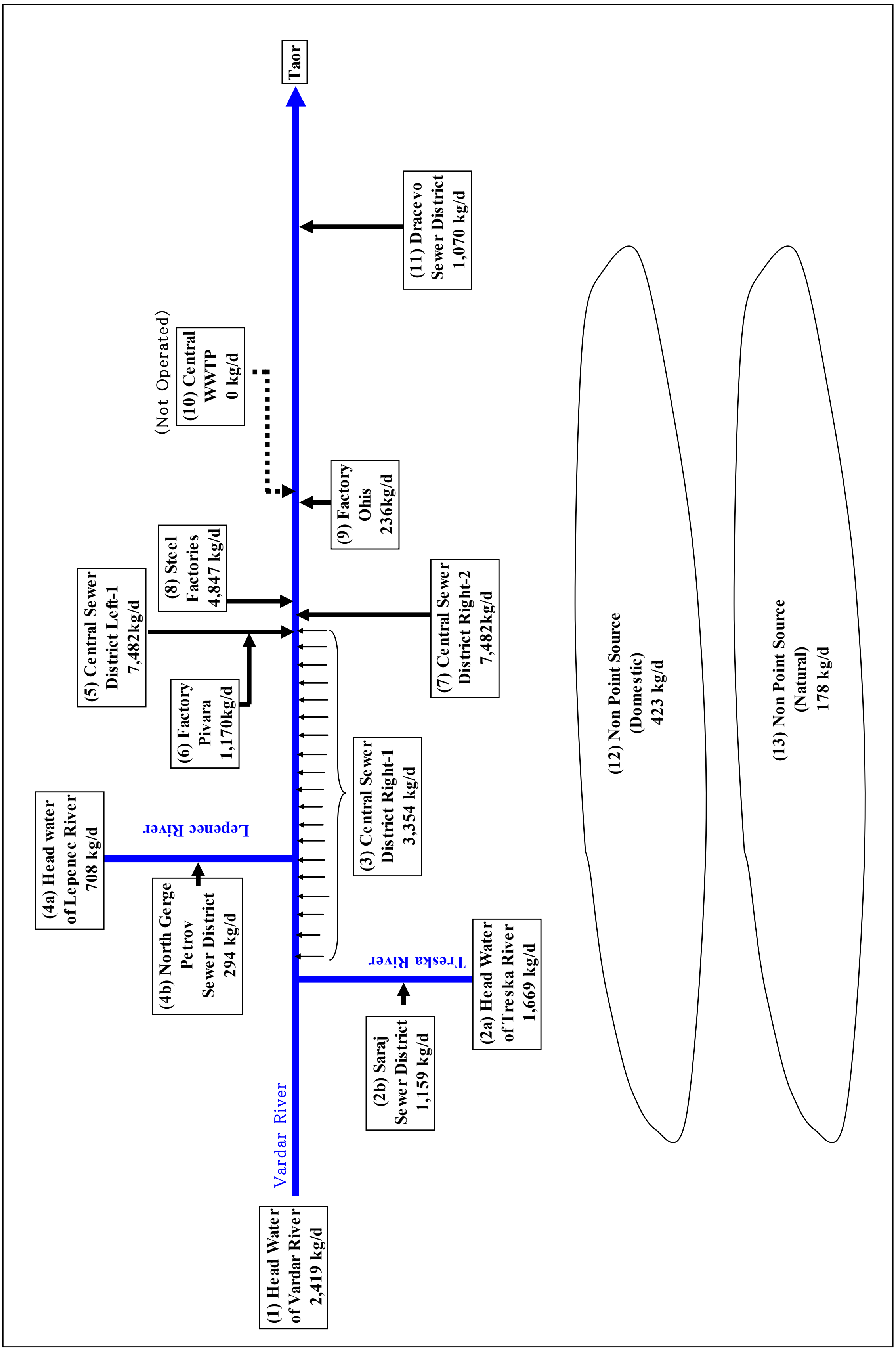


Figure 4.5 Effluent BOD Load (Current 2006)

(2) BOD Load Generation in"Case-1: No Measures (2020)"

Table 4.15 shows BOD load in Case-1: No Measures (2020). In this case, neither wastewater treatments are provided nor industrial wastewater management is enforced. Therefore, discharge points are the same as in 2006.

Effluent BOD load from the Study area is calculated as 53,344 kg/d; 52,218 kg/d originated from the point-source and 1,126 kg/d from the non-point source. The generation in the year 2020 is about 1.9 times higher than current (2006). This is partly because of population growth and industrial growth but mostly because of per capita BOD load increase. The run-off BOD load to the Vardar River is 37,223 kg/d.

Figure 4.6 indicates discharge points and their effluent BOD load.

Table 4.15 BOD Load Generation in"Case-1: No Measures (2020)"

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off Rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b	52,500	10,500	300	3,150	0.30	945
(2) North Gorce Petrov	4b	13,200	2,640	300	792	0.30	238
(3) Central	3,5,7	513,570	102,714	300	30,814	0.70	21,570
(4) Dracevo	11	39,900	7,980	300	2,394	0.30	718
Sub-total		619,170	123,834		37,150		23,471
2. Industry							
(1) Pivara	6		2,232	850	1,897	1.00	1,897
(2) Steel-related 4 Factories	8		80,784	60	4,847	1.00	4,847
(3) Ohis	9		3,819	100	382	1.00	382
(4) Others	5,7		38,000	209	7,942	0.80	6,354
Sub-total			124,835		15,068		13,480
3. Wastewater Treatment Plant							
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	10						
(4) Dracevo	11						
Sub-total							
Total (Point Source)		619,170	248,669		52,218		36,950
B. Non-point Source							
1. Domestic	12	15,800	3,160	300	948	0.10	95
2. Natural	13	0.5×355 km^2			178	1.00	178
Total (Non-Point)		15,800	3,160		1,126		273
Total		634,970	251,829		53,344		37,223

Note:
(1) Pollutant source location numbers correspond with these in Figure 4.6.
(2) BOD load of domestic of Central Sewer District is allocated into No.3 (25%) of medium and small outlets, No.5 (37.5%) of left bank side trunk sewer and No.7 (37.5%) of right bank side trunk sewer.
(3) BOD load of industrial (others) of Central Sewer District is allocated into No.5 (50%) of left bank side trunk sewer and No.7 (50%) of right bank side trunk sewer.
(4) Run-off ratio of domestic wastewater in central district (weighted average efficiency) is 0.7 and the calculation is show in the table below.

	Run-off ratio	% of the area	Weighted average efficiency
Out of service area	0.3	20%	$0.3 \times 20\% + 0.8 \times 80\% = 0.70$
Service area (Present)	0.8	80%	

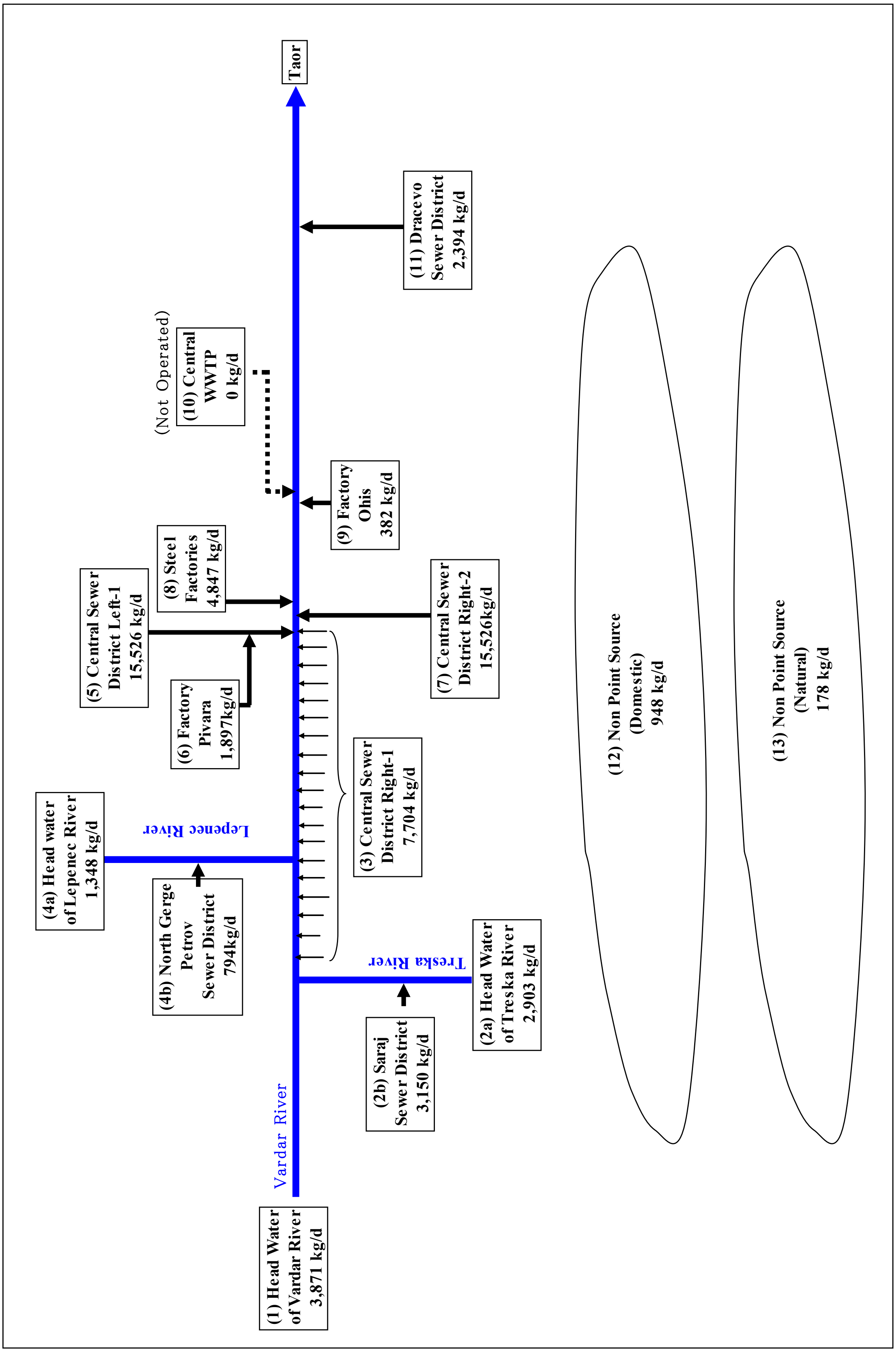


Figure 4.6 Effluent BOD Load (Case-1: No Measures (2020))

(3) BOD Load Generation in "Case-2: Industrial Wastewater Management (2020)"
Table 4.16 shows wastewater generation in Case-2: Industrial Wastewater Management (2020). BOD load discharge is assumed as 25 mg/l according to full implementation of the IPPC system. On the other hand, no wastewater treatment plant is provided. However, BOD of 25 mg/l from industrial wastewater is assumed to be 25 mg/l.

Effluent BOD load is calculated as 40,929 kg/d; 39,803 kg/d originated from the point-source and 1,126 kg/d from the non-point source. This value is 23% lower than the "Case-1". This is because of the regulated industrial effluent quality (BOD 25 mg/l). The run-off BOD load to the Vardar River is 26,236 kg/d.

Figure 4.7 indicates discharge points and their effluent BOD load.

Table 4.16 BOD Load in "Case-2: Industrial Wastewater Management (2020)"

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off Rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b	52,500	10,500	300	3,150	0.30	945
(2) North Gorce Petrov	4b	13,200	2,640	300	792	0.30	238
(3) Central	3,5,7	513,570	102,714	300	30,814	0.70	21,571
(4) Dracevo	11	39,900	7,980	300	2,394	0.30	718
Sub-total		619,170	123,834		37,150		23,472
2. Industry							
(1) Pivara	6		1,897	25	47	1.00	47
(2) Steel-related 4 Factories	8		68,666	25	1,717	1.00	1,717
(3) Ohis	9		3,246	25	81	1.00	81
(4) Others	5,7		32,300	25	808	0.80	646
Sub-total			106,109		2,653		2,491
3. Wastewater Treatment Plant							
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	10						
(4) Dracevo	11						
Sub-total							
Total (Point Source)		619,170	229,943		39,803		25,963
B. Non-point Source							
1. Domestic	12	15,800	3,160	300	948	0.10	95
2. Natural	13	0.5×355 km^2			178	1.00	178
Total (Non-point Source)		15,800	3,160		1,126		273
Total		634,970	233,103		40,929		26,236

Note:
(1) Pollutant source location numbers correspond with these in Figure 4.7.
(2) BOD load of domestic of Central Sewer District is allocated into No.3 (25%) of medium and small outlets, No.5 (37.5%) of left bank side trunk sewer and No.7 (37.5%) of right bank side trunk sewer.
(3) BOD load of industrial (others) of Central Sewer District is allocated into No.5 (50%) of left bank side trunk sewer and No.7 (50%) of right bank side trunk sewer.
(4) Run-off ratio of domestic wastewater in central district (weighted average efficiency) is 0.7 and the calculation is show in the table below.

	Run-off ratio	% of the area	Weighted average efficiency
Out of service area	0.3	20%	0.3×20%+0.8×80%=0.70
Service area (Present)	0.8	80%	

(5) Industrial wastewater flow decreases by 15% mainly due to introduction of CP despite an industrial growth.
(6) BOD concentration of industrial wastewater is 25 mg/l due to enforcement of the IPPC system.
(7) No wastewater treatment plant is operated.

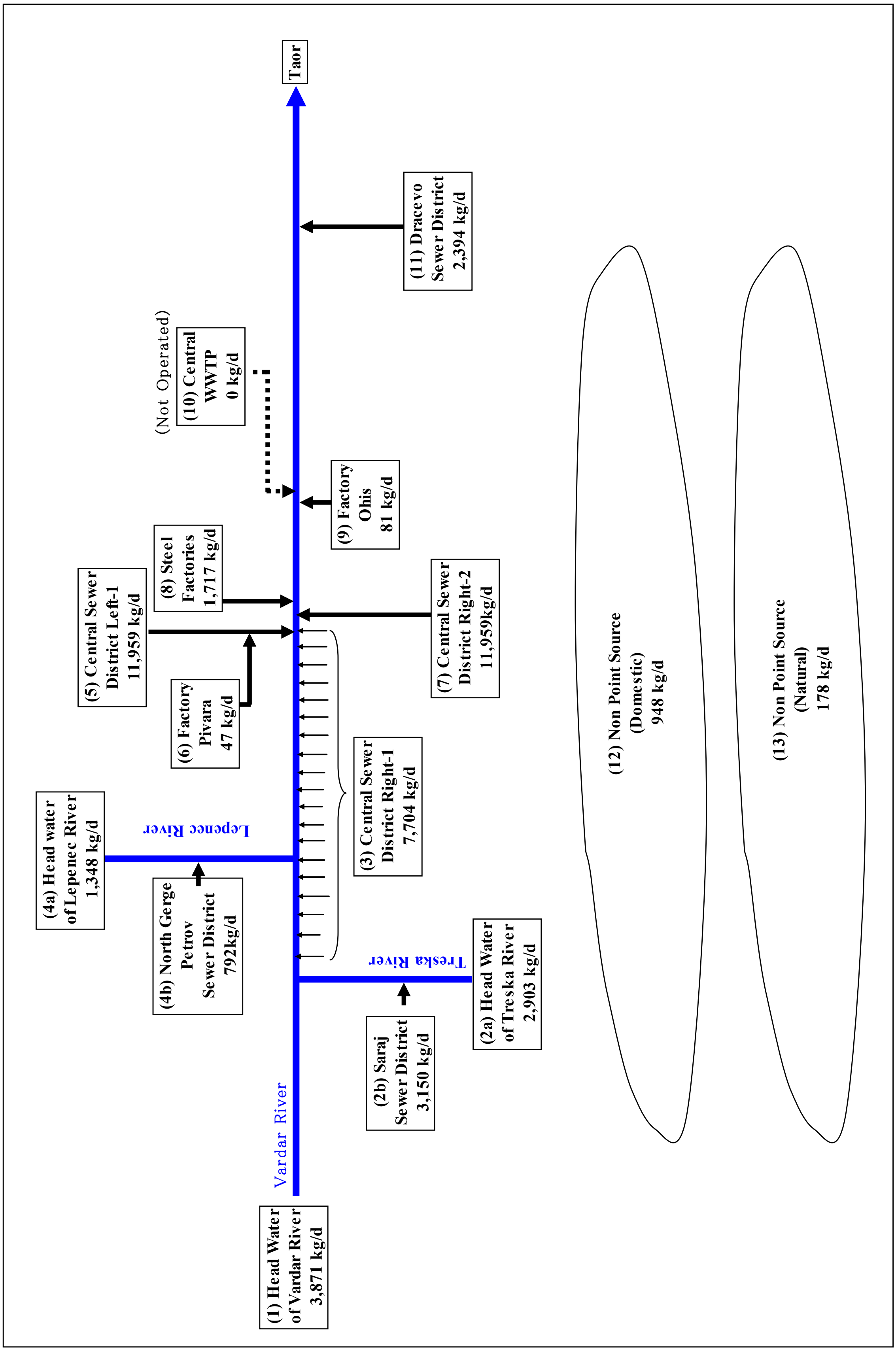


Figure 4.7 Effluent BOD Load (Case-2: Industrial Wastewater Management (2020))

(4) BOD Load Generation in "Case-3: Primary Treatment in the Central District"

Table 4.17 shows wastewater generation in "Case-3: Primary Treatment in Central District". This case is, in addition to "case-2" measures, namely industrial wastewater management, providing primary treatment in the central district.

Effluent BOD load is calculated as 28,614 kg/day; 27,488 kg/day originated from the point-source and 1,126 kg/day from the non-point source. This value is 30 % lower than the "Case-2". This is because of the primary treatment of wastewater. The run-off BOD load to the Vardar River is 23,326 kg/d.

Figure 4.8 indicates discharge points and their effluent BOD load.

Table 4.17 BOD Load in "Case-3: Primary Treatment in the Central District"

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off Rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b	52,500	10,500	300	3,150	0.30	945
(2) North Gorce Petrov	4b	13,200	2,640	300	792	0.30	238
(3) Central	3,5,7	-	-	-	-	-	-
(4) Dracevo	11	39,900	7,980	300	2,394	0.30	718
Sub-total		105,600	21,120		6,336		1,901
2. Industrial							
(1) Pivara	6		1,897	25	47	1.00	47
(2) Steel-related 4 Factories	8		68,666	25	1,717	1.00	1,717
(3) Ohis	9		3,246	25	81	1.00	81
(4) Others	5,7						
Sub-total			73,809		1,845		1,845
3. Wastewater Treatment Plant	(Primary Treatment)						
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	10	513,570	135,014	143	19,307	1.00	19,307
(4) Dracevo	11						
Sub-total		513,570	135,014		19,307		19,307
Total (Point Source)		619,170	229,943		27,488		23,053
B. Non-point Source							
1. Domestic	12	15,800	3,160	300	948	0.10	95
2. Natural	13	0.5×355 km^2			178	1.00	178
Total (Non-point Source)		15,800	3,160		1,126		273
Total		634,970	233,103		28,614		23,326

Note:
(1) Pollutant source location numbers correspond with these in Figure 4.8.
(2) BOD load of domestic of Central Sewer District is allocated into No.3 (25%) of medium and small outlets, No.5 (37.5%) of left bank side trunk sewer and No.7 (37.5%) of right bank side trunk sewer.
(3) BOD load of industrial (others) of Central Sewer District is allocated into No.5 (50%) of left bank side trunk sewer and No.7 (50%) of right bank side trunk sewer.
(4) Industrial wastewater flow decreases by 15% compared with that in 2006 mainly due to introduction of CP despite an industrial growth.
(5) BOD from industrial wastewater is 25 mg/l due to enforcement of the IPPC system.
(6) Domestic load as well as Industrial (others) load is counted under the Central wastewater treatment plant that is the only WWTP in operation.
(7) BOD in the primary effluent of Central Treatment Plant is assumed 143 mg/l (=239 mg/l × 0.6), namely 40% removal rate.

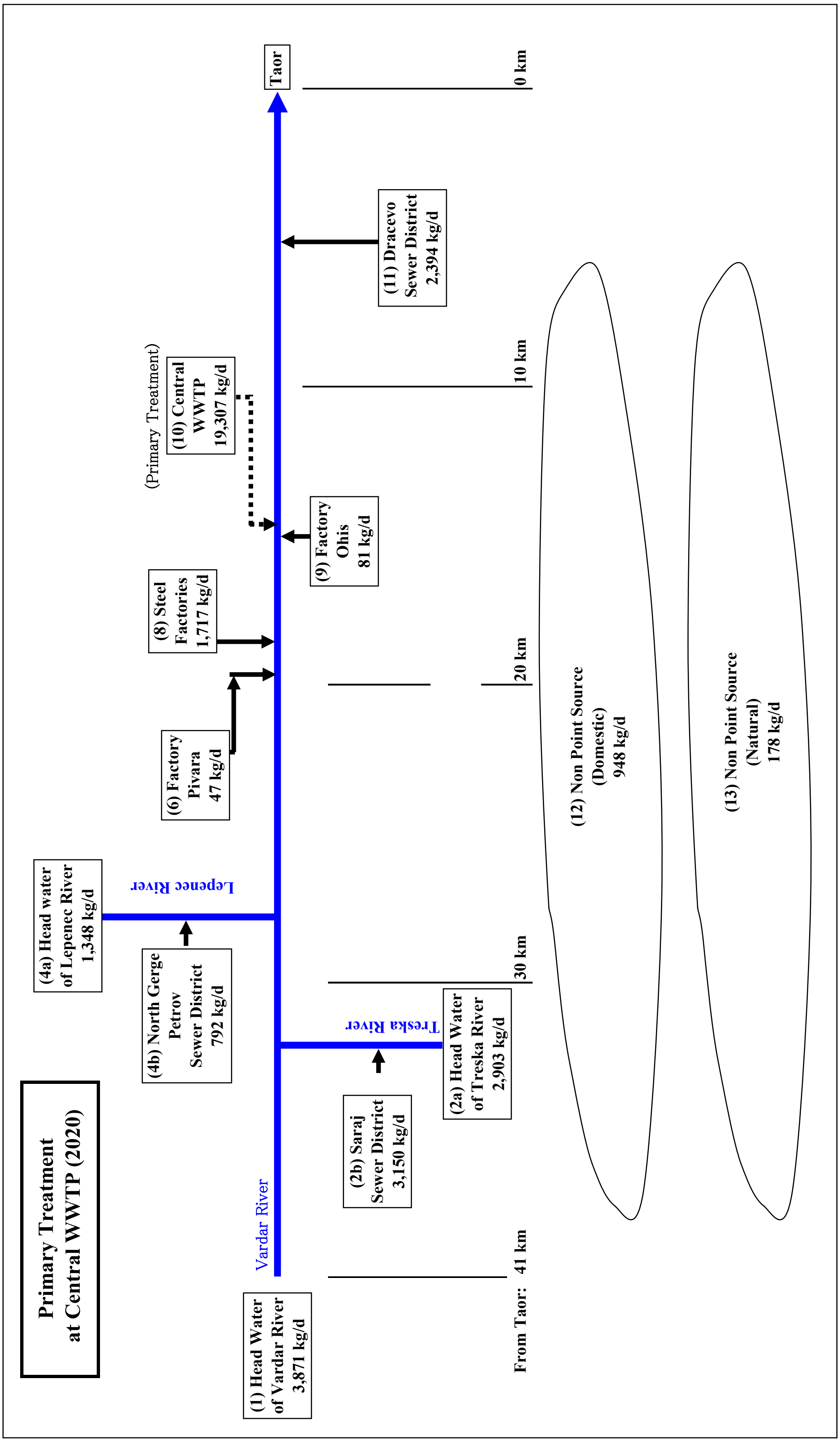


Figure 4.8 Effluent BOD Load (Case-3: Primary Treatment in the Central (2020))

(5) BOD Load Generation in "Case-4: Secondary Treatment in the Central (2020)"
Table 4.18 shows BOD load generation in "Case-4: Secondary Treatment in the Central District". This case is, in addition to "case-2" measures, namely industrial wastewater management, providing secondary treatment in the central district.

Effluent BOD load is calculated as 12,682 kg/day; 11,556 kg/day originated from the point-source and 1,126 kg/day from the non-point source. This value is 56 % lower than the "Case-3" which is primary treatment plant in the Central district. This is because of the secondary treatment in the central WWTP. The run-off BOD load to the Vardar River is 7,394kg/d.

Figure 4.9 indicates discharge points and their effluent BOD load.

Table 4.18 BOD Load in "Case-4: Secondary Treatment in the Central (2020)"

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off Rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b	52,500	10,500	300	3,150	0.30	945
(2) North Gorce Petrov	4b	13,200	2,640	300	792	0.30	238
(3) Central	3,5,7	0	0	-	0	0.00	0
(4) Dracevo	11	39,900	7,980	300	2,394	0.30	718
Sub-total		105,600	21,120		6,336		1,901
2. Industrial							
(1) Pivara	6		1,897	25	47	1.00	47
(2) Steel-related 4 Factories	8		68,666	25	1,717	1.00	1,717
(3) Ohis	9		3,246	25	81	1.00	81
(4) Others	5,7		0	-	0	0.00	0
Sub-total			73,809		1,845		1,845
3. Wastewater Treatment Plant							
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	10	513,570	135,014	25	3,375	1.00	3,375
(4) Dracevo	11						
Sub-total		513,570	135,014		3,375		3,375
Total (Point Source)		619,170	229,943		11,556		7,121
B. Non-point Source							
1. Domestic	12	15,800	3,160	300	948	0.10	95
2. Natural	13	0.5×355 km^2			178	1.00	178
Total (Non-point Source)		15,800	3,160		1,126		273
Total		634,970	233,103		12,682		7,394

Note:
(1) Pollutant source location numbers correspond with these in Figure 4.9.
(2) BOD load of domestic of Central Sewer District is allocated into No.3 (25%) of medium and small outlets, No.5 (37.5%) of left bank side trunk sewer and No.7 (37.5%) of right bank side trunk sewer.
(3) BOD load of industrial (others) of Central Sewer District is allocated into No.5 (50%) of left bank side trunk sewer and No.7 (50%) of right bank side trunk sewer.
(4) Industrial wastewater flow decreases by 15% compared with that in 2006 mainly due to introduction of CP despite an industrial growth.
(5) BOD from industrial wastewater is 25 mg/l due to enforcement of the IPPC system.
(6) Domestic load as well as Industrial (others) load is counted under the Central wastewater treatment plant that is the only WWTP in operation.
(7) BOD in the Central Treatment Plant with secondary treatment is assumed to be 25 mg/l.

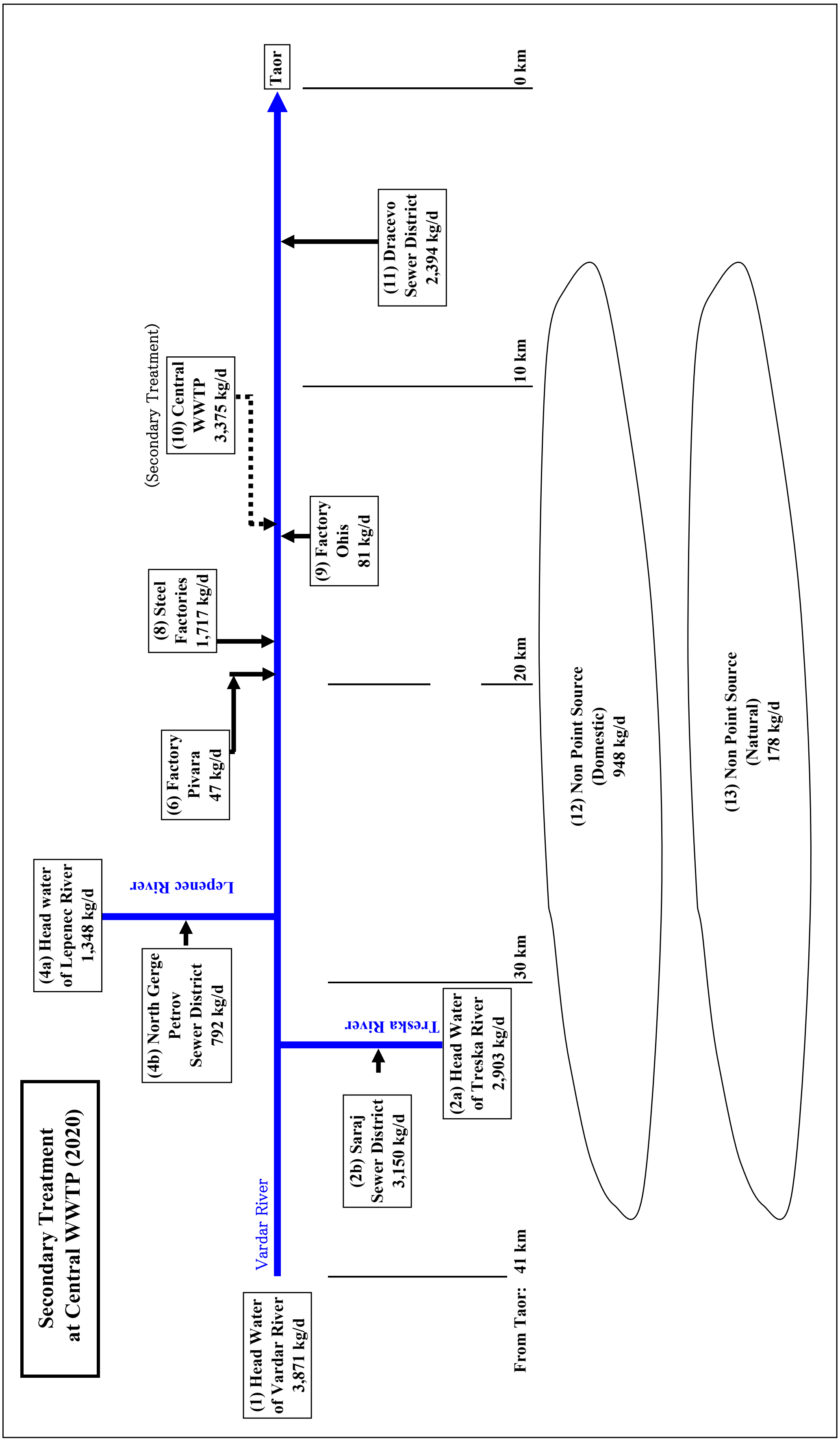


Figure 4.9 Effluent BOD Load (Case-4: Secondary Treatment in the Central (2020))

(6) BOD Load Generation in"Case-5: Secondary Treatment in All 4 (2020)"
Table 4.19 shows BOD load generation in "Case-5. This case, in addition to case-4, is providing secondary treatment in all 4 treatment plants.

Effluent BOD load is calculated as 6,875 kg/day; 5,749 kg/day originated from the point-source and 1,126 kg/day from the non-point source. This value is 46 % lower than the "Case-4". This is because of the secondary treatment in all four WWTP. The run-off BOD load is 6,022 kg/d.

Figure 4.10 indicates discharge points and their effluent BOD load generation.

Table 4.19 BOD Load in"Case-5: Secondary Treatment in All 4 (2020)"

	Pollutant Source Location	Population (Persons)	Flow (m^3/d)	Effluent Quality (mg/l)	Effluent BOD Load (kg/d)	Run-off Rate	Run-off BOD Load (kg/d)
A. Point Source							
1. Domestic							
(1) Saraj	2b						
(2) North Gorce Petrov	4b						
(3) Central	3,5,7						
(4) Dracevo	11						
Sub-total							
2. Industrial							
(1) Pivara	6		1,897	25	47	1.00	47
(2) Steel-related 4 Factories	8		68,666	25	1,717	1.00	1,717
(3) Ohis	9		3,246	25	81	1.00	81
(4) Others	5,7						
Sub-total			73,809		1,845		1,845
3. Wastewater Treatment Plant							
(1) Saraj	2b	52,500	10,500	25	263	1.00	263
(2) North Gorce Petrov	4b	13,200	2,640	25	66	1.00	66
(3) Central	10	513,570	135,014	25	3,375	1.00	3,375
(4) Dracevo	11	39,900	7,980	25	200	1.00	200
Sub-total		619,170	156,134		3,904		3,904
Total (Point Source)		619,170	229,943		5,749		5,749
B. Non-point Source							
1. Domestic	12	15,800	3,160	300	948	0.10	95
2. Natural	13	0.5×355 km^2			178	1.00	178
Total (Non-point Source)		15,800	3,160		1,126		273
Total		634,970	233,103		6,875		6,022

Note:
(1) Pollutant source location numbers correspond with these in Figure 4.10.
(2) BOD load of domestic of Central Sewer District is allocated into No.3 (25%) of medium and small outlets, No.5 (37.5%) of left bank side trunk sewer and No.7 (37.5%) of right bank trunk sewer.
(3) BOD load of industrial (others) of Central Sewer District is allocated into No.5 (50%) of left bank side and No.7 (50%) of right bank side.
(4) Industrial wastewater flow decreases by 15% compared with that in 2006 mainly due to introduction of CP despite an industrial growth.
(5) BOD from industrial wastewater is 25 mg/l due to enforcement of the IPPC system.
(6) After all the WWTPs begin their operation with secondary treatment, BOD in the industrial wastewater is assumed to be 25 mg/l.
(7) Domestic load as well as Industrial (others) load is counted under each wastewater treatment plant.

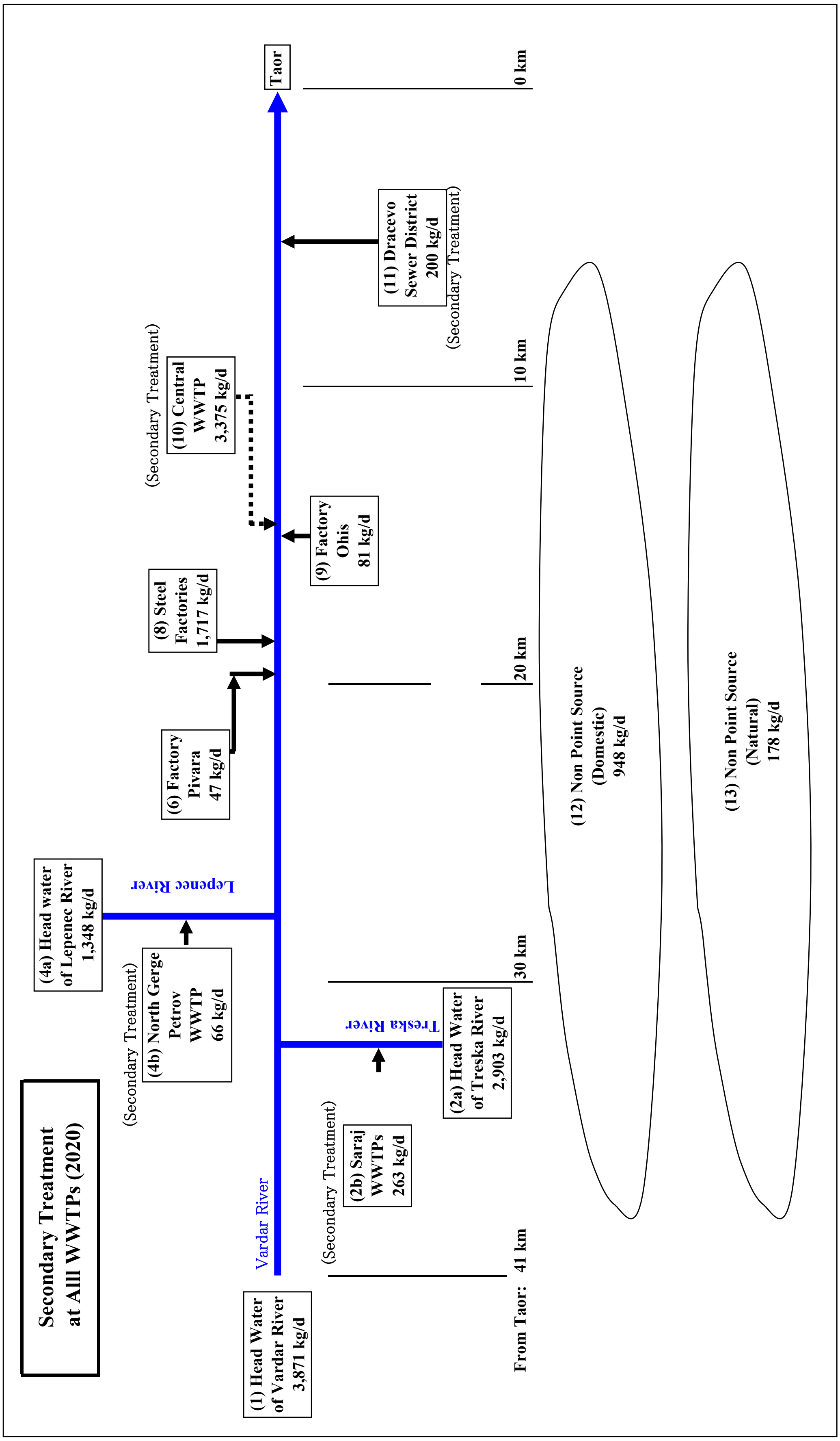


Figure 4.10 Effluent BOD Load (Case-5: Secondary Treatment in All 4 Districts (2020))

Wastewater generations by source and by case are shown in Table 4.20 and Figure 4.11. Wastewater generation in the year 2020 increases by two times from the current one if “no-measures” taken. By implementing various measures corresponding to cases 2 to 5, it will decrease by 22%” to 86%” compared with “case-1”.

Table 4.20 Effluent BOD Load by Case

(BOD-kg/d)

	Current (2006)	Target Year (2020)				
		Case-1	Case-2	Case-3	Case-4	Case-5
BOD Load Reduction Measures						
Industrial Wastewater Management	Without	Without	With (25 mg/l)	With (25 mg/l)	With (25 mg/l)	With (25 mg/l)
Wastewater Treatment Plant in Central	-	-	-	Primary (143 mg/l)	Secondary (25 mg/l)	Secondary (25 mg/l)
Wastewater Treatment Plant in Other 3	-	-	-	-	-	Secondary (25 mg/l)
Effluent BOD Load						
Point Source						
Domestic	15,939	37,150	37,150	6,336	6,336	0
Industrial	11,155	15,068	2,653	1,845	1,845	1,845
Wastewater Treatment Plant	0	0	0	19,307	3,375	3,904
Sub-total	27,094	52,218	39,803	27,488	11,556	5,749
Non-point Source						
Domestic	423	948	948	948	948	948
Natural	178	178	178	178	178	178
Sub-total	601	1,126	1,126	1,126	1,126	1,126
Total	27,695	53,344	40,929	28,614	12,682	6,875
BOD Reduction Rate	-	1.00	0.77	0.54	0.24	0.13

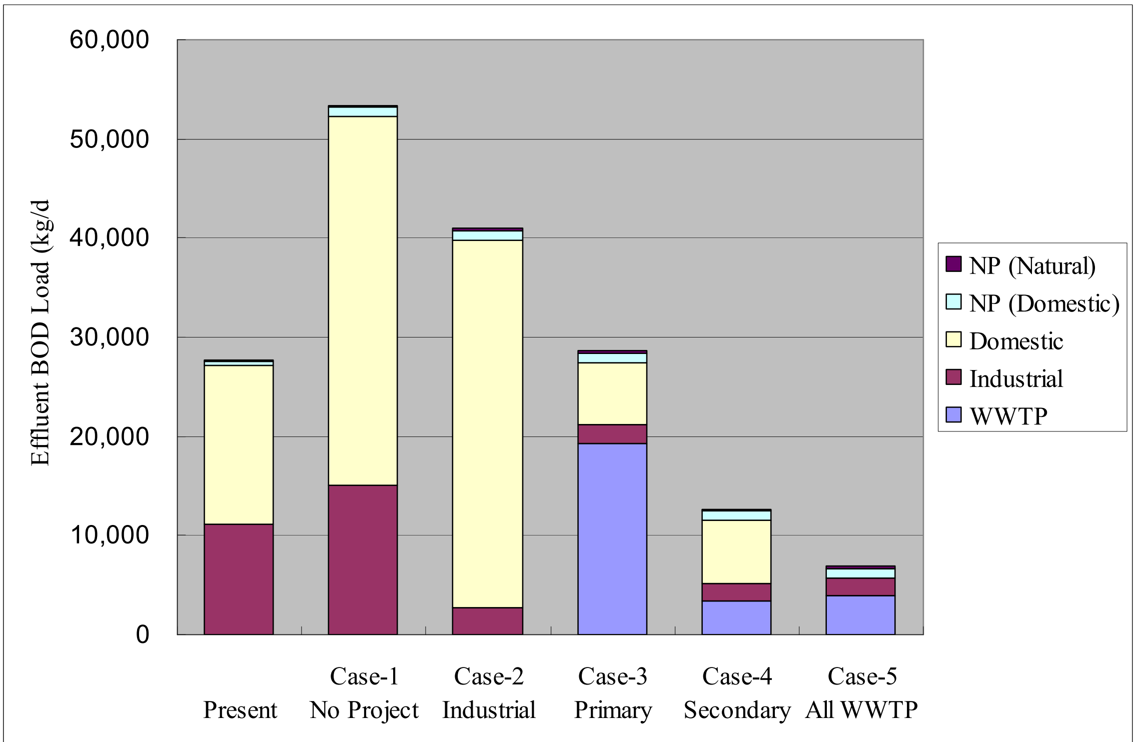


Figure 4.11 Effluent BOD Load by Case

4.5 Estimated Water Quality

Table 4.21 and Figure 4.12 show the simulated water quality (BOD) based on the calculated wastewater generation in section 4.4. The darkened Columns indicate exceeding environmental water quality standard.

Table 4.21 Estimated Water Quality (BOD, 2020)

(mg/l)

	Rasce	Main Load Discharge Point							Taor
		Treska	Lepenec	Left-bank Outlet	Right-bank Outlet	Steel Outlet	Central WWTP	Trubarevo Bridge	
Current	2.5	2.6	2.5	5.7	7.9	9.7	9.3	7.1	5.8
Case-1	4.0	4.1	4.1	10.3	14.8	16.3	15.6	12.4	11.0
Case-2	4.0	4.1	4.1	8.2	11.6	11.9	11.5	8.8	7.5
Case-3	4.0	4.1	3.8	3.0	3.0	3.6	11.3	8.4	7.0
Case-4	4.0	4.1	3.8	3.0	3.0	3.6	4.6	3.4	2.8
Case-5	4.0	3.7	3.5	2.8	2.7	3.4	4.4	3.2	2.5
Water Quality Standard	Class II				Class III				
	4				7				

Note: Darkened columns indicate exceeding environmental water quality standard.

	Title	Industrial Wastewater Management	Wastewater Treatment Plant	
			Central	Other 3
Current (2006)		No enforcement	Without	Without
Target Year of WWTP (2020)				
Case-1	No measures	No enforcement	Without	Without
Case-2	Industrial Wastewater Management only	All	Without	Without
Case-3	Primary Treatment in the Central	All	Primary	Without
Case-4	Secondary Treatment in the Central	All	Secondary	Without
Case-5	Secondary Treatment in All 4	All	Secondary	Secondary

The results of analysis describe the water quality of the Vardar River in 2020 as follows.

(1) In case-1 (No measures), water quality exceeds the designated water quality standard through every stretches from Rasce to Taor.
(2) In case-2 (Industrial Wastewater Management), water quality is improved but still exceeds the standard throughout every stretches.
(3) In case-3 (case 2 + Primary treatment in the Central), most stretches down to the Central WWTP satisfy the water quality standard due to transferring the sewerage discharge point to the WWTP. However, water quality downstream WWTP does not satisfy it.
(4) In case-4 (Secondary treatment in the Central), water quality in every sections except influences with the Treska and the Lepenec meet the standard.
(5) Water quality standards are met if secondary treatment plants are provided in all 4 districts (case-5).

EU Directives necessitates every settlement with more than 2,000 P.E. to construct secondary treatment plants. The simulation confirms the necessity of secondary treatment plants in every 4 district.

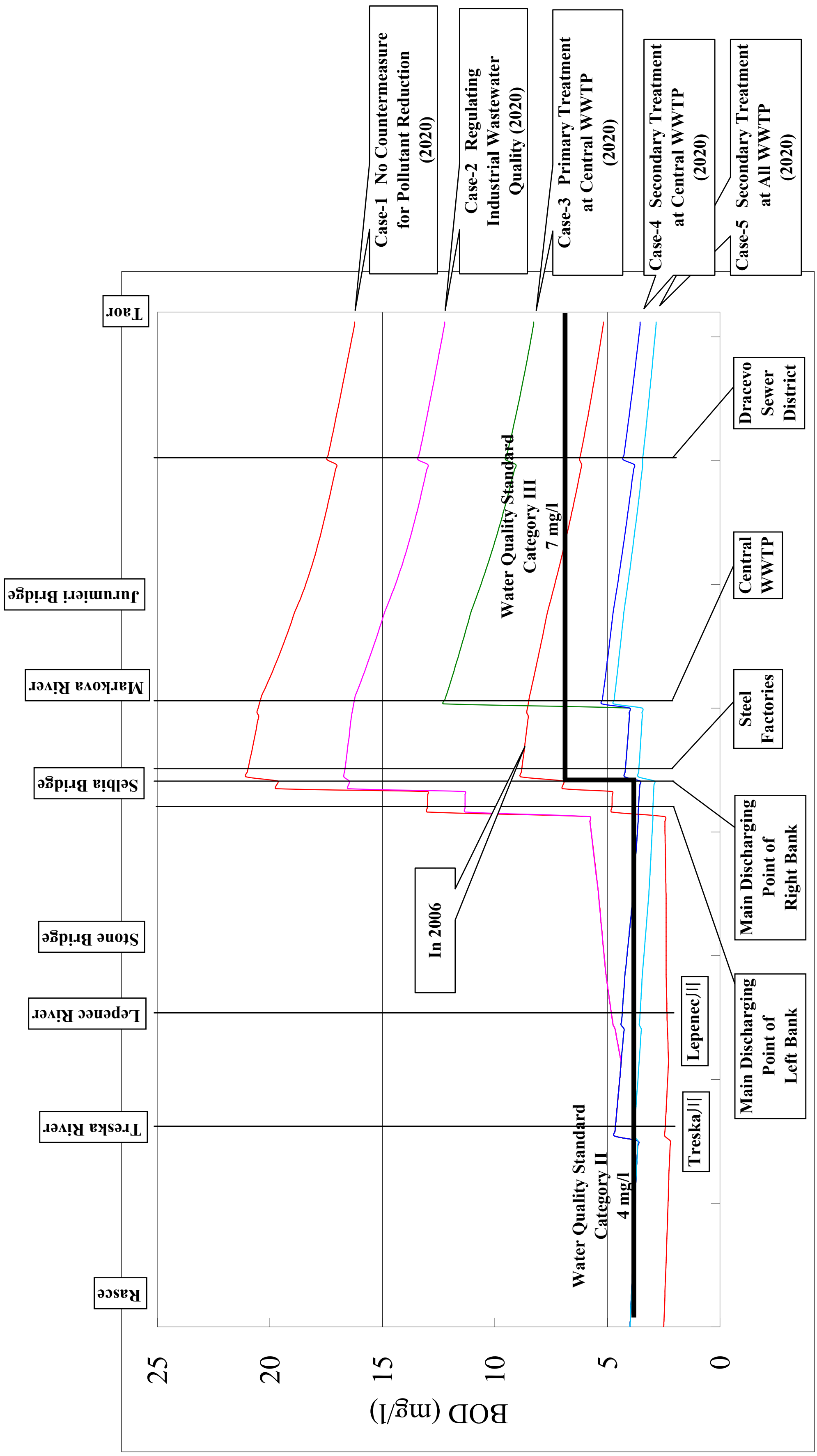


Figure 4.12 Estimated Water Quality (BOD, 2020)

4.6 Estimated Water Quality (in draught flow)

Pollution analysis for low water flow showed that environmental water quality standard can be met if all the WWTPs are provided secondary treatment and industrial wastewaters are controlled in an appropriate manner. This section projects water quality for draught water flow. Environmental water quality standard of Macedonia does not mention at which flow the standard has to be met. EU Directive 91/271/EEC pertaining to effluent qualities which will be applied in Macedonia stipulates that effluent qualities can violate the effluent standard for a certain times according to the number of sampling. If the effluent is sampled and analyzed every day, it can violate the effluent standard for 25 times in a year. In other words, the effluent has to meet the standard for 340 days out of 365 days. Supposing the provision can be applied to the environmental water quality standard, pollution analysis is done for draught flow.

4.6.1 Assumptions

(1) Draught flow
Pollution analysis is done for the draught flow shown in Table 4.22.

Table 4.22 Conditions of the Vardar River and its Tributaries (Boundary Conditions)

(m^3/s)

River	Point	Low-water (275-day) Flow Rate	Draught-water (355-day) Flow Rate	Note
Vardar	Rasce	11.2	6.6	(Flow rate at Vlae) – (Flow rate in Treska River) Low-water: 19.6 – 8.4 = 11.2 Draught-water: 12.1 – 5.5 = 6.6
Treska	Upstream	8.4	5.5	
Lepenec	Upstream	3.9	2.4	

(2) Water quality at the upstream boundary during draught flow
It is supposed that pollutants flowing from the upstream during draught flow are the same as that during low water. Water quality during draught flow is somewhat higher than that during low flow because of its smaller flow.

Table 4.23 River Water Quality during Draught Flow (Boundary Conditions)

(1) Year 2006

	Low-water Condition			Draught-water Condition	
	Flow rate (m^3/s)	BOD (mg/l)	BOD Load (kg/d)	Flow Rate (m^3/s)	BOD (mg/l)
Vardar River	11.2	2.5	24,192	6.6	4.2
Treska River	8.4	2.3	18,144	5.5	3.5
Lepenec River	3.9	2.1	7,076	2.4	3.4

(2) Year 2020

	Low-water Condition			Draught-water Condition	
	Flow rate (m^3/s)	BOD (mg/l)	BOD Load (kg/d)	Flow Rate (m^3/s)	BOD (mg/l)
Vardar River	11.2	4.0	38,707	6.6	6.8
Treska River	8.4	4.0	29,030	5.5	6.1
Lepenec River	3.9	4.0	13,478	2.4	6.5

(3) Pollutants contained in domestic wastewater, industrial wastewater and WWTP effluent
Various parameters used for draught flow analysis are the same as those for low flow analysis.

4.6.2 Result of analysis

Table 4.24 shows the result of analysis for draught flow.

Table 4.24 Estimated Water Quality（BOD, 2020, Draught-water）

(mg/l)

	Rasce	Main Load Discharging Point							Taor
		Treska	Lepenec	Left-Bank Outlet	Right-bank Outlet	Steel outlet	Central WWTP	Trubarevo Bridge	
Current	4.2	3.8	3.5	8.2	11.6	14.0	13.3	9.7	7.8
Case-1	6.8	6.6	6.4	15.9	22.7	24.5	23.4	19.1	17.0
Case-2	6.8	6.6	6.4	12.6	17.7	17.9	17.1	13.2	11.4
Case-3	6.8	6.6	6.0	4.6	4.5	5.4	16.9	12.5	10.7
Case-4	6.8	6.6	6.0	4.6	4.5	5.4	6.7	4.7	3.8
Case-5	6.8	5.9	5.4	4.1	4.0	5.0	6.4	4.5	3.4
Water Quality Standard	Class II				Class III				
	4				7				

Note: Darkened columns indicate exceeding environmental water quality standard.

	Title	Industrial Wastewater Management	Wastewater Treatment Plant	
			Central	Other 3
Current (2006)		No enforcement	Without	Without
Target Year of WWTP (2020)				
Case-1	No Measures	No enforcement	Without	Without
Case-2	Industrial Wastewater Management only	All	Without	Without
Case-3	Primary Treatment in the Central	All	Primary	Without
Case-4	Secondary Treatment in the Central	All	Secondary	Without
Case-5	Secondary Treatment in All 4	All	Secondary	Secondary

The result of analysis describes the water quality of the Vardar River in 2020 as follows.

(1) Even during draught flow, secondary treatment at all the WWTPs (Case 5) will make the quality standard to be met within the Class III area in spite of somewhat deteriorated water quality.

(2) Quality standard can not be met within the Class II area even if all the WWTPs are provided with secondary treatment. It is because the upstream BOD is supposed to be 6.8 mg/l. If the upstream BOD is 4 mg/l corresponding to Class II, the quality standard at Class II area is expected to be met.