No.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

STATE WATER DIRECTORATE
CROATIAN WATERS
THE REPUBLIC OF CROATIA

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN IN THE REPUBLIC OF CROATIA

FINAL REPORT

Vol. 2 : MAIN REPORT

AUGUST 2001

CTI ENGINEERING INTERNATIONAL CO., LTD.

IN ASSOCIATION WITH

NIHON SUIDO CONSULTANTS CO., LTD.

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EXCHANGE RATE

The currency exchange rates used in this Study are:

US Dollar (US$) 1.00 = Japanese Yen (¥) 116

= Croatian Kuna (Kn.) 8.3

As of February 2001

PREFACE

In response to a request from the Government of the Republic of Croatia, the Government of Japan decided to conduct the Study for Water Pollution Reduction on the Sava River Basin and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Naohito Murata of CTI Engineering International Co., Ltd., and consisting of members from CTI Engineering International Co., Ltd. and Nihon Suido Consultants Co., Ltd., to the Republic of Croatia three times between October 2000 to July 2001. In addition, JICA set up an advisory committee headed by Mr. Shigeharu Iinoue, Senior Researcher, Urban Development Corporation, between September 2000 and August 2001, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of the Republic of Croatia and conducted field surveys at 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 the project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Croatia for their close cooperation extended to the team.

August, 2001

Kunihiko Saito
President
Japan International Cooperation Agency

August, 2001

Mr. Kunihiko Saito
President
Japan International Cooperation Agency
Tokyo, Japan

Sir:

LETTER OF TRANSMITTAL

We are pleased to submit herewith the Final Report on the Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia.

The study was conducted by CTI Engineering International Co., Ltd. in association with Nihon Suido Consultants Co., Ltd., under contracts with JICA during the period from September 2000 to August 2001. In conducting the study, particular attention was paid to the formulation of a master plan, complying with the required conditions for the country to join the European Union in the future. A feasibility study was also conducted on the urgent sewerage development projects of the priority five (5) towns.

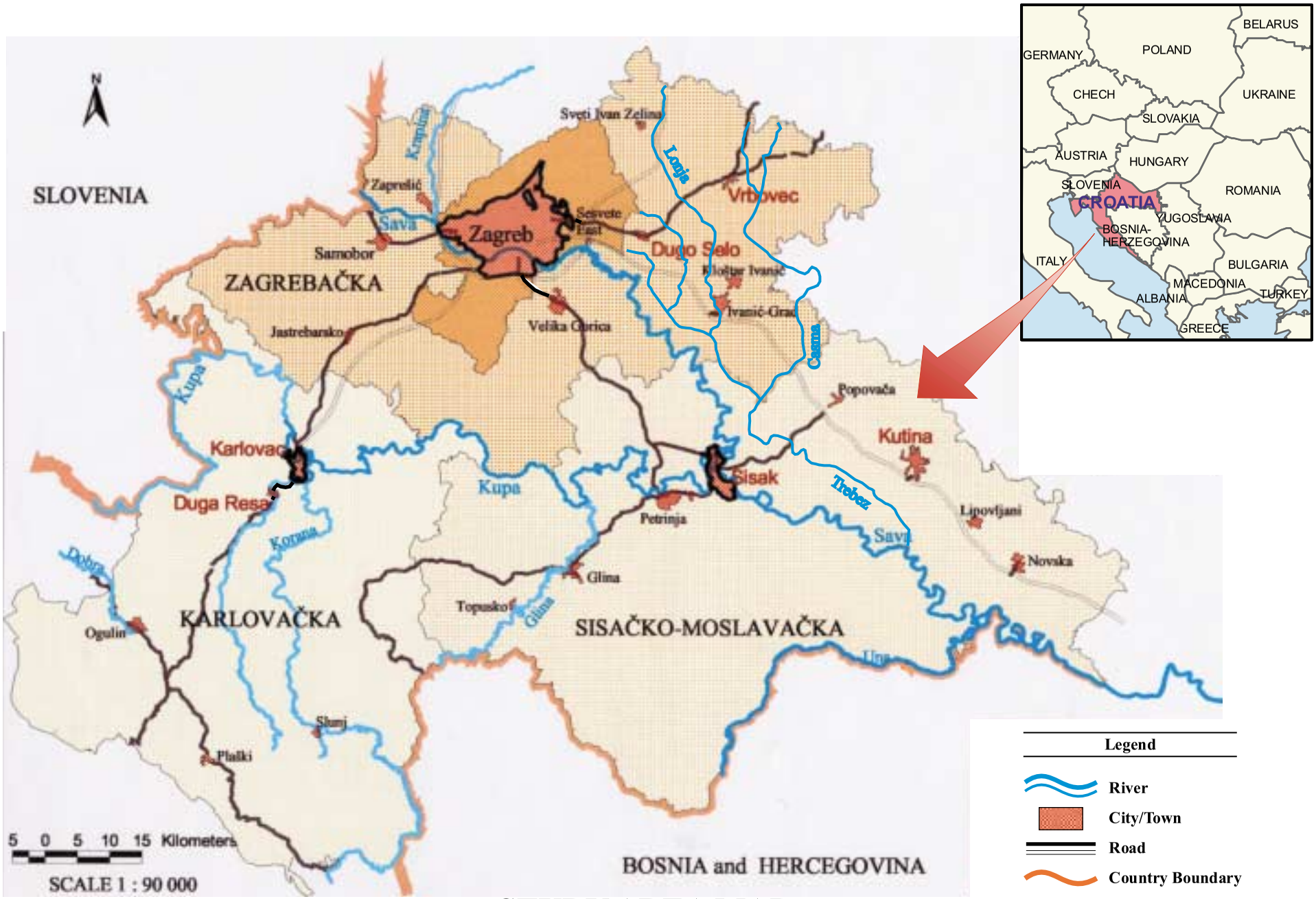
We wish to take this opportunity to express our sincere gratitude to the Government of Japan, particularly, JICA, the Ministry of Foreign Affairs, the Ministry of Land, Infrastructure and Transport, and other offices concerned. We also wish to express our deep appreciation to the State Water Directorate and the Croatian Waters, the Ministry of Environment, and other authorities concerned of the Government of Croatia for their close cooperation and assistance extended to the JICA study team during the study.

Finally, we hope that this report will contribute to the further promotion of the project.

Very truly yours,

Naohito Murata
Leader, JICA Study Team
CTI Engineering International Co., Ltd.

Encl. : a/s



STUDY AREA MAP

COMPOSITION OF REPORT

Vol. 1 EXECUTIVE SUMMARY

Vol. 2 MAIN REPORT

Vol. 3 SUPPORTING REPORT (APPENDIX A TO K)

APPENDIX	A	Socio-economy
APPENDIX	B	Water Quality and Pollution Mechanism
APPENDIX	C	Industrial Wastewater Treatment
APPENDIX	D	Sewerage Development (Master Plan Study)
APPENDIX	E	Sewerage Development (Feasibility Study)
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APPENDIX	I	Environmental Aspects
APPENDIX	J	Sewer Maintenance
APPENDIX	K	Planning Manual for Small Scale Sewage Treatment System

Vol. 4 DATA BOOK

ABSTRACT

PART I MASTER PLAN STUDY

1. INTRODUCTION

The Study Area in the basin of the Sava River, a tributary of the Donau, covers the whole administrative area (11,794 km^2) of Zagreb City, the capital of Croatia, and the three (3) surrounding counties of Zagrebacka, Sisacko-Moslavacka and Karlovacka. Approximately 1,590,000 people live in the Study Area at present. For location of the Study Area, see the Study Area Map.

The Sava River within the territory of Croatia is much polluted due to the untreated domestic, commercial, public and industrial wastewaters of Zagreb City and the neighboring towns/municipalities. The Government of Croatia undertakes water pollution control of the river by constructing and operating wastewater treatment plants in Zagreb City and these towns/municipalities.

In response to the request of the Government of Croatia, the Japan International Cooperation Agency decided to conduct "The Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia" from September 2000 to August 2001. The Study has the following objectives:

(1) To formulate a master plan for water environmental management of the Sava River Basin including pollution loading reduction up to the target year 2015;

(2) To conduct the feasibility study on the wastewater treatment of the selected five (5) towns neighboring Zagreb City (Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac); and

(3) To pursue technology transfer on planning methods and skills to counterpart personnel in the course of the Study.

2. INDUSTRIAL WASTEWATER TREATMENT

In this Study, to meet the government regulations, the optimum treatment processes and discharge systems (to sewerage system or directly to river) for the 51 large industries identified as significant pollution sources are proposed. The industries in Zagreb City are excluded since they will be treated under the ongoing Zagreb Sewerage Project. Wastewater of the other small industries is dealt as part of municipal wastewater.

The treated wastewater quantity and pollution load effluent from the industries and their recipients in the future (2015) are shown in the table below compared with the existing ones (1999). Since many large industries will change recipient from river to public sewerage, the industrial pollution load into the sewerage systems will increase and the pollution load into the rivers will decrease. As a result, the total pollution load effluent from the industries will remain at almost the present level even in 2015.

Recipient	Number of Industry		Wastewater Quantity (m^3/d)		BOD Load (kg/d)	
	1999	2015	1999	2015	1999	2015
Sewerage	26	37	9,132	31,560	1,896	4,797
River	25	14	36,339	43,330	3,240	769
Total	51	51	45,471	74,890	5,135	5,565

The total construction cost for the improvement of industrial wastewater treatment systems is roughly estimated to be Kn. 128 million at 2001 prices.

3. SEWERAGE DEVELOPMENT

3.1 Objective Urban Centers for Sewerage Master Plan Study

Twenty-four (24) urban centers in 22 sewerage systems were selected for the master plan study on sewerage development, based on the policy of the National Water Protection Plan. The selected urban centers are given below. For the locations, see Outline of the Proposed Project.

Zagreb, Sesvete East, Dugo Selo, Sveti Ivan Zelina, Vrbovec, Ivanić Grad–Kloštar Ivanić, Samobor, Zaprešić, Velika Gorica, Jastrebarsko, Sisak, Petrinja, Glina, Topusko, Popovača, Kutina, Lipovljani, Novska, Karlovac–Duga Resa, Ogulin, Plaški, Slunj

3.2 Proposed Sewerage Development Plan

The proposed sewerage system will serve almost all the population of Zagreb City (95% of the future total population). In the other 23 towns/municipalities, it will cover 19,186 ha (174% of the existing urban area) and serve the total population 381,800 people (122% of the future urban population or 70% of the future total town/municipality population).

All the sewerage systems are provided with necessary treatment plants to treat the wastewater to the permissible limits of the regulations. However, the treatment of nutrients is limited to T-P only and that of T-N is deferred to the later stage after 2015.

The main features of the proposed sewerage development are summarized below.

Urban Center	Service Area (ha)		Served Population		Design Wastewater (m^3/d) (2015)			BOD Load (kg/d)
	1999	2015	1999	2015	Municipal	Industry	Total	
Zagreb	25,600	25,600	800,000	935,000	274,860	167,510	442,370	90,000
Others	10,549	19,186	210,500	381,800	149,726	32,643	182,369	34,376
Total	36,149	44,786	1,010,500	1,316,800	424,586	200,153	624,739	124,376 (2,073,000 PE)

The total construction cost of the 22 sewerage development projects is estimated to be Kn. 2,739 million, broken down into Kn. 1,365 million for the Zagreb Sewerage Development Project and Kn. 1,374 million for the other 21 sewerage development projects. The total construction cost of the 21 sewerage development projects is further broken down into Kn. 531 million for collectors and Kn. 843 million for treatment plants.

4. EVALUATION OF RIVER WATER QUALITY IMPROVEMENT

The river water quality under existing, future without project, and future with project situations was simulated for the river flow rate of 95% probability according to the government standard. The results of simulation of river water quality at the principal river locations are shown below.

(Unit: BOD, mg/l)

River	Location	Existing	Future		Standard (Category)
			Without Project (2015)	With Project (2015)	
Sava Main	Oborovo	8.8	11.6	4.6	≤8.0 (III)
	Utok Kupe Nizvodno	5.6	7.4	3.1	≤4.0 (II)
Kupa	Recica	4.3	6.2	3.1	≤4.0 (II)
	Brest	3.5	4.7	2.6	≤4.0 (II)
Lonja	K. Lonja Strug (Crnec River)	27.1	49.1	7.2	≤8.0 (III)
	Struzec (Lonjsko Polje)	8.5	14.6	3.4	≤4.0 (II)
Kutina	Kutina	70.0	70.0	16.0	≤4.0 (II)

The proposed master plan will improve the river water quality to a large extent. The improved river water quality will satisfy the national standards in the Sava Main, Kupa and Lonja rivers. However, improvement of the Kutina River is limited due to the small dilution effect of natural river flow.

PART II FEASIBILITY STUDY

1. INTRODUCTION

Five (5) sewerage development projects; namely, Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa, were selected for the feasibility study from among the 22 projects proposed in the master plan. The target year of F/S projects is set at the year 2007, since these projects are the first stage projects of the master plan.

2. PLANNING BASIS

(1) The proposed sewerage system aims to serve almost all the population living within the existing service area in 2007, in principle. No significant extension of the service area is proposed.

(2) Necessary transport collectors, main sewers and secondary/tertiary sewers are proposed to attain the objective services. The collector/sewer size is designed to meet the design wastewater flow of the master plan.

(3) The treatment plant is proposed as the first stage of the master plan. The capacity is designed to treat the wastewater flow in 2007 and the process is applied to meet the requirement of river water quality improvement in 2007.

3. WASTEWATER TREATMENT LEVEL

The water quality of the Sava Main River in 2007 is expected to greatly improve due to the ongoing Zagreb Project. The water quality of the Kupa River will not exceed the standard quality to a serious level even in the case of without-project. Hence, the treatment level of primary sedimentation is applicable for the Sisak and Karlovac-Duga Resa F/S projects.

The Lonja and Kutina rivers are much polluted even at present. Biological treatment is definitely necessary for the Dugo Selo, Vrbovec and Kutina sewerage improvement projects to mitigate the water pollution of the respective rivers to the possible extent.

Hence, the Dugo Selo, Vrbovec and Kutina projects will treat the wastewater to BOD 25 mg/l; whereas, the Sisak and Karlovac-Duga Resa projects will treat the influent BOD by 40%. However, the treatment of T-P will be deferred to the second stage in all the projects in due consideration of priority sequence.

4. PROPOSED SEWERAGE DEVELOPMENT

4.1 Design Bases for Sewerage System and Treatment Plant

The design bases of the sewerage systems and treatment plants for the five (5) projects are summarized below.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Service Area (ha)	516	422	944	734	1,142
Served Population	10,300	5,900	45,400	19,600	43,800
Served Large Industry (No.)	-	2	3	1	10
Wastewater Quantity (m^3/d)	3,605	4,539	16,973	7,678	23,285
Municipal Wastewater (m^3/d)	3,605	1,770	15,890	6,860	15,430
Industrial Wastewater (m^3/d)	-	2,769	1,083	818	7,855
Influent BOD Concentration (mg/l)	211	198	211	190	193
Pollution Load (PE)	12,700	14,600	59,900	24,500	74,800
Effluent BOD Concentration (mg/l)	25	25	127	25	116

4.2 Proposed Sewer

The main features of the proposed collectors for the five (5) projects are summarized below.

Urban Center	Transport /Main Collector		Secondary/Tertiary Sewer		Total	
	∅ (mm)	L (m)	∅ (mm)	L (m)	∅ (mm)	L (m)
Dugo Selo	800-1,200	5,490	400	2,100	400-1,200	7,590
Vrbovec	350-400	1,880	100	750	100-400	2,630
Sisak	450-1,000	6,340	-	-	450-1,000	6,340
Kutina	400	180	100-200	9,000	100-400	9,180
Karlovac-Duga Resa	300-1,700	11,670	400	1,000	300-1,700	12,670
Total		25,560		12,850		38,410

4.3 Proposed Treatment Plant

The main features of the proposed treatment plants of the five (5) projects are summarized below.

Main Features	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Treatment Process	Activated Sludge	Activated Sludge	Primary Sedimentation	Activated Sludge	Primary Sedimentation
Preliminary Treatment (unit)	1	1	1	1	1
Primary Sedimentation Tank (unit)	3	3	6	3	5
Aeration Tank (unit)	3	3	-	3	-
Secondary Sedimentation Tank (unit)	2	2	-	2	-
Belt Press Filter (unit)	2	2	2	2	2

4.4 Construction and Annual O&M Costs

The construction and annual O&M costs of each of the five (5) projects are estimated as follows at 2001 prices.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa	Total
Construction Cost (million Kn)	50.94	39.51	68.95	41.16	129.76	330.31
Collector	15.34	3.56	20.88	8.95	61.43	110.15
Treatment Plant	35.60	35.95	48.08	32.21	68.33	220.16
Annual O&M Cost (million Kn)	1.59	1.53	1.98	2.52	2.33	9.95

5. ENVIRONMENTAL IMPACT ASSESSMENT

The environmental impacts of the proposed projects were assessed on the following items: (i) land acquisition, (ii) noise during construction/operation, (iii) foundation geology of treatment plant, (iv) flora/fauna, (v) dust/odor, (vi) water pollution/water use, and (vii) sludge disposal/groundwater. No significant adverse effects were predicted for all the projects.

6. FINANCIAL ANALYSIS

6.1 Implementation Schedule

The proposed projects are assumed to start in 2003 with completion in 2007. The proposed implementation schedules of the five (5) projects are shown below.

Item	Construction Works	Dugo Selo, Vrbovec, Kutina	Sisak, Karlovac-Duga Resa
Detailed Design and Land Acquisition		2003	2003
Stage I Construction	Collector, Primary Treatment, Sludge Treatment, etc.	2004 - Mid 2005	2004 - 2006
Monitoring		Mid 2005 - Mid 2006	-
Stage II Construction	Biological Treatment	Mid 2006 - 2007	-

6.2 Financial Evaluation

6.2.1 General

Each municipal service company should perform a sound sewerage business by collecting sewerage charges set within the users' affordability. For this purpose, a considerable amount of financial assistance from the Central Government (including Croatian Waters) is considered necessary for the construction of the proposed projects. The possible financial sources of construction cost are the Central Government (Grant and Water Management Fund Loan) and external loan (ODA).

The required sewerage charge and financial assistance from the Central Government were estimated by analyzing the financial statement of each municipal service company. To ensure financial feasibility of the municipal service companies,

(1) Annual net income should be mostly positive through the entire period of 25 years;

(2) Loan liability of the company should be zero in 25 years; and

(3) Necessary cash should be reserved before the replacement of mechanical/electrical equipment.

6.2.2 Proposed Sewerage Charge and Financial Assistance

The required sewerage charge for each municipal service company to perform a sound sewerage business was estimated under the following assumptions.

(1) The proposed projects mainly benefit the populations downstream and enhance the environment nationwide, so that they are of national importance. Therefore, the financial assistance of the Central Government is set higher than has been usually extended.

(2) Sixty percent (60%) of the construction cost is provided by the Central Government as Grant. The remaining 40% is financed by an external ODA loan through the Central Government. The loan conditions are assumed as: 2.0% interest and 25-year repayment with a 7-year grace period.

(3) The loan repayment, and the O&M and depreciation costs of the sewerage systems are to be covered by sewerage charges.

(4) At present, two (2) kinds of sewerage charges are individually set for each town. One is for domestic user and the other is for other users (institution and small/large industries). The domestic unit sewerage charge will increase in proportion to the growth of per capita GDP. However, the existing ratio between the two (2) unit sewerage charges will be maintained.

(5) In the Karlovac-Duga Resa sewerage system, the replacement cost of damaged sewers in Karlovac Town is considered apart from the proposed sewerage development cost. The replacement cost is to be covered by both grant from the Local Government and sewerage charges.

The proposed sewerage charges of the five (5) municipal service companies in 2001 are shown below at 2001 prices, along with the existing ones and the internal rate of return (FIRR) of the proposed projects.

Item	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Existing Unit Sewerage Charge (Kn/m^3)					
Domestic User	0.36	0.59	1.34	4.12	1.45 (0.54)*
Other Users	0.74	0.81	4.00	4.12	2.67 (0.54)*
Proposed Unit Sewerage Charge (Kn/m^3)					
Domestic User	2.55	2.25	1.41	4.12	1.86
Other Users	5.24	3.09	4.21	4.12	2.87
Domestic Charge Rate to Household Income (%)					
Existing	0.12	0.20	0.45	1.37	0.48 (0.18)*
Proposed	0.85	0.75	0.47	1.37	0.62
FIRR of Proposed Project (%)	6.58	5.98	5.48	Large	5.91

* Values not in parentheses are charges of Karlovac, while values in parentheses are those of Duga Resa

In order to set the sewerage charges within the user's affordability, 60% of the construction cost need to be provided by the Central Government as a Grant and the remaining 40% shall be financed by an external loan through the Central Government as assumed above.

However, it should be noted that the above external loan does not mean the actual amount of loan to be obtained by the Central Government but only the loan amount to be repaid from sewerage charges. In case the financial resources of the Central Government are limited, it may need to obtain more external loan to be able to extend the necessary grant (60% of construction cost) to the municipal service companies.

7. RECOMMENDATIONS

(1) The proposed five (5) sewerage development projects consisting of Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa are technically feasible and financially viable. The early implementation of these projects is necessary to cope with the existing water pollution in the Sava River Basin.

(2) For this purpose, the Central Government/State Water Directorate/Croatian Waters and the local governments concerned should immediately proceed with the necessary legal procedures and financial arrangements.

(3) Water pollution of the Lonja River is the worst in the entire Sava River Basin. Early implementation of the Sesvete East and Ivanić Grad-Kloštar Ivanić sewerage development projects is also awaited to attain a satisfactory water pollution control of the Lonja River.

(4) Since the available data on river water quantity and quality in the Lonja River are limited, necessary monitoring of the river water quantity and quality should be commenced immediately.

Study Area

	MP	Treatment Process
1	Zagrb	AS
2	Sesvete East	AO
3	Dugo Selo	AO
4	Vrbovec	AO
5	Sisak	AO
6	Kutina	AO
7	Karlovac and Duga Resa	AO
8	Sv.Ivan Zelina	OD
9	Ivanic Grad and Klostar Ivanic	AO
10	Samobor	AO
11	Zapresic	AO
12	Velika Gorica	AS
13	Jastrebarsko	OD
14	Petrinja	AO
15	Glina	OD
16	Topusko	AL
17	Popovaca	OD
18	Lipovljani	OD
19	Novska	OD
20	Ogulin	AO
21	Plaski	OD
22	Slunj	OD

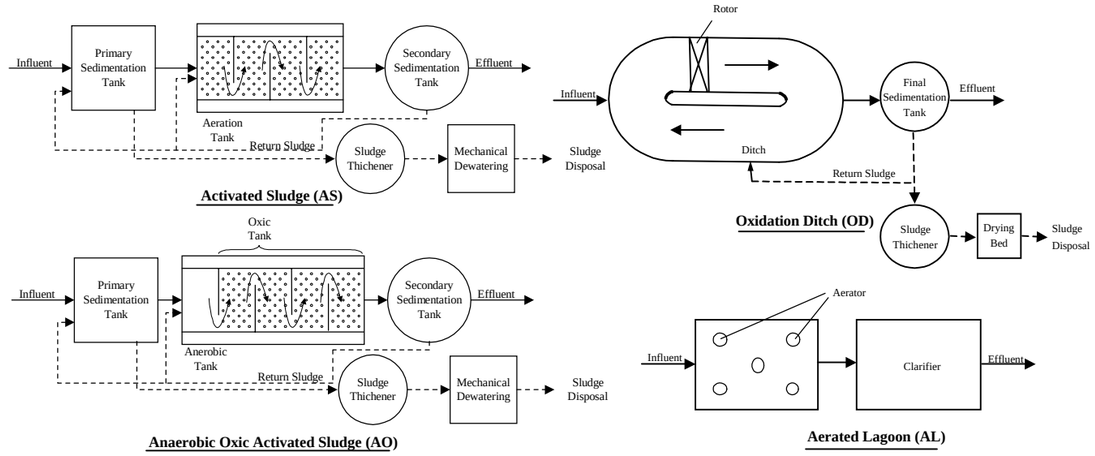
	FS Project	Treatment Process
1	Dugo Selo	AS
2	Vrbovec	AS
3	Sisak	PS*
4	Kutina	AS
5	Karlovac and Duga Resa	PS*

*Primary Sedimentation

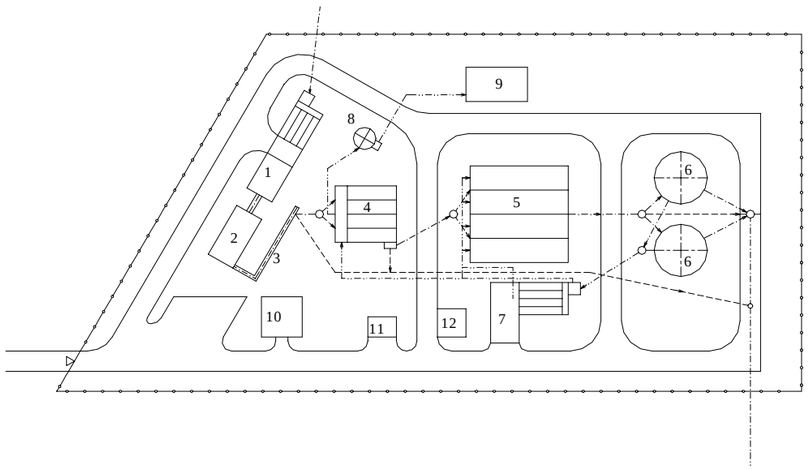
Water Quality Evaluation Point

① Sava River at Oborovo
② Sava River at Utok Kupe Nizvodno
③ Kupa River at Recica
④ Kupa River at Brest
⑤ Lonja River at K.Lonja Strug
⑥ Lonja River at Struzec

Flow Sheet of Wastewater Treatment Process



Typical Layout of Wastewater Treatment Plant (F/S Project)

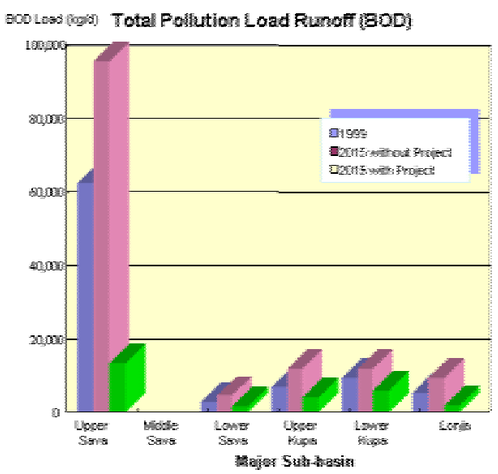


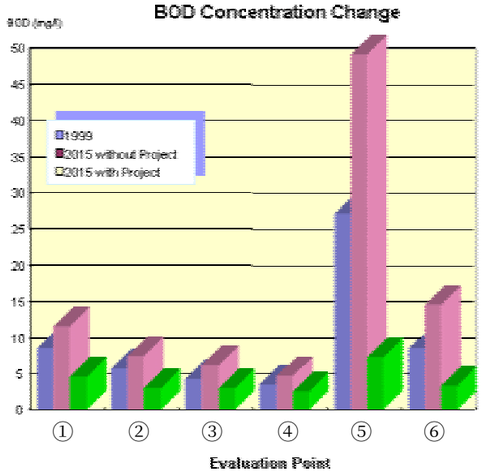
Legend

1 Influent pumping station
2 Grit oil/sand removal equipment
3 Parshall flume
4 Primary sedimentation tank
5 Aeration tank
6 Secondary sedimentation tank
7 Return sludge pumping station (Blower building)
8 Sludge thickener
9 Dewatering equipment
10 Administration building
11 Generator
12 Electricity reception, Transformer station

Boundary
Wastewater line
Sludge line
By Pass line

Pollution Load Runoff and River Water Quality





Proposed Projects

Proposed Projects		*Outline of Project Components*	*Construction Cost and Beneficiaries*
Master Plan *	1 Industry	Development of wastewater treatment system of 51 large industries	• 128 million Kuna
	2 Sewerage	Development of wastewater treatment plants and collectors of 21 Sewerage Systems for 23 urban centers	• 1,374 million Kuna • Served population: 381,800
Feasibility Study	1 Dugo-Selo	A wastewater treatment plant with Activated Sludge process and collectors	• 50.94 million Kuna • Served population: 10,300
	2 Vrbovec	A wastewater treatment plant with Activated Sludge process and collectors	• 39.51 million Kuna • Served population: 5,900
	3 Sisak	A wastewater treatment plant with primary sedimentation and collectors	• 68.95 million Kuna • Served population: 45,400
	4 Kutina	A wastewater treatment plant with Activated Sludge process and collectors	• 41.16 million Kuna • Served population: 19,600
	5 Karlovac-Duga Resa	A wastewater treatment plant with primary sedimentation and collectors	• 129.76 million Kuna • Served population: 43,800

* Descriptions in this table are for the urban centers other than Zagreb.

OUTLINE OF THE PROPOSED PROJECT

THE STUDY FOR
WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN
IN THE REPUBLIC OF CROATIA

FINAL REPORT

VOL. 2: MAIN REPORT

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ABBREVIATIONS AND ACRONYMS

AGENCIES/ORGANIZATIONs

API	American Petroleum Institute
ATV	Abwassertechnische Vereinigung e.V. = German Association for Water Pollution Control
CW	Croatian Waters
CWWTPZ	Central Wastewater Treatment Plant of Zagreb
EPDRB	Environmental Program for the Danube River Basin
EU	European Union
GOC	Government of Croatia
GOJ	Government of Japan
HBOR	Croatian Bank for Reconstruction and Development
ISO	International Organization for Standardization
JICA	Japan International Cooperation Agency
MEPP	Ministry of Environmental Protection and Physical Planning
NGO	Non-Government Organization
SWD	State Water Directorate

OTHER ABBREVIATIONS/ACRONYMS

2-AS	Two-Stage Activated Sludge
A/D	Alternating Current / Direct Current
A_2O	Anaerobic-Anoxic-Oxic Activated Sludge
AA	Aeroaccelerator
AC	Asbestos Cement
AL	Aerated Lagoon
AO	Anaerobic-Oxic Activated Sludge
AS	Activated Sludge
Ave.	Average
BOD	Biochemical Oxygen Demand
BOD_5	Fine Day Biochemical Oxygen Demand
BOT	Build, Operate and Transfer
C	BOD Concentration (mg/l)
C	BOD/COD Concentration (mg/l)
C.A.	Catchment Area
CA	Contact Aeration
Ca	Calcium
CAST	Cyclic Activated Sludge Technology
CCTV	Closed Circuit Television
Ci	BOD/COD Concentration at Objective Point (i) (mg/l)
CI	Cast Iron
COD_{Cr}	Chemical Oxygen Demand (Chromium)
COD_{Mn}	Chemical Oxygen Demand (Manganese)
CPI	Corrugated Plate Interceptor
CS	Carbon Steel
CSO	Combined Sewer Overflow
CT	Chemical Clarification
D	Depth
DIP	Ductile Iron Pipe
DO	Dissolved Oxygen
DWF	Dry Weather Flow
EC	Electro-Conductivity

EIA	Environment Impact Assessment
ETM	Landsat 7
F.Col	Fecal Coliform
F/S, FS	Feasibility Study
Fe	Iron
Fig.	Figure
FIRR	Financial Internal Rate of Return
FRP	Fiberglass Reinforced Plastic Pipe
GC-MS	Gas Chromatography-Mass Spectrography
GDP	Gross Domestic Product
GIS	Geographic Information System
H	Height / high
HDPE	High Density Polyethylene
IBA	Important Bird Areas
K	Potassium
K	Variation Speed Coefficient (day^{-1})
K	Self-purification Constant (l/day)
L	Length
Li	Pollution Load at Objective Point (i)
Mg	Magnesium
M/P, MP	Master Plan
max.	Maximum
min.	Minimum
MLSS	Mixed Liquor Suspended Solid
Mn	Manganese
N	Nitrogen
N.D.	Non-detected
Na	Sodium
NH_4	Ammonia
NN	Narodne Novine = Official Gazette
No.	Number
O&M, O/M	Operation and Maintenance
OD	Oxidation Ditch
ODA	Official Development Assistance
OJT	On-the-Job Training
Org-N	Organic Nitrogen
P	Phosphorus
PCB	Polychlorinated Biphenyl
PE	Person Equivalent
pH	Hydrogen Ion Concentration (lit., Hydrogen Power)
PO_4^{3-}	Phosphate
PO_4-P	Phosphate-P
PS	Pumping Station
PVC	Polyvinyl Chloride
Q	Dry Weather Flow
Qi	River Flow Rate at Objective Point (i)
R_1	Runoff Coefficient of Pollution Load
R_2	Self-purification Rate of the Tributaries
RC	Reinforced Concrete
RGDP	Regional Gross Domestic Product
RPM	Reinforced Mortar Pipe
SS	Suspended Solids
SUS	Stainless Steel
SVI	Stage Volume Index
SWDS	Solid Waste Disposal Site

T	Temperature
TF	Trickling Filter
T-N	Total Nitrogen
TNMN	Trans-National Monitoring Network
T-P	Total Phosphorous
TSS	Total Suspended Solids
TVS	Total Volatile Substance
VAT	Value Added Tax = PDV
VS	Volatile Substance
W	Width / wide
W&S	Water Supply and Sewerage
WD	Wastewater Department
WWT	Wastewater Treatment Plant
WWTP	Wastewater Treatment Plant

MEASUREMENTS/SYMBOLS

cm	Centimeter
cm^2	Square Centimeter
ha	Hectare
km	Kilometer
km^2	Square kilometer
kw	Kilowatt
lcd	Liter per Capita per Day
m	Meter
m^2	Square Meter
m^3	Cubic Meter
mg	Milligram
mg/l	Milligram per Liter
mm	Millimeter
sec	Second
%	Percent
°C	Degree Centigrade
∅	Diameter
Kn, HRK	Croatian Kuna
DM	German Mark, Deutsche Mark
¥, JP¥	Japanese Yen
US$	United States Dollar

PART I

MASTER PLAN STUDY

PART I MASTER PLAN STUDY

CHAPTER I INTRODUCTION

1.1 Background

The Sava River runs a 945 km distance draining a total area of 95,551 km^2 in the countries of Slovenia, Croatia, Bosnia-Herzegovina and Yugoslavia before it joins the Donau as a tributary. The river length and the drainage area within the territory of Croatia are 518 km and 25,100 km^2, respectively. The population of the Sava River Basin in Croatia is 2,340,000, which include the 1,590,000 inhabitants of Zagreb City, the capital of Croatia, and those of surrounding towns/municipalities and cities and of the three (3) counties of Zagrebacka, Sisacko-Moslavacka and Karlovacka.

The Sava River is much polluted by untreated domestic, commercial, public and industrial wastewaters of Zagreb City and the neighboring towns/municipalities and cities. The Government of Croatia (GOC) undertakes water pollution control of rivers by constructing wastewater treatment plants in the urban center of Zagreb City and the above neighboring areas.

Under the above circumstances, GOC requested technical assistance from the Government of Japan (GOJ) for "The Study for Water Pollution Reduction on the Sava River Basin in the Republic of Croatia" (the Study). In response, the Japan International Cooperation Agency (JICA) carried out a preparatory survey and, in June 2000, the Scope of Work of the Study was agreed upon between the State Water Directorate of the GOC and JICA. Then, JICA dispatched the JICA Study Team in October 2000 to carry out the Study in accordance with the Scope of Work, with completion slated at the end of August 2001.

1.2 Objectives and Area of the Study

1.2.1 Study Objectives

The objectives of the Study are:

(1) To formulate a master plan for water environmental management of the Sava River Basin, including pollution load reduction up to the target year 2015;

(2) To conduct a feasibility study on wastewater treatment of the selected five (5) towns neighboring Zagreb City (Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac); and

(3) To pursue technology transfer on planning methods and skills to counterpart personnel in the course of the Study.

1.2.2 Study Area

The study area of the Master Plan covers the entire administrative area (11,794 km^2) of Zagreb City and the three (3) counties: Zagreb (Zagrebacka), Sisac-Moslavina (Sisacko-Moslavacka) and Karlovac (Karlovacka) [hereinafter referred to as the Study Area]. However, the related drainage basin of the Sava River covers approximately an area of 18,281 km^2, encompassing areas outside the above city and counties (hereinafter referred to as the Drainage Basin). On the other hand, the feasibility study was made for five (5) towns selected from the master plan; namely, Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac. For locations of the Study Area and the Drainage Basin, see the Study Area Map.

1.3 Implementation of the Study

1.3.1 Study Organization

The Study was carried out by a Study Team commissioned by JICA, composed of experts from Japanese consulting firms: CTI Engineering International Co., Ltd. and Nihon Suido Consultants Co., Ltd. In the Croatian side, Croatian Waters organized a Counterpart Team to work together with the JICA Study Team. To review the findings of the Study, JICA and the State Water Directorate established an Advisory Committee and a Steering Committee, respectively.

The members of the JICA Advisory Committee, JICA Study Team, State Water Directorate Steering Committee and Croatian Waters Counterpart Team are given at the end of this Chapter.

1.3.2 Study Schedule

The Study was started in mid-September 2000 with completion in late August 2001 inclusive of the Final Report. Field and home office studies, as well as reporting were scheduled, as mentioned below.

(1) Stage I (Home Office Work: Mid-September 2000 to late September 2000)

The Inception Report was prepared in the home office in Japan.

(2) Stage II (Field Work: Early October 2000 to late December 2000)

The Inception Report was submitted by the JICA Study Team to State Water Directorate/Croatian Waters at the start of the Study in Croatia and discussed with concerned officials of the Croatian Government. The report contained the study methodology and work schedule.

At the end of Stage II, the Progress Report was presented to State Water Directorate/Croatian Waters and discussed with concerned officials of the Croatian Government. The report covered the analyses on existing situations of socio-economy, river/waste water quality, river ecology, industrial wastewater treatment, sewerage system and related laws/regulations. Further, it contained the future projection of socio-economy, the preparation of GIS system, and the recommendation on sewer maintenance technologies.

(3) Stage III (Field Work: Early January 2001 to late March 2001)

The Study was continued in Croatia to prepare the master plan and to conduct the feasibility study for the selected sewerage improvement projects. The master plan study included the simulation of river water quality, analyses of existing public awareness and sewerage management system, proposal on industrial wastewater treatment and sewerage development, and institutional recommendation. On the other hand, the feasibility study included proposals for priority sewerage projects, design and cost estimates of sewerage facilities, and environmental impact assessment.

At the end of Stage III, the Interim Report was presented to State Water Directorate/Croatian Waters and discussed with the officials concerned of the Croatian Government. The report covered all the results of the studies made in Stage II and Stage III.

(4) Stage IV (Home Office/Field Work: Early May 2001 to late June 2001)

The Study was continued in the home office to analyze the financial viability of the proposed priority sewerage projects and to complete the feasibility study. Further, a design manual for small-scale sewage treatment plant was prepared in the home office and a supplementary analysis of river water quality was conducted in Croatia.

(5) Stage V (Field Work: Late June 2001 to early July 2001)

The Draft Final Report was submitted to State Water Directorate/Croatian Waters and discussed with the officials concerned of the Croatian Government. The report included all the results of the Study.

(6) Stage VI (Home Office Work: Mid-July 2001 to late August 2001)

This Final Report was prepared, incorporating comments of the Croatian side on the Draft Final Report. It is submitted to State Water Directorate/Croatian Waters upon completion of the Study.

1.3.3 Technology Transfer

Transfer of technical knowledge on water pollution reduction to the counterpart personnel of Croatian Waters and the officials concerned of the related local governments was carried out through the series of studies and meetings, as follows:

(1) Through the weekly meetings with Croatian Waters, planning methodologies/criteria of the master plan and design criteria of sewerage facilities were understood.

(2) Through the report discussion meetings with the government officials concerned, details of projects were confirmed.

(3) Through the three (3) seminars conducted in Zagreb and Karlovac, technical knowledge on water pollution control planning, sewerage development/management, and sewer maintenance was imparted to the personnel concerned in both the government and the private sector.

1.4 Composition of Report

This Final Report consists of four (3) volumes in English, as follows:

Vol. I : Executive Summary

Vol. II : Main Report

Vol. III : Supporting Report

Vol. IV : Data Book

Vol. 2, Main Report, consists of two (2) parts. Part I presents the summarized results of the master plan study, and Part II presents those of the feasibility study. On the other hand, Vol. 3, Supporting Report, gives a further explanation of the various studies made, as follows:

Appendix A : Socio-economy
Appendix B : Water Quality and Pollution Mechanism
Appendix C : Industrial Wastewater Treatment
Appendix D : Sewerage Development (Master Plan Study)
Appendix E : Sewerage Development (Feasibility Study)
Appendix F : Water Quality Monitoring and GIS Data Base
Appendix G : Institutional Aspects
Appendix H : Economic and Financial Analysis
Appendix I : Environmental Aspects
Appendix J : Sewer Maintenance
Appendix K : Planning Manual for Small Scale Sewage Treatment System

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(2) Mr. Shigeharu INOUE	Chairman (Jan. 2001 ~)
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Members of Croatian Steering Committee

Name	Designation
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(2) Mr.Vladimir Tonković	Representative, Ministry of Environmental Protection and Physical Planning
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Name	Designation
(1) Mr. Miroslav Steinbauer	Head, Water and Sea Pollution Control Sector, CW
(2) Mr. Danijel Brundic	Head, Harmful Water Efflects Protection Sector, CW
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(4) Ms. Dubravka Mokos	Project Engineer, CW
(5) Ms. Stojanka Janković	Project Engineer, CW
(6) Mr. Zlatko Juriša	Project Engineer, CW
(7) Mr. Zeljko Ostojić	Senior Advisor, SWD
(8) Ms. Mojca Lukšić	Adivisor, SWD

CW: Croatian Waters, SWD: State Water Directorate

CHAPTER II STUDY AREA

2.1 Existing Natural Conditions

2.1.1 Climate

The climate of the Study Area is affected by both the Continental and Mediterranean climates. There are three (3) meteorological stations where long-time climatic data are available; namely, Zagreb Center, Karlovac Center and Sisak Center.

The monthly average temperature at Zagreb Center varies from 1.6°C in December to 22.3°C in July, with a yearly average of 12.2°C.

Monthly rainfall is abundant from June to September and scarce from February to March. The average monthly rainfall at Zagreb Center ranges from 33 mm in February to 125 mm in August, with the yearly average of 921 mm. However, daily rainfall varies much in summer (June to September), when severe storms and droughts frequently occur.

The seasonal variations of monthly temperature and rainfall at the three (3) stations are shown in Fig. I.2.1.

2.1.2 River System

The Sava River runs a 945 km distance draining a total area of 95,551 km^2 in the countries of Slovenia, Croatia, Bosnia-Herzegovina and Yugoslavia before joining the Donau as a tributary. The river length and drainage area within the territory of Croatia are 518 km and 25,100 km^2, respectively. The objective Sava Drainage Basin in this Study is the drainage basin bounded by the border of Croatia with Slovenia on the northwest, and stretches down to the confluence of Sava River and Una River on the east (i.e., from the Slovenian border down to Jasenovac).

The Sava Drainage Basin within the Croatian territory is divided into three (3) main basins named as Upper Sava River Basin, Middle Sava River Basin and Lower Sava River Basin. These three main basins are further subdivided into 32 sub-basins.

Moreover, considering also the main tributaries of Sava River, the Sava Drainage Basin can be divided into the following six (6) major sub-basins: (i) Upper Sava River, (ii) Middle Sava River, (iii) Lower Sava River, (iv) Upper Kupa River, (v) Lower Kupa River, and (vi) Lonja River. The main features of the six (6) major sub-basins are summarized below and the the drainage basin divisions in the Study Area are shown in Fig. I.2.2.

River Basin	Reaches	C.A. (km^2)		Length (km)	Major Tributaries Included
Upper Sava	Border - Zagreb	2,035	(863)	63	Sulta, Krapina, Zagreb City, etc.
Middle Sava	Zagreb - Sisak		(77)	58	Riverine Area
Lower Sava	Downstream of Sisak	3,807	(2,049)	124	Ilova-Pakra, Sunja-Jastrebica, Veliki-Strug, etc.
Upper Kupa	Upstream of Karlovac	4,257	(2,768)	76	Dobra, Mrežnica, Korana, etc.
Lower Kupa	Karlovac - Sisak	3,784	(3,784)	146	Glina, Odra, Utinja-Petrinjcica, etc.
Lonja	Upstream of Trebez Channel	4,321	(2,089)		Zelina, Glogovnica, Cesma, Lonja, etc.
Total		18,281	(11,631)		

Note: C.A. means catchment area. Amounts not enclosed in parentheses refer to C.A. within Croatia, while those in parentheses refer to C.A. within the Study Area.

2.1.3 Land Use

The land use map of the Study Area was only partially available. The latest land use map of the entire Study Area was prepared by using the satellite digital data taken on August 2, 2000. The land use distribution in the Study Area is summarized below.

Land Use Category	Area (km^2)	(%)
1. Deciduous Forest	3,674	31.2
2. Coniferous Forest	1,756	14.9
3. Water Body	265	2.2
4. Agricultural Land	858	7.3
5. Built up Area	286	2.4
6. Grassland	1,456	12.3
7. Pastureland	296	2.5
8. Shrub Land	1,705	14.5
9. Mixed Grassland/Shrub Land	1,479	12.5
10. Bare Land	18	0.2
Total	11,794	100.0

The present land use is shown in Fig. I.2.3. For the breakdown of the above land use in the six (6) major sub-basins, see Appendix F, Table F.2.4.

2.1.4 Natural Park

There are eight (8) national parks and 10 nature parks in the country covering a total area of 450,000 ha. Lonjsko Polje is one of the nature parks, and it is located in the downstream reaches of the Lonja River system (a flood plain of Sava River). It covers a total area of 56,000 ha that is reserved as a valuable wetland of Europe. For the location, see Fig. I.2.4.

In Lonjsko Polje, about 260 bird species have been identified to date. Some 120 of them (including 30 endangered species in Europe) nest there. The typical endangered and rare species are as follows: (i) white-tailed eagle, (ii) corn crake, (iii) spoonbill, (iv) spotted eagle, and (v) black stork. The park is characterized as having one of the largest white stork concentrations in Europe. Approximately 580 pairs of white stork were counted in 1998.

Further, more than 45 species of fish live in this park. The most common fish is Cyprinidae.

2.2 Existing Socio-economic Conditions

2.2.1 General

The country had faced a serious socio-economic confusion for a long period due to the war that broke out in 1991. More than 8% of the total population had since been compelled to emigrate and economic activities had been hampered. The socio-economic situation of the country has not still recovered.

2.2.2 Administrative Units of the Study Area

The Study Area consists of Zagreb City and the three (3) counties of Zagreb, Sisak-Moslavina and Karlovac, which include 19 towns and 55 municipalities. The administrative areas of the City and the three (3) counties are shown below. The boundaries of the respective towns and municipalities are shown in Fig. I.2.5.

City/County	Administrative Area (km^2)	No. of Towns	No. of Municipalities
Zagreb City	641	-	-
Zagreb County	3,062	8	26
Sisak-Moslavina County	3,623	6	13
Karlovac County	4,468	5	16
Total	11,794	19	55

2.2.3 Population

(1) Population of the Country

The available official data on population is only that of the 1991 census conducted before the war. As estimated by the Central Bureau of Statistics and other government agencies, the population of the country has been nearly constant during the recent nine (9) years, as shown below.

(Unit: 10^3)

Year	1991*	1991**	1992	1993	1994	1995	1996	1997	1998	1999
Population	4,784	4,513	4,470	4,641	4,649	4,669	4,494	4,572	4,501	4,600

* Census population; ** After outbreak of war

(2) Population of the Study Area

Even on the local level, no official population data is available other than that of the 1991 census. Hence, the existing population (1999) of the towns and municipalities in the Study Area were estimated, based on the survey of the concerned government offices and the electricity service data.

The population of the Sisak-Moslavina and Karlovac counties much decreased during 1991-1999 since these areas were directly affected by the war. On the other hand, those of Zagreb City and its neighboring towns and municipalities increased to a significant extent during the same period.

The estimated existing population (1999) of the Study Area is summarized as follows, compared to that of the 1991 census. For the population by town/municipality, see Appendix A, Table A.1.1 to Table A.1.3.

Administrative Unit	1991			1999			Ratio
	Total (1)	Urban	Rural	Total (2)	Urban	Rural	(2)/(1)
Zagreb City	777,826	777,826	-	935,000	935,000	-	1.20
Zagreb County							
Suburban Area*	175,606	81,769	93,837	205,361	96,883	108,478	1.17
Other Area**	107,383	26,566	80,817	108,451	26,830	81,621	1.01
Sub-total	282,989	108,335	174,654	313,812	123,713	190,099	1.11
Sisak-Moslavina County							
Town	166,660	97,956	68,704	143,149	84,289	58,860	0.86
Municipality	84,672	20,480	64,192	51,171	13,315	37,856	0.60
Sub-total	251,332	118,436	132,896	194,320	97,604	96,716	0.77
Karlovac County							
Town	124,330	81,579	42,751	107,944	73,024	34,920	0.87
Municipality	60,247	11,285	48,962	40,948	8,097	32,851	0.68
Sub-total	184,577	92,864	91,713	148,892	81,122	67,770	0.81
Total	1,496,724	1,097,461	399,263	1,592,024	1,237,439	354,585	1.06

Note: * Including five (5) towns and six (6) municipalities; ** Including three (3) towns and 20 municipalities
Source: Zagreb City Institute for Planning of Development and Environmental Protection, Zagreb County Institute of Physical Planning and Environmental Protection, Karlovac County Department for Physical Planning, and Institute of Physical Planning of the Ministry Environmental Protection and Physical Planning

2.2.4 Gross Domestic Product

Data on the regional gross domestic product (RGDP) of the Study Area was not available. Hence, GDP and per capita GDP on the national level were made as reference in this Study.

GDP and per capita GDP were US$20,176 million and US$4,384 in 1999, respectively. The average structure of GDP in the recent four (4) years (1995-1998) was as follows.

Sector	Contribution (%)	Industrial Activities
Primary Production	8	Agriculture, Fishery, Forest, etc.
Secondary Production	24	Mining, Manufacturing, Construction, etc.
Basic Services	11	Electricity/Gas/Water Supply, Transport/Communication, etc.
Other Services	57	Commerce, Tourism, Public, Education, Social Service, etc.
Total	100	

2.2.5 Industrial Activities

(1) Manufacturing

There were 8,553 factories registered in the Study Area, and 5,158 or 60% of them were active in 1999. The breakdown by city/county is as follows.

City/County	Registered (No.)	Active (No.)	Active Rate (%)
Zagreb County	1,527	951	62
Sisak - Moslavina County	422	249	59
Karlovac County	469	293	62
Zagreb City	6,135	3,665	60
Study Area	8,553	5,158	60
Country	18,133	10,807	60

The production of factories in the Study Area has decreased since 1986. The historical change of production is available for only Zagreb City. The production change in Zagreb City is shown below in terms of production index.

	1986	1990	1991	1995	1996
Production Index in Zagreb City	100	90.2	66.3	54.0	54.1

The major factories in the Study Area were categorized into the following nine (9) sectors: (i) beverage, (ii) petroleum, (iii) chemical, (iv) iron and steel, (v) thermoelectric power, (vi) food, (vii) textile, (viii) metal products, and (ix) machinery/equipment. However, no data concerning industrial production by category was available in the Study Area.

At the national level, only the sectors of beverage and thermoelectric power had experienced a considerable growth of production during the recent 10 years (1989-1998). Production in all the other sectors had decreased considerably during the same period. The growth or reduction rate of the above nine (9) sectors is as shown below.

Increase/ Decrease	Beverage	Petroleum	Chemical	Iron & Steel	Thermal Power	Food	Textile	Metal	Machinery
(1989-1998)	50%	- 32%	- 32%	- 76%	27%	- 33%	- 85%	- 63%	- 76%

(2) Agriculture, Livestock and Inland Fishery

The major crops cultivated in the Study Area are wheat, barley, rape-seed, maize and potato. The cultivated area of each crop has shown no significant change in the recent years. The total cultivated area by crop in 1998 is shown below.

Crop	Wheat	Barley	Rape Seed	Maize	Potato	Total
Cultivated Area (ha)	32,735	6,218	1,150	75,887	13,112	129,102

Livestock production in the Study Area is not large. The production of major livestock in 1999 is shown below.

Livestock	Bovine	Pig	Horse	Sheep
Number (head)	32,735	6,218	1,150	75,887

There are several large fish-ponds in the Study Area where eight (8) species of fish are cultivated. Among the fish species, Cyprinus Carpio, Ctenopharyngodon Idealla Val and Siluris Glaris are the major ones. The total fish production of the Study Area in 1999 was 560 tons.

(3) Tourism

There are several attractive recreational areas in the Study Area; however, the number of tourists is limited. Most tourists visiting Zagreb City are involved in business. The number of tourists that visited the Study Area in 1999 is summarized below, compared to that of the whole country.

Area	No. of Tourists
Zagreb City	253,210
Three Counties	57,140
Whole Country	4,364,833

2.3 Projection of Future Socio-economy

2.3.1 Development Policy of the Country

The Government of Croatia established the Spatial Planning Strategy in 1997 for planning the long-term land use development in line with the total economic, social and cultural development. The Strategy gives the following goals to the development sectors related to this Study.

(1) Settlement Development Sector

(a) Growth reduction of large cities

(b) Functional restoration of small and medium sized towns and local centers

(c) Prevention of unnecessary expansion, mainly along the state road networks and in areas of valuable natural resources

(2) Water Management Sector

(a) Forecasted increase of total water supply coverage of the country from 63% to 81-90%

(b) Significant investments in the construction of sewer networks and treatment plants

(3) Economic Development Sector

(a) Transformation and rehabilitation of the existing, partially used or shut down industrial zones

(b) Improvement of tourism industry making use of the existence of preserved and attractive natural environments as an advantage of the country space

2.3.2 Population of the Study Area

(1) Zagreb City

According to the Institute of Physical Planning and Environmental Protection of Zagreb County, the total population of Zagreb City is projected to increase from 935,000 in 1999 to 998,000 in 2015 at the average annual growth rate of 0.4%.

(2) Zagreb County

The same institute of Zagreb County estimated the population of the County in 2015 to be 352,000 with the following breakdown.

(a) Suburban Area

The population of the suburban area of Zagreb City covering five (5) towns (Dugo Selo, Ivanić Grad, Samobor, Velika Gorica and Zaprešić) and six (6) municipalities (Bistra, Brckovljani, Brdovec, Rugvica, Stupnik, Sveta Nedjelja) will increase from 205,361 in 1999 to 239,000 in 2015 at an annual growth rate of 0.95%.

(b) Other Areas

The population of the remaining area of the County covering three (3) towns and 20 municipalities is expected to increase from 108,451 in 1999 to 113,000 in 2015 at an annual growth rate of 0.25%.

(3) Sisak-Moslavina County

The total population of Sisak-Moslavina County is projected to increase from 194,320 in 1999 to 227,138 in 2015, based on the survey of the Institute of Physical Planning of the Ministry of Environmental Protection and Physical Planning. The annual growth rate during the period is equivalent to 1.0%.

(4) Karlovac County

According to the estimate of the County Department for Physical Planning, the future population of Karlovac Town will further decease until 2005 and thereafter, will recover to the present level of population by 2015. The future population of the other towns and municipalities is also estimated, based on the same assumption as Karlovac Town. Therefore, the total county population in 2015 is assumed as equal to the population in 1999 (148,892).

From the above estimates, the future population (2015) of the Study Area is summarized as follows, compared to the existing one (1999). For the population by town/municipality, see Appendix A, Table A.2.1 to Table A.2.3.

Administrative Unit	1999			2015			Ratio
	Total (1)	Urban	Rural	Total (2)	Urban	Rural	(2)/(1)
Zagreb City	935,000	935,000	-	998,000	998,000	-	1.07
Zagreb County							
Suburban Area*	205,361	96,883	108,478	239,000	112,754	126,246	1.16
Other Area**	108,451	26,830	81,621	113,000	27,956	85,044	1.04
Sub-total	313,812	123,713	190,099	352,000	140,710	211,290	1.12
Sisak-Moslavina County							
Town	143,149	84,289	58,860	163,745	96,351	67,394	1.14
Municipality	51,171	13,315	37,856	63,393	17,328	46,065	1.24
Sub-total	194,320	97,604	96,716	227,138	113,679	113,459	1.17
Karlovac County							
Town	107,944	73,024	34,920	107,944	74,429	33,515	1.00
Municipality	40,948	8,097	32,851	40,948	8,252	32,696	1.00
Sub-total	148,892	81,122	67,770	148,892	82,682	66,210	1.00
Total	1,592,024	1,237,439	354,585	1,726,030	1,335,071	390,959	1.08

2.3.3 GDP of the Country

The Ministry of Finance had estimated in its short term economic revitalization program, which is under consideration by the Parliament, the following growth rates of GDP for the period 2000-2004.

Year	2000	2001	2002	2003	2004	Average
Growth Rate (%)	2.8	3.0	3.5	4.0	5.0	3.6

On the other hand, the Zagreb Economy Institute is preparing some strategies to be recommended to the government to make up for the continuous deficit in the balance of payment of the country recorded in the recent years. The following table presents the major strategies and the expected growth rates of GDP when they are applied by the government in the period 2000-2015.

Period	Strategies	Expected Growth Rate
2000-2005	(1) Government expenditure reduction by 10% for the period in terms of GDP (2) Reforms on pension and health system (3) Social agreement among employees, government and employers to maintain a low increase of wages for the period (4) Preparation of legal framework for industrial promotion (5) Promotion of tourism (6) Preparation of grounds to enter EU	3 - 4%
2006-2010	(1) Promotion of tourism (2) Foreign and domestic investment in industrial sector (3) Application of new technology to increase industrial production (4) Increase of exports taking advantage of the lower prices reached with the above-mentioned strategy (5) Negotiation to enter EU	5 - 6%
2011-2015	Once entering EU, the country will follow the policies of EU. This means that the economic growth of the country will mainly depend on the economic growth of EU	4 - 5%

From the above policy and strategies, the JICA Study Team assumed the growth rate of GDP as follows: 3.6% for 2000-2005, 5.5% for 2006-2010, and 4.5% for 2011-2015.

2.3.4 Growth of Manufacturing Industry

The Ministry of Finance estimated the current growth rate of the manufacturing industry at 2.7% based on the data during January-September 2000. However, no data concerning the projection of future industrial production at both national and local levels is available.

Therefore, the future growth rate of the manufacturing industry is assumed in this Study to be the same as that of GDP, as shown below.

Period	2000 - 2005	2006 - 2010	2011 - 2015
Growth Rate (%)	3.6	5.5	4.5

CHAPTER III RIVER WATER QUALITY AND USE

3.1 Classification of Water and Standard Water Quality

The effluent receiving waters are classified in the Decree on Water Classification (NN No. 77/98) into five (5) categories according to water quality that corresponds to the established conditions of general ecological function of water and to the conditions under which it is used for a particular purpose. The five (5) categories correspond to the following water uses, respectively.

Category	Water Use
I	(1) Drinking and food processing industry in its natural condition or after disinfection (2) Breeding of high quality fish species (trout)
II	(1) Drinking and other industrial purposes after proper treatment (2) Bathing, recreation, water sports (3) Breeding of other fish species (cyprinid)
III	(1) Industrial purposes requiring no specific water quality and agricultural purpose
IV	(1) Water uses with treatment in great water shortage areas
V	(1) Unsuitable for any water use

The water categorization relates to all flows equal to or larger than the monthly low water of 95% probability for watercourses with unregulated flow, and to flows larger than the guaranteed low water for watercourses with a regulated flow.

The Decree prescribes the standard water quality of each category. The major parameters of water quality are summarized below.

Parameter/Category	I	II	III	IV	V
DO (mg/l)	> 7	7-6	6-4	4-3	< 3
BOD (mg/l)	< 2	2-4	4-8	8-15	> 15
COD-Mn (mg/l)	< 4	4-8	8-15	15-30	> 30
T-N (mg/l)	< 1.0	1.0-3.0	3.0-10.0	10.0-20.0	> 20
T-P (mg/l)	< 0.1	0.10-0.25	0.25-0.60	0.60-1.50	> 1.50
Total Coli. MPN/100ml	$< 5\times10^2$	5×10^2-5×10^3	5×10^3-10^5	10^5-10^6	$> 10^6$
Mineral Oil (mg/l)	< 0.02	0.02-0.05	0.05-0.10	0.10-0.25	> 0.25

3.2 River Flow Rate and Existing Water Use

3.2.1 River Flow Rate

There are 183 water-gauging stations in the Study Area, which are operated by the Meteorological and Hydrological Service of Croatia. However, those in the Lonja River System are limited. Among the water-gauging stations, several principal ones were selected to analyze the river flow regime of the Sava River Main, the Kupa River and the Lonja River System.

The river flow lowers in the summer season (July-September) and rises in spring season (March-April) independently of the rainfall in the Study Area. The seasonal variation of the monthly average flow rate at the five (5) principal stations is shown in Fig. I.2.1.

The flow regime (flow rate - frequency curve) at the principal stations in the Sava Main, Kupa and Lonja rivers for the latest 20 years was analyzed as follows. For the location of the principal stations, see Fig. I.2.2.

River/Station	C.A (km^2)	Observation Period	Average (m^3/s)	75% (m^3/s)	85% (m^3/s)	95% (m^3/s)	Remarks
Sava River Main							
Jesenice	10,750	1964 - 1995	292.0	186.0	152.0	109.0	Slovenian border
Zagreb	12,450	1926 - 1995	309.0	199.0	157.0	120.0	
Crnac	22,852	1955 - 1990	527.0	273.0	212.0	149.0	After confluence with Kupa
Kupa River							
Upper Kupa	3,405	1957 - 1995	57.5	46.2	31.2	19.6	After confluence with Dobra
Mrežnica	975	1947 - 1995	24.4	9.2	7.0	4.6	
Korana	1,297	1946 - 1990	27.3	9.9	6.1	4.0	
Recica	5,806		(134.0)	(66.8)	(45.3)	(28.8)	Downstream of Karlovac
Farkasic	8,902	1965 - 1990	1940	84.9	59.8	36.5	Upstream of Sisak
Lonja River System							
Cazma	2,877	1963 - 1995	17.0	3.39	1.96	1.16	Cesma River (after confluence with Glogovnica)

Note: C.A. means Catchment area; figures in parenthesis are JICA estimates

3.2.2 Existing River Water Use

(1) Consumptive Water Use

In the Study Area, most of the domestic and industrial water is taken from the groundwater and river water uses are limited. No irrigation water is taken from the rivers. River water intake volumes in 1999 are shown below.

Intake Site	User	Purpose	Intake Volume (10^3 m^3/year)	River	Treatment
Sisak	Termoelektrana Sisak	Industrial	179	Sava	
Sisak	Segestica Sisak	Industrial	214	Kupa	
Kutina	Petrokemija Kutina	Industrial	40,400	Pakra	
Petrinja	Vodoopakrba Kupa (Sisak and Ptrinja)	Municipal	8,760	Kupa	Conventional
Duga Resa	Pamucna Ind.	Industrial	1,016	Mrežnica	
Duga Resa	Duga Resa Town	Municipal	1,095	Dobra	Chlorination
Total			51,664		

Further, the municipal water source of Karlovac Town is regarded as river water. The domestic water is extracted from the groundwater in the riverbank of Korana. However, it is recharged from the river water since the groundwater wells are located very close to the watercourse. The intake volume is estimated at 6.21 million m^3/year.

(2) Water Recreation

Swimming is not common in the Sava River Basin. There are only some swimming river beaches in the Korana, Glina, Dobra, Mrznica and Kupa rivers.

A considerable number of people (40,000-60,000) enjoy sport fishing in the Sava River Basin.

3.2.3 Existing Aquatic Life

In the Sava River, 49 species of fish exist. This number of species is 16 lower than those in the Drava River in the same Danube River Basin. The Sava River Basin belongs to the European-Mediterranean ichthyological region, which is characterized by a small number of sub-families. The identified species of fish in the Sava River belong to the following eight (8) families: Petromyzoniade, Salmonidae, Cyprinidae, Cottidae, Cobitidae, Percidae, Centrarchidae and Siluridae

The JICA Study Team conducted a field survey on the existing species of fish in the Sava River Basin in cooperation with the Department of Zoology, Zagreb University in December 2000. The existing species of fish in the basin are distributed as shown below, and the dominant fish fauna are shown in Fig. I.3.1.

River	Sampling Location	No. of Species	Dominant Fish Fauna
Sava	Podsused	6	Albumoides bipuctatus
	Savski Most	12	Leuciscus cephalus
	Toplana (near Zagreb)	15	Leuciscus cephalus
	Confluence point with Una	13	Albumoides bipuctatus
Odra	Selce bridge, Donji gaz and Pescenka-Vratovo Channel	23	Rutius rutilus
Kupa	Source	4	
	Upper area	23	Salmonid
	Middle area	27	
	Lower area	24	Cyprinidae
Dobra	Source	7	Phoxinus phoxinus-minow
	Upper area	19	Alburnodes bipuntatus-shneider
	Middle area	18	Alburnodes bipuntatus-shneider
	Lower area	13	Alburnodes bipuntatus-shneider
Mrežnica	Previous Data	15	Cyprinidae
Korana	Upper area	15	Phoxinus phoxinus-minow
	Lower area	26	Leuciscus cephalus-chab
Krapina	Previous Data	23	Schneider
Lonja	Upstream of Ivan Zelina	10	Pseudirasbora parva
	Near Ivanić Grad	10	Carassius auratus
	Near Lonijsko polje	9	Leuciscus cephalus
Crnec	Previous Data	7	Carassius auratus
Zelina	Previous Data	10	Albumus albumus

As shown in the above table, the number of fish species in the Sava Main, Lonja and Crnec rivers are definitely less than those in the other rivers. This may be attributable to river water pollution.

3.3 River Water Categorization in the Study Area

The category of major rivers in the Study Area is as shown in the following table.

River	Existing Water Use	Category
Trans-national River		
Sava Main (Upstream of Zagreb)	Recreation, Scenic View, Aquatic Life	II
Sava Main (Zagreb - Sisak)	Industrial, Recreation, Scenic View, Aquatic Life	III
Sava Main (Downstream of Sisak)	Recreation, Scenic View, Aquatic Life	II
Kupa (Upstream of Metlika)	Recreation, Scenic View, Aquatic Life	I
Kupa (Metlika - Confluence with Korana)	Recreation, Scenic View, Aquatic Life	II
Kupa (Karlovac - Sisak)	Drinking, Industrial, Recreation, Scenic View, Aquatic Life	II
Glina (Source to Topusko)	Recreation, Scenic View, Aquatic Life	II
Glina (Topusko to Confluence with Kupa)	Recreation, Scenic View, Aquatic Life	II
Korana (Plitvice Lake - Slunj)	Recreation, Scenic View, Aquatic Life	I
Korana (Slunj - Confluence with Kupa)	Drinking, Recreation, Scenic View, Aquatic Life	II
Other National/Major Rivers		
Odra River		II
Dobra River	Drinking, Recreation, Scenic View, Aquatic Life	II
Mrežnica River	Industrial, Recreation, Scenic View, Aquatic Life	II
Kupcina River	Recreation, Scenic View, Aquatic Life	II
Linking/Relief/Rim Channel		
Lonja - Strug Channel	Recreation, Scenic View, Aquatic Life	II
Kupa - Kupa Channel		II
Sava - Odra Channel		II
Zelina - Lonja - Glogovnica - Cesma Channel		II

3.4 Existing River Water Quality

3.4.1 River Water Quality

Croatian Waters had analyzed the river water quality at 27 stations in the Study Area. The oldest observation dates back to 1973. However, the water quality analysis in the Lonja River Basin has been limited to only one (1) location, i.e., immediately downstream of Ivanić Grad. For the location, see Fig. I.2.2.

The average and 95% water quality during the period 1994-1999 were estimated for the above stations. The average and 95% water quality in major parameters at the eight (8) principal stations are summarized in the following table.

River/Station/ Category	DO (mg/l)	BOD (mg/l)	COD-Mn (mg/l)	F. Col. (N/100 ml)	T-N (mg/l)	T-P (mg/l)	PO_4-P (mg/l)	Mineral Oil (mg/l)	Remarks (Code No.)
Sava River Main									
Jesenice (II)	6.7 (9.3)	5.6 (2.7)	8.4 (4.4)	12×10^4 (26×10^3)	5.97 (3.39)	- (-)	0.33 (0.13)	0.30 (0.13)	Slovenia Border (289)
Oborovo (III)	4.2 (7.8)	8.6 (4.8)	9.5 (5.3)	39×10^5 (71×10^4)	7.38 (4.29)	- (-)	0.40 (0.18)	0.44 (0.18)	After Zagreb (242)
Martinska Ves (III)	4.3 (7.8)	5.9 (3.3)	6.5 (4.4)	31×10^3 (21×10^3)	4.67 (2.68)	0.49 (0.26)	0.79 (0.46)	0.07 (0.20)	Before Sisak (241)
Utok Kupe Nizvodno (II)	5.5 (8.5)	5.7 (3.1)	5.2 (3.7)	33×10^3 (16×10^3)	4.34 (2.36)	0.53 (0.23)	0.65 (0.38)	0.19 (0.05)	After Sisak (237)
Lonja River									
Ivanić Grad	1.6 (6.1)	21.2 (10.0)	23.5 (14.1)	24×10^4 (68×10^3)	6.46 (6.46)	- (-)	0.43 (0.43)	0.25 (0.1)	After Ivanic G. (245)
Kupa River									
G. Pokupje (II)	7.2 (10.2)	3.7 (2.1)	2.7 (1.9)	92×10^3 (23×10^3)	- (-)	- (-)	0.04 (0.04)	- (0.01)	Before Karlovac (267)
Reica (II)	6.6 (9.8)	4.3 (2.5)	3.0 (2.2)	78×10^4 (15×10^4)	- (-)	- (-)	0.34 (0.21)	- (0.03)	After Karlovac (254)
Brest (II)	7.4 (10.0)	3.5 (1.4)	4.3 (2.8)	25×10^3 (76×10^2)	2.65 (1.48)	0.21 (0.09)	0.19 (0.09)	- (-)	Before Sisak (249)
Category II Standard	7 - 6	2-4	4 -8	2×10^2 - 10^3	1.0 - 3.0	0.10 - 0.25		0.02 - 0.05	
Category III Standard	6 - 4	4 - 8	8 - 15	10^3 - 10^4	3.0 - 10.0	0.25 - 0.60		0.05 - 0.10	

Note: Figures not enclosed in parentheses are 95%; figures in parentheses are the average.

The longitudinal variation of water quality (BOD, T-N, PO_4-P) in the Sava Main and Kupa rivers are shown in Fig. I.3.2.

The river water quality in the Study Area has the following characteristics:

(1) The river water quality in most of the river sections in the Study Area worsens at 95% probability in drought time compared to the criteria.

(2) The water quality of the Sava Main River already exceeds the criteria at the border with Slovenia and the pollution much increases immediately after inflow of the wastewater of Zagreb City. Similarly, the river water is affected by the untreated industrial and domestic wastewater of Sisak Town. However, pollution of the river water is mitigated by the self-purification effect while the water flows down the river reaches between Zagreb and Sisak.

(3) The Kupa River is also affected by the untreated industrial and domestic wastewater of Karlovac Town.

(4) The Lonja River is extremely polluted immediately after Ivanić Grad due to the industrial and domestic wastewater of the upstream towns, and lack of dilution effects of the river.

(5) BOD, Fecal Coliform, T-P, PO_4-P, and Mineral Oil show very high values immediately downstream of Zagreb, Sisak, Karlovac and Ivanić Grad. This is definitely due to the untreated wastewater of these urban centers.

3.4.2 River Deposit Quality

The JICA Study Team analyzed the river deposit quality at five (5) locations in Sava Main, at two (2) locations in Kupa, at three (3) locations in Lonja, at one (1) location in Crnec and at one (1) location in Kutina in December 2000. The average heavy metal concentration in the deposits is summarized below.

(Unit: mg/dry-kg)

Item	Sava River	Kupa River	Lonja River	Crnec River	Kutina River
Hg	N.D.	N.D.	N.D.	N.D.	N.D.
As	N.D.	N.D.	N.D.	N.D.	N.D.
Cd	0.26	1.25	0.37	0.90	7.10
Pb	5.3	0.2	1.6	N.D.	N.D.
Se	N.D.	N.D.	N.D.	N.D.	N.D.
Cr	27.4	26.3	21.7	8.8	35.9
Cu	24.3	16.7	31.1	6.0	23.1
Zn	124	60.5	115	37.0	179
Ni	22.3	34.3	35.7	16.0	25.3
F	6.2	5.4	15.5	25.2	229
PCB	0.01	0.01	N.D.	N.D.	0.53
Pesticides	0.036	0.003	0.023	0.005	0.001

N.D.: Not detected

As shown in the above table, the river deposits of Kutina are highly contaminated by Cd, F and PCB due to the effluent of the industries. However, the concentration of other parameters is as low as those of ordinary soils. The deposits of the other rivers are not contaminated and the concentration of heavy metals is on the level of ordinary soils.

CHAPTER IV INDUSTRIAL WASTEWATER TREATMENT

4.1 Planning Basis

4.1.1 Objectives of the Study

The major objectives of the industrial wastewater treatment study are:

(1) To establish the existing discharge systems of industrial wastewater.

(2) To estimate the existing and future wastewater quantity and quality and to evaluate the pollution load to the sewerage systems and rivers.

(3) To propose the optimum discharge system, i.e., to sewerage system with necessary pre-treatment or directly to river with necessary treatment. This is essential for the planning of sewerage development projects in the following Chapter.

(4) To propose the necessary improvements to the existing treatment systems. Required construction cost is roughly estimated. The estimated cost is employed as the basic data in the preparation of the financial policy on the promotion of industrial wastewater treatment.

There are a number of factories in the Study Area. The large factories that may cause river water pollution are mostly found in the Vrbovec, Sisak, Kutina and Karlovac towns, and in Zagreb City. However, among the factories in Zagreb City, those located in the service area of the ongoing Zagreb Sewerage Development Project are excluded from this Study since they will all be treated under the said project. Only the factories located in Sesvete East (part of Zagreb City but not covered by the above ongoing project) are studied.

The large factories existing in the above five (5) towns and district mostly discharge their wastewater into the public sewerage systems or the natural water systems either with no treatment or with insufficient treatment.

4.1.2 Selection of the Objective Large Industries for the Study

Among the industries existing in the Study Area, 51 large industries were selected for the Study. The other small industries were dealt with as municipal wastewater sources. In the selection, the large industries that discharge wastewater of more than 100 m^3/day were selected, in principle. However, the industries in Zagreb City (except Sesvete East Area) were excluded since all of them will be treated under the ongoing Zagreb Sewerage Project.

The selected 51 large industries are distributed over 14 towns and municipalities, as shown in Table I.4.1. Among them, 18 large pollutant industries were further selected for detailed study (see the table below). These 18 large pollutant industries generate most of the industrial wastewater quantity (approx. 80%) and pollution load (approx. 90% in BOD) in the Study Area.

Town/Municipality	Industry Name	Activity	Existing Recipient
Sesvete East	Agroproteinka	Food/Beverage	Canal
	Duma Koze	Leather	Canal
Vrbovec	PIK Vrbovec Mesna Ind.	Food/Beverage	Canal
Sisak	INA Zagreb Rafinerija Nafte Sisak	Oil Refinery	River
	Herbos d.d.	Chemicals	Sewerage
	Termoelektrana Sisak	Electric Power	River
	Tvornica Segestica	Food/Beverage	Sewerage
	Zeljezara Poduzeč Metaval	Metal/Machinery	River
	Ljudevit Posavski Mlini i Pekare	Food/Beverage	Sewerage
Kutina	Petrokemija Kutina	Chemicals	River/Sewerage
Karlovac	Krlovacka Pivovara	Food/Beverage	Sewerage
	PPK Karlovacka Industrija Mesna	Food/Beverage	Sewerage
	Velebit	Textile	River
	Lola Ribar	Textile	River
	Karlovacka Industrija Mlijeka	Food/Beverage	River
Duga Resa	Pamucna Industrija Duga Resa	Textile	River
Zaprešić	Pliva	Chemicals	River
Petrnja	Gavrilovic d.o.o.	Food/Beverage	River

4.1.3 Permissible Limits of Industrial Effluent

The permissible limits of major parameters of industrial wastewater discharged into natural receiving waters and public sewerage systems are prescribed in NN No. 40/99 as amended by NN No. 6/01, and as shown below. For the other parameters including heavy metals and other toxic materials, see Appendix C, Table C.1.1. All the above-mentioned objective 51 large industries shall treat their wastewater to comply with the above regulations. Industrial wastewater discharge into waters of Category I is not allowed.

Parameter/Category	II	III	IV	V	Sewerage
pH	6.5 - 8.0	6.0 - 8.5	5.5 - 9.0	5.0 - 9.5	5.0 - 9.5
TSS (mg/l)	35	35 - 60	60 - 150	150	*
BOD (mg/l)	25	25	40	80	250 [1)]
COD-Cr (mg/l)	125	125	200	400	700 [1)]
T-P (mg/l)	1	2	4	8	10
T-N (mg/l)	21	31	42	42	-
Oil and Grease ((mg/l)	25	30	40	50	100

* To be determined at sewerage company's option.

1) Sewerage company can change the values depending on its treatment capacity.

4.1.4 Projection of Future Industrial Wastewater Quantity

The future wastewater quantity of the 51 objective large industries in the year 2015 is estimated based on the following assumptions:

(1) GDP Growth Rate: 2000-2005 (3.6%); 2006-20010 (5.5%); 2010-2015 (4.5%)

(2) Industrial production will increase in proportion to the growth of GDP.

(3) However, unit wastewater quantity per production will decrease in the future due to the technological improvement of production process.

(4) The decreasing rate of the objective industries will be different per industry. In this study, the objective factories are classified into three (3) categories, based on the following policies:

(a) Classify the factories by comparing the existing unit wastewater quantity with the standards in Japan. The factories with a higher unit wastewater quantity have room to decrease it in the future (Category A).

(b) Classify the factories, considering the existing share of cooling water use in the total water use. The factory with a larger cooling water use has room to increase the rate of recycle use, resulting in decrease of unit wastewater quantity (Category B).

(c) Classify the factories, considering the age of equipment. The factory with old equipment has room to decrease the unit wastewater quantity by improving the equipment in the future (Category C).

(5) The unit wastewater quantity of each category is assumed to decrease as follows: Category A: 10% reduction by 2015; Category B: 1% reduction per year; and Category C: 20% reduction by 2015.

Indices of industrial production and total wastewater quantity of the industries in 2015 are compared by category, as follows.

GDP/Industrial Category		1999	2000	2015
Industrial Production		1.000	1.000	1.944
Total Wastewater Quantity	(Category A)	1.000	1.000	1.750
	(Category B)	1.000	1.000	1.652
	(Category C)	1.000	1.000	1.555

4.1.5 Selection of Wastewater Recipient

The industrial wastewater is discharged into public sewerage, in principle, except the following cases, to promote the pollution control of industrial wastewater at the minimum cost. On the other hand, the public sewerage can allocate the necessary cost for industry and as a result, the integrated treatment of municipal and industrial wastewater will attain the target at the minimum cost.

(1) The industry is already provided with a high level treatment system and can easily discharge the wastewater into river with a small improvement as required.

(2) The wastewater is not much polluted in quality and industry can easily discharge it into river with a small improvement as required.

(3) The wastewater quality is not proper for the treatment of public sewage.

(4) The industry is located far from the sewerage system, requiring a large additional cost.

The wastewater recipient (public sewerage or natural watercourse) of the objective 51 large industries is determined individually in consideration of the above factors.

4.1.6 Selection of Wastewater Treatment Process

The optimum treatment process varies depending on the wastewater quality and the recipient of the industry. However, the four (4) typical treatment processes shown in the following table are applied in the master plan study. The adequate process for each industry is selected from these four (4) processes according to the required treatment conditions. The generated sludge is treated by a combination of thickening and mechanical dewatering in consideration of the limitation of available space in the factories.

Treatment Process	Applicable Industry
Conventional Activated Sludge (AS)	Industry that treats BOD and COD at the normal concentration for discharge into public sewerage or natural water
Two Stage Activated Sludge (2-AS)	Industry that treats BOD and COD at a high concentration for discharge into natural water
Chemical Clarification (CT)	Industry that treats TSS, heavy metals, color and insoluble BOD, COD for discharge into public sewerage or natural water
Conventional Activated Sludge + Chemical Clarification (AS + CT)	Industry that treats BOD, COD, TSS, heavy metals, color and oil for discharge into natural water

4.1.7 Cost Estimate

The construction costs of the proposed treatment plants are roughly estimated with the following breakdown. In this estimate, the currency exchange rate at the end of February 2001 is employed as follows: US$1.00 = Kn. 8.3 = JP¥ 116.

Item	Remarks
1. Direct Construction Cost (1) Mechanical/Electrical Works (2) Civil/Architectural Works (3) Miscellaneous Works	
2. Indirect Cost	10% of 1.
3. VAT	22% of 1.
4. Customs Duties	10% of 1.(1)
5. Contingency	20% of 1.

4.2 Wastewater Treatment of Large Pollutant Industries

The selected 18 large pollutant industries are located in Sesvete East, Vrbovec, Sisak, Kutina, Karlovac, Duga Resa, Zaprešić and Petrinja. Their existing wastewater discharge system and proposed development of treatment system are described in detail below.

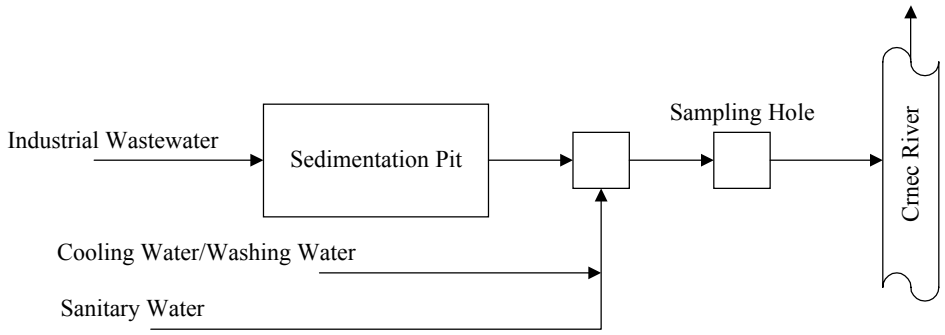
4.2.1 Agroproteinka d.d. (Sesvete East)

(1) Existing Wastewater Discharge System

The factory with 57 employees produces animal foods. All the wastewater including industrial process, cooling/washing and sanitary wastewater is discharged into the neighboring canal through one (1) outlet. The wastewater discharged into the canal is further drained into the Crnec River by pumps in the downstream at Dugo Selo.

The industrial wastewater is treated by a simple system of grease trap/sedimentation pit. The cooling/washing and sanitary wastewater are discharged with no treatment.

The existing wastewater discharge system is illustrated below. For the existing wastewater quantity and quality, see Table I.4.2.



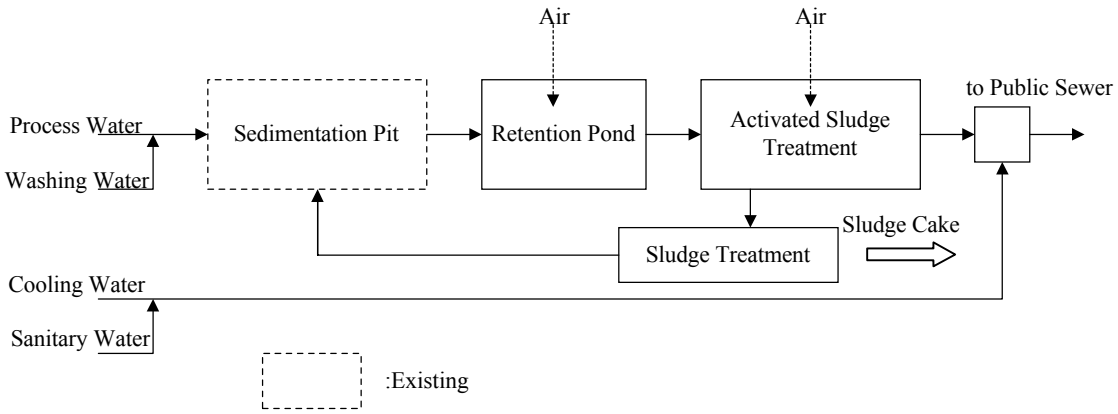
(2) Development of Wastewater Treatment

(a) Selection of Recipient

The pre-treated wastewater is discharged into the sewerage of Sesvete East since the construction of a sewage treatment plant has already been determined at the location neighboring to the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 228 m^3/d in 1999 to 377 m^3/d in 2015 by assuming the unit wastewater of Category B. A conventional Activated Sludge process with a retention pond is proposed to treat BOD, COD, T-P and Oil/Grease to the permissible limits. The proposed treatment system is shown below.



(c) Construction Cost

The total construction cost is estimated at Kn. 9.91 million. For details, see Appendix C, Subsection 2.2.5.

4.2.2 Duma Koze d.o.o. (Sesvete East)

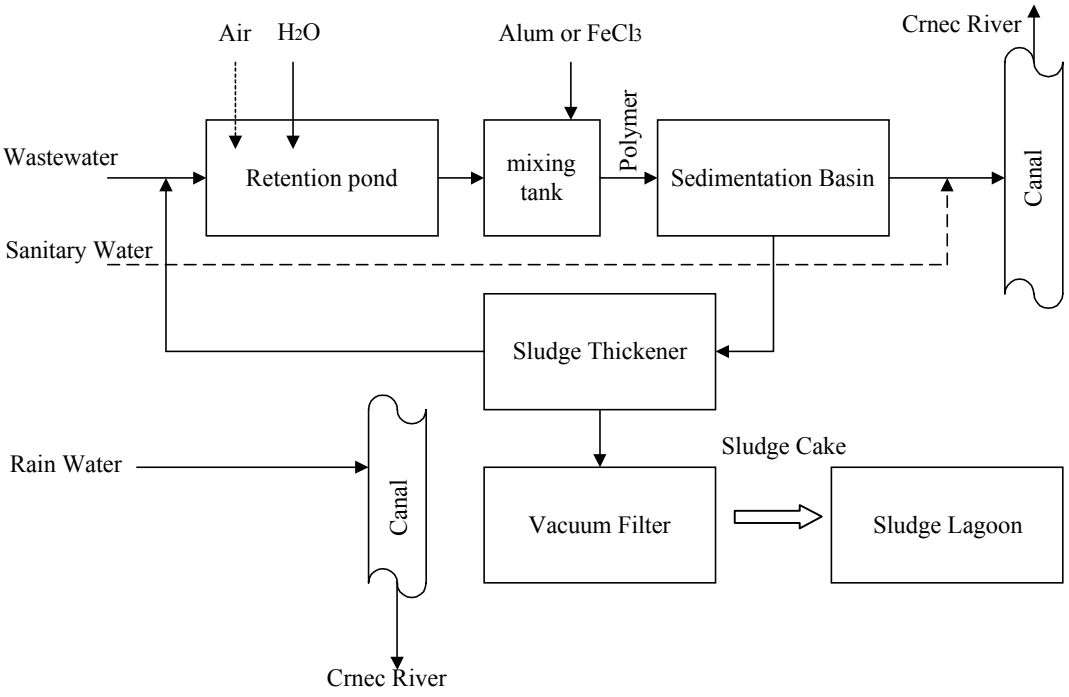
(1) Existing Wastewater Discharging System

The factory with 36 employees is located next to Agroproteinka and processes leather. The wastewater including industrial process and sanitary wastewater is also

discharged into the same canal as Agroproteinka through one (1) outlet. The wastewater discharged into the canal is further drained into the Crnec River by the same pumps as above mentioned at Dugo Selo.

The industrial wastewater is treated by a primary chemical treatment system consisting of equalization tank, retention pond, mixing tank, and sedimentation basin. A sludge treatment system is also provided.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The pre-treated wastewater is discharged into the sewerage of Sesvete East since the construction of a sewage treatment plant has already been determined at the location neighboring to the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The factory has already approximately three (3) times production capacity of the current operation. Hence, the industrial production in 2015 is assumed to be three (3) times of the existing one. On the other hand, this factory is classified into Category C of unit wastewater quantity. Therefore, the wastewater quantity is estimated to increase from 509 m^3/d in 1999 to 1,222 m^3/d in 2015.

The existing treatment plant of primary chemical process has a large capacity. Hence, it will be able to treat the future wastewater to the permissible limits with a minor improvement of the chemical injection system.

(c) Construction Cost

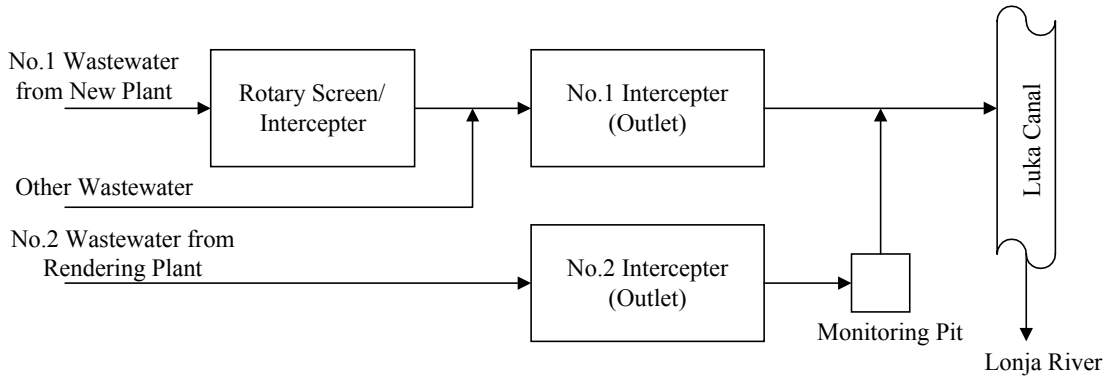
The required construction cost is roughly estimated at Kn. 2.0 million.

4.2.3 PIK Vrbovec Mesna Ind. (Vrbovec)

(1) Existing Wastewater Discharge System

The factory with 2,000 employees produces meat products and fat. The wastewater is discharged into the neighboring Luka Canal through two (2) outlets and is finally discharged from the Luka Canal into the Lonja River. However, the wastewater treatment is insufficient. The system is provided with only rotary screen and oil interceptor.

The existing wastewater discharge system is illustrated below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

Recipient of the wastewater will be changed from the canal to the public sewerage since a sewage treatment plant is proposed at the location near the existing industrial wastewater outlet and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 2,132 m^3/d in 1999 to 3,523 m^3/d in 2015 by assuming the unit wastewater of Category B. The effluent quality is lower than the permissible limits to public sewerage in all the major parameters of BOD, COD, T-N, T-P and T-Oil. Hence, no improvement of the existing treatment plant is necessary.

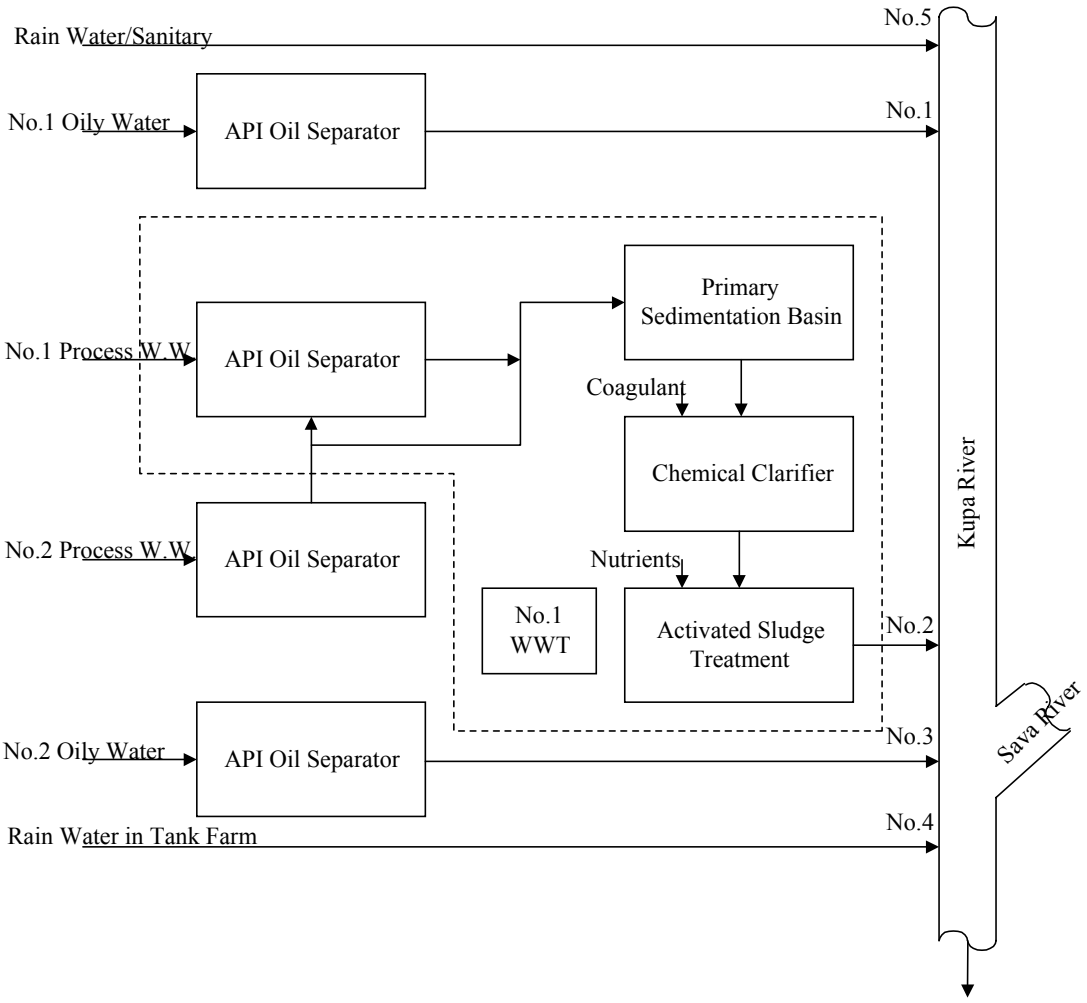
4.2.4 INA Zagreb Rafinerija Nafte Sisak (Sisak)

(1) Existing Wastewater Discharge System

The factory with 1,798 employees produces gasoline, heavy oil and fuel oil. All wastewater is discharged into the Kupa and Sava rivers through five (5) outlets. Outlet No. 2, the most important one, discharges the process wastewater of the entire refinery treated by the system consisting of API oil separator, primary sedimentation,

chemical clarifier and activated sludge treatment to the Kupa River. The old treatment plant (No. 1 WWT) treats all of the process wastewater at present. A new plant (No. 2 WWT) was 90% completed when construction was suspended due to financial constraints.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2. For detailed system of No. 2 WWT, see the flow chart in Subsection 4.2.5.



(2) Development of Wastewater Treatment

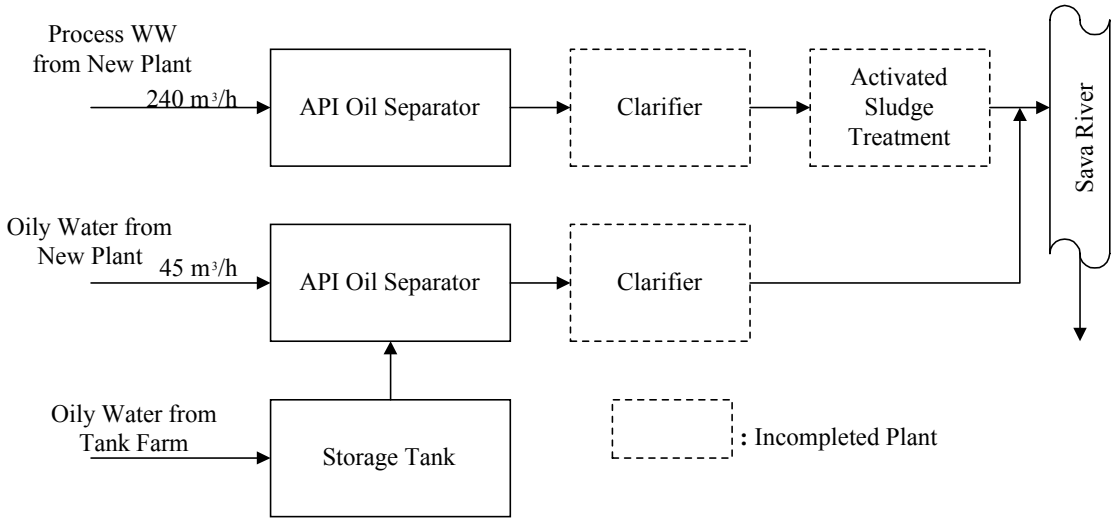
(a) Selection of Recipient

The industrial wastewater is directly discharged into the Kupa and Sava rivers through a full-scale but old treatment system at present. It barely meets the permissible limits of the receiving rivers except TSS and Phenol. However, the new plant will function in the near future. Hence, the wastewater may be discharged into the rivers even in the future.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 9,399 m^3/d in 1999 to 15,531 m^3/d in 2015, by assuming the unit wastewater of Category B.

The new treatment plant (No. 2 WWT) should be completed at the earliest time to maintain a satisfactory treatment. The part to be completed is shown below. A minor improvement of the existing No. 1 WWT is necessary to treat TSS and Phenol to a satisfactory level.



(c) Construction Cost

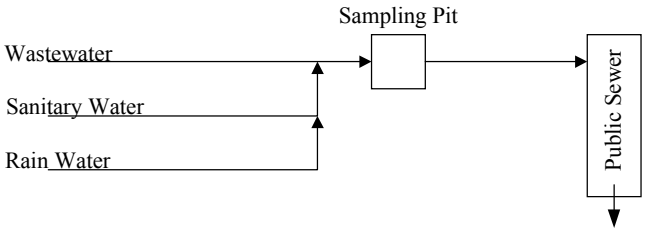
The required total construction cost is roughly estimated at Kn. 10.3 million composed of Kn. 10.0 million for No. 2 WWT and Kn. 0.3 million for No. 1 WWT.

4.2.5 Herbos d.d. (Sisak)

(1) Existing Wastewater Discharge System

The factory with 340 employees produces atrazin and plant protection materials. All of the wastewater including process water, sanitary water and rainwater is discharged into the public sewerage through one (1) outlet with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

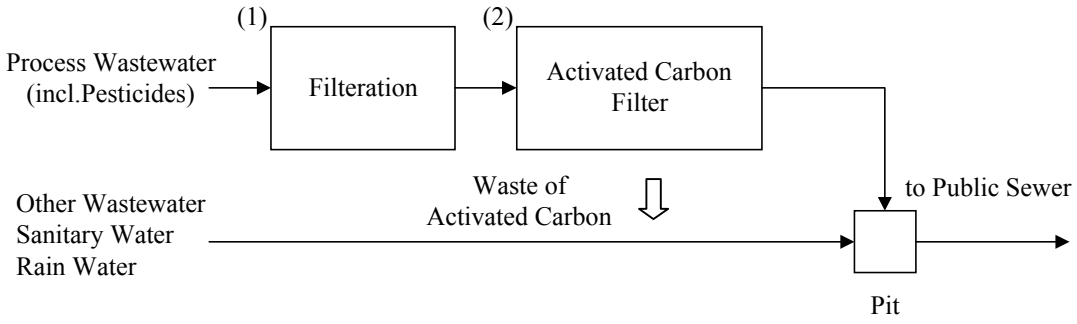
(a) Selection of Recipient

The existing wastewater effluent quality satisfies the permissible limits to public sewerage in all parameters except pesticides. Hence, the wastewater is discharged into the public sewerage as at present.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 604 m^3/d in 1999 to 939 m^3/d in 2015, by assuming the unit wastewater of Category C.

An in-plant treatment facility is proposed for the removal of pesticides at the generating source before it mixes with other wastewaters. The wastewater to be treated is assumed at 30 m^3/d. The proposed treatment system is shown below.



(c) Construction Cost

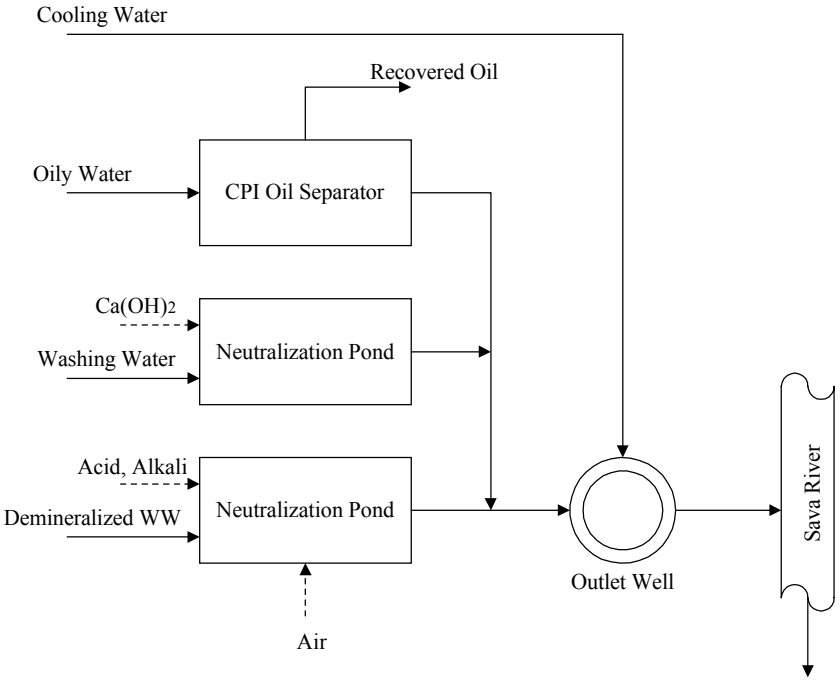
The required construction cost is roughly estimated to be Kn. 1.5 million.

4.2.6 Termoelektrana Sisak (Sisak)

(1) Existing Wastewater Discharge System

The factory with 229 employees generates electric power. All of the wastewater is discharged into the Sava River through one (1) outlet; namely, oily wastewater is discharged after treatment with a CPI oil separator, washing wastewater is discharged after neutralization, de-mineralized wastewater is discharged through a neutralization pond, and used cooling water is returned to the River with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The existing wastewater effluent quality satisfies the permissible limits to Sava Main River in all parameters. Hence, the wastewater is discharged into the River as at present.

(b) Proposed Improvement of Treatment System

The wastewater quantity (excluding cooling water) is estimated to increase from 451 m^3/d in 1999 to 745 m^3/d in 2015, by assuming the unit wastewater of Category B. An additional treatment plant of the existing type is necessary to meet the increasing wastewater quantity.

(c) Construction Cost

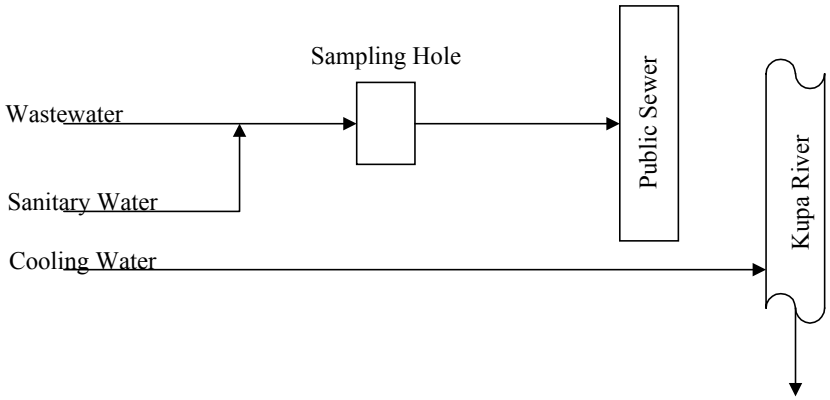
The required construction cost is roughly estimated to be Kn. 1.0 million.

4.2.7 Tvornica Segestica (Sisak)

(1) Existing Wastewater Discharge System

The factory with 159 employees produces juice, syrup, vinegar, liquor and ethyl alcohol. The wastewater including process water and sanitary water is discharged into the public sewerage through one (1) outlet with no treatment. The cooling water is directly discharged into the Kupa River with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

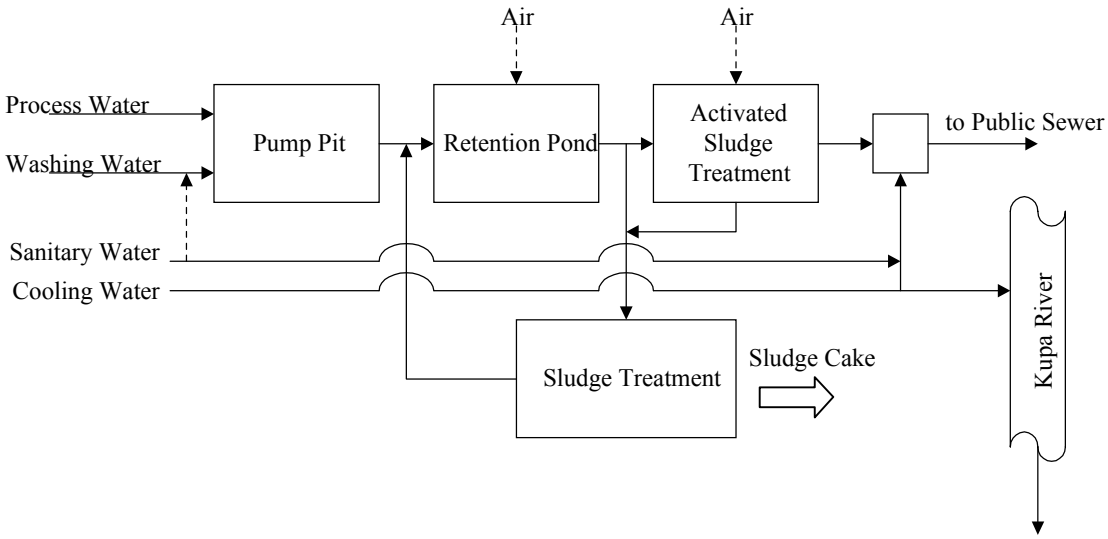
(a) Selection of Recipient

The wastewater (excluding cooling water) will be discharged into the public sewerage as at present since the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity (excluding cooling water) is estimated to increase from 204 m^3/d in 1999 to 337 m^3/d in 2015, by assuming the unit wastewater of Category B.

The existing effluent quality exceeds the permissible limits to public sewerage in BOD, COD and T-P. Hence, a pre-treatment system of Activated Sludge is proposed in order to meet the regulations. The proposed pre-treatment system is shown below.



(c) Construction Cost

The required total construction cost is estimated at Kn. 7.16 million. For details, see Appendix C, Subsection 4.5.5.

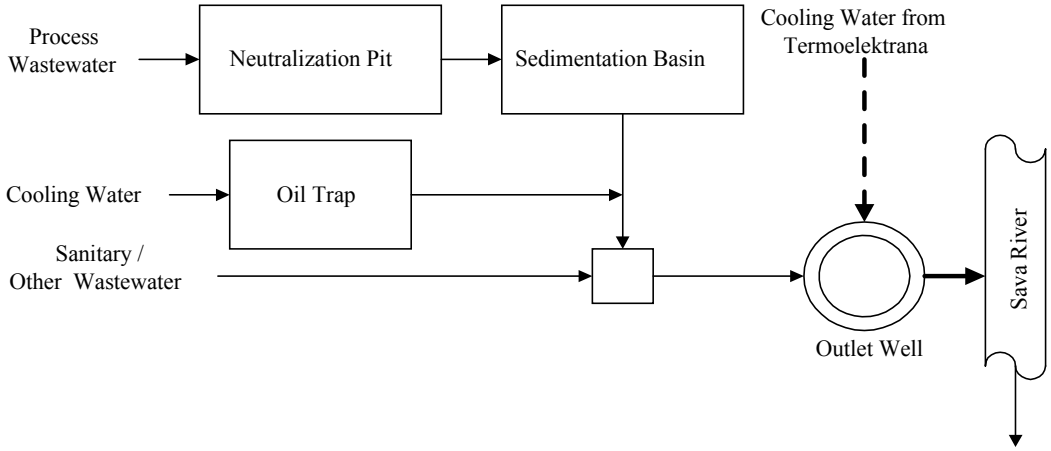
4.2.8 Zeljezara Poduzece Metaval (Sisak)

(1) Existing Wastewater Discharge System

The factory with 2,056 employees produces seamless tube, seam tube, and proof seam tube. The wastewater including process water, cooling water and sanitary water is discharged into the Sava River along with the cooling water from the Termoelektrana Sisak through one (1) outlet.

The neutralization pit and sedimentation basin treat the process wastewater. The cooling water is treated by oil trap. However, the sanitary and miscellaneous wastewater is discharged with no treatment.

The existing wastewater discharging system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The wastewater will be directly discharged into the Sava Main River as at present since the existing effluent quality satisfies the permissible limits.

(b) Proposed Improvement of Treatment System

The wastewater quantity (excluding cooling water) is estimated to increase from 3,182 m^3/d in 1999 to 4,949 m^3/d in 2015, by assuming the unit wastewater of Category C. An additional one (1) train of the existing treatment system is proposed to meet the increasing wastewater quantity.

(c) Construction Cost

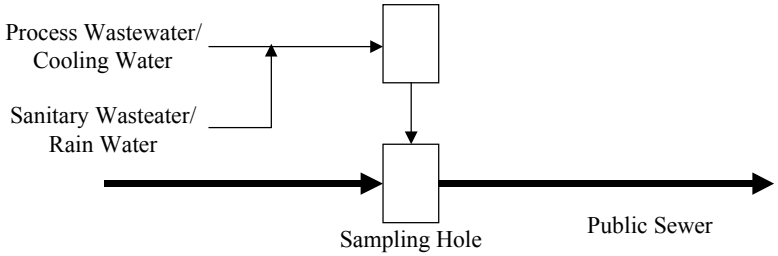
The required total construction cost is estimated at Kn. 2.0 million.

4.2.9 Ljudevit Posavski Mlini i Pekare (Sisak)

(1) Existing Wastewater Discharge System

The factory with 200 employees produces bread and cake. The wastewater including process water, cooling water and sanitary water is discharged into the public sewer installed across the factory through one (1) outlet with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

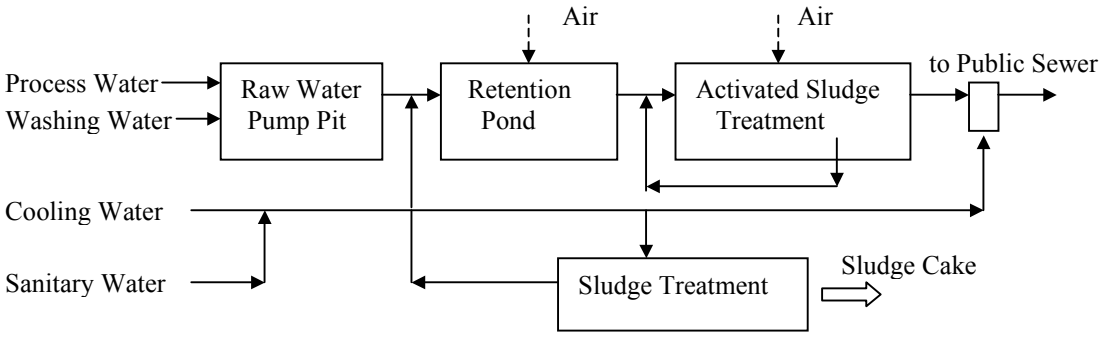
(a) Selection of Recipient

The wastewater will be discharged into the public sewerage as at present since the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity (excluding cooling water) is estimated to increase from 83 m^3/d in 1999 to 137 m^3/d in 2015, by assuming the unit wastewater of Category B.

The existing effluent quality exceeds the permissible limits of BOD and COD to public sewerage. Hence, a pre-treatment system of Activated Sludge is proposed to meet the regulations. The proposed pre-treatment system is shown below.



(c) Construction Cost

The required total construction cost is estimated at Kn. 5.91 million. For details, see Appendix C, Subsection 4.7.5.

4.2.10 Petrokemija Kutina (Kutina)

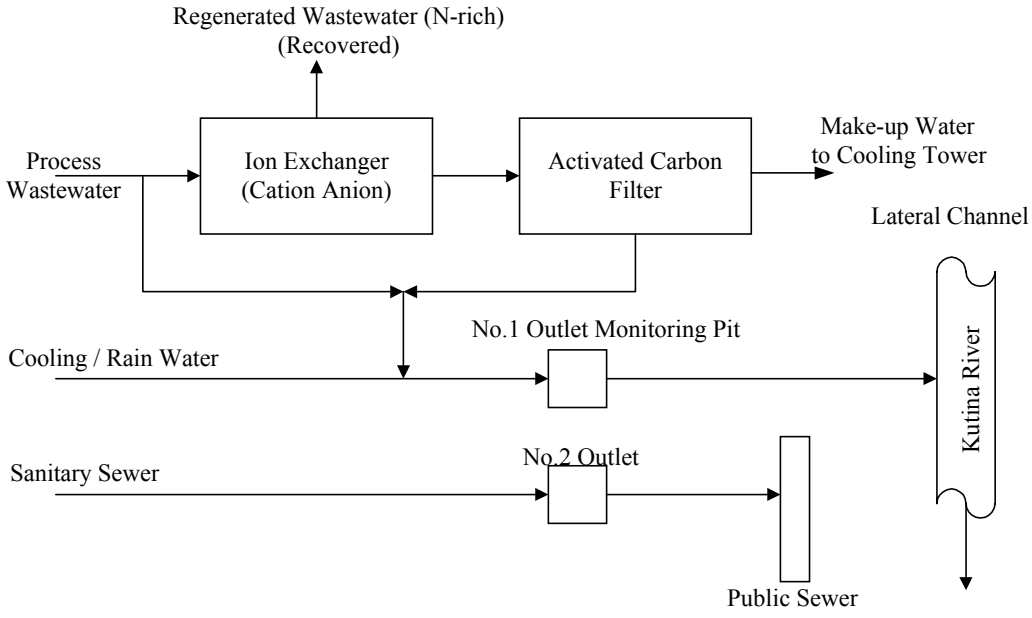
(1) Existing Wastewater Discharge System

The factory produces fertilizer of urea, ammonium sulfate, etc. It discharges three (3) kinds of wastewater; namely, (i) process wastewater, (ii) cooling water/rainwater, and (iii) sanitary wastewater, through two (2) outlets.

Ion Exchanging and Adsorption Process is used to treat the process wastewater , and the treated water is reused as make-up water of the cooling towers. The N-rich regenerated wastewater is reused as part of raw nitrogen. The process effluent is finally discharged into the lateral channel through the No. 1 outlet, together with cooling water/rainwater.

The cooling water/rainwater is discharged into the lateral channel through the No. 1 outlet with no treatment. The sanitary wastewater is discharged into the public sewerage through No. 2 with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The industry discharges a large quantity of process wastewater with a low concentration of organic materials (BOD, COD) but high T-N. Therefore, the discharge of process wastewater into the public sewerage is not recommendable without improvement of the existing plant. Only sanitary wastewater will be discharged into the public sewerage as at present.

(b) Proposed Improvement of Treatment System

The process wastewater quantity (including cooling water) is estimated to increase from 10,388 m^3/d in 1999 to 17,165 m^3/d in 2015, by assuming the

unit wastewater of Category B. The sanitary wastewater will increase from 663 m^3/d in 1999 to 1,063 m^3/d in 2015, by assuming the increase rate in number of employees and per capita wastewater.

The existing treatment plant of process wastewater (Ion Exchanger and Activated Carbon Filter) needs to be improved to lower the T-N to the permissible limit. One (1) more train of the existing treatment system, with a capacity of 280 m^3/h, needs to be installed.

The sanitary wastewater can be discharged into the public sewerage with no treatment as at present.

(c) Construction Cost

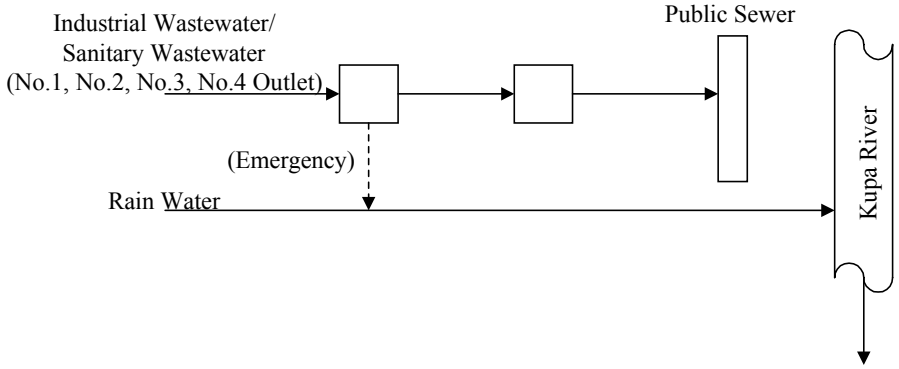
The required total construction cost is roughly estimated at Kn. 10.0 million.

4.2.11 Karlovacka Pivovara (Karlovac)

(1) Existing Wastewater Discharge System

The factory with 707 employees produces beer, sugar, condensate, masut (fat) and glycol. All wastewater (including process and sanitary wastewater) is discharged through four (4) outlets (finally integrated into one (1) outlet) into the public sewerage with no treatment.

The existing wastewater discharging system is shown below. For the wastewater quantity and quality, see Table I.4.2.



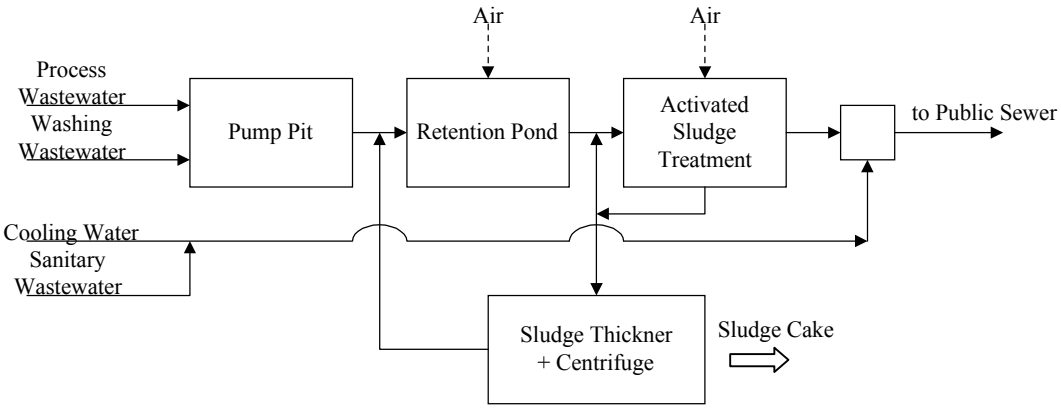
(2) Development of Wastewater Treatment

(a) Selection of Recipient

The wastewater will be discharged into the public sewerage as at present since the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 2,301 m^3/d in 1999 to 3,802 m^3/d in 2015, by assuming the unit wastewater of Category B. Since the existing effluent quality exceeds the permissible limits of BOD and COD to public sewerage, a pre-treatment system of Activated Sludge is proposed to meet the regulations. The proposed pre-treatment system is shown below.



(c) Construction Cost

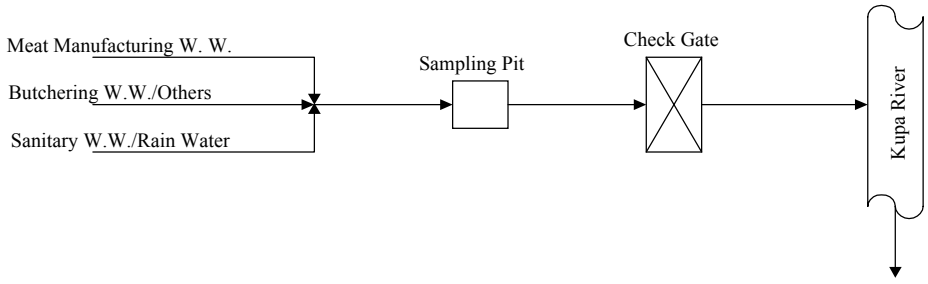
The required total construction cost is estimated at Kn. 16.28 million. For details, see Appendix C, Subsection 6.2.5.

4.2.12 PPK Karlovacka Industrija Mesna (Karlovac)

(1) Existing Wastewater Discharge System

The factory with 246 employees produces sausage, smoked meat, permanent products and fresh meat. All wastewater (including production process, butchering, sanitary and rain) is directly discharged into the Kupa River through one (1) outlet with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



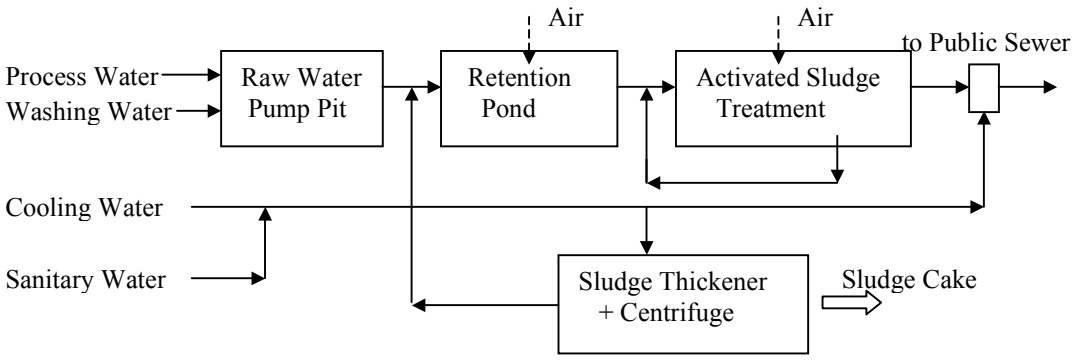
(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system of the town is planned to extend to the location of the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 348 m^3/d in 1999 to 609 m^3/d in 2015, by assuming the unit wastewater of Category B. Since the existing effluent quality exceeds the permissible limits of BOD to the public sewerage, a pre-treatment system of Activated Sludge is proposed to meet the regulations. The proposed pre-treatment system is shown below.



(c) Construction Cost

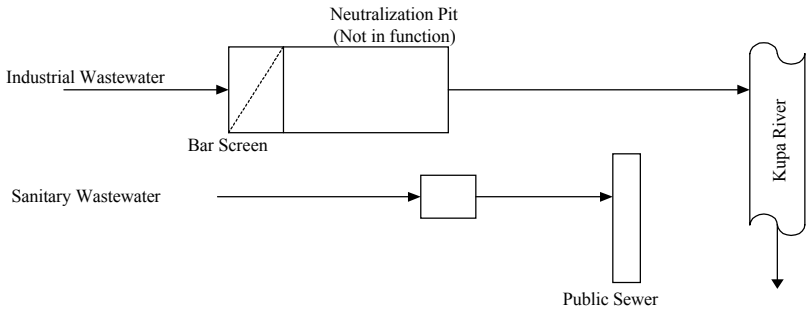
The required total construction cost is estimated at Kn. 7.46 million. For details, see Appendix C, Subsection 6.3.5.

4.2.13 Velebit (Karlovac)

(1) Existing Wastewater Discharge System

The factory with 280 employees produces cotton cloth. The process wastewater is directly discharged into the Kupa River through a neutralization pit (but functioning as only a pond at present due to lack of chemical feeding equipment). The sanitary wastewater is discharged to the public sewerage with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the existing sewerage system covers the area of the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

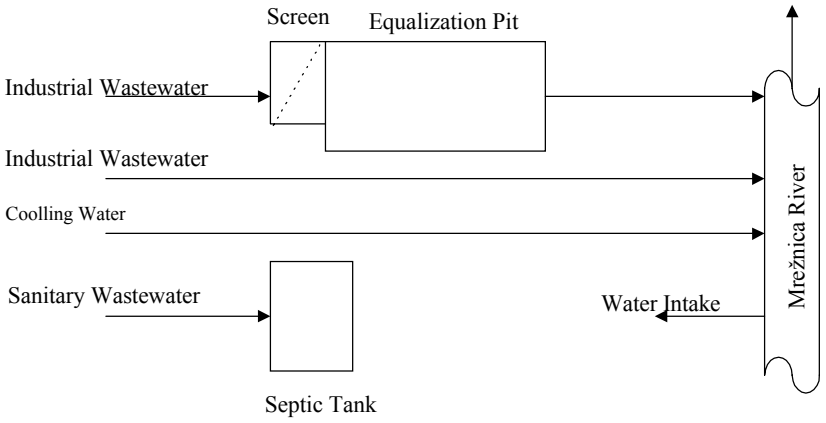
The wastewater quantity is estimated to increase from 248 m3/d in 1999 to 410 m^3/d in 2015, by assuming the unit wastewater of Category B. Since the effluent quality meets the permissible limits to public sewerage at present, no improvement of the existing treatment system is necessary.

4.2.14 Lola Ribar (Karlovac)

(1) Existing Wastewater Discharge System

The factory with 352 employees produces cotton and gauze. The process wastewater is discharged into the Mrežnica River either through an equalization pit or with no treatment. On the other hand, the cooling water is discharged to the river with no treatment and the sanitary wastewater is treated by septic tank.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage since the sewerage system is planned to cover the area of the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

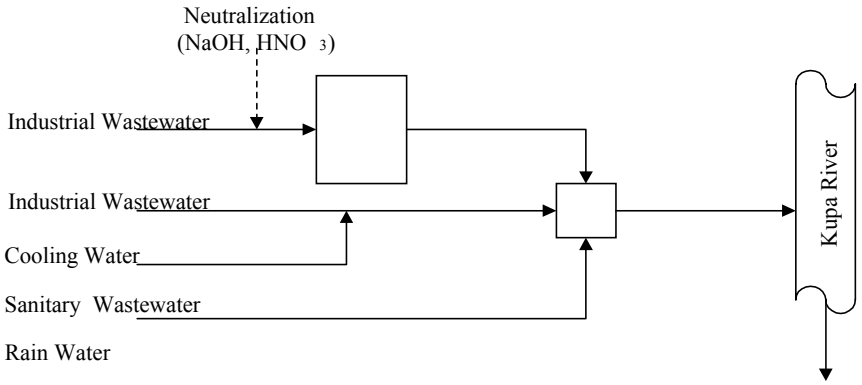
The wastewater quantity (excluding cooling water) is estimated to increase from 307 m^3/d in 1999 to 507 m^3/d in 2015, by assuming the unit wastewater of Category B. Since the effluent quality meets the permissible limits to public sewerage at present, no improvement of the existing treatment system is necessary.

4.2.15 Karlovacka Industrija Mlijeka (Karlovac)

(1) Existing Wastewater Discharge System

The factory with 174 employees processes milk and dairy products. The process wastewater is discharged into the Kupa River either through a neutralization pit or with no treatment. The cooling/sanitary wastewater is discharged to the river with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of wastewater will be changed from river to public sewerage since the sewerage system is planned to cover the industrial area and the effluent quality of this industry does not present a problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity (excluding cooling water) is estimated to increase from 250 m^3/d in 1999 to 413 m^3/d in 2015, by assuming the unit wastewater of Category B. Although the existing effluent quality meets the permissible limits to public sewerage, an additional neutralization tank is necessary to meet the increasing wastewater quantity.

(c) Construction Cost

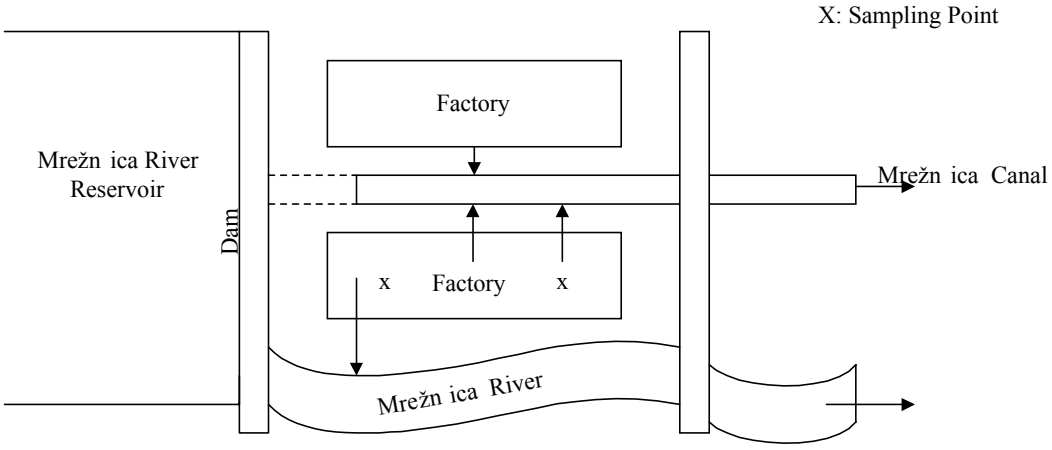
The required total construction cost is roughly estimated at Kn. 0.5 million.

4.2.16 Pamucna Industrija Duga Resa d.d. (Duga Resa)

(1) Existing Wastewater Discharge System

The factory produces cotton clothes. It is provided with 16 outlets to discharge the wastewater including sanitary wastewater and rainwater. However, most of the wastewater is directly discharged through four (4) outlets into the Mrežnica River and the by-pass canal with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of the wastewater will be changed from the river to the public sewerage since the sewerage system is planned to cover the area of the industry and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 2,416 m^3/d in 1999 to 3,992 m^3/d in 2015, by assuming the unit wastewater of Category B. Since the existing effluent quality meets the permissible limits to public sewerage except pH, only a pH control unit should be installed.

(c) Construction Cost

The required total construction cost is roughly estimated at Kn. 0.3 million.

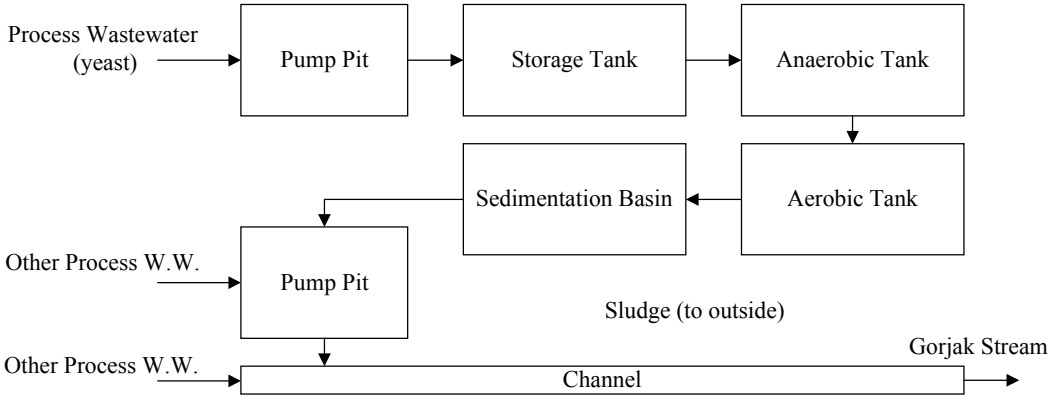
4.2.17 Pliva (Zaprešić)

(1) Existing Wastewater Discharge System

The factory with 2,000 employees produces pharmaceuticals, bulk pharmaceuticals, animal health products and agrochemicals, foodstuffs, cosmetics and personal hygiene products.

The process wastewater is discharged into the neighboring Gorjak Brook and finally, into the Sava Main River after the biological treatment. The cooling water is directly discharged through the same stream with no treatment.

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of the wastewater will be changed from the stream to the public sewerage. This is because the sewerage system of Zaprešić Town is planned to receive also the industrial wastewater from the surrounding areas and treat it by a central sewage treatment plant, and because the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 1,928 m^3/d in 1999 to 3,186 m^3/d in 2015, by assuming the unit wastewater of Category B. Although the existing treatment system will be able to treat the wastewater to the permissible limits to public sewerage when a minor improvement is made, the wastewater quantity will increase by 1,260 m^3/d in 2015. Hence, an additional plant of the same process as the existing one needs to be constructed to cope with the increased wastewater.

(c) Construction Cost

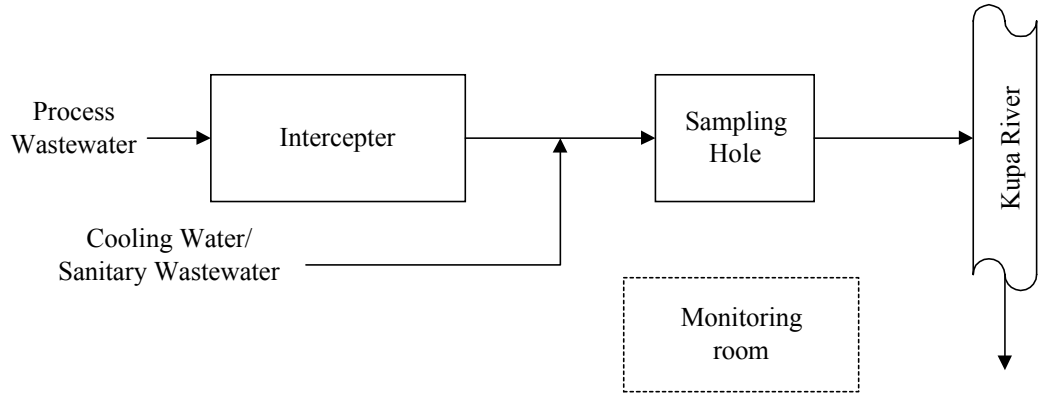
The total construction cost is roughly estimated to be Kn. 15.3 million, composed of Kn. 0.3 million for the improvement of the existing plant and Kn. 15.0 million for the construction of a new plant.

4.2.18 Gavrilovic d.d. (Petrinja)

(1) Existing Wastewater Discharge System

The factory produces cooked sausage, meat specialties, canned meat, cured/smoked and dried meat, and ready-to-eat meals. The process wastewater is discharged into the Kupa River through one (1) outlet with interceptor to remove fat and scum. The cooling water and sanitary wastewater is discharged through the same outlet with no treatment

The existing wastewater discharge system is shown below. For the wastewater quantity and quality, see Table I.4.2.



(2) Development of Wastewater Treatment

(a) Selection of Recipient

The recipient of wastewater will be changed from the river to the public sewerage. This is because the sewage treatment plant of Petrinja Town is proposed near the existing outlet of the industrial wastewater to the river and the effluent quality of this industry has no problem in sewage treatment.

(b) Proposed Improvement of Treatment System

The wastewater quantity is estimated to increase from 1,357 m^3/d in 1999 to 1,979 m^3/d in 2015, by assuming the unit wastewater of Category B. Although the existing effluent quality meets the permissible limits to public sewerage, the wastewater will increase by 630 m^3/d in 2015. Hence, an additional plant of the same treatment system as the existing one will be necessary to cope with the increase wastewater quantity.

(c) Construction Cost

The total construction cost is roughly estimated to be Kn. 1.0 million.

4.3 Other Large Industries

The existing wastewater quantity, quality, treatment system and wastewater recipient of the other 33 large industries are summarized in Table I.4.3. The estimated future wastewater quantity in 2015 is also given in the same table. Some improvement of the existing treatment systems will be necessary for the following 19 industries. The required total improvement cost of the existing treatment systems is estimated to be Kn. 37.5 million.

Town	Industry Name	Wastewater (m^3/d)		Wastewater Recipient		Improvement of WWTP	Const. Cost (million Kn)
		1999	2015	Present	Future		
Karlovac	Kordun Karlovac	128	212	Sewerage	Sewerage	Necessary	0.50
	Ze-Ce	305	504	Sewerage	Sewerage	Necessary	0.70
	Tvornica Plinski Turbuna	134	221	Sewerage	Sewerage	Necessary	0.50
	Adria-Diesel	129	213	Sewerage	Sewerage	Necessary	0.50
	Autotransport d.d.	104	172	Sewerage	Sewerage	Necessary	0.30
Ivanić Grad	INA Naftaplin Pogon ETAN	460	760	Sewerage	Sewerage	Necessary	1.00
	Crosco Naftini Servisi	200	330	Sewerage	Sewerage	Necessary	0.50
	Naftalan Ljeciliste	117	193	Sewerage	Sewerage	Necessary	0.30
	INA Naftaplin Radiliste Oroi	229	378	Brook (II)	Brook (II)	Chemical Clarifier	1.50
Samobor	Imes	89	147	Sewerage	Sewerage	Activated Sludge	4.20
	PLIVA Kalinovica	578	955	River (II)	River (II)	Chemical Clarifier	5.00
	TOP	207	342	River (II)	River (II)	Chemical Clarifier	2.40
Zaprešić	HZ Infrastrucktura	275	454	Sewerage	Sewerage	Oil trap	0.30
	Inker	391	646	River (II)	River (II)	Chemical Clarifier	3.50
	Viadukt	242	400	River (II)	River (II)	Activated Sludge	7.50
Jastrebarsko	Mladina d.d.	109	180	Sewerage	Sewerage	Necessary	0.30
	Jamnica Zagreb, Jamnika Kiselica	736	1,216	Canal (II)	Canal (II)	Chemical Clarifier	5.00
Ogulin	Opca Bolnica Ogulin	206	340	Under-ground	Sewerage	Necessary	0.50
	Bjelolasic	163	269	Brook (II)	Brook (II)	Necessary	3.00
Total							37.50

4.4 Summary of Industrial Wastewater Treatment

The 51 selected large industries in the Study Area discharge a total wastewater of 45,471 m^3/d into the public sewerage and the rivers at present (1999). Of the 51 industries, 18 are large pollutant industries sharing approximately 80%. The total wastewater quantity is projected to increase to 74,890 m^3/d in 2015.

On the other hand, the existing total pollution load effluent (BOD) of the 51 industries is estimated to be 5,135 kg/d in 1999. The BOD load is mostly (88%) discharged from the 18 large pollutant industries. Many large pollutant industries will change their recipients from river to public sewerage and the industries that discharge into the rivers are required to comply with the strict regulations. Hence, the industrial pollution load into the sewerage will increase, while the pollution load into the rivers will decrease. As a result, the total pollution load effluent will be maintained at almost the present level even in 2015 by means of improvement of the existing treatment system.

The existing (1999) and future (2015) wastewater quantity and pollution load effluent (BOD) are broken down by industry and by recipient as shown below. For details, see Table I.4.4 and Table I.4.5.

Industry	Recipient	Wastewater Quantity (m^3/d)		Pollution Load (BOD, kg/d)	
		1999	2015	1999	2015
18 Large Pollutant Industries	Sewerage	3,855	22,496	1,494	4,175
	River	33,143	38,390	3,041	644
	Sub-total	36,998	60,886	4,534	4,818
Other 33 Large Industries	Sewerage	5,277	9,064	402	622
	River	3,196	4,940	199	125
	Sub-total	8,473	14,004	601	747
Total Large Industries	Sewerage	9,132	31,560	1,896	4,797
	River	36,339	43,330	3,240	769
	Total	45,471	74,890	5,135	5,565

The required total construction cost for the improvement of treatment systems is roughly estimated to be Kn. 128 million (including direct construction cost, indirect construction cost, VAT, Customs Duties, and contingency). It is broken down into Kn. 90 million for the large pollutant industries and Kn. 38 million for the other large industries. The required construction cost for each industry is also shown in Table I.4.4 and Table I.4.5.

CHAPTER V SEWERAGE DEVELOPMENT

5.1 Planning Basis

5.1.1 National Policy for Sewerage Development

The government had established a national sewerage development program in the National Water Protection Plan (NN No. 8/99). The construction of public sewerage system and wastewater treatment plant will be implemented in three (3) stages as mentioned below; namely, short term program up to 2005, medium term program up to 2010, and long term program up to 2025. The discharge of sewerage wastewater into Category I watercourses is not permitted irrespective of the treatment level.

(1) The construction of public sewerage system from which wastewater is to be discharged into the watercourse should be completed by:

   (a) 2005, for facilities greater than 15,000 PE that discharge wastewater into Category III and Category IV watercourses;

   (b) 2010, for facilities between 2,000 PE and 15,000 PE that discharge wastewater into Category III and Category IV watercourses; and

   (c) 2005, for facilities of over 10,000 PE that discharge wastewater into Category II watercourses.

   However, the target year for facilities smaller than 10,000 PE that discharge wastewater into a Category II watercourse has not been determined yet.

(2) As regards the construction of wastewater treatment plant, this can go ahead when the construction of at least 70% of the total capacity of the sewerage system has been completed.

(3) The construction of secondary treatment plant (biological treatment) from which wastewater is to be discharged into watercourses should be completed by:

   (a) 2010, for facilities greater than 15,000 PE that discharge effluent into Category III and Category IV watercourses;

   (b) 2025, for facilities between 2,000 PE and 15,000 PE that discharge effluent into Category III and Category IV watercourses; and

   (c) 2005, for facilities of over 10,000 PE that discharge effluent into Category II watercourses.

   However, the target year for facilities smaller than 10,000 PE that discharge effluent into a Category II watercourse has not been determined yet.

5.1.2 Objective Urban Centers for Sewerage Master Plan Study

Twenty-four (24) urban centers with 22 sewerage systems were selected for the master plan study on sewerage development based on the National Water Protection Plan. The selected urban centers meet either of the following criteria.

(1) Urban centers that are expected to discharge wastewater of over 2,000 PE in 2015.

(2) Urban centers that are located in areas where drinking water sources may be affected.

The selected urban centers are shown below. For location of the selected objective urban centers, see Fig. I.5.1

Zagareb, Sesvete East, Dugo Selo, Sveni Ivan Zelina, Vrbovec, Ivanić Grad – Kloštar Ivanić, Samobor Zaprešić, Velika Gorica, Jastrebarsko, Sisak, Petrinja, Glina, Topusko, Popovača, Kutina, Lipovljani, Novska, Karlovac – Duga Resa, Ogulin, Plaški, Slunj

Among the above selected urban centers, Ivanić Grad, Kloštar Ivanić, Karlovac and Duga Resa are administratively independent of each other. However, they are integrated into two (2) sewerage systems; namely, Ivanić Grad-Kloštar Ivanić and Karlovac-Duga Resa.

5.1.3 Permissible Quality of Plant Effluent

The permissible limits of effluent (TSS, BOD, COD-Cr, T-N, T-P) discharged into water from the sewage treatment plant are prescribed in NN No. 40/99. They vary according to the size of the treatment plant and the category of the receiving water, as follows.

Category	Plant Size	TSS (mg/l)	BOD (mg/l)	COD-Cr (mg/l)	T-P (mg/l)	T-N (mg/l)
Water Course II	< 10,000 PE	60	40	150	-	-
(sensitive area)	10,000 PE - 100,000 PE	35	25	125	2	15
	> 100,000 PE	35	25	125	1	10
Water Course III	< 10,000 PE	120 - 150	-	-	-	-
(less sensitive area)	> 10,000 PE	35	25	125	-	-
Water Course IV	< 10,000 PE	appropriate	-	-	-	-
(less sensitive area)	10,000 PE - 50,000 PE	120 - 150	-	-	-	-
	> 50,000 PE	35	25	125	-	-
Lake V (sensitive area)	All Plants	35	25	125	1	10

Wastewater discharge into Category I watercourse (very sensitive area) is not allowed irrespective of the treatment level. For the category of major rivers in the Study Area, see Chapter III.

5.1.4 Wastewater Flow

The wastewater of sewerage system includes domestic, institutional and industrial (including commercial) wastewater, and groundwater infiltration. There are a number of industries in the Study Area, and the wastewater of large industries is estimated individually in Chapter IV. The wastewater of the remaining small industries is dealt as part of the municipal wastewater, as well as domestic and institutional wastewater.

(1) Design Unit Municipal Wastewater Quantity

(a) Unit Municipal Water Consumption

The existing domestic water consumption in the Study Area (household use only) ranges from 80 l/capita/day (lcd) to 170 lcd, mostly less than 150 lcd. It is nearly constant irrespective of the population size of town. However, domestic water consumption in the urban centers is larger than the above average value. Hence, the existing domestic water consumption in the objective sewerage development areas is assumed to be 170 lcd.

On the other hand, the unit municipal water consumption (including domestic, institutional and small industry uses) increases according to the population size of town. The unit municipal water consumption in the Study Area is classified into 190 lcd for towns with less than 10,000 inhabitants and 230 lcd for towns

with 10,000 population or more. For details, see Appendix D, Subsection 1.3.1.

The future unit municipal water consumption will increase according to the improvement of living standards. The annual growth rate is assumed at 2%.

(b) Unit Municipal Wastewater

Most of the consumed municipal water returns to the sewerage system. The unit municipal wastewater is estimated from the unit municipal water consumption on the assumption that the return rate is 80%.

(c) Municipal Wastewater Fluctuation

The wastewater flow seasonally fluctuates throughout the year. Therefore, the capacity of treatment plant is usually designed to meet the daily maximum wastewater flow in the month when the largest water consumption occurs. The daily maximum ratio (ratio of the daily maximum in the largest consumption month to the daily average) in the towns of the Study Area is in the range of 1.10 and 1.30. In this study, the daily maximum ratio is assumed at 1.30 for safety. The wastewater flow also hourly varies. Therefore, the capacity of sewer and pump is designed to meet the maximum hourly wastewater flow. The hourly maximum ratio to the daily maximum is estimated, based on the data of inflow to the treatment plant of Kutina Town in the driest season (July and August) when the effects of storm water are negligible. The estimated ratio is 1.50. For details, see Appendix D, Subsection 1.3.1.

(d) Groundwater Infiltration

Groundwater infiltration is usually expressed as a ratio of the infiltrated groundwater to the municipal wastewater quantity. Ratio of groundwater infiltration is estimated from the inflow data of the Kutina treatment plant in the driest season (July and August) when the storm water effects are negligible. The estimated ratio is 30%. For details, see Appendix D, Subsection 1.3.1.

(e) Design Unit Municipal Wastewater Quantity

The design unit municipal wastewater quantity and groundwater infiltration for the master plan study targeting the year 2015 is summarized below.

(Unit: l/capita/day)

Population Size		<10,000	>10,000
Daily Average	Domestic	190	190
	Institutional/small industry	30	70
	Municipal	220	260
	Infiltration	70	70
	Total	290	330
Daily Maximum	Domestic	240	240
	Institutional/small industry	30	90
	Municipal	270	330
	Infiltration	70	70
	Total	340	400
Hourly Maximum	Domestic	370	370
	Institutional/small industry	40	130
	Municipal	410	500
	Infiltration	70	70
	Total	480	570

(2) Design Unit Pollution Load of Municipal Wastewater

(a) Domestic Wastewater

The design unit pollution load of domestic wastewater is set at BOD = 60 g/capita/day, COD-Cr = 120 g/capita/day, TSS = 70 g/capita/day, T-N = 11 g/capita/day and T-P = 2.5 g/capita/day, by employing the design units widely used in Croatia, which are the same as the ATV Standards.

(b) Institutional and Small Industrial Wastewater

The design unit pollution load of institutional and small industrial wastewater is determined based on the following assumptions on pollution load concentration:

The BOD concentration of the wastewater is assumed at 200 mg/l. The concentration of COD-Cr, TSS, T-N and T-P are calculated at COD-Cr = 400 mg/l, TSS = 233.3 mg/l, T-N = 36.7 mg/l and T-P = 8.3 mg/l, by assuming the same ratio of BOD load to the other loads as in the domestic wastewater.

(3) Design Total Sewerage Wastewater

The wastewater quantity and quality of large industry is estimated individually. The industrial wastewater will be discharged into public sewerage in compliance with the government regulation. The total wastewater quantity and pollution loads into public sewerage are estimated by adding those of large industries to the municipal ones.

5.1.5 Wastewater Treatment

(1) Treatment of Nutrients (P, N)

The required sizes of the objective 22 sewage treatment plants are definitely smaller than 100,000 PE except the ongoing Zagreb Treatment Project. The sewage treatment plant with a size of 10,000 to 100,000 PE shall treat phosphorus (P) and nitrogen (N) up to the level: T-P < 2 mg/l, T-N < 15 mg/l when the effluent from the plant is discharged into a Category II water course.

Generally, the biological treatment process can coincidentally remove approximately 40% of T-P and about 30% of T-N. However, the application of an advanced treatment process is necessary to meet the government regulations. As shown in Table I.5.1, eleven (11) sewage treatment plants need to be provided with an advanced treatment process.

To check the feasibility of nutrients treatment, the three (3) typical treatment processes; namely, (i) conventional activated sludge (AS), (ii) anaerobic-oxic activated sludge (AO), and (iii) anaerobic-anoxic-oxic activated sludge (A_2O), are compared for the typical sewage influent in the objective urban centers (load: 30,000 PE, wastewater discharge: 10,000 m^3/d, BOD: 200mg/l, TSS: 200 mg/l, T-P: 5 mg/l, T-N: 30 mg/l).

The expected removal rates of BOD, TSS, T-P and T-N are shown below.

Case	Biological Treatment	Advanced Treatment (I)	Advanced Treatment (II)
Treatment Process	Conventional Activated Sludge (AS)	Anaerobic-Oxic Activated Sludge (AO)	Anaerobic-Anoxic-Oxic Activated sludge (A_2O)
Removal Rate			
BOD	< 25 mg/l	< 25 mg/l	< 25 mg/l
TSS	< 35 mg/l	< 35 mg/l	< 35 mg/l
T-P	Coincidentally 40%	< 2.0 mg/l	< 2.0 mg/l
T-N	Coincidentally 30%	Coincidentally 30%	< 15 mg/l

Operation of the AO process is not difficult. On the other hand, operation of the A_2O process is very complicated and requires a hi-tech operation system.

The indices of the required construction and O&M costs for the above three (3) treatment processes are roughly estimated as follows.

Treatment Process	AS Process	AO Process	A_2O Process
Required Site Area	100	111	199
Construction Cost			
Civil	100	110	186
Mechanical	100	102	175
Electrical	100	110	140
Total	100	108	172
O&M Cost			
Electricity	100	104	218
Sludge Disposal	100	100	77

The additional cost required to treat T-P is less than 10%. However, approximately 100% of additional construction and O&M costs are necessary to treat both T-P and T-N, respectively.

The main objective of treatment of the above nutrients is to prevent or mitigate eutrophication problems (excessive growth of phytoplankton), which are liable to occur in lakes, reservoirs and other stagnant water areas due to the excessive concentration of nutrients (T-P, T-N). However, in the Study Area, there is no potential water area, except Lonjsko Polje, where eutrophication problems may be caused by the wastewater of the above-mentioned 24 objective urban centers.

Generally, T-P is considered more critical for the growth of plankton than T-N in inland stagnant water areas. Hence, the control of T-P shall be given priority.

Therefore, only the treatment of T-P is considered in this master plan study (target year: 2015). The treatment of T-N is considered as one of the long-term measures

defined in the National Water Protection Plan. It is not included in the master plan, but it should be implemented after 2015.

From the above discussions, the permissible limits of effluent of the objective sewage treatment plants were determined, as shown in Table I.5.1.

(2) Selection of Wastewater Treatment Process

(a) Alternative Treatment Processes

The treatment processes for this alternative study were selected from among the processes that have been widely developed in consideration of the following conditions:

(i) The treatment plant with a size of less than 10,000 PE shall be designed to treat wastewater to BOD 40mg/l when the effluent is discharged into a Category II river. In this case, the biological processes that require a high operation/maintenance technology are not recommended.

(ii) The treatment plant of a size larger than 10,000 PE shall be designed to treat wastewater to BOD 25mg/l and T-P 2mg/l when the effluent is discharged into a Category II river. In this case, the applicable processes are technically limited.

(iii) The treatment plant of a size larger than 10,000 PE shall be designed to treat wastewater to BOD 25mg/l when the effluent is discharged into a Category III river. Such a large plant is proposed for large urban centers where available land space is limited. Hence, treatment processes that require a large land space such as aerated lagoon are not recommended.

From the above considerations, the following treatment processes were selected for the study on alternatives. For the flowchart of the treatment processes, see Appendix D, Fig. D.1.2 and Fig. D.1.3.

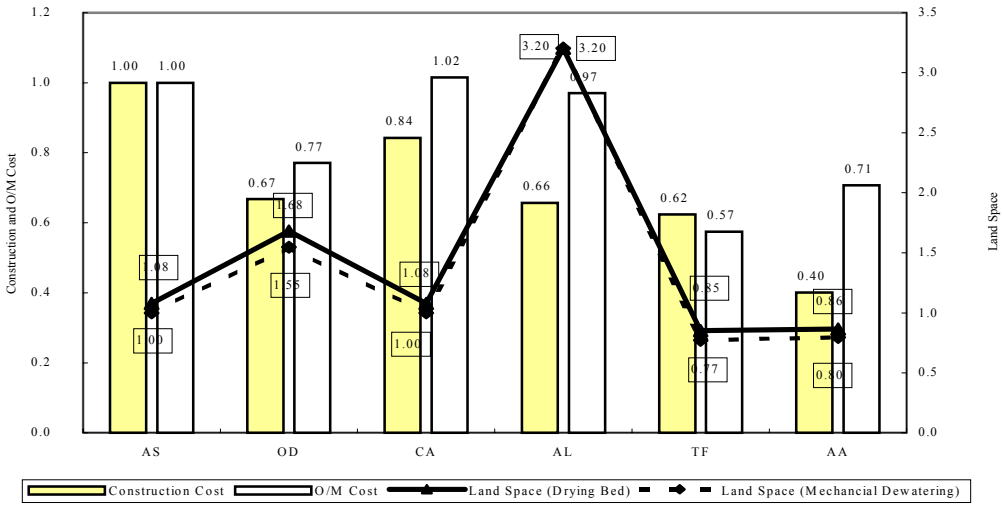
Plant Size	Category II	Category III
< 10,000 PE	Activated Sludge (AS) Oxidation Ditch (OD) Contact Aeration (CA) Aerated Lagoon (AL) Trickling Filter (TF) Aeroaccelerator (AA)	Sedimentation
> 10,000 PE	Anaerobic Oxic Process (AO) Activated Sludge with Coagulation (AS+CO) Cyclic Activated Sludge Technology (CAST)	Activated Sludge (AS) Oxidation Ditch (OD) Cyclic Activated Sludge Technology (CAST)

(b) Optimum Treatment Process

The optimum treatment process was selected from among those listed in the above table by comparing their required construction cost, O&M cost and land space, and technical problems in operation. In this comparison, the treatment processes are designed to treat the following influent: Q = 1,500 m^3/d, BOD = 200 mg/l, TSS = 200 mg/l for the case of small plant size, and Q = 10,000 m^3/d, BOD = 200 mg/l, TSS = 200 mg/l for the case of large plant size. The results are described below.

(i) Case A: Plant Size <10,000 PE; Receiving River: Category II

The required construction cost, O&M cost and land space of the six (6) processes (AS, OD, CA, AL, TF and AA) are compared in index as shown in the figure below.

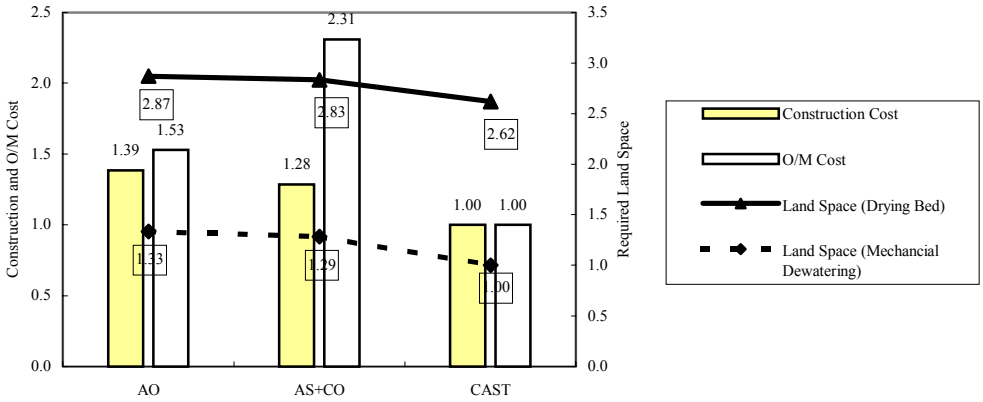


In this cost comparison, sludge treatment cost is not included. On the other hand, the required land space varies according to the sludge treatment method. Hence, the required land space of the treatment plant is estimated for two (2) cases of sludge treatment; namely, (i) Thickener + Drying Bed, and (ii) Thickener + Mechanical Dewatering. Both two (2) cases are shown in the same figure.

- The construction and O&M costs of TF and AA are comparatively small. However, their treatment efficiency is limited. The maximum efficiency is 80%. The treatment efficiency of TF is considered to further decrease in winter season. They cannot meet the permissible limit when the influent quality exceeds BOD 200 mg/l. TF and AA are not recommended since the influent quality is considered to frequently exceed BOD 200 mg/l.
- AL requires a large land space and O&M cost although the construction cost is comparatively small. The treatment efficiency varies depending on the water temperature. The treatment efficiency may lower considerably in winter season. It is not reliable except in Topusko where the influent water temperature is high due to the wastewater from the hot spring resort.
- The construction and O&M costs of AS are high although the required land space is small. Further, it requires a comparatively high technology in operation.
- OD is the most widely used process in small towns or villages. The operation is easy. Hence, this process is proposed in the master plan.

(ii) Case B: Plant Size >10,000 PE; Receiving River: Category II

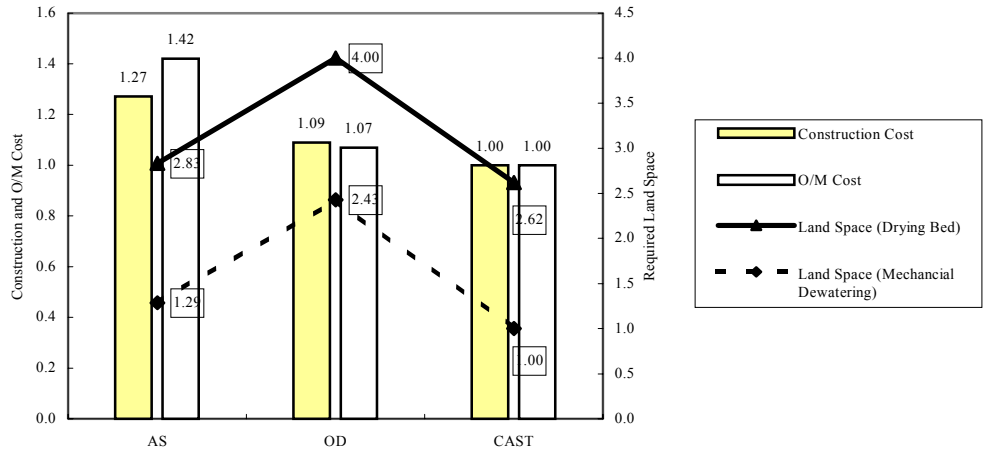
The required construction cost, O&M cost and land space of the three (3) processes (AO, AS+CO and CAST) are compared in index in the same way as Case A. The results are also shown in the figure below.



- The construction and O&M costs of CAST are both the smallest. However, CAST requires a high level of technology in operation, especially in the case of the combined sewerage system. The plant operation rule must be changed according to the fluctuation of the influent quantity and quality. Usually, an automatic control system must be installed for satisfactory operation; however, experienced operators are also necessary to operate the automatic control system in accordance with the fluctuation of influent. Hence, this system is not recommended.
- AS+CO requires a higher O&M cost due to the requirement of additive input. Further, it produces a large quantity of sludge.
- On the other hand, AO is the most widely used process for removal of T-P. Hence, AO is proposed in the master plan.

(iii) Case C: Plant Size >10,000 PE; Receiving River: Category III

The required construction cost, O&M cost and land space of the three (3) processes (AS, OD and CAST) are compared in index in the same way as Case A. The results are also shown in the figure below.



- CAST is not recommended from the reasons mentioned above.
- OD will not meet the future requirement of T-P removal. Further, OD requires a larger land space. It is usually not suitable in urban areas.
- AS is the most prevailing process for the treatment plant of a larger capacity. Further, AS can easily meet the future requirement of T-P removal only by adding anaerobic tank to the aeration tank. Hence, AS is proposed in the master plan.

(3) Selection of Sludge Treatment Method

(a) General

The wastewater treatment produces a large quantity of sludge everyday. Hence, the sludge treatment process is as important as wastewater treatment in designing a sewage treatment plant. The sludge treatment process consists of the following three (3) kinds of unit processes: thickening, digestion and dewatering. The most cost effective sludge treatment process is obtained through the optimum combination of these unit processes.

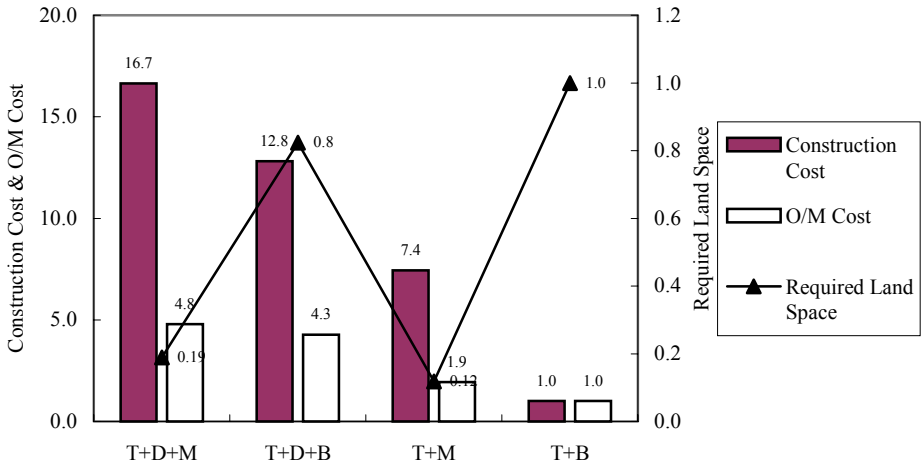
(i) Thickening is a process to condense the sludge extracted from the treatment plant so that the size of the subsequent processes can be minimized.

(ii) Digestion process has the following major functions: (i) reduction of disease population existent in sludge, (ii) reduction of total solid mass by emitting carbon dioxide and methane gas, and (iii) improvement of dewaterability. The digestion tank must maintain a high temperature (about 35°C) to obtain a satisfactory digestion of sludge, resulting in the tank-heating requirement.

(iii) Dewatering has the purpose to reduce the sludge volume of final disposal. There are two (2) types of dewatering processes: (i) air drying process, and (ii) mechanical process.

(b) Selection of Optimum Sludge Treatment Process

The construction cost, O&M cost and required land space are compared for four (4) alternative sludge treatment processes prepared by combining the above-mentioned three (3) kinds of unit processes. In all of these alternatives, the thickening process is used since it is essentially necessary to reduce the required capacity of the subsequent processes. Results of the comparison are shown in terms of index below.



Note: T: Thickener; D: Digestion Tank; M:Mechanical Dewatering (Belt Filter); B: Drying Bed

As evident from the above comparison, the alternatives with digester (T+D+M; T+D+B) require larger construction and O&M costs compared to the other processes (T+M; T+B). Besides, the digester requires a large energy in winter and a high investment cost and O&M technology.

The (T+B) alternative is definitely economical in construction and O&M costs. However, it requires a large land space and emits odor that may affect the people living in the areas surrounding the treatment plant. Hence, the (T+M) alternative is applied for the treatment plant with the size larger than 10,000 PE and the (T+B) alternative is proposed for the treatment plant with the size of less than 10,000 PE.

5.1.6 Cost Estimate

The construction cost of collector and treatment plant is estimated as below. In this estimate, the currency exchange rate at the end of February 2001 is employed as follows: US$1.00 = Kn. 8.3 = JP¥116.

Item	Remarks
(1) Direct Construction Cost	
(2) Land Acquisition Cost	
(3) Engineering Cost	10% × (1)
(4) Administration Cost	3% × (1)
(5) Customs Duties	10% of Mechanical/Electrical Works
(6) VAT	22% × [(1) + (3)]
(7) Contingency	20% × (1)

5.2 Sewerage Development for Zagreb City

5.2.1 Existing Sewerage System

The following descriptions exclude the existing system of Sesvete East, which is independent of the system of Zagreb City, although Sesvete East administratively belongs to the city.

(1) Service Area, Population and Industries

Zagreb City had developed on both left and right banks of the Sava River. The city consists of 70 settlements covering a total area of 63,378 ha, which are urbanized. The total population was 920,200 in 1999, of which 800,000 was served by a sewerage system. The service area is about 25,600 ha, including 235 ha of industrial zone. About 230 industries are connected to the existing sewerage system; however, most of the industries are not provided with appropriate pre-treatment facilities. The existing sewerage service area is shown in Fig. I.5.2.

(2) Sewer Networks

The sewer networks of combined type were developed independently on the left and right banks, and the collected wastewater is discharged into the Sava River at the downstream end of the city. There is no treatment plant on the sewerage system.

The total length of the existing pipes is approximately 1,500 km comprising 1,000 km of primary/secondary collectors and 500 km of tertiary sewers. The maximum and minimum diameters of the pipes are 800 cm to 540 cm and 20 cm, respectively. The sewer networks are provided with 12 pumping stations with capacities of 72 m^3/h to 300 m^3/h.

5.2.2 Sewerage Development Project

(1) General

The central wastewater treatment project of Zagreb (CWWTPZ) is ongoing. The treatment plant is proposed at a location on the left bank of the Sava River in the downstream end of the city. The wastewater in the right bank side of the city will be conveyed to the treatment plant by a pipe that crosses the river. This project is being implemented through the BOT system. The concessionaire (ZOV: a consortium of German and Croatian companies) was selected in December 2000.

(2) Project Features

The total service area of the project is as follows.

Service Area	Area (ha)
Urban Part of Zagreb on the Left Bank	8,247.9
Medvednica Catchments Area	14,217.1
Right Bank Catchment Area	1,112.5
Total	23,557.5

The present and future wastewater generation and influent pollution loads are as follows.

Parameter	Unit	Present (1997)	Future (2015-2020)
Water Consumption/Household	m^3/day	208,000	283,040
Water Consumption/Industry	m^3/day	90,000	172,500
Population Served	Person	750,000	935,000
Wastewater Flow	m^3/day	238,000	442,370
Population Equivalent	PE	1,000,000	1,500,000
BOD_5 Load	Kg/day	60,000	90,000
COD-Load	Kg/day	103,050	191,540
TSS (Total Suspended Solids) Load	Kg/day	91,000	136,430
TN (Total Nitrogen) Load	Kg/day	13,000	19,640
TP (Total Phosphorus) Load	Kg/day	3,000	4,500

The receiving water of this project (Sava Main River between Zagreb and Sisak) is classified as Category III (less sensitive area) at present. The effluent from the treatment plant should conform to the following permissible limits of quality.

Parameter	Concentration (mg/l)	Lowest Reduction Rate (%)
BOD_5 at 20°C	25	70 - 90
COD	125	75
Total Dissolved Substances	35	90

The major construction works of the project are summarized below.

Type	Dimension/Features
Collector/Culvert	21,850 m
Force Main	4,200 m
Outlet Channel	2,150 m
Pump Stations	1 place, 1.5 m^3/s
Wastewater Treatment Plant	Biological Treatment Process

The treatment site covers a total area of 100.3 ha. However, the land has not been acquired yet.

The concessionaire is responsible for the construction and operation of the treatment plant that has the following capacity: Q in Dry Period = 20,050 m^3/h (5.6 m^3/s) and Q in Rainy Period = 37,790 m^3/h (10.5 m^3/s).

For location of the proposed collectors and treatment plant, see Fig. I.5.2.

(3) Construction Cost

Total construction cost of the project is approximately DM 350 million.

5.3 Sewerage Development for Sesvete East

5.3.1 Existing Sewerage System

(1) Service Area, Population and Industries

Sesvete is one of the settlements in Zagreb City that is located in the eastern part. Sesvete East covers a part of the Sesvete settlement, namely, the south-east fringe area consisting of eight (8) communities.

The sewerage system of Sesvete East is independent from that of Zagreb City. The existing sewerage served population and service area are approximately 11,900 and 555 ha, respectively. The existing sewerage service area and sewer networks are shown in Fig. I.5.3.

There are two (2) large industries: Agroproteinka (food/beverage) and Duma Koža (leather). The wastewater of these industries is not discharged into the sewerage system but into a neighboring canal with simple pre-treatment. The discharged industrial wastewater is finally drained into the Crnec River at Dugo Selo in the downstream.

(2) Sewer Network

The sewer network collecting the municipal wastewater of 555 ha discharge the wastewater into the Crnec River with no treatment. The system is a combined one.

The sewer network of the area is almost completed for a total sewer length of about 42,000 m.

5.3.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

The proposed sewerage development will cover the entire area and population of the eight (8) communities in Sesvete East. The above-mentioned existing two (2) large industries will also be served by the sewerage system. The service area will extend from 555 ha to 837 ha and the served population will increase from 1,190 to 17,600. For location of the extended service area and served large industries, see Fig. I.5.3.

(b) Wastewater Flow and Pollution Load

The total design wastewater flow and pollution load are determined as follows. The pollution load effluent from the industries to the sewerage system is estimated with pre-treatment. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 3.2.2.

	Municipality	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	5,808	1,598	7,407
Daily Maximum	7,040	1,598	8,639
Hourly Maximum (dry)	10,032	2,398	12,430
Hourly Maximum (rainy)	17,132	2,398	19,530
Pollution Load			
BOD Load (kg/d)	1,373	400	1,773 (29,600 PE)
BOD Concentration (mg/l)			205.2

(2) Structural Plan

A wastewater treatment plant is proposed at the left bank of the Crnec River to discharge into the Crnec River. The plant will treat all the municipal wastewater of the above eight (8) communities, as well as the industrial wastewater of Agroproteinka and Duma Koza.

(a) Transport Collector

To transport the wastewater to the treatment plant, the following seven (7) transport collectors are proposed.

Transport Collector	Length (m)	Diameter (cm)
T1	4,386	60 - 120
T0	1,000	40
T2	559	40 - 50
T3	835	30 - 50
T4	61	40
T5	1,220	460 m (30 cm), 760 m (10 cm, force main)
T6	1,377	40 - 60
Total	9,438	

Part of T1 is under construction. All of the transport collectors except a part of T5 are gravitational.

(b) Secondary/Tertiary Sewer

The secondary/tertiary sewers of 20 cm in diameter and with a total length of 3,270 m will be constructed to collect the wastewater of the extended service area of 282 ha.

(c) Treatment Plant

The Anaerobic-Oxic treatment process (AO) with a capacity of 29,600 PE will be used to treat the transported wastewater. The thickener and mechanical dewatering system will be used to treat generated sludge. The treatment plant requires 2.5 ha of land space and land acquisition has already been completed. For location of the proposed transport collectors and treatment pant, see Fig. I.5.3.

The dimensions of main facilities are summarized below.

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	1
Primary Sedimentation Tank	3.0 m W × 19.0 m L × 3.0 m D	4
Aeration Tank	5.0 m W × 32.0 m L × 5.0 m D	4
Secondary Sedimentation Tank	∅15 m × 3.5 m D	2
Belt Press Filter	1.5 m W × 1.5 kw	2

(3) Construction Cost

The construction cost is estimated at Kn. 66.5 million, broken down as follows:

	Cost (million Kn)
Direct Construction Cost	41.36
Collector	10.96
Transport/Main	9.35
Secondary/Tertiary	1.61
Treatment Plant	30.40
Land Acquisition	-
Indirect Construction Cost	16.91
Contingency	8.27
Total	66.54

5.4 Sewerage Development for Dugo Selo

5.4.1 Existing Sewerage System

(1) Service Area, Population and Industries

The town of Dugo Selo is located along the eastern suburbs of Zagreb City. The total population of the town was estimated at 15,326 in 1999 of which 10,570 lived in the urban area. The sewerage system serves not only the densely populated central urban area (300 ha) but also some surrounding areas at present. The existing sewerage service area and population are estimated to be approximately 516 ha and 9,100, respectively. The existing sewerage service area and sewer networks are shown in Fig. I.5.4. No large industries exist in the town.

(2) Sewer Network

The existing sewer networks are of combined type and their construction started in 1950. The total length of the existing sewer is 16,541 m. The diameter of sewer pipes ranges from 30 cm to 120 cm. The sewer network collecting the municipal wastewater of 516 ha discharge the wastewater into the neighboring canals through five (5) outfalls and finally into the Crnec River with no treatment. Municipal wastewater in all the sewerage area is discharged by gravity without pump.

5.4.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

The proposed sewerage development will extend the existing service area of 516 ha to 1,072 ha, increasing the total served population from 9,100 to 14,200. There are no large industries to be served. For location of the extended service area, see Fig. I.5.4.

(b) Wastewater Flow and Pollution Load

The total design municipal wastewater flow and pollution load are determined as below. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 4.2.2.

	Municipal Wastewater
Wastewater Quantity (m^3/d)	
Daily Average	4,686
Daily Maximum	5,680
Hourly Maximum (dry)	8,094
Hourly Maximum (rainy)	15,194
Pollution Load	
BOD Load (kg/d)	1,108 (18,500 PE)
BOD Concentration (mg/l)	195.0

(2) Structural Plan

A wastewater treatment plant is proposed at the left bank to discharge into the Crnec River. The plant will treat all the municipal wastewater of 1,072 ha. For location of the proposed transport collectors and treatment plant, see Fig. I.5.4.

(a) Transport Collector

To transport the wastewater to the treatment plant, the following three (3) transport collectors are proposed. All the transport collectors are gravitational.

Transport Collector	Length (km)	Diameter (mm)
T1	2.32	800 - 1,200
T2	0.50	800
T3	2.63	800 -1,000
Total	5.45	

(b) Secondary/Tertiary Sewer

Secondary/tertiary sewers of 400 mm in diameter and with a total length of 29.11 km will be constructed to collect the wastewater of the extended service area of 282 ha.

(c) Treatment Plant

The Anaerobic Oxic treatment process (AO) with a capacity of 18,500 PE will be used to treat the transported wastewater. The thickener and mechanical dewatering system will treat generated sludge. The treatment plant requires 1.4 ha of land acquisition.

The dimensions of main facilities are summarized below.

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	1
Primary Sedimentation Tank	3.0 m W × 12.0 m L × 3.0 m D	4
Aeration Tank	5.0 m W × 20.0 m L × 5.0 m D	4
Secondary Sedimentation Tank	∅12 m × 3.5 m D	2
Belt Press Filter	1.5 m W × 1.5 kw	2

(3) Construction Cost

The construction cost is estimated at Kn. 91.0 million, broken down as follows.

	Cost (million Kn)
Direct Construction Cost	56.76
Collector	31.60
Transport/ Main	8.77
Secondary/Tertiary	22.83
Treatment Plant	25.15
Land Acquisition	0.19
Indirect Construction Cost	22.66
Contingency	11.35
Total	90.96

5.5 Sewerage Development for Vrbovec

5.5.1 Existing Sewerage System

(1) Service Area, Population and Industries

The town of Vrbovec is located in a catchment area between the Lonja and Glogovnica rivers. The establishment of a food processing industry resulted in the present urban, industrial and commercial developments in the town. The total population of the town in 1999 is estimated at 13,435, of which 4,190 lived in the urban area.

The sewerage system serves not only the densely populated central urban area (238 ha) but also some surrounding areas at present. The existing service area and population are estimated to be approximately 393 ha and 5,000, respectively. The existing sewerage service area and sewer networks are shown in Fig. I.5.5.

There are three (3) large industries, but only one of them, Gradip, is served by the sewerage system. The other industry, PIK Vrbovec Farma Polijanski, is treated on

land and the remaining one, PIK Vrbovec Mesna, directly discharges wastewater into the canal with simple pre-treatment. PIK Vrbovec Mesna (food/beverage) is one of the largest industrial pollutant sources in the Sava River Basin.

(2) Sewer Networks

The sewerage wastewater of the town (including domestic, institutional, small industries and one large industry) is discharged into the neighboring two (2) canals, mostly into Canal Luka, through four (4) main collectors.

The sewer networks are of combined type, which have been constructed since 1977. The total length of the existing sewer pipes is approximately 28,000 m with diameters of 30 to 120 cm. The sewerage system is neither provided with pump nor treatment plant.

5.5.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

The proposed sewerage development will extend the existing service area of 393 ha to 791 ha, increasing the total served population from 5,000 to 8,400. Two (2) large industries (Gradip and PIK Vrbovec Mesna) will also be served. For location of the extended service area and served large industries, see Fig. I.5.5.

(b) Wastewater Flow and Pollution Load

The total design wastewater flow and pollution load are determined as follows. The pollution load effluent from the industries to the sewerage system is estimated with pre-treatment. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 5.2.2.

	Municipal	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	2,436	3,710	6,146
Daily Maximum	2,856	3,710	6,566
Hourly Maximum (dry)	4,032	3,803	7,835
Hourly Maximum (rainy)	6,287	7,326	13,613
Pollution Load			
BOD Load (kg/d)	554	669	1,224 (20,400 PE)
BOD Concentration (mg/l)			186.3

(2) Structural Plan

A wastewater treatment plant is proposed at the southern fringe of the town to discharge into the Luka Canal. The plant will treat all the municipal wastewater of the 791 ha, as well as the industrial wastewater of Gradip and PIK Vrbovec Mesna. For location of the proposed transport collectors and treatment plant, see Fig. I.5.5

(a) Transport Collector

To transport the wastewater to the treatment plant, the following three (3) transport collectors are proposed. All the transport collectors are gravitational.

Transport Collector	Length (km)	Diameter (mm)
T1	0.59	400
T2	0.85	400
T3	0.44	350
Total	1.88	

(b) Secondary/Tertiary Sewer

Secondary/tertiary sewers of 100 to 200 mm in diameter and with a total length of 21.7 km will be constructed to collect the wastewater of the extended service area of 398 ha.

(c) Treatment Plant

The Anaerobic Oxic treatment process (AO) with a capacity of 20,400 PE will be used to treat transported wastewater. The thickener and mechanical dewatering system will treat generated sludge. The treatment plant requires a land space of 1.2 ha.

The dimensions of main facilities are summarized below.

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	1
Primary Sedimentation Tank	3.0 m W × 14.0 m L × 3.0 m D	4
Aeration Tank	5.0 m W × 22.0 m L × 5.0 m D	4
Secondary Sedimentation Tank	∅13m × 3.5 m D	2
Belt Press Filter	1.5 m W × 1.5 kw	2

(3) Construction Cost

The construction cost is estimated at Kn. 78.2 million, broken down as follows.

	Cost (million Kn)
Direct Construction Cost	48.59
Collector	23.23
Transport/ Main	4.13
Secondary/Tertiary	19.10
Treatment Plant	25.35
Land Acquisition	0.20
Indirect Construction Cost	19.68
Contingency	9.72
Total	78.18

5.6 Sewerage Development for Sisak

5.6.1 Existing Sewerage System

(1) Service Area, Population and Industries

The town has developed on the flood plains of the Sava, Kupa and Odra rivers. The Kupa River divides the urban center of the town into two (2) parts. The central business area is located on the low-lying land encompassed by the right bank of the Sava River and the left bank of the Kupa River. The industrial zone is developed on the southern end of the left bank of the Kupa River.

Total population of the town in 1999 is estimated at 69,283 of which 44,175 lived in the urban area (1,770 ha). The sewerage system covers almost all the urban area. The sewerage service area and population are 944 ha and 39,400 persons or 89% of the total urban population of 44,175 persons. The existing sewerage service area, sewer networks and outfalls are shown in Fig. I.5.6 (1).

The heavy industries of oil refinery and steel have developed by taking advantage of land and inland transportation. There are six (6) large industries of which three (3) are served by the sewerage system while the others directly discharge wastewater into the rivers with no treatment or with insufficient pre-treatment as given below. INA oil refinery is one of the largest pollution sources in the Sava River.

Classification	Industry
Served by Sewerage	Herbos, Tvornica Segestica, Ljudevit Posavski Mlin i Pekare
Discharged to River	INA Zagreb Rafinerija Nafte Sisak, Zeljezara Poduzece Metaval, Termoelektrana Sisak

(2) Sewer Networks

The sewer networks are of combined type constructed since 1946. The sewerage service area is divided into two (2) areas; namely, the Old Sisak encompassed by the Sava, Kupa and Odra rivers, and the New Sisak extending on the right banks of Kupa River. The entire area of Old Sisak is drained through two (2) outfalls, each one with a pumping station, namely, PS Galdovo (capacity: 5.9 m^3/s) into the Sava River and PS Odra (capacity: 2.2 m^3/s) into the Odra River. The whole area of New Sisak is drained by gravity through seven (7) outfalls into the Kupa River.

Total length of the existing sewer pipes is approximately 77 km, consisting of 22 km of main collectors and 55 km of secondary sewers. The maximum and minimum diameters of the sewers are 200 cm and 20 cm, respectively. The existing sewerage system is not provided with a treatment plant.

5.6.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

The proposed sewerage development will extend the existing service area of 944 ha to 2,380 ha, increasing the total served population from 39,400 in 1999 to 52,400. There are six (6) large industries in the service area and three (3) of them (Herbos, Tvornica Segestica, and Ljudevit Posavski Mlin i Pekare) will be served. The existing recipients of the other three (3) industries will not change. For location of the extended service area and the six (6) large industries, see Fig. I.5.6 (1).

(b) Wastewater Flow and Pollution Load

The total design wastewater flow and pollution load are determined as follows. The pollution load effluent from the industries to the sewerage system is estimated with pre-treatment. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 6.2.2.

	Municipal	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	17,292	1,413	18,705
Daily Maximum	20,960	1,413	22,373
Hourly Maximum (dry)	29,868	1,582	31,450
Hourly Maximum (rainy)	55,268	3,164	55,432
Pollution Load			
BOD Load (kg/d)	4,087	311	4,398 (73,400 PE)
BOD Concentration (mg/l)			196.6

(2) Structural Plan

A wastewater treatment plant is proposed on the right bank at the southern end of the town to discharge into the Sava River. The plant will treat all the municipal wastewater of 2,380 ha along with the industrial wastewater of the above-mentioned three (3) factories.

(a) Transport Collector

Two (2) lines of transport collector are proposed to intercept the existing outfalls and convey the intercepted wastewater to the treatment plant. One of them is the New Sisak transport collector which will run for a total length of 5.78 km from the Zitna outfall to the treatment plant along the right bank of the Kupa and Sava rivers. The second transport collector is the Old-New Sisak transport collector which will connect the Goldovo Pumping Station to the New Sisak transport collector across the Kupa River for a length of approximately 0.5 km to convey the wastewater of the Old Sisak area.

For the design of the above transport collectors, two (2) issues need to be resolved. One of them is the transport collector that will receive the wastewater of the Stpuno area on the west bank of the Odra River, and the other is the way the Old-New Sisak transport collector will cross the Kupa River. To resolve these issues, the following four (4) alternatives are compared. Refer to Fig. I.5.6(2).

Alternative 1: Stpuno area is connected to New Sisak through a pipe that will cross the Kupa River and the Old-New transport collector will cross the Kupa River by siphon.

Alternative 2: Stpuno area is connected to New Sisak through a pipe that will cross the Kupa River and the Old-New transport collector will cross the Kupa River by hanging on the existing railway bridge.

Alternative 3: Stpuno area is connected to Old Sisak through a pipe that will cross the Odra River and the Old-New transport collector will cross the Kupa River by siphon.

Alternative 4: Stupno area is connected to Old Sisak through a pipe that will cross the Odra River and the Old-New transport collector will cross the Kupa River by hanging on the existing railway bridge.

In Alternative 2 and Alternative 4, a large pumping station is required for the Old-New transport collector to transport the wastewater by pressure across the Kupa River.

The total construction cost including construction and O&M costs of each of the above four (4) alternatives are compared in terms of present value at 5% discount rate, as shown below.

Present Value	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Construction Cost (10^6 Kn)	10.4	8.4	8.9	6.8
O&M Cost (10^3 Kn/year)	64	300	64	300
Total Present Value (10^6 Kn)	11.2	12.1	9.6	10.5

As evident from the above table, Alternative 3 is the most economical. Hence, it is proposed.

The main features of the proposed transport collectors are shown below. All the transport collectors are gravitational except one (1) location. A pumping station is proposed at the connection point of Old-New Sisak and New Sisak transport collectors.

Transport Collector	Length (km)	Diameter (mm)
Old-New	0.37	800
Old-New (Siphon)	0.19	500×2
New Sisak (Zitna Outfall - Victorovac Outfall)	1.42	450
New Sisak (Victorovac Outfall - Railway Bridge)	0.36	500
New Sisak (Railway Bridge - Skolska Outfall)	0.89	900
New Sisak (Skolska Outfall - WWTP)	3.11	1,000
Total	6.34	

(b) Main and Secondary/Tertiary Sewers

Two (2) lines of main sewers are proposed. One line will be installed between Stupno and Old Sisak to collect from the north-western fringe area. This main sewer, with diameter of 250 to 400 mm, is 3.60 km long including the siphon (100 m long) that will cross the Odra River. The other line is planned between Galdovo and the treatment plant. The total length and diameter of this main sewer are 3.50 km and 250 to 350 mm with an additional force main of 730 m of 150 mm in diameter. The main sewers will cross the Kupa River or the Sava River by siphon.

Secondary/tertiary sewers of 200 mm in diameter will be installed for a total length of 36.55 km to collect the wastewater of the extended service area of 1,773 ha.

(c) Treatment Plant

Anaerobic-Oxic treatment process (AO) with a capacity of 73,400 PE will be used to treat the transported wastewater. The thickener and mechanical dewatering system will treat the generated sludge. The treatment plant requires a land space of 5.4 ha.

The dimensions of main facilities are summarized below. For location of the proposed transport collectors and treatment plant, see Fig. I.5.6 (1).

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	1
Primary Sedimentation Tank	4.0 m W × 18.0 m L × 3.0 m D	8
Aeration Tank	5.0 m W × 39.0 m L × 5.0 m D	8
Secondary Sedimentation Tank	∅17 m × 3.5 m D	4
Belt Press Filter	2.0 m W × 2.2 kw	4

(3) Construction Cost

The construction cost is estimated to be Kn. 159.8 million, broken down as follows.

	Cost (million Kn)
Direct Construction Cost	99.65
Collector	43.15
Transport/ Main	17.75
Secondary/Tertiary	25.40
Treatment Plant	56.50
Land Acquisition	-
Indirect Construction Cost	40.22
Contingency	19.93
Total	159.79

5.7 Sewerage Development for Kutina

5.7.1 Existing Sewerage System

(1) Service Area, Population and Industries

The town of Kutina is located midway of the main railway between Zagreb and Vinkovci. The establishment of the industrial complex of Petrokemija resulted in the urbanization of the town. Total population of the town in 1999 is estimated at 23,052 of which 16,800 lived in the urban area (902 ha).

The sewerage system serves 549 ha covering the central urban area and some surrounding areas. The existing served population is 16,100. The wastewater of the town is discharged into the Kutina River with preliminary treatment.

There is only one (1) large industry in the town (Petrokemija Kutina). Petrokemija Kutina is one of the largest pollution sources in the Sava River of which only sanitary wastewater is served by the sewerage system while a large quantity of process wastewater is discharged into the Kutina River.

(2) Sewer Network

The existing sewerage system in the urban area is of combined type. The wastewater of this urban area is collected and transported to the treatment plant located at the southern end of Grad Kutina. On the other hand, some fringe areas covering small settlements are served by a separate sewerage system and the wastewater is discharged into the neighboring streams with no treatment.

Total length of the existing sewer pipes with a diameter of 30 to 180 cm is 45 km. All the wastewater is collected and transported by gravity without pump.

The existing sewerage system is shown in Fig. I.5.7.

(3) Treatment Plant

The existing treatment plant of preliminary mechanical process was constructed in 1990 as the first stage of the project. The treatment plant was designed to meet the pollution load of 20,000 PE and daily average quantity of 3,600 m^3/day. The plant consists of screw pump, automatic fine grid, airing grit chamber, oil trap and measuring device. However, the existing treatment efficiency is as low as 10-15%. For location of the plant, see Fig. I.5.7.

The wastewater quality of influent and effluent of the treatment plant is periodically analyzed. The average quality during 1998-1999 are shown below.

	Water Temp. (°C)	pH	BOD (mg/l)	COD-Cr (mg/l)	TSS (mg/l)
Influent	9.8	7.7	88.3	130.9	60.8
Effluent	9.9	7.7	64.9	105.1	27.9

5.7.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

The proposed sewerage development will extend the existing service area of 549 ha to 1,303 ha, increasing the total served population from 16,100 to 24,800. The sanitary wastewater of Petrokemija will also be served. For location of the extended service area and served large industry, see Fig. I.5.7.

(b) Wastewater Flow and Pollution Load

The total design wastewater flow and pollution load are determined as below. The pollution load effluent from the industry to the sewerage system is estimated with pre-treatment. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 7.2.2.

	Municipal	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	8,184	1,063	9,247
Daily Maximum	9,920	1,063	10,983
Hourly Maximum (dry)	14,136	1,063	15,199
Hourly Maximum (rainy)	23,986	2,126	26,112
Pollution Load			
BOD Load (kg/d)	1,954	20	1,974 (32,900 PE)
BOD Concentration (mg/l)			177.9

(2) Structural Plan

Improvement of the existing treatment plant will be made to treat all the municipal wastewater in 1,303 ha of the town and the sanitary wastewater of Petrokemija.

(a) Main and Secondary/Tertiary Sewer

The existing transport collector to the treatment plant is available. Hence, no additional transport collector is necessary. Only one (1) main sewer of 400 mm in diameter is proposed for a total length of 0.18 km to integrate the eastern fringe area, which is currently not covered by the treatment plant.

The secondary/tertiary sewer of 100 to 200 mm in diameter will be constructed for a total length of 46.05 km to collect the wastewater of the extended service area of 754 ha.

(b) Treatment Plant

The Anaerobic-Oxic treatment process (AO) with a capacity of 32,900 PE will be used to treat the collected wastewater. The thickener and mechanical dewatering system will treat the generated sludge. The treatment plant requires a land space of 2.8 ha.

The dimensions of main facilities are summarized below. For location of the proposed main sewer and treatment plant, see Fig. I.5.7.

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	(1)
Primary Sedimentation Tank	4.0 m W × 18.0 m L × 3.0 m D	4
Aeration Tank	5.0 m W × 64.0 m L × 5.0 m D	4
Secondary Sedimentation Tank	∅17 m × 3.5 m D	2
Belt Press Filter	2 m W × 2.2 kw	2

Note: No. of Unit in parentheses is existing.

(3) Construction Cost

The construction cost is estimated to be Kn. 84.0 million, broken down as follows.

	Cost (million Kn)
Direct Construction Cost	52.47
Collector	27.83
Transport/ Main	0.29
Secondary/Tertiary	27.54
Treatment Plant	24.64
Land Acquisition	-
Indirect Construction Cost	21.00
Contingency	10.49
Total	83.96

5.8 Sewerage Development for Karlovac-Duga Resa

5.8.1 Existing Sewerage System

The sewerage systems of the towns of Karlovac and Duga Resa are independent of each other at present. However, the systems are planned to be integrated to treat the wastewater of both towns by a central treatment plant proposed on the right bank of the Kupa River immediately downstream of Karlovac. The transport collector between Duga Resa and the treatment site has been mostly completed. Hence, the existing systems of both towns are described together below.

(1) Service Area, Population and Industries

(a) Karlovac

The town has developed on the flood plains of the Kupa, Korana and Mrežnica rivers. It links with Zagreb City through a superhighway and a railway, and this resulted in the intensive urbanization and development of industries. Total

population of the town in 1999 is estimated at 60,000 of which 52,000 lived in the urban area.

The sewerage system serves 966 ha covering the central urban area (Grad Area: 952 ha) and some surrounding areas. The served settlements are Grad, Banija, Švarča and South Industrial Zone. The existing served population is 28,200 people.

There are 12 large industries in the whole town area of which seven (7) are served by the sewerage and the remaining five (5) discharge wastewater into the rivers/canals, as given below.

Classification	Served Industry
Served by Sewerage	Karlovack Pivovora, Kordun Karlovac, Ze-Ce, Tvornica Plinski Turbuna, Adria-Diesel, ABB Alstom Power, Autotransport
Discharge into River	PPK Karlovacka Industrija Mesna, Velebit, Lola Ribar, Karlovacka Industrija Mlijeka, Linde Plin

(b) Duga Resa

The town of Duga Resa is located immediately upstream of Karlovac along the Mrežnica River. Total population of the town in 1999 is estimated at 15,500 of which 8,266 lived in the urban area.

The sewerage system serves not only the densely populated central urban area (185 ha) but also some surrounding areas at present. The existing sewerage service area and served population are estimated to be approximately 133 ha and 3,800, respectively.

There is only one (1) large industry (Pamucna Industrija Duga Resa) which discharges wastewater into the Mrežnica River.

(2) Sewer Networks

(a) General

Karlovac and Duga Resa established a master plan of integrated sewerage development in 1989. The main components of the project are: (i) to construct a central treatment plant on the right bank of the Kupa River (Ostrog district of Gornje Mekusje settlement), 3 km east of the urban center of Karlovac Town; (ii) to intercept all the wastewaters discharged from Duga Resa, as well as Švarča and the South Industrial Zone of Karlovac, into the Mrežnica River and transport them to the treatment plant; and (iii) to collect all the wastewaters of Grad and the Banija areas of Karlovac and transport them to the treatment plant.

On the other hand, the domestic water of Karlovac is supplied from the wells located on the right and left banks of the lower Korana River (after the confluence of the Mrežnica River). The wastewater of Duga Resa, Švarča and South Industrial Zone is a potential pollution source to this groundwater. Hence, construction of the transport collector between Duga Resa and the treatment plant (South Transport Collector) is considered essential to protect the sources of domestic water of Karlovac Town.

The South Transport Collector is under construction and almost completed. The planned total length and pipe diameters are 11,000 m and 80 to 120 cm, respectively. Duga Resa has already been connected to the transport collector,

but the treatment plant and the other transport collectors (Grad Karlovac - treatment plant and Banija - treatment plant) have not been constructed yet.

The existing sewerage system is shown in Fig. I.5.8 (1).

(b) Karlovac

Construction of the sewerage system started in 1920. The combined sewer system of the town covers 952 ha, serving 28,200 inhabitants at present. The total sewer length is approximately 90 km with diameter of 30 to 300 cm. The system is divided into four (4) sub-systems: Grad, Banija (Banija I, Banija II and Drežnik), Svarca, and South Industrial Zone. The main features of the sub-systems are described below.

"Grad" system serves 16,900 people, covering 617 ha of the central area of the town by a combined system. The wastewater of this area is discharged into the Kupa River by gravity during normal time. However, wastewater is discharged through the pumping station with a capacity of 2.5 m^3/s during high river water. Total sewer length of the system is 69,500 m and pipe diameter is 30/40 to 140/210 cm.

"Banija" system serves 7,300 people, covering 114 ha on the left bank of the Kupa River. The wastewater is drained into the Kupa River by gravity through the outfalls of Banija I, Banija II and Drežnik. Total sewer length is 11,700 m and pipe diameter is 40 to 60/90 cm.

"Švarča" serves 4,000 people covering 235 ha in the southern background of Grad. Wastewater is drained into the Mrežnica River. The total length of sewer pipe is 4,100 m.

"South Industrial Zone" has seven (7) sub-systems mostly serving industries. Each sub-system has its own outfalls into the Mrežnica River.

(c) Duga Resa

Duga Resa Town is served by the combined sewerage system with a total sewer length of 9,200 m at present. The sewer pipe diameter is 30 to 105 cm. The wastewater of the town is discharged through 10 outfalls into the Mrežnica River. The Duga Resa sewerage system is already connected to the South Transport Collector. However, the wastewater of the town is directly discharged into the Mrežnica River at present because the South Transport Collector is not yet completed.

5.8.2 Proposed Sewerage Development

(1) Planning Basis

(a) Service Area, Population and Industries

Karlovac: The proposed sewerage development will extend the existing service area of 966 ha to 1,978 ha, increasing the total served population from 28,200 to 55,800. Among the 12 large industries existing in the whole town area, 11 will be served by the proposed sewerage system. Only Linde Plin located outside the sewerage service area will discharge into the river/canal. For location of the extended service area and the 11 large industries located within the service area, see Fig. I.5.8 (1).

Duga Resa: Similarly, the sewerage service area will be extended from 133 ha to 205 ha by the proposed project and as a result, the served population will increase from 3,800 to 10,900. The recipient of the existing large industry (Pamucna Industrija Duga Resa) will change from the river to the public sewerage. For location of the extended service area and the large industry, see Fig. I.5.8(1).

(b) Wastewater Flow and Pollution Load

The total design wastewater flow and pollution load are determined as below. The pollution load effluent from the industries to the sewerage system is estimated with pre-treatment. For COD-Cr, TSS, T-N and T-P loads, see Appendix D, Subsection 8.2.2.

Item	Municipal		Industry		Total
	Karlovac	Duga Resa	Karlovac	Duga Resa	
Wastewater Quantity (m^3/d)					
Daily Average	18,414	3,597	7,603	3,992	33,606
Daily Maximum	22,320	4,360	7,603	3,992	38,275
Hourly Maximum (dry)	31,806	6,213	9,435	3,992	51,446
Hourly Maximum (rainy)	52,356	9,313	15,766	7,984	85,419
Pollution Load					
BOD Load (kg/d)	4,352	850	1,334	479	7,016 (117,000 PE)
BOD Concentration (mg/l)					183.5

(2) Structural Plan

A wastewater treatment plant is proposed on the right bank of the Kupa River (Ostrog district of Gornje Mekusje settlement), in the eastern fringe of the urban center of Karlovac Town, to discharge into the Kupa River. The plant will treat all the municipal wastewater of 2,183 ha along with the industrial wastewater of 12 industries in the Karlovac and Duga Resa towns.

(a) Transport Collector

The proposed service area of the central treatment plant is divided into five (5) sub-service areas: Grad, Banija, Švarča, South Industrial Zone and Duga Resa.

The South Transport Collector (almost completed) covers the South Industrial Zone and Duga Resa areas. The Švarča area can be easily and economically connected to the South Transport Collector that will cross the Mrežnica River. The wastewater of the Grad area can also be directly transported eastward to the treatment plant through the collector crossing the Korana River at the shortest distance.

However, some alternatives are considered for the route of the Banija Transport Collector and the way of transport (with or without lift pump) of the Grad Transport Collector. The following four (4) alternatives are compared. Refer to Fig. I.5.8 (2).

Alternative 1: The Banija Transport Collector is connected to the Grad Transport Collector after crossing the Kupa River by siphon. The wastewater of both areas is then transported to the treatment plant through the Grad Transport Collector. The Grad Transport Collector crosses the Korana River midway by siphon but no lift pump is provided.

Alternative 2: The wastewater of the two (2) areas is separately transported to the treatment plant. The Banija Transport Collector runs along the left bank of the Kupa River to bypass the urban center of the town and crosses the river by siphon in the downstream near the treatment plant. A lift pump is constructed midway. The Grad Transport Collector is the same as Alternative 1 although the discharge capacity is different.

Alternative 3: The Banija and Grad transport collectors are the same as Alternative 1. However, a lift pump is installed midway on the Grad Transport Collector.

Alternative 4: The Banija and Grad transport collectors are the same as Alternative 2. However, a lift pump is installed midway on the Grad Transport Collector.

The above four (4) alternatives are compared as to ease of construction work, and construction and O&M costs, as below. The total construction and O&M costs are estimated in terms of present value at 5% discount rate.

Item	Alternative 1	Alternative 2	Alternative 3	Alternative 4
Pipe Length (m)	8,120	10,950	8,120	10,950
Pipe Diameter (mm)	300 - 1,700	300 - 1,700	300 - 1,700	300 - 1,700
No. of Pump Stations	0	1	1	2
No. of Siphons	2	2	2	2
Construction Work	Not easy in urban center	Easy	Not easy in urban center	Easy
Construction Cost (10^6 Kn)	46.5	59.0	23.2	41.8
O&M Cost (10^3 Kn/year)	111	175	175	216
Total Present Value (10^6 Kn)	47.9	61.2	25.3	44.5

As evident from the above, Alternative 3 is the most economical although construction work is not easy in the congested urban area. Hence, it is proposed.

The proposed transport collectors of the Karlovac-Duga Resa area are summarized below.

Transport Collector	Length (km)	Size (∅mm)	Siphon (No.)	Remarks
Drežnik - Banija	2.88	300 - 350		
Banija - Grad	2.63	700 - 800	1	
Grad - Treatment Plant	2.61	1,300 - 1,700	1	
Švarča - South Transport Collector	3.82	400 - 600	1	
South Transport Collector	(9.95)	(800 - 1,200)	(2)	Almost completed
Duga Resa Left Bank	1.83	400 - 1,200		
Total	13.77 (23.72)			

(b) Main and Secondary/Tertiary Sewer

The main sewer is proposed only on the right bank of Duga Resa. The sewer is 1.25 km long with the diameter of 300 mm.

The secondary/tertiary sewers are proposed for the extended service area, as follows.

Urban Center	Diameter (mm)	Length (km)
Karlovac	250 - 400	50.0
Duga Resa	250	11.6
Total		61.6

(c) Treatment Plant

The Anaerbic Oxic treatment process (AO) with a capacity of 117,000 PE will be used to treat transported wastewater. The thickener and mechanical dewatering system will treat the generated sludge. The treatment plant requires a land space of 5.3 ha.

The dimensions of main facilities are summarized below. For location of the proposed transport collectors and treatment plant, see Fig. I.5.8 (1).

Facilities	Specification	No. of Units
Preliminary Treatment	Pump, Screen, Oil/Sand Trap	1
Primary Sedimentation Tank	6.5 m W × 19.0 m L × 3.0 m D	8
Aeration Tank	5.0 m W × 64.0 m L × 5.0 m D	8
Secondary Sedimentation Tank	∅22 m × 3.5 m D	4
Belt Press Filter	2 m W × 2.2 kw	6

(3) Construction Cost

The construction cost is estimated to be Kn. 259.9 million, broken down as follows.

	Cost (million Kn)
Direct Construction Cost	161.75
Collector	84.72
Transport/ Main	51.47
Secondary/Tertiary	33.25
Treatment Plant	77.02
Land Acquisition	1.45
Indirect Construction Cost	64.33
Contingency	32.35
Total	259.88

5.8.3 Replacement of Major Damaged Sewers in Karlovac

Some sewers in the central part of Karlovac Town are damaged to a considerable extent and they need to be replaced. The major damaged sewers are approximately 5 km long, 800 mm to 1,400 mm in diameter and 7 m in depth on the average. However, this replacement project is dealt with separately from the sewerage development projects proposed by this Study. The replacement cost is therefore not included in the cost of the proposed sewerage development project for Karlovac-Duga Resa. The required replacement cost is estimated at Kn. 58.9 million including direct construction cost, indirect construction cost and contingencies.

5.9 Sewerage Development for Local Urban Centers

The objective local urban centers include 16 towns/municipalities served by 15 sewerage systems; namely, Sveti Ivan Zelina, Ivanić Grad, Kloštar Ivanić, Samobor, Zaprešić, Velika Gorica, Jastrebarsko, Petrinja, Glina, Topusko, Popovača, Lipovljani, Novska, Ogulin, Plaški

and Slunj. Ivanić Grad and Kloštar Ivanić are administratively independent of each other, however, their sewerage systems are integrated.

5.9.1 Existing Sewerage System

(1) Service Area, Population and Industries

The existing service area, served population and number of industries served by the above 15 sewerage systems are given below, compared to the existing total town/municipality population, urban area and number of large industries in the respective towns/municipalities.

As shown in the table below, the existing sewerage system covers not only the central urban area of the towns/municipalities but also some surrounding areas.

Sewerage System	Area (ha)		Population			Industry (No.)	
	Urban	Served	Total	Urban	Served	Total	Served
Sveti Ivan Zelina	144	251	15,707	2,560	3,200	-	-
Ivanić Grad-Kloštar Ivanić	821	662	19,662	10,409	6,300	4	3
Samobor	557	1,518	39,920	16,154	15,400	7	5
Zaprešić	462	949	34,289	20,329	13,300	5	2
Velika Gorica	701	1,453	65,680	36,502	33,500	4	3
Jastrebarsko	242	409	18,073	5,434	5,300	2	1
Petrinja	940	419	23,573	12,545	10,300	1	-
Glina	459	175	13,617	4,098	2,000	-	-
Topusko	92	34	4,800	1,116	500	-	-
Popovača	204	123	11,383	3,462	1,800	1	1
Lipovljani	269	60	3,571	2,245	800	-	-
Novska	389	380	12,296	5,747	4,000	-	-
Ogulin	431	-	15,800	10,252	-	2	-
Plaški	195	-	3,270	1,720	-	-	-
Slunj	127	62	6,500	1,304	600	-	-
Total	6,033	6,495	288,141	133,877	97,000	26	15

Note: Zaprešić includes Brvovec area.

(2) Sewer Networks

The main features of the existing sewer networks of the above 15 sewerage systems are summarized below and shown in Fig. I.5.9 (1 to 15).

Sewerage System	Sewer Type	Length (km)	Diameter (∅cm)	Pump/ Gravity	Treatment Plant	Others
Sveti Ivan Zelina	C	5.2	30 - 100	Gravity	None	
Ivanić Grad-Kloštar Ivanić	C	35.8	50 - 120 (main)	Gravity	Preliminary	
Samobor	C	83.8	30 - 120	Gravity	Not working	
Zaprešić	C	47.5	20 - 195	Gravity	None	
Velika Gorica	S	143.3	25 - 80	Gravity/Pump	Biological	Force main: 11 km
Jastrebarsko	C	33.0	30 - 120	Gravity	None	
Petrinja	C	33.0	180 (max.)	Gravity	None	
Glina	C	38.4	100 (max.)	Gravity	None	
Topusko	C/S	6.5	25 - 120	Gravity	Not working	
Popovača	C	9.4	30 - 60	Gravity	None	
Lipovljani	C	4.5	40 - 100 (main)	Gravity	None	
Novska	C	44.0	30 - 100	Gravity	None	
Ogulin	C	0.7	25 - 80	Gravity	None	
Plaški	-	-	-	-	-	
Slunj	C	2.3	30 - 100	Gravity	None	
Total		487.4				

(3) Treatment Plant

There are four (4) treatment plants in the above 15 local sewerage systems of which only two (2) plants are functioning. The main features of the treatment plants are summarized below.

Item	Ivanić Grad	Samobor	Velika Gorica	Topusko
Starting Time	1995	1977	1973	1987
Operation	Working	Suspended since 1995	Working	Suspended since 1990
Capacity (PE)	15,000	20,000 - 25,000	35,000	6,000
Capacity (Q)	142 l/s (Ave. 1999)	178 l/s	12,800 m^3/day	1,300m^3/d
Process	Preliminary	Activated Sludge	Activated Sludge	Aerated Lagoon
Main Facilities	- Pump/ Screen - Grit Chamber	- Pump/ Screen - Primary ST (3) - Aeration Tank (2) - Secondary ST - Digester	- Pump/ Screen - Primary ST - Aeration Tank - Secondary ST - Digester (suspended)	- Pump/ Screen - Grit Chamber - Aerated Lagoon (3) - ST

ST: sedimentation tank

5.9.2 Proposed Sewerage System

(1) Planning Basis

The proposed 15 sewerage systems of the local urban centers will cover a total service area of 10,622 ha in 2015. The total served population by the sewerage systems in 2015 is estimated to be 197,700. Further, the systems will receive the wastewater of 18 industries. The above service area, population and number of industries are compared with those in 1999 as below. For the service area, population and number of industries of each urban center, see Table I.5.2.

Service Area (ha)		Served Population		Served Number of Industries	
1999	2015	1999	2015	1999	2015
6,495	10,622	97,000	197,700	15	18

The total design wastewater and pollution load (BOD) of the 15 sewerage systems are shown below. For the design wastewater flow and BOD load of each sewerage system, see also Table I.5.2.

Wastewater Flow (m^3/d)			BOD Load/Concentration		
Municipal	Industry	Total	(kg/d)	(PE)	Ave. (mg/l)
78,534	11,319	89,853	16,883	281,800	189

(2) Structural Plan

The sewer pipes for a total length of 206.82 km (transport collector/main sewer: 96.11 km and secondary/tertiary sewer: 110.71 km) are proposed to meet the service area extension of 4,117 ha in the 15 sewerage systems.

Each sewerage system will be provided with a proper treatment system to meet the regulation. The existing plants of Ivanić Grad, Samobor, Velika Gorica and Topusko will be rehabilitated and extended. On the other hand, one (1) new treatment plant will be constructed for each of the other 11 sewerage systems. The proposed treatment process for each town is shown in Table I.5.2. For the proposed sewerage systems of the 15 towns/municipalities, see Fig. I.5.9 (1 to 15).

(3) Construction Cost

The total construction cost of the 15 sewerage system improvement works is estimated to be Kn. 634 million. For the total construction cost for each urban center, see Table I.5.2. For details, see Appendix D, Chapter IX.

5.10 Summary of Proposed Sewerage Development

The existing sewerage system and the proposed sewerage development plan are summarized by urban center in Table I.5.3 and Table I.5.4. The proposed improvement works are as mentioned below.

(1) Future Service Area and Treatment Plant Site

Future service areas have been delineated through detailed discussion with each local government (town/municipality) along with Croatian Waters. Service areas shall cover not only the existing urban centers but also the surrounding rural areas to the possible extent. Locations of treatment plant have been determined in accordance with the existing physical plan of each local government as far as setting of location was not technically difficult.

(2) Future Sewer System

In principle, the combined sewer type will serve central urban areas while the separate type will serve the surrounding areas.

The proposed sewerage system will serve almost all the population of Zagreb City (95% of the future total population). As for the 23 towns/municipalities, 21 sewerage systems will cover 19,186 ha (174% of the existing urban area: 11,006 ha) and serve a total population of 381,800 people (122% of the future urban population: 313,300 or 70% of the future total population: 549,000).

The main features of the proposed sewerage improvement works are summarized below.

Area	Service Area (ha)		Served Population		Design Wastewater (m^3/d) (2015)			BOD Load (kg/d)	Const. Cost (mil. Kn)
	1999	2015	1999	2015	Municipal	Industrial	Total		
Zagreb	25,600	25,600	800,000	935,000	274,860	167,510	442,370	90,000 (1,500,000 PE)	1,365
Others	10,549	19,186	210,500	381,800	149,726	32,643	182,369	34,376 (573,000 PE)	1,374
Total	36,149	44,786	1,010,500	1,316,800	424,586	200,153	624,739	124,376 (2,073,000 PE)	2,739

(3) Construction Cost

The total construction cost of the 21 sewerage improvement works (excluding Zagreb City) is broken down as follows.

Item	Cost (million Kn)
Direct Construction	853.5
Collector	337.7
Transport/Main Collector	153.4
Secondary/Tertiary Sewer	184.3
Treatment Plant	515.8
Land Acquisition	3.6
Indirect Construction	345.9
Contingency	170.7
Total	1,373.8

CHAPTER VI EVALUATION OF RIVER WATER QUALITY IMPROVEMENT

6.1 General

(1) Objective River Stations for Simulation

The existing and future river water qualities under without and with-project situations were simulated for the following stations on the Sava River, Kupa River, Lonja River and Kutina River.

River	Location of Simulation
Sava Main River	Oborovo (code: 242, downstream of Zagreb), Utok Kupe Nizvodno (code: 237, downstream of Sisak)
Kupa River	Recica (code: 254, downstream of Karlovac), Brest (code: 245, immediately upstream of Petrinja)
Lonja River	K. Lonja Strug (code: 292, before confluence with Cesma River), Struzec (code: 294, after confluence with Cesma River)
Kutina River	Kutina (code: 295, downstream of treatment plant)

(2) Objective River Basin for Simulation

For the simulation of river water quality at the above-mentioned principal river stations, the generated pollution load has to be calculated not only for the Study Area (Zagreb City and Zagreb, Sisak-Moslavina and Karlovac counties with a total area of 11,794 km^2) but also for the outer drainage basins (Krapina River, Upper Glogovinica River, Upper Cesma River, Upper Ilova River and other river basins with a total area of approximately 6,487 km^2).

(3) Pollution Load Generation and Runoff

Generated pollution loads are classified into point load and non-point load. In this Study, these are defined as follows:

Point load includes (i) municipal wastewater discharged into rivers from sewerage system, (ii) industrial wastewater discharged into rivers from sewerage system, and (iii) industrial wastewater directly discharged into rivers. However, domestic wastewater not covered by a sewerage system is considered as non-point load. Hence, the non-point load includes wastewater from households (not covered by sewerage system), livestock and lands (agricultural land, pasture and shrub/forest).

All (100%) generated point loads are assumed to run off to the receiving water. The generated non-point loads infiltrate into the ground or run off on land, and through ditches/small channels, to the receiving water. During this runoff process, a large portion of the generated non-point load is lost, especially in drought time.

The point and non-point loads that enter the receiving water run through a tributary to the main river, and further flow down the main river to reach the principal river station. The pollution loads decrease due to the self-purification effects of the tributary and the main river while the wastewaters flow down.

6.2 Pollution Load Runoff

6.2.1 Analysis of Pollution Load Runoff

(1) General

In this Study, pollution load runoff is defined as the pollution load that has entered the main river. It is estimated through the following steps:

(a) The objective drainage basin for the simulation (18,281 km^2) is divided into 20 sub-basins. Then, the point and non-point pollution loads generated from each sub-basin are estimated. For the objective drainage basin for simulation, see Fig. I.6.1.

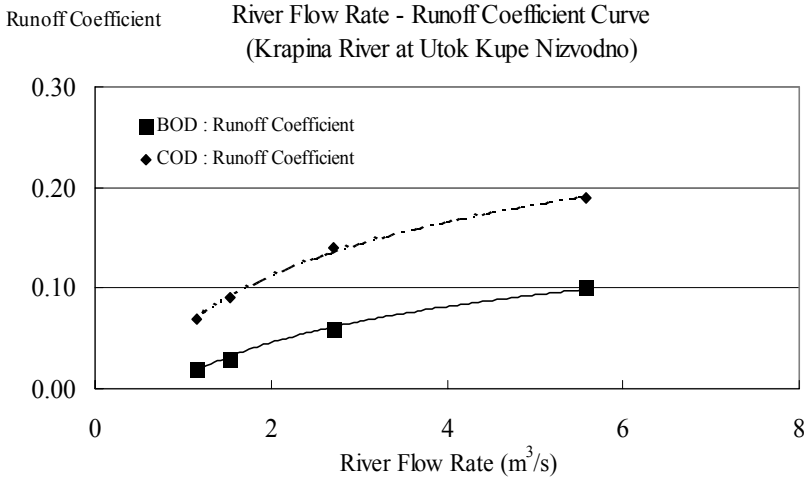
(b) The runoff coefficients of pollution loads (R_l) to a tributary in each sub-basin are estimated. The coefficient of point load is assumed at 1.0 and that of non-point load is estimated for each sub-basin.

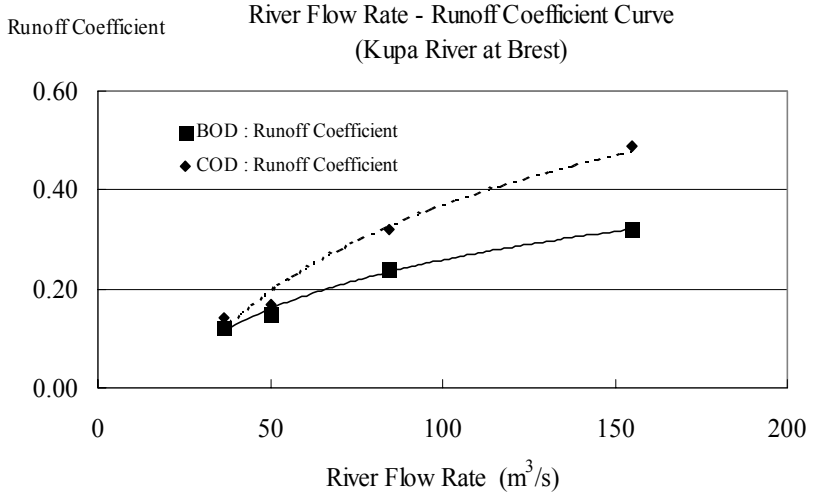
(c) The self-purification rate of river water is estimated for the objective tributaries and main rivers. In this Study, main river refers to the following river courses: Sava Main (Jesenice - Utok Kupe Nizvodno), Kupa (Karlovac - Confluence with Sava Main) and Lonja River (Sveti Ivan Zelina - Cazma - Struzec - Trebez and Sesvete East - K. Lonja Strug - Confluence with Cesma River). All other rivers are defined as tributary.

(2) Runoff Coefficient of Non-Point Pollution Load

Non-point loads mostly run off in rainy time; on the other hand, the runoff becomes smaller in drought time. Further, the runoff coefficient of non-point load varies according to the river flow rate.

The runoff coefficients of the Krapina River at Utok Krapinice Nizvodno and Kupa River at Brest were analyzed, as shown in the following figures.





Considering the topographic features of the Sava River Basin, the runoff coefficients of the Krapina River were applied for the left side sub-drainage basins of the Sava Main River and those of the Kupa River were applied for the right side sub-drainage basins.

In this Study, runoff coefficients for 95% river flow rate are employed according to the government standards. Further, the runoff coefficients of T-P and T-N are roughly assumed by using the limited available data to the maximum extent.

From the above discussions, the runoff coefficients of non-point loads (BOD, COD, T-P and T-N) for 95% river flow rate are assumed, as follows.

Parameter	Left Side Area of Sava Main River	Right Side Area of Sava Main River
BOD	0.02	0.12
COD	0.07	0.14
T-P	0.01	0.06
T-N	0.03	0.18

(3) Self-purification Rate of Tributary

The Streeter-Phelps Formula is usually used to calculate the self-purification rate of rivers. According to this formula, the self-purification rate exponentially decreases according to the flowing time. However, for practical purposes, the self-purification rate of tributaries (R_2) is assumed to decrease in proportion to the flowing time.

The self-purification rate of the Sava Main River was analyzed based on the water quality data at Oborovo (downstream of Zagreb) and Galdovo (upstream of Sisak). At these river sections, no lateral pollution loads enter. The average self-purification rate of BOD between the two (2) locations is estimated to be 0.5% per km at drought time.

On the other hand, the self-purification rate of tributaries was roughly estimated by comparing the flow velocity of the representative tributaries with that of the Sava Main River at drought time. The self-purification rates (BOD) of 0.5% per km and 2% per km were applied for the tributaries on the right side sub-basins and the left side sub-basins of the Sava Main River, respectively.

The self-purification rate of COD is roughly assumed as one-half of BOD, based on the analysis of the Sava Main River. No significant self-purification effects are expected for T-P and T-N in any river course.

(4) Pollution Load Runoff

As mentioned above, pollution load runoff is defined as the pollution load that has entered the main river. Hence, it is estimated by the following equations:

Point load runoff = Generated point load from sub-basin × R1 (= 1.0) × R2

Non-point load runoff = Generated non-point load from sub-basin × R1 × R2

Where R1 is runoff coefficient from each sub-basin, and R2 is self-purification rate of tributary of each sub-basin.

6.2.2 Pollution Load Runoff to Main River Without Project

(1) Existing Pollution Load Runoff

(a) Point Pollution Load Generation

Point load in the Study Area consists of the municipal wastewater (domestic, institutional and small industries) of 22 sewerage systems and the industrial wastewater of 51 large industries. Pollution load generation of the 22 sewerage systems and the 51 large industries are then estimated.

(b) Non-point Pollution Load Generation

Non-point load consist of the wastewater of households (not served by sewerage system), livestocks and lands. The generation of these loads is estimated based on the standard unit generation rates obtained in previous studies and researches.

(c) Estimated Pollution Load Runoff

The existing point and non-point pollution load runoffs to the main rivers are calculated by multiplying the generated loads with R_1 and R_2 for the 20 sub-basins, respectively. These are aggregated into the six (6) major sub-basins as shown below in terms of BOD. As for the runoffs of COD, T-P and T-N, see Appendix B, Section 6.2. For the location of the six (6) major sub-basins, see Fig. I.6.1.

Existing Pollution Load Runoff (BOD, 1999)

(Unit: kg/d)

Source	Upper Sava 2,035 km² *	Middle Sava 77 km²	Lower Sava 3,807 km² *	Upper Kupa 4,257 km²	Lower Kupa 3,784 km²	Lonja 4,321 km² *	Total 18,281 km² *	
Municipal	50,594	0	1,734	2,208	3,878	2,862	61,308	(70%)
Industrial	10,942	0	159	1,639	906	1,540	15,196	(17%)
Sub-total	61,536	0	1,894	3,847	4,783	4,402	76,504	(88%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(12%)
Total	62,384	22	2,857	7,046	9,334	5,468	87,153	(100%)

* Including outer drainage basins of the Study Area

In the above estimates, point and non-point load runoffs from the outer drainage basins of the Study Area are incorporated. Point loads include those

of wastewaters of Bjelovar, Krizevci, Cazma, Krapina and other towns located in the outer drainage basins.

(2) Future Pollution Load Runoff

(a) Point Pollution Load Generation

Municipal wastewater will increase according to the growth of sewerage served population and per capita wastewater quantity. On the other hand, industrial wastewater will increase according to the growth of industrial production.

(b) Non-point Pollution Load Generation

Non-point pollution load generation is assumed as constant since no significant development of land and livestock is expected in the future.

(c) Estimated Pollution Load Runoff

The future point and non-point pollution load runoffs to the main rivers of the six (6) major sub-basins in 2015 are as estimated below in the same way as the existing pollution load runoffs in terms of BOD. For those of COD, T-P and T-N, see Appendix B, Section 6.3.

Future Pollution Load Runoff Without Project (BOD, 2015)

(Unit: kg/d)

Source	Upper Sava 2,035 km^2 *	Middle Sava 77 km^2	Lower Sava 3,807 km^2 *	Upper Kupa 4,257 km^2	Lower Kupa 3,784 km^2	Lonja 4,321 km^2 *	Total 18,281 km^2 *	
Municipal	78,141	0	3,396	8,637	6,705	7,768	104,648	(77%)
Industrial	16,535	0	216	8	507	485	23,752	(13%)
Sub-total	94,676	0	3,612	8,664	7,212	8,253	125,950	(92%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(8%)
Total	95,524	22	4,575	11,845	11,762	9,319	133,047	(100%)

* Including outer drainage basins of the Study Area

6.3 Simulated River Water Quality

6.3.1 Self-purification Rate of Main River

The pollution load runoff to the main river (pollution load that entered the main river) is naturally purified while it flows down the main river. BOD concentration decreases as given below according to the Streeter-Phelps.

Decrease Rate of BOD: $dC/dt = - K \bullet C$

Where, C: BOD concentration (mg/l), t: time (day), K: self-purification constant (1/day)

The self-purification constant K of the Sava Main River is estimated to be 0.188 (1/day), based on the water quality data at the Oborovo and Galdovo monitoring stations. This constant is also applied for the Kupa River and the Lonja River.

With regard to COD, the decreasing speed of COD concentration is estimated by using the same equation for practical purposes. The self-purification constant K is estimated at 0.071 (1/day).

No significant self-purification effects are expected for T-P and T-N.

6.3.2 Existing and Future River Water Quality Without Project

The above-mentioned pollution load runoffs and self-purification rates are used in the simulation of river water quality at the principal stations of the three (3) main rivers.

The simulated river water quality (BOD) under the existing and future conditions without project (2015) are summarized in the table below. For COD, T-P and T-N, see Appendix B, Section 6.5.

(Unit: BOD, mg/l)

River	Location	Existing (1999)	Future Without (2015)
Sava	Jesenice	(5.6)	(5.6)
	Oborovo	8.8 (8.6)	11.6
	Utok Kupe Nizvodno	5.6 (5.7)	7.4
Kupa	Recica	4.3 (4.3)	6.2
	Brest	3.5 (3.5)	4.7
Lonja	K. Lonja Strug	27.1	49.1
	Struzec	8.5	14.6
Kutina	Kutina	70*	70*

Note: Values in parentheses are the observed quality; * means roughly estimated.

The water quality simulation of the Kutina River is different from the above-mentioned three (3) main rivers. The objective location for the simulation is immediately downstream of the sewage treatment plant, and the natural river flow is negligible.

6.3.3 Future River Water Quality With Project

(1) Basic Assumptions for the Simulation

River water quality is estimated under the following assumptions:

(a) By the year 2015, all the municipal wastewater (domestic, institutional and small industries) covered by the proposed 22 sewerage development projects will be treated by the biological process to meet the permissible limits of plant effluent. For the permissible limits, see Table I.5.1.

(b) There are 51 large industries in the Study Area (excluding Zagreb City) at present. Among them, 40 industries will discharge wastewater into the sewerage systems with necessary pre-treatment. The wastewater is finally treated in the proposed sewage treatment plants. The remaining 11 industries will directly discharge wastewater into the neighboring rivers with necessary treatment to satisfy the government regulations.

(c) Non-point loads are not controlled.

(d) Point loads in the outer drainage basins (wastewater of Bjelovar, Krizevci, Cazma, Krapina and other towns) are assumed as reduced to the same level as the Study Area.

(e) River water quality is evaluated at the river flow rate of 95% probability.

(2) Simulated River Water Quality

The simulated river water quality (BOD) at the six (6) principal stations in the year 2015 is shown below. For COD, T-P and T-N, see Appendix B, Section 6.5.

(Unit: BOD, mg/l)

River	Location	Existing	Future Without Project (2015)	Future With Project (2015)
Sava	Jesenice	(5.6)	(5.6)	(5.6)
	Oborovo	8.8 (8.6)	11.6	4.6
	Utok Kupe Nizvodno	5.6 (5.7)	7.4	3.1
Kupa	Recica	4.3 (4.3)	6.2	3.1
	Brest	3.5 (3.5)	4.7	2.6
Lonja	K. Lonja Strug	27.1	49.1	7.2
	Struzec	8.5	14.6	3.4
Kutina	Kutina	70*	70*	16*

Note: Values in parentheses are the observed quality; * means roughly estimated.

(3) Conclusion

The proposed master plan will considerably improve the river water quality at all principal stations in the Sava Main and Kupa rivers to satisfy the national standards. In the Lonja River, the water quality will meet the Category II standards at Struzec of Lonjsko Polje and Category III standards at K. Lonja Strug in the Crnec River. As for the Kutina River, the improvement to BOD 16 mg/l is the maximum due to the limitation of dilution water.

CHAPTER VII RIVER WATER QUALITY MANAGEMENT

7.1 Legal and Institutional Aspects

7.1.1 Law and Regulations

The most important legal basis of river water quality management is the Water Act enacted in 1995 (NN No. 107/95). This Act regulates the methods/conditions of water management (water use, water protection, water course regulation, flood control and others), the method of organizing/performing water management tasks, basic conditions for carrying out water management activities (powers/duties of Government bodies and local authorities) and other issues.

For water management purposes, the country is divided into the following five (5) catchment areas: (i) Sava River catchment area, (ii) Zagreb City catchment area, (iii) Drava and Danube catchment areas, (iv) Littoral and Istrian catchment areas, and (v) Dalmatian catchment area. This Study deals with the Sava River and Zagreb City catchment areas.

Since the enforcement of the Water Act, the Government of Croatia (GOC), State Water Directorate, Croatian Waters, City/County Assemblies and Municipal/Town Councils have issued various related laws, regulations and ordinances. For a list of the related laws, regulations and ordinances, see Appendix G, Table G.1.1.

7.1.2 Institutional Framework

The institutional framework of water management is shown in Fig. I.7.1. Water of the country is managed by the following organizations in the national and the local level, respectively.

(1) Government of Croatia

The Government of Croatia had established the National Water Council (NWC) consisting of the representatives of Parliament, scientists and professionals in the field of water management. The NWC deliberates on essential issues of water management and coordination of various needs and interests, and it proposes measures for the development and improvement of the water system in the country.

(2) State Water Directorate (SWD)

SWD develops laws and regulations and ensures the administrative supervision of the implementation of the legislation on water. In particular, it exercises control over water quality standards and pollution levels, and is the principal International Alert Center for early warning in the case of accidents on Trans-National waters.

SWD controls Croatian Waters and arbitrates on all problems between it and the county offices in charge of water management.

SWD through its State Water Inspectorate is responsible for inspection of national waters and acts together with county water management inspectors who are responsible for local waters. The State Inspectorate is responsible for the monitoring of water quality.

(3) Croatian Waters

Croatian Waters has responsibility for State and local water management. Its principal duties are to manage Croatia's waters according to the adopted water management plans and schemes, issue administrative and other orders, and make

decisions on important matters. In terms of water quality management, its jurisdiction includes the following:

Water protection: (i) monitoring and determination of water quality; (ii) organizing implementation of the National Water Protection Master Plan; (iii) coordination of water protection plans of the local administrative units and other plans for investment in water protection; and (iv) control over their implementation, measures for prevention and elimination of water pollution.

(4) County and City Assemblies

County and Zagreb City Assemblies play an important role in water management. With the enactment of the new Water Law, the Assemblies were given the responsibility of drawing up planning documents for the County Water Protection Plan, limit values of hazardous and other substances, method of wastewater disposal, and limits of sanitary protection zones. County offices in charge of water management play a continuous role in the water sector and carry out inspection at county level.

(5) Local Government

With regard to water quality management, Municipal/Town Councils and the Zagreb City Council are responsible for drawing up and issuing the following regulations under the Water Act:

(a) Sanitary protection zones around sources of water used for public supply;

(b) The method of wastewater disposal, the obligation to connect to the public sewerage system, the conditions and manner of wastewater disposal in areas where such systems do not exist, particular measures for the disposal and elimination of hazardous and other substances, and the obligation to maintain the public sewerage system; and

(c) Maintenance of improved drainage system.

Zagreb City and Municipal/Town Councils carry out municipal services including water supply and wastewater treatment/disposal. “Privatized” municipal service companies perform most of these services.

7.1.3 National Policy on River Water Quality Management

(1) National Water Protection Plan

The National Water Protection Plan issued in January 1999 (NN No. 8/99) includes definitions, plans, measures and others; namely, (i) Necessary research and monitoring of water quality; (ii) Categorization of water; (iii) Measures for water conservation; (iv) Measures for contamination emergencies of water; (iv) Plan to build sewerage facilities and sewage treatment plant; (v) Source and manner of financing the plan; and (vi) A list of legal and natural persons charged with carrying out the plan.

(a) Water Quality Monitoring

Water quality monitoring programs for national waters (national monitoring program) are drawn up and carried out by Croatian Waters. National waters are as listed in NN No. 8/99 and local waters are all other waters. A county water protection plan lays down the program for monitoring the quality of local water.

The results of the monitoring are delivered to Croatian Waters and published together with the report on monitoring of the national water.

(b) Categorization of Water

The Plan contains the categorization of national waters, while categorization of local waters are contained in the county water protection plan.

The receiving waters for effluent are categorized in the Decree on Water Classification (NN No. 77/98) whose prescribed conditions have to be met. Water is classified into five (5) types according to its quality that corresponds to the established conditions of its general ecological function and to the conditions of water use. The categorization of national waters has been completed, and that for local waters will be contained in the county water protection plans when issued. For categorization of the major rivers in the Study Area, see Chapter III.

(c) Limit Values of Wastewater Effluent Quality

For the protection of water quality and the environment, limit values of hazardous and other substances in the effluents of industrial wastewater and sewage treatment plant are prescribed by the Decrees issued by the State Water Directorate (NN No. 40/99, as amended by NN No. 6/01 for industrial wastewater and NN No. 40/99 for effluent from sewage treatment plant).

The limit values of the water quality parameters in industrial wastewater effluent and effluent from sewage treatment plant are given in Chapter IV and Chapter V, respectively.

(d) Measures for Contamination Emergencies

The Plan contains measures for cases of extraordinary water contamination and contamination emergencies. For Threat Level 1 (minor quantities of dangerous substance) and Level 2 (major quantities of dangerous substance), measures laid down in the county water protection plan are applied. In the case of Threat Level 3 (quantities of dangerous substances with possible cross-border consequence), the provisions of the National Water Protection Plan are applied.

(e) Sewerage Development Plan

The Plan sets up the implementation program in three (3) stages for the construction of public sewerage system and wastewater treatment plant; namely, short-term program up to 2005, medium term program up to 2010 and long term program up to 2025. For the detailed program, see Chapter V.

(2) International Agreements

Trans-boundary water issues are very important to Croatia. The National Water Protection Plan includes water quality monitoring programs for cross-border watercourses, and these are subject to treaties between the Republic of Croatia and neighboring states in connection with water industry relationships.

The national monitoring program on the Trans-National Monitoring Network (TNMN) for the Danube Drainage Basin is the program of the Permanent Commission of the Danube Protection Convention.

Programs for water quality monitoring in trans-national waters, pursuant to water management relations between the Government of Croatia and the Government of Hungary (Treaty No. 10/94), and between the Government of Croatia and the Government of Slovenia (Treaty No. 10/97) are to be found in the Plan.

With regard to the Danube cooperation, Croatia held a National Planning Workshop in September 1998 as part of the planning process to develop the Danube Pollution Reduction Program in line with the policies of the Danube Convention.

7.1.4 Ownership of Sewerage Facilities

The Municipal Services Act (NN No. 36/95), which defines the municipal activities, includes, among others, water supply and wastewater disposal services. Municipal services may be carried out by either or among the following entities:

(1) A company founded by one or several local administration units

(2) A public institution founded by a local administrative unit

(3) A service plant, established by one or several local administration units

(4) A legal entity or a person subject to concession agreement

Presently, private companies provide most of the municipal services (wastewater disposal). There are about 130 such companies located in the larger urban areas. Privatization of municipal service companies has been carried out under the Municipal Services Act.

When municipal companies are formed, they are usually established as limited liability companies (d.o.o.), with local administration unit(s) as founders and owners.

Local Administration Units must hold at least 51% of the shares, with the remaining shares available for other private entities. No one from the private sector has yet bought into these companies since their financial situations are unattractive to investors.

The municipal companies are the owners of the assets, and if others buy in, their ownership would be in proportion to their shareholdings.

7.1.5 Institutional Recommendations

(1) Water Management Master Plan

Medium and long-term planning of sewerage facilities is difficult without a corresponding master plan for the development of water supply systems. The Water Management Master Plan of Croatia is scheduled for completion by the end of 2002, and it should provide the basis for planning of all water related facilities. It is recommended that the Water Management Master Plan be completed as soon as possible.

(2) County Water Pollution Control Plan

The National Pollution Control Plan has been completed, and it introduces measures to ensure that Croatia's natural water bodies are protected from pollution by both municipal and industrial wastewaters. The plan sets time horizons for the building of facilities and plant for wastewater treatment. However, the plan only sets the framework for general policy.

County plans for the construction of wastewater treatment plants are incomplete and it is recommended that the State Water Directorate and Croatian Waters take action to assist the counties with this task, on a basin-by-basin framework. This should

include a strategy for the drawing up of master plans with implementation schedules and financing mechanisms.

(3) Jurisdiction for Sewerage Development

The State Water Directorate, Croatian Waters, and the Counties have the responsibility for the organization of physical and financial planning with respect to the detailed plans within their areas of jurisdiction. The operation and maintenance of water and sewerage facilities, and the setting of tariffs rest with the municipal companies under the jurisdiction of the local governments.

In order to avail themselves of the loans provided by Croatian Waters, the municipal companies should have both the institutional and financial capacity to operate and maintain the facilities. Further, they should have the financial resources to contribute to the project finance and service the loans from Croatian Waters.

For the success of the project, there is a need to amend the regulations in order to ensure that Loan Agreements between SWD/Croatian Waters and the Local governments/W&S Companies will contain conditions to ensure due performance of sewerage development contracts by the municipal companies.

(4) Formation of Municipal Companies

It is essential to ensure that the water and sewerage companies have the institutional as well as the financial capacity for the operation and maintenance of the enhanced sewerage systems.

The formation of private municipal companies has lead to many municipal services, in addition to water supply and sewerage, being transferred to the new limited liability companies (d.o.o). Within the Study Area, there are only three (3) companies that provide water, and sewerage services only, two (2) of which are in F/S towns. The remaining companies are communal service companies that provide a range of other services from gas supply and solid waste disposal to open air markets and cemetery maintenance.

In the interest of economy, there is logic to the sharing of financial and management services, and to group together environmental and other services, which can share both labor and transport. However, as the sewerage network expands and the treatment plants come on stream, there will be need for a dedicated management team and labor force for the water supply and sewerage services.

It is recommended that the whole policy regarding the services to be provided by a municipal company be re-assessed nationally, particularly where large sewerage (and water supply) projects are planned.

(5) Organizations for Sewerage Development

It is recommended that the municipal companies that provide a variety of services, form a separate water supply and sewerage department to cope with the proposed expansion to the sewerage system and the construction of treatment plants. Water and sewerage form an integral system and their operation, maintenance and development must be compatible.

Such a department should have one (1) manager for the technical and financial operations of both the water supply and sewerage sections, sharing the services of plant and vehicles, the laboratory, etc. The sewerage section should have units for drainage, the sewerage network, and the treatment plant.

There must be a Management/Finance/Administration structure to support the technical services of the water supply and sewerage units within the new combined department. Whereas it is desirable for the department to have its own finance and administration section, this may not always be possible, particularly in the smaller companies.

However, it is essential that any finance department providing services to a number of departments has a separate cost center for water supply and sewerage accounts, a sound billing system and be able to provide essential statistical information.

In the three (3) cases where the municipal company provides water supply and sewerage services only, it should only be necessary to add a unit for the operation and maintenance of the wastewater treatment plant.

(6) Staffing and Manpower Development

A Manpower Development Program should be formulated as soon as possible at the national level to provide for all aspects of the management, financial and technical skills required by the staff of the water supply and sewerage departments.

The manager of the water supply and sewerage department should be technically qualified and have a reasonable knowledge of finance and accounting. Leaders of the drainage system, sewerage network and treatment plant should be suitably qualified and experienced in their particular field of work.

In particular, it will be necessary to provide training in the management, operation and maintenance of the wastewater treatment plants. This should apply at all levels and should include visits by separate groups such as management, plant operators, mechanical and electrical technicians, etc., to existing treatment plants in Croatia.

Depending upon the type of plant to be installed and the strengths and weaknesses identified in management and the workforce, it may be necessary to organize short courses for the various groups and to arrange visits outside the country for key personnel identified.

It is recommended that the State Water Directorate and Croatian Waters be responsible for the organization and content of the manpower development program, and finance be made available through the Water Management Fund. The program should be drawn up in close liaison with the local governments and municipal companies.

7.2 Water Quality Monitoring System

7.2.1 River and Wastewater Quality Monitoring

(1) River Water

The river water quality in the Study Area is periodically observed by Croatian Waters at 27 stations; namely, nine (9) at the Sava Main River, one (1) at Krapina River, seven (7) at Kupa River, one (1) at Odra River, one (1) at Lonja River, four (4) at Korana River, two (2) at Mrežnica River, and two (2) at Dobra River. For location of the monitoring stations, see Fig. I.2.2.

The Government had established the standard river water quality for 29 parameters. Most of the above monitoring stations observe nearly 40 parameters, but not including heavy metals.

There is only one (1) monitoring station (Ivanić Grad) in the Lonja River system, although the river water is much polluted. Several monitoring stations should be installed additionally in the Lonja River System to evaluate the river water quality in more detail. For location of the proposed six (6) monitoring locations, see Appendix F, Subsection 1.1.3.

(2) Wastewater

Each municipality periodically monitors sewage effluent and each industry periodically monitors industrial wastewater according to the government regulations, including frequency and parameters of analysis. Licensed laboratories perform the laboratory analyses and the results are submitted to Croatian Waters.

7.2.2 Accidental Water Pollution

In the year 2000, accidental water pollution took place 18 times in the Sava River Basin, resulting in damages to aquatic life. Highly concentrated organic compounds, oil/grease, N/P compound, anionic detergents, Cr, Cl, Phenol, Sulfide and others had caused these accidents.

Early detection of abnormal changes in river water quality is the most important to cope with accidental water pollution. For this purpose, a real time monitoring system should be established for the representative locations of the Study Area. The real time monitoring system will include the sub-systems and equipment shown in the following table. Soon after warning by the real time monitoring, a prompt detailed water quality sampling and analysis should follow to identify the causes of pollution and sources.

Sub-systems	Equipment	Item
Monitoring	Sensor Unit	pH, CN, Oil, DO, Turbidity, EC, etc.
Data Communication	Data Transmission Data Processing	Exclusively used line or telephone line
Information System	Terminal Data Output	PC/Computer, Fax. Graphic Display, Sound, etc.

7.2.3 Improvement of Laboratory

Croatian Waters is currently monitoring the river water quality of the Sava River Basin in cooperation with the licensed semi-public laboratories. The laboratory of Croatian Waters is provided with unsatisfactory equipment to monitor the water quality of the Sava River. The laboratory should be improved and strengthened to cope with the above-mentioned accidental water pollution as well as to meet the increasing requirement of river water quality analysis.

The required improvement cost is roughly estimated to be Kn. 8.7 million composed of Kn. 6.7 million for the procurement of equipment and Kn. 2.0 million for the construction of building.

7.3 GIS

7.3.1 Existing GIS

GIS related works are carried out in the GIS Section (under Planning and Development Division) of Croatian Waters. This section has four (4) engineering staff with the following hardware, software and GIS database:

Types	Items/Data
Hardware:	
Computer	Six (6) Computers [one (1) Unix, one (1) Windows NT, four (4) PC]
Plotter	Two (2) color Plotters [one (1) A0 size, one (1) A4 size]
Scanner	Two (2) Scanners (A0 size)
Software:	
Arc/Info	Three (3) Arc/Info
ArcView	Four (4) ArcView
ArcView Extensions	Two (2) 3D analyst, two (2) spatial analyst, one (1) image analysis
Arc SDE 8.02	
Arc IMS	
GIS Database:	
Natural Conditions	Topography, Administrative Border, Settlement, Transport, Geology and Hydrogeology, Land Use, Protected Area, Soil, and Forest
Water/Wastewater	River, Lake, Fishpond, Canal, Dike, Spillway, Siphon, Manipulation Gate
Water Quality & Others	Climate, Flood Potential Area in Central Sava

Altogether, this section has six (6) computers, two (2) color plotters, and two (2) scanners. Out of the two (2) plotters, one (1) has the ability to plot up to A0 size. Similarly, as software, this section has three (3) Arc/Info, and four (4) ArcView. Extensions of ArcView are also available.

In general, the available GIS data are prepared either from existing topographic maps or under the Project named Central Sava River Basin Flood Control. The topographic (TOPO) maps are 20 years or older, with some updating in 1998. Some of the water related data like canal, dike, wastewater effluent locations, spillway, siphon, and control gate are updated ones. The GIS data such as land use prepared under the Central Sava River Basin Flood Control project are limited only to the central Sava area.

7.3.2 Additional GIS Input

To enhance the power of GIS activities for raster data (like satellite data), the latest version of software named Erdas Imagine (Version 8.4; Professional product) has been purchased and installed in the GIS Section. The professional product is considered as the most sophisticated tool for remote sensing and complex image analysis. Also, the existing computers have been upgraded with additional hardware like Hard Drive, Monitor, SDRAM.

Since the existing land use map is available only for part of the current Study Area, an updated land use map covering the whole Study Area and surroundings was prepared using the satellite digital data of Landsat 7 (ETM) dated August 2, 2000. The other prepared/updated GIS data include the division of Sava River Basin into sub-basins, inputting the location of meteorological stations, industries, river water sampling, major industrial and public sewerage effluents, and so on.

Pollution maps and land use map are the two (2) major kinds of maps prepared for the Study Area. For pollution maps, the unit of analysis is based on twenty (20) sub-basins located in the Study Area. These twenty (20) sub-basins are aggregation of all thirty-two (32) sub-basins prevailing in the Study Area.

CHAPTER VIII ECONOMIC BENEFITS AND FINANCING

8.1 Economic Benefit

The proposed master plan will produce benefit in two (2) categories of river water use; namely, consumptive water use benefit (preservation of drinking and industrial uses) and non-consumptive water use benefit (recovery of aquatic life, recovery/promotion of water recreation, improvement of scenic view, etc.).

8.1.1 Benefit on Consumptive River Water Use

As stated in Chapter III, Subsection 3.2.2, there are seven (7) river water users for municipal and industrial purposes in the Study Area (including municipal water use of Karlovac Town taken from the groundwater wells on the riverbank). Among them, the industrial water of Termoelektrana Sisak and Segestica Sisak is used only for cooling purposes, and the industrial water of Petrokemija Kutina is not affected by wastewaters of the objective 24 urban centers of the master plan study. Hence, the proposed sewerage development projects will produce beneficial effects on municipal and industrial water use in the respective towns/municipalities as summarized below along with the list of benefit producing sewerage projects.

Item	Sisak/Petrinja Municipal Water	Karlovac Municipal Water	Duga Resa Industrial Water	Duga Resa Municipal Water
Intake River (category)	Kupa (II) (surface water)	Korana (II) (groundwater)	Mrežnica (II) (surface water))	Dobra (II) (surface water)
Intake Location	Immediately upstream of Petrinja Town	Riverbank at Karlovac Town	At Duga Resa Town	Near Duga Resa Town
Intake Volume	8,760 (10^3 m^3/yr)	6,211 (10^3 m^3/yr)	1,016 (10^3 m^3/yr)	1,095 (10^3 m^3/yr)
Treatment System	Conventional	Chlorination	None	Chlorination
Direct Water Production Cost	1.35 (Kn/m^3)	2.9 (Kn/m^3)	0.4 (Kn/m^3)	2.2 (Kn/m^3)
Benefit Producing Sewerage Project	Karlovac-Duga Resa, Glina, Topsko, Jastrebarsko, Slunj, Plaški, Ogulin	Karlovac-Duga Resa, Slunj, Plaški	Duga Resa, Plaški	Ogulin

8.1.2 Benefit on Non-consumptive River Water Use

(1) Aquatic Life

There are 49 species of fish in the Sava River and this number is 16 species lower than those in the Drava River in the same Danube River Basin. As mentioned in Chapter III, Subsection 3.2.3, the current number of fish species in the Sava Main, Lonja and Crnec rivers are less, compared to those in the Kupa and Korana rivers, which may be attributed to river water pollution.

(2) Fishing

Commercial fishing is small and permitted only on Sava Main River downstream from Sisak. However, sport fishing is active, enjoyed by about 40,000 to 60,000 people. There are about 30 active sport-fishing associations in the Sava River Basin.

(3) Swimming

Swimming is not common in the Sava River Basin except for some river sections. There are some beaches utilized for swimming in the rivers of Korana, Glina, Dobra, Mrežnica and Kupa.

The proposed master plan will contribute to the recovery/promotion of aquatic life, fishing, water recreation, scenic view and others. Since these benefits are difficult to estimate in monetary term, the JICA Study Team conducted a questionnaire survey on the willingness to pay sewerage charges for the preservation of water environment in the Sava River Basin.

The survey results show that the people are willing to pay 0.55% of their monthly income on the average. The average monthly income in the Study Area is estimated to be 3,500 Kn/household/month for the year 2001 and 6,121 Kn/household/month for the year 2015.

The total population of the Study Area in 2015 is projected to be 1,726,000 inhabitants or 575,000 households by assuming the average family size at 3 persons. Hence, it is considered that the annual economic benefit of 234.7 million Kn/year will accrue from a satisfactory river water environment in the year 2015.

8.2 Project Financing Policy

8.2.1 Current Financing Situation

(1) Water Management Financing Act

This Act defines the source of funds and purposes for which they may be used and funds from each source may only be used for specific purposes. For example, the water protection charge may only be used for the protection of water resources (including construction of sewerage system), and the water use charge, on exploitation of water resources (including construction of water supply system). For details, see Table I.8.1.

(2) Water Management Fund

The Water Management Fund forms part of the consolidated central government budget, and the financial plan is drawn up annually by Croatian Waters in consultation with the municipal companies providing water and sewerage services. The financial plan for the year 2000 shows the following major features:

(a) Income

Income		Amount (10^3 Kn)	Rate (%)
1. Income From Fees	Water Use Charge	210,000	14.5
	Water Protection Charge	235,000	16.3
	Extraction of Sand & Gravel	3,000	0.2
	River Basin Fee	310,000	21.5
	Power Generation Charges	40,000	2.8
	Sub-total	798,000	55.3
2. Income from Government Budget		390,794	27.1
3. Income from Towns & Municipalities		27,000	1.9
4. Min. of Public Works Reconstruction & Development		33,500	2.3
5. Income from Power Generation		15,000	1.0
6. Sale of Croatian Privatization Fund Stock		85,000	5.9
7. Other Income		94,910	6.6
Total Income		1,444,204	100.0

Source: Croatian Waters

(b) Expenditure

Expenditure		Amount (10^3 Kn)	Rate (%)
1. Running Costs	Operating Expenditure	203,000	13.5
	Carrying out of Obligations	545,650	36.2
	Sub-total	748,650	49.6
2. Capital Expenditures & Transfers	Investment for Tangible/Intangible Assets	25,000	1.7
	Investment for Pollution Control Facilities - National Waters	77,600	5.1
	Investment for Water Supply Reconstruction & Development	357,694	23.7
	Investment for Water & Sea Pollution Control Facilities	238,265	15.8
	Investment for Water Management Design	61,000	4.0
	Sub-total	759,559	50.4
Total Expenditure		1,508,209	100.0

Source: Croatian Waters

The water protection charge shares 16% of the total income, while the investment for water and sea pollution control facilities is also 16% of the total expenditure. In the absence of a master plan, funds for water pollution control facilities are allocated annually for small urgent works.

(3) Financing of Pollution Control Facilities

The water supply and sewerage companies (W&S companies) collect water pollution charges from customers and remit the amount collected to Croatian Waters. Croatian Waters is required to return 50% of this amount to the W&S companies for the construction of pollution control facilities (sewer networks and treatment plant). This is given in the form of an interest free loan over 50 years. Generally, the Local Government (LG) and the W&S company must match this amount with funds from their own budget. If the loan is not repaid, Croatian Waters becomes the owner of that proportion of the assets financed.

(4) Financial Situation of Local Government

Local governments (LG) are reported to have fiscal problems and public expenditure is increasing above income (Ministry of Finance Annual Report, 1999). Their ability to finance sewerage projects is very limited in consideration of all the municipal services they must provide.

(5) Municipal Water Supply and Sewerage Company

The owners of the companies are the LG authorities, which decide policy and approve the tariffs proposed by the company. Hence, the companies are responsible to the LG and not Croatian Waters, with development being in line with LG aims and objectives.

Profit and Loss accounts usually show that income and expenditure is balanced, except when loan-financing charges are included which usually leads to a loss situation. O&M is generally limited to the amount of finance available rather than to a rational plan.

(6) Financing Policy of Croatian Waters

The current policy for W&S Company sewerage projects is: Equity (20%); Water Management Fund (40%); and local funding (40%). This means that the LG and W&S Company must finance 80% of the total cost since finance from the Water Management Fund is by way of a 50-year interest free loan.

As regards pre-treatment facilities for industry, these are not financed by the Water Management Fund. Industry must find its own sources of finance.

8.2.2 Recommendations for the Financing Policy

(1) Greater Government Contribution

The proposed master plan project will require a large amount of investment. The costs (excluding Zagreb City) are estimated to be: (i) Kn. 530 million for collectors, and (ii) Kn. 840 million for treatment plants.

Recent financing mechanisms for municipal company sewerage projects have been:

Equity (20%); Water Management Fund (40%); Local Funding (40%)

Since the loan from the Water Management Fund is an interest free loan, the municipal companies have to shoulder 80% of the investment cost which is severe, given the low profitability of the companies and the lack of financial resources available to local governments. Furthermore, while the sewerage network is of benefit to the local population, wastewater treatment plants benefit the population downstream, enhance the environment and are therefore of national importance.

It is therefore recommended that consideration be given to a higher level of government subsidy than has been used in the recent past.

(2) Utilization of the Water Management Fund

The Water Management Financing Act, basically, limits the source of finance for protection of water resources to the payments collected through the Water Protection Charge. (There are other financial sources such as government or external loans and grants.)

The planning of development of water supply and sewerage systems should be done on an integrated basis, as one is dependent on the other. The general situation in Croatia is that water supply systems are more developed than sewerage systems; hence, more funds will be required in the sewerage sector in the immediate future. This is particularly true given the low level of wastewater treatment facilities and the high cost of construction of sewerage systems compared to water supply projects.

A more flexible approach is recommended and it is suggested that the water use charge and the water protection charge be combined and made available for water supply and/or sewerage projects. This will result in a larger source of funds being available which can be allocated on a priority basis to meet the particular needs of the sewerage sector in the immediate future.

(3) Financial Arrangements for Sewerage Development

Since the National Water Master Plan is still under preparation, and the counties have not yet completed their Water Pollution Control Plans, there is no national financing strategy at present.

However, it is important to the success of the project in the Sava River Basin that a policy is developed to enhance the financial capability of the municipal companies to part finance the projects and repay loans. Of major importance are the collection efficiency of the municipal companies and the level of tariff for sewerage services. Currently, the local governments who are the owners of the companies are largely in control of the situation.

Source of funds for government is the 22% VAT paid on the amount billed for water supply and sewerage services. This government source would not be enhanced by an increase in collection efficiency. However, the municipal companies would benefit as they currently pay the tax on uncollected bills.

Source of funds for Croatian Waters is the Water Protection Charge, which would be increased by improved collection efficiency. In addition, the level of the water pollution charge should not be lower than the cost of wastewater treatment in accordance with the Water Management Financing Act. This charge should be determined annually and enforced within the limitations of affordability.

Source of funds for the municipal companies is the tariff, which should be set to cover the cost of operation, maintenance and development. Realistic tariffs should be set, again within the limitations of affordability. The sources of funds to the companies could be increased immediately by improved collection efficiencies, which would increase revenue for water supply as well as sewerage and also, increase the amount of water use charge payable to Croatian Waters.

In order to improve collection, it is necessary for all municipalities to have by-laws to enforce disconnection for none payment. It also appears to be necessary to simplify the legal process to reduce time and costs for any necessary court action.

To ensure the financial viability of projects, it is recommended that Croatian Waters should review its policy on the percentage of loans made available to municipal companies for development projects to minimize the loan charges to the municipal companies.

In addition, loan agreements between Croatian Waters and the municipal companies should include provisions for the attainment of collection efficiency targets for the setting of tariff levels necessary to meet financial obligations, and for the achievement of the appropriate wastewater effluent quality, etc.

(4) Financial Assistance for Industrial Wastewater Treatment

A substantial sum is billed annually by Croatian Waters to industries that pollute, and it appears that some would rather continue to pay the charge than pay the cost of improving the effluent. The amount contributed by industry to the water protection charge is allocated for the protection of water resources in general and not specifically returned to industry for investment in prevention of pollution.

In the case of the water protection fee collected from municipal authorities, 50% of the sum collected may be returned as investment for sewerage projects under current policy. This is not the case for industries, and they have little incentive to improve their pre-treatment processes.

The success of the water pollution reduction project will depend on the compliance of industry to meet effluent standards for either discharge to the new treatment plant or direct to watercourses. It is estimated that, as a minimum, Kn. 130 million (excluding Zagreb) will be required to upgrade pre-treatment facilities for the large industries in the Study Area.

It is therefore recommended that soft loans be made available to industry, through the Water Management Fund, to upgrade their pre-treatment facilities.

TABLES

Table I-4.1 List of Selected Large Industries

Town/Municipality	Code No.	Industry Name	Activities	Recipient
Sesvete East	310001	Agroproteinka	Food/Beverage	Canal
	310248	Duma Koze	Leather	Canal
Vrbovec	360004	PIK Vrbovec Mesna Ind.	Food/Beverage	Canal
	360008	PIK Vrbovec Farma Poljanski	Food/Beverage	Land
	360002	Gradip	Clay Industry	Canal
Sisak	374001	INA Zagreb RafineriJa Nafte Sisak	Oil Refinery	River
	374002	Herbos d.d.	Chemistry	Sewerage
	374003	Termoelektrana Sisak	Electricity	River
	374004	Tvornica Segestica	Food/Beverage	Sewerage
	374005	Zeljezara Poduzece Metaval	Metal/Machinery	River
	374006	Ljudevit Posavski Mlin i Pekare	Food/Beverage	Sewerage
Kutina	357009	Petrokemija Kutina (industrial)	Chemistry	River
	357016	(sanitary)		Sewerage
Karlovac	333006	Karlovacka Pivovara	Food/Beverage	Sewerage
	333015	PPK Karlovacka Industrija Mesna	Food/Beverage	River
	333005	Velebit	Textile	River
	333012	Lola Ribar	Textile	River
	333016	Karlovacka Industrija Mlijeka	Food/Beverage	River
	333003	Kordun Karlovac	Metal/Machinery	Sewerage
	333008	Ze-Ce	Metal/Machinery	Sewerage
	333010	Trornica Plinski Turbuna	Metal/Machinery	Sewerage
	333011	Adria-Diesel	Metal/Machinery	Sewerage
	333017	ABB Alstom Power	Metal/Machinery	Sewerage
	333019	Linde Plin d.o.o.	Gas Service	Canal
	333029	Autotransport d.d.	Transportation	Sewerage
Duga Resa	331001	Pamucna Industrija Duga Resa	Textile	River
Ivanic Grad	355005	INA Naftaolin Pogon Etan	Oil Refinery	Sewerage
	355010	Crosco Naftini Servisi	Shopping Center	Sewerage
	355015	Naftaplin Ljeciliste	Hospital	Sewerage
	355019	INA Naftaolin Radilist Oroi	Oil/Gas Service	Brook
Samobor	309021	Chromos Graficke Boje	Chemistry	Sewerage
	309047	Fotokemika	Photography	Sewerage
	309069	Imes	Food/Beverage	Sewerage
	309123	Pliva Kalinovica	Chemistry	River
	309180	Chromos Graficke Boje	Chemistry	Sewerage
	309233	Imunoloski Zavod Brezje	Pharmacy/Drug	Sewerage
	309278	TOP	Others	River
Zapresic	315127	Pliva	Chemistry	River
	315062	HZ Infrastrucktura	Transportation	Sewerage
	315080	Inker	Ceramic	River
	315089	Karbon	Chemistry	River
	315157	Viadukt	Others	River
Velika Gorica	314038	Dalekovod	Metal/Machinery	Sewerage
	314077	Industrogradnja	Concrete	Sewerage
	314079	Industrogradnja	Concrete	River
	314205	Zracna Luka Zagreb	Transportation	Sewerage
Jastrebarsko	332001	Mladina d.d.	Food/Beverage	Sewerage
	332002	Jamnica Zagreb, Jamnicka Kiselica	Food/Beverage	Canal
Petrinja	373001	Gavrilovic d.o.o.	Food/Beverage	River
Popovaca	357003	Neutropsihijatrijska Bolnica	Hospital	Sewerage
Ogulin	335001	Opca Bolnica Ogulin	Hospital	Underground
	335004	Bjelolasic	Hotel	Brook

Table I-4.2 Existing Main Features of Large Pollutant Industries

Town	Industry Name	Watewater Quantity (m^3/d)	Wastwater Quality (mg/l)								Existing Treatment	Effluent Recipient (Category)
			BOD	COD	TSS	T-N	T-P	T-Oil	Phenol	Pesti-cides		
Sesvete-East	Agroproteinka d.d.	228	2,230	2,699	1,675	226.6	45.7	218.5	-	-	Sedimentation	Lonja R. (II)
	Duma Koze d.o.o.	509	686	2,097	14,111	1,105.0	-	75.5	-	-	Coagulation Tank	Lonja R. (II)
Vrbovec	PIK Vrbovec Mesna Ind.	2,132	186.0	406	327	19.8	3.9	52.6	-	-	Oil Interceptor	Lonja R. (II)
Sisak	Industrija Nafte d.d. Rafinerija	9,399	26.7	62	311.0	72.2	-	12.1	1.3	-	Chemical Clarifier/Activated Sludg	Kupa R. (II)
	Herbos d.d.	604	205	577	1,406	24.7	-	10.3	-	0.4	None	Sewerage
	Termoelektrana Sisak	451	4.5	25.5	178	2.3	0.1	3	-	-	Neutralization	Sava R. (III)
	Tvornica Segestica	204	866	1,195	692	355	13	4.5	-	-	None	Sewerage
	Zeljezara Poduzece Metaval	3,182	12.4	28.3	143.0	3	0.3	4.4	-	-	Neutralization	Sava R. (III)
	Ljudevit Posavski Mlin i Pekare	83	1,584	2,600	456	-	-	9.3	-	-	None	Sewerage
Kutina	Petrokemija (Industry)	10,388	11.1	38.8	157	53	4.9	1.4	-	-	Ion Exchanger/Cabon Filter	Kutina R. (II)
	Petrokemija (Sanitary)	663	18.7	57.6	398	49	-	0.3	-	-	None	Sewerage
Karlovac	Karlovaeka Pipovara d.d.	2,301	456	911	595	7.6	7.6	4.2	-	-	None	Sewerage
	PPK-karlovacka Industrija Mesn	348	484	514	606	12.2	5.1	5.8	-	-	None	Kupa R. (II)
	Velebit	248	150	328	256	-	0.4	3.7	-	-	None	Kupa R. (II)
	Lola Ribar	307	116	243	307	0.1	0.1	2.7	-	-	None	Mrzenica R. (II)
	Karlovacka Industrija Mlijeka	250	147	282	294	-	-	15.3	-	-	Neutralization	Kupa R. (II)
Duga Resa	Pamuena Industrija Duga Resa	2,416	120	288	277	4.8	0.8	1.1	-	-	None	Mrzenica R. (II)
Zapresic	PLIVA	1,928	339	1,768	1,944	166.3	3.2	0.2	0.19	-	Biological	Sava R. (II)
Petrinja	Gavrilovic d.d.	1,357	116	234	182	4.8	2.6	13.4	-	-	Oil Interceptor	Kupa R. (II)
Permissible Limit of Category II River			25	125	35	21	1	25	0.1			
Permissible Limit of Category III River			25	125	35-60	31	2	30				
Permissible Limit of Public Sewerage			250	700	-	-	10	100	10	0.05		

Table I-4.3 Existing Main Features of Other Large Industries

Town	Industry Name	Watewater Quantity (m^3/d)		Wastwater Quality (mg/l)						Existing Treatment	Effluent Recipient (Category)
		1999	2015	BOD	COD	TSS	T-N	T-P	T-Oil		
Vrbovec	PIK Vrbovec Farma Poljanski	75	124	2,786	4,873	5,428	(30.0)	(5.0)	3.4	Lagoon	Land
	Gradip	110	187	74	148	385	(30.0)	(5.0)	13.9	None	Sewerage
Karlovac	Kordun Karlovac	128	212	30	73	423	(30.0)	(5.0)	5.9	Yes	Sewerage
	Ze-Ce	305	504	7	32	285	(30.0)	(5.0)	6.9	Yes	Sewerage
	Trornica Plinski Turbuna	134	221	26	73	342	(30.0)	(5.0)	5.9	Yes	Sewerage
	Adria-Diesel	129	213	30	97	734	(30.0)	(5.0)	30.0	Yes	Sewerage
	ABB Alstom Power	240	397	24	62	56	(30.0)	(5.0)	(3.0)	None	Sewerage
	Linde Plin d.o.o.	129	213	19	58	499	(30.0)	(5.0)	5.0	None	Canal (II)
	Autotransport d.d.	104	172	23	147	244	(30.0)	(5.0)	5.7	Yes	Sewerage
Ivanic Grad	INA Naftaolin Pogon Etan	460	760	22	48	733	(30.0)	(5.0)	4.2	Yes	Sewerage
	Crosco Naftini Servisi	200	330	20	17	494	(30.0)	(5.0)	10.0	Yes	Sewerage
	Naftaplin Ljeciliste	117	193	43	240	662	(30.0)	(5.0)	169.0	Yes	Sewerage
	INA Naftaolin Radilist Oroi	229	378	13	13	646	(30.0)	(5.0)	1.9	Yes	Brook (II)
Samobor	Chromos Graficke Boje	213	352	33	93	1,568	(30.0)	(5.0)	4.2	-	Sewerage
	Fotokemika	432	714	50	100	300	(30.0)	(5.0)	5.0	-	Sewerage
	Imes	89	147	631	951	2,107	(30.0)	(5.0)	155.6	-	Sewerage
	Pliva Kalinovica	578	955	28	128	513	(30.0)	(5.0)	8.1	-	River (II)
	Chromos Graficke Boje	189	312	18	35	563	(30.0)	(5.0)	1.5	-	Sewerage
	Imunoloski Zavod Brezje	682	1,127	40	221	649	(30.0)	(5.0)	3.4	-	Sewerage
	TOP	207	342	44	84	1,161	(30.0)	(5.0)	5.0	-	River (II)
Zapresic	HZ Infrastrucktura	275	454	130	137	577	(30.0)	(5.0)	167.8	-	Sewerage
	Inker	391	646	43	102	2,567	(30.0)	(5.0)	6.9	-	River (II)
	Karbon	535	884	40	212	827	(30.0)	(5.0)	14.7	-	Sewerage
	Viadukt	242	400	269	744	1,625	(30.0)	(5.0)	152.9	-	River (II)
Velika Gorica	Dalekovod	192	317	126	342	691	(30.0)	(5.0)	29.5	-	Sewerage
	Industrogradnja	101	167	50	100	300	(30.0)	(5.0)	5.0	-	Sewerage
	Industrogradnja	240	397	50	100	300	(30.0)	(5.0)	5.0	-	River (III)
	Zracna Luka Zagreb	108	178	87	125	889	(30.0)	(5.0)	0.6	-	Sewerage
Jastrebarsko	Mladina d.d.	109	180	230	369	300	(30.0)	(5.0)	5.0	Yes	Sewerage
	Jamnica Zagreb, Jamnicka Kiseli	736	1,216	68	96	1,232	(30.0)	(5.0)	0.3	Biological	Canal (II)
Popovaca	Neutropsihijatrijska Bolnica	452	747	260	400	473	(30.0)	(5.0)	6.3	None	Sewerage
Ogulin	Opca Bolnica Ogulin	206	340	41	126	553	(30.0)	(5.0)	7.1	Yes	Underground
	Bjelolasic	163	269	99	201	333	(30.0)	(5.0)	7.6	Biological	Brook (II)
Permissible Limit of Category II River				25	125	35	21	1	25.0		
Permissible Limit of Category III River				25	125	35-60	31	2	30.0		
Permissible Limit of Public Sewerage				250	700	-	-	10	100.0		

Note: ( ): JICA estimate

Table I-4.4 Proposed Wastewater Treatment of Large Pollutant Industries

Town	Industry Name	Watewater Quantity (m^3/d)		Wastwater Quality BOD (mg/l)		Pollution Load BOD (kg/d)		Effluent Recipient (Category)		Construction Cost (million Kn)
		1999	2015	1999	2015	1999	2015	Existing	Future	
Sesvete-	Agroproteinka d.d.	228	377	2,230	250	508	94	Lonja R. (II)	Sewerage	9.91
East	Duma Koze d.o.o.	509	1,222	686	250	349	306	Lonja R. (II)	Sewerage	2.00
Vrbovec	PIK Vrbovec Mesna Ind.	2,132	3,523	186	186	397	655	Lonja R. (II)	Sewerage	-
Sisak	Industrija Nafte d.d. Rafinerija	9,399	15,531	27	25	251	388	Kupa R. (II)	Kupa R. (II)	10.30
	Herbos d.d.	604	939	205	205	124	192	Sewerage	Sewerage	1.50
	Termoelektrana Sisak	451	745	5	5	2	3	Sava R. (II)	Sava R. (II)	1.00
	Tvornica Segestica	204	337	866	250	177	84	Sewerage	Sewerage	7.16
	Zeljezara Poduzece Metaval	3,182	4,949	12	12	39	61	Sava R. (II)	Sava R. (II)	2.00
	Ljudevit Posavski Mlin i Pekare	83	137	1,584	250	131	34	Sewerage	Sewerage	5.91
Kutina	Petrokemija (Industry)	10,388	17,165	11	11	115	191	Kutina R. (II)	Kutina R. (II)	10.00
	Petrokemija (Sanitary)	663	1,063	19	19	12	20	Sewerage	Sewerage	-
Karlovac	Karlovaeka Pipovara d.d.	2,301	3,802	456	250	1,049	951	Sewerage	Sewerage	16.28
	PPK-karlovacka Industrija Mesna	348	609	484	250	168	152	Kupa R. (II)	Sewerage	7.46
	Velebit	248	410	150	150	37	62	Kupa R. (II)	Sewerage	-
	Lola Ribar	307	507	116	116	36	59	Mrzenica R. (II	Sewerage	-
	Karlovacka Industrija Mlijeka	250	413	147	147	37	61	Kupa R. (II)	Sewerage	0.50
Duga Resa	Pamuena Industrija Duga Resa	2,416	3,992	120	120	290	479	Mrzenica R. (II	Sewerage	0.10
Zabresic	PLIVA	1,928	3,186	339	250	654	797	Sava R. (II)	Sewerage	15.30
Petrinja	Gavrilovic d.d.	1,357	1,979	116	116	157	230	Kupa R. (II)	Sewerage	1.00
Sub-total	(Sewerage)	3,855	22,496			1,494	4,175			
Sub-total	(River)	33,143	38,390			3,041	644			
Total		36,998	60,886			4,534	4,818			90.42

Table I-4.5 Proposed Wastewater Treatment of Other Large Industries

Town	Industry Name	Wastewater Quantity (m^3/d)		Wastwater Quality BOD (mg/l)		Pollution Load BOD (kg/d)		Effluent Recipient (Category)		Construction Cost (million Kn)
		1999	2015	1999	2015	1999	2015	Existing	Future	
Vrbovec	Gradip	110	187	74	74	8	14	Sewerage	Sewerage	-
	PIK Vrbovec Farma Poljanski	75	124	2,786	2,786	0	0	Land	Land	-
Karlovac	Kordun Karlovac	128	212	30	30	4	6	Sewerage	Sewerage	0.50
	Ze-Ce	305	504	7	7	2	4	Sewerage	Sewerage	0.70
	Tvornica Plinski Turbuna	134	221	26	26	3	6	Sewerage	Sewerage	0.50
	Adria-Diesel	102	169	30	30	3	5	Sewerage	Sewerage	0.50
	ABB Alstom Power	240	397	24	24	6	10	Sewerage	Sewerage	-
	Linde Plin d.o.o.	129	213	19	19	2	4	Canal (II)	Canal (II)	-
	Autotransport d.d.	104	172	23	23	2	4	Sewerage	Sewerage	0.30
Ivanić Grad	INA Naftaolin Pogon Etan	460	760	22	22	10	17	Sewerage	Sewerage	1.00
	Crosco Naftini Servisi	200	330	20	20	4	7	Sewerage	Sewerage	0.50
	Naftaplin Ljeciliste	117	193	43	43	5	8	Sewerage	Sewerage	0.30
	INA Naftaolin Radilist Oroi	229	378	13	13	3	5	Brook (II)	Brook (II)	1.50
Samobor	Chromos Graficke Boje	213	352	33	33	7	12	Sewerage	Sewerage	-
	Fotokemika	432	714	50	50	22	36	Sewerage	Sewerage	-
	Imes	89	147	631	250	56	37	Sewerage	Sewerage	4.20
	Pliva Kalinovica	578	955	28	25	16	24	River (II)	River (II)	5.00
	Chromos Graficke Boje	189	312	18	18	3	6	Sewerage	Sewerage	-
	Imunoloski Zavod Brezje	682	1,127	40	40	27	45	Sewerage	Sewerage	-
	TOP	207	342	44	25	9	9	River (II)	River (II)	2.40
Zaprešic	HZ Infrastrucktura	275	454	130	130	36	59	Sewerage	Sewerage	0.30
	Inker	391	646	43	25	17	16	River (II)	River (II)	3.50
	Karbon	535	884	40	40	21	35	Sewerage	Sewerage	-
	Viadukt	242	400	269	25	65	10	River (II)	River (II)	7.50
Velika Gorica	Dalekovod	192	317	126	126	24	40	Sewerage	Sewerage	-
	Industrogradnja	101	167	50	50	5	8	Sewerage	Sewerage	-
	Industrogradnja	240	397	50	50	12	20	River (III)	River (III)	-
	Zracna Luka Zagreb	108	178	87	87	9	15	Sewerage	Sewerage	-
Jastrebarsko	Mladina d.d.	109	180	230	230	25	41	Sewerage	Sewerage	0.30
	Jamnica Zagreb, Jamnicka Kiselic	736	1,216	68	25	50	30	Canal (II)	Canal (II)	5.00
Popovača	Neutropsihijatrijska Bolnica	452	747	260	260	118	194	Sewerage	Sewerage	-
Ogulin	Opca Bolnica Ogulin	206	340	41	41	8	14	Underground	Sewerage	0.50
	Bjelolasic	163	269	99	25	16	7	Brook (II)	Brook (II)	3.00
Sub-total (Sewerage)		5,277	9,064			402	622			
Sub-total (River)		3,196	4,940			199	125			
Total		8,473	14,004			601	747			37.50

Note: ( ): JICA estimate

Table I-5.1 Permissible Limits of Effluent Quality of Objective Sewage Treatment Plants

	Sewerage System	Urban Center Population (2015)	Expected Plant Size (PE)	Receiving Water (Category)		Permissible Limits of Effluent Quantity				Remarks
						TSS (mg/l)	BOD (mg/l)	COD (mg/l)	T-P (mg/l)	
1	Zagreb	980,400	> 100,000	Middle Sava	(III)	35	25	125	-	Excluding Sesvete East
2	Sesvete-East	17,600	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	
3	Dugo Selo	12,301	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	
4	Vrbovec [1)]	4,366	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	Considering industry
5	Sisak	44,842	10,000 - 100,000	Lower Sava	(II)	35	25	125	2	
6	Kutina	19,679	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	
7	Karlovac -Duga Resa [2)]	61,425	10,000 - 100,000	Lower Kupa	(II)	35	25	125	2	
8	Sveti Ivan Zelina	2,668	< 10,000	Lonja-Strug	(II)	60	40	150	-	
9	Ivanić Grad -Kloštar Ivanić [2)]	11,797	10,000 - 100,000	Lonja-Strug	(II)	35	25	125	2	
10	Samobor	18,800	10,000 - 100,000	Upper Sava	(II)	35	25	125	2	
11	Zaprešić	23,658	10,000 - 100,000	Upper Sava	(II)	35	25	125	2	Including Brdovec
12	Velika Gorica	42,482	10,000 - 100,000	Middle Sava	(III)	35	25	125	-	
13	Jastrebarsko	5,661	< 10,000	Kupcina	(II)	60	40	150	-	
14	Petrinja	14,466	10,000 - 100,000	Lower Kupa	(II)	35	25	125	2	
15	Glina	4,490	< 10,000	Glina	(II)	60	40	150	-	
16	Topusko	1,227	< 10,000	Glina	(II)	60	40	150	-	
17	Popovaća	3,604	< 10,000	Lonja-Strug	(II)	60	40	150	-	
18	Lipovljani	2,457	< 10,000	Lonja-Strug	(II)	60	40	150	-	
19	Novska	8,276	< 10,000	Lonja-Strug	(II)	60	40	150	-	
20	Ogulin	10,449	10,000 - 100,000	Dobra	(II)	35	25	125	2	
21	Plaški	1,753	< 10,000	Dretulja	(II)	60	40	150	-	
22	Slunj	1,329	< 10,000	Lower Korana	(II)	60	40	150	-	

Note: 1) : Pollution load including industry is expected to be larger than 10,000 PE

2): Ivanic Grad - Klostar Ivanic, and Karlovac - Duga Resa are an integrated system of two (2) urban centers respectively.

Table I-5.2 Main Features of Sewerage Development of Local Urban Centers

Urban Center	Served Features			Wastewater Flow (m^3/d)			BOD Load /Content			Sewer					Treatment Process	Construction Cost (million Kn)
	Area (ha)	Population	Nos. of Industry	Muni-cipal	Industry	Total	(Kg/d)	(PE)	(mg/l)	Transport/Main Size (mm)	Transport/Main Length (m)	Secondary/Tertiary Size (mm)	Secondary/Tertiary Length (m)	Total Length (m)		
Sv. Ivan Zelina	569	7,000	0	2,380	0	2,380	462	7,700	194.1	200 - 300	16,370	200	1,470	17,840	OD	43.61
Ivanić Grad - Kloštar Ivanić	1,013	11,400	3	4,512	1,283	5,795	911	15,200	157.2	200	2,690	200	11,240	13,930	AO	43.37
Samobor	1,914	29,200	5	11,680	1,528	13,208	2,367	39,500	179.2	200 -800	9,230	200	10,540	19,770	AO	58.49
Zaprešić	1,491	30,500	3	14,144	4,600	18,744	3,678	61,300	196.2	400 - 1,000	8,430	200	19,220	27,650	AO	106.25
Velika Gorica	2,011	62,400	3	24,960	662	25,622	4,931	82,200	192.5	200 - 400	21,500	200	13,980	35,480	AS	77.50
Jastrebarsko	623	8,100	1	2,754	180	2,934	576	9,600	196.3	200 - 800	4,100	200	3,650	7,750	OD	36.04
Petrinja	650	13,100	1	5,240	1,979	7,219	1,249	20,900	173.1	200 - 600	3,890	200	7,130	11,020	AO	55.59
Glina	480	5,200	0	1,768	0	1,768	343	5,800	194.1	200	5,410	200	12,710	18,120	OD	36.60
Topusko	84	1,600	0	544	0	544	106	1,800	194.1	200	3,660	200	630	4,290	AL	6.46
Popovača	179	3,600	1	1,224	747	1,971	432	7,200	219.1	200 - 400	3,820	200	680	4,500	OD	26.73
Lipovljani	328	3,000	0	1,020	0	1,020	198	3,300	194.1	200 - 250	5,170	200	9,420	14,590	OD	28.30
Novska	541	9,000	0	3,060	0	3,060	594	9,900	194.1	200 - 600	3,650	200	5,490	9,140	OD	37.23
Ogulin	468	10,400	1	4,160	340	4,500	825	13,800	183.4	200 - 300	4,040	200	5,930	9,970	AO	42.49
Plaški	52	800	0	272	0	272	53	900	194.1	200	2,380	200	1,610	3,990	OD	12.37
Slunj	219	2,400	0	816	0	816	158	2,700	194.1	100 -250	1,770	200	7,010	8,780	OD	23.43
Total	10,622	197,700	18	78,534	11,319	89,853	16,883	281,800			96,110		110,710	206,820		634.46

Note: 1): OD: Oxidation Ditch, AO: Anerobic Oxic Activated Sludge, AS: Activated Sludge, AL: Aerated Lagoon

2): Zaprešić includes Brdovec.

Table I-5.3 Existing Sewerage System

Name of City/Town /Municipality	Urban Center				Industry (nos.)		Sewerage System [2]	Existing Sewer Length (km)	Treatment Process [3]
	Urban Area (ha)	Served Area (ha)	Total Population	Served Population	Total	Served			
1 Zagreb[1]	63,378	25,600	920,200	800,000	230	230	C	1,500.0	
2 Sesvete-East	626	555	14,800	11,900	2	0	C	42.0	
3 Dugo Selo	300	516	10,570	9,100	0	0	C	16.5	
4 Vrbovec	238	393	4,190	5,000	3	1	C	28.0	
5 Sisak	1,770	944	44,175	39,400	6	3	C	77.0	
6 Kutina	902	549	16,800	16,100	1	0	C	45.0	Preliminary
7 Karlovac -Duga Resa	1,137	1,099	60,266	32,000	13	7	C	99.1	
8 Sv. Ivan Zelina	144	251	2,560	3,200	0	0	C	5.2	
9 Ivanić Grad -Kloštar Ivanić	821	662	10,409	6,300	4	3	C	35.8	Preliminary
10 Samobor	557	1,518	16,154	15,400	7	5	C	83.8	Activated Sludge (×)
11 Zaprešić[3]	462	949	20,329	13,300	5	2	C	47.5	
12 Velika Gorica	701	1,453	36,502	33,500	4	3	S	143.3	Activated Sludge
13 Jastrebarsko	242	409	5,434	5,300	2	1	C	33.0	
12 Petrinja	940	419	12,545	10,300	1	0	C	33.0	
13 Glina	459	175	4,098	2,000	0	0	C	38.4	
14 Topusko	92	34	1,116	500	0	0	C/S	6.5	Aerated Lagoon （×）
15 Popovaća	204	123	3,462	1,800	1	1	C	9.4	
17 Lipovljani	269	60	2,245	800	0	0	C	4.5	
18 Novska	389	380	5,747	4,000	0	0	C	44.0	
20 Ogulin	431	0	10,252	0	2	0	C	0.7	
21 Plaški	195	0	1,720	0	0	0	None	0.0	
22 Slunj	127	62	1,304	600	0	0	C	2.3	
Total	74,384	36,149	1,204,878	1,010,500	281	256		2,295.0	
Total Except Zagreb	11,006	10,549	284,678	210,500	51	26		795.0	

Note 1) Sesvete - East is excluded

2) C: Combined system, S: Separate system

3) Including Brdovec

(×): Not Working

Table I-5.4 Proposed Sewerage Development Plan

	Name	Served Population		Served Area (ha)		Design Quantity (m^3/day)			Person Equivalent (PE)	Treatment Process *	Construction Cost (Million Kuna)		
		1999	2015	1999	2015	Domestic	Industry	Total			Collector	WWTP	Total
1	Zagreb	800,000	935,000	25,600	25,600	274,860	167,510	442,370	1,500,000	AS			1,365.0
2	Sesvete-East	11,900	17,600	555	837	7,040	1,599	8,639	29,600	AO	17.2	49.3	66.5
3	Dugo Selo	9,100	14,200	516	1,072	5,680	0	5,680	18,500	AO	49.7	41.3	91.0
4	Vrbovec	5,000	8,400	393	791	2,856	3,710	6,566	20,400	AO	36.5	41.7	78.2
5	Sisak	39,400	52,400	944	2,380	20,960	1,413	22,373	73,400	AO	67.8	92.0	159.8
6	Kutina	16,100	24,800	549	1,303	9,920	1,063	10,983	32,900	AO	43.7	40.2	84.0
7	Karlovac -	28,200	55,800	966	1,978	22,320	7,603	29,923	94,800	AO	133.2	126.7	259.9
	Duga Resa	3,800	10,900	133	205	4,360	3,992	8,352	22,200				
8	Sv. Ivan Zelina	3,200	7,000	251	569	2,380	0	2,380	7,700	OD	18.1	25.5	43.6
9	Ivanić Grad -	5,700	10,600	524	863	4,240	1,283	5,523	14,300	AO	10.9	32.4	43.4
	Kloštar Ivanić	600	800	138	150	272	0	272	900				
10	Samobor	15,400	29,200	1,518	1,914	11,680	1,528	13,208	39,500	AO	14.4	44.0	58.4
11	Zaprešić	13,300	30,500	949	1,491	12,200	6,544	18,744	61,300	AO	29.4	76.8	106.3
12	Velika Gorica	33,500	62,400	1,453	2,011	24,960	662	25,622	82,200	AS	30.0	47.5	77.5
13	Jastrebarsko	5,300	8,100	409	623	2,754	180	2,934	9,600	OD	8.4	27.7	36.0
14	Petrinja	10,300	13,100	419	650	5,240	1,979	7,219	20,900	AO	10.4	45.2	55.6
15	Glina	2,000	5,200	175	480	1,768	0	1,768	5,800	OD	14.3	22.3	36.6
16	Topusko	500	1,600	34	84	544	0	544	1,800	AL	3.5	3.0	6.5
17	Popovaća	1,800	3,600	123	179	1,224	747	1,971	7,200	OD	3.7	23.1	26.7
18	Lipovljani	800	3,000	60	328	1,020	0	1,020	3,300	OD	11.2	17.1	28.3
19	Novska	4,000	9,000	380	541	3,060	0	3,060	9,900	OD	9.0	28.2	37.2
20	Ogulin	0	10,400	0	468	4,160	340	4,500	13,800	AO	8.5	34.0	42.5
21	Plaški	0	800	0	52	272	0	272	900	OD	3.0	9.3	12.4
22	Slunj	600	2,400	62	219	816	0	816	2,700	OD	7.8	15.7	23.4
	Sub-total (except Zagreb)	210,500	381,800	10,549	19,186	149,726	32,643	182,369	573,600				2738.8
	Total	1,010,500	1,316,800	36,149	44,786	424,586	200,153	624,739	2,073,600		530.8	843.0	1,373.8

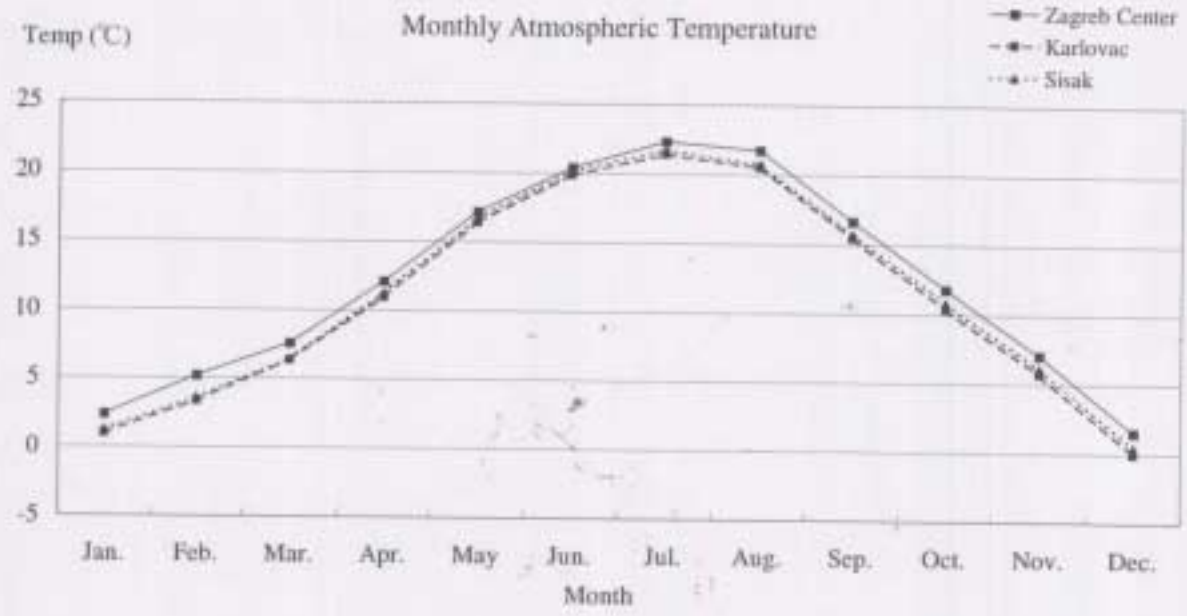
1): * AS:Activated Sludge, AO: Anaerobic Oxic Activated Sludge, OD: Oxidation Ditch, AL: Aerated Lagoon

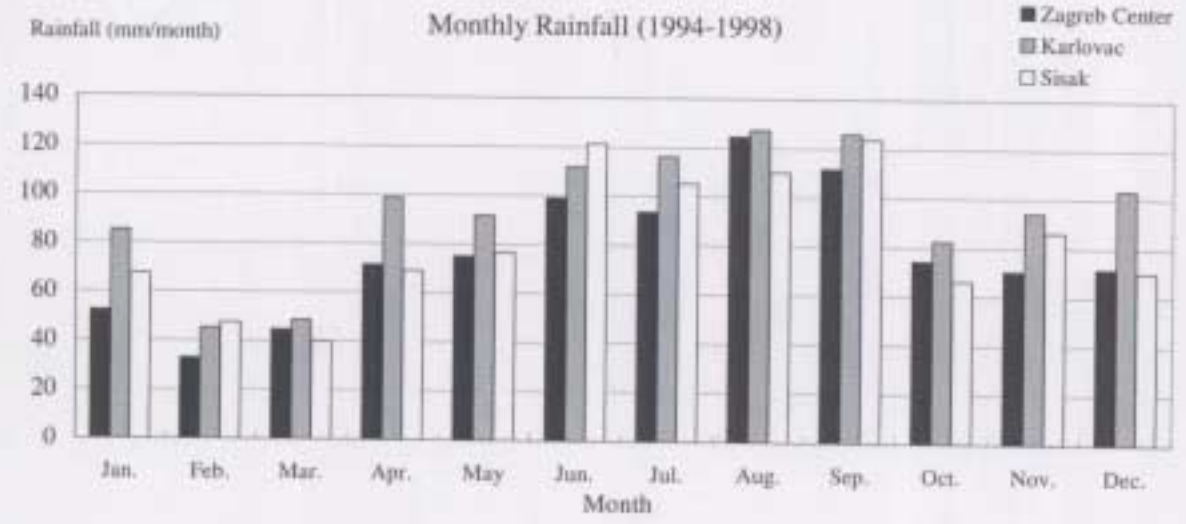
2): Zaprešić includes Brovec

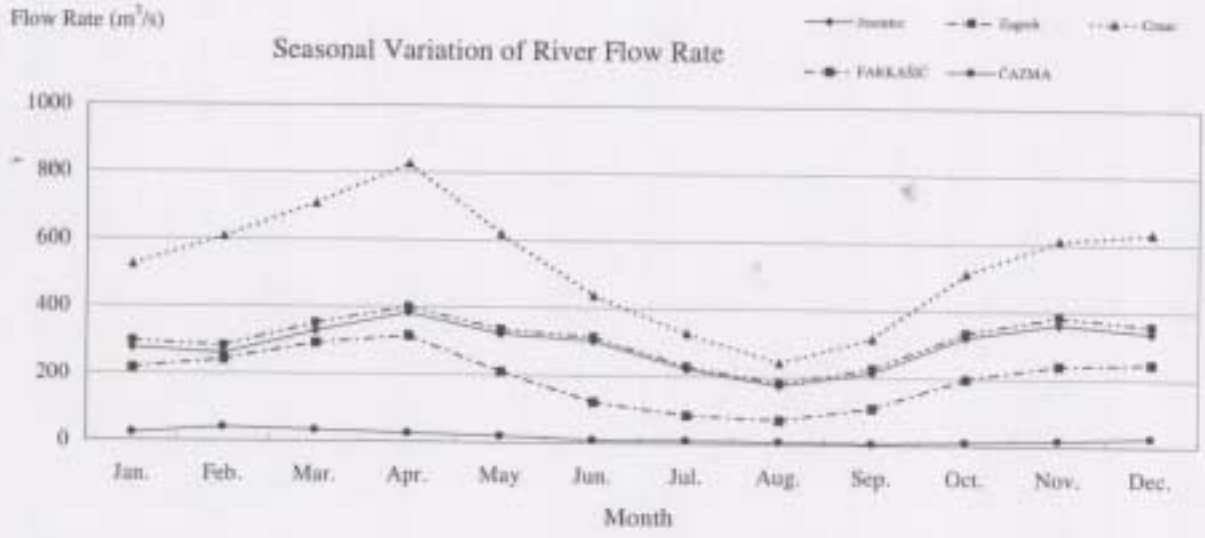
Table I-8.1 Water Management Financing Act (NN:107/95, 19/96, 88/98)

Sources of Funds	Funds Used For Financing	Paid by	Payment set by	Paid to
1. Contributions for Water Management	1. Expert, Admin & Other Activities in Water System Mangt (Public Service) 2. Mangt of Water Courses&Resources and Protection from Water	Government (Replaced the previous system of a tax for all employed persons)	Parliament	Water Management Fund
2. Water Use Charge	3. Exploitation of Water Resources (Provision of Water Reserves) 1. Expert, Admin & Other Activities in Water System Mangt (Public Service)	Payers using the Water from Water Supply Systems Persons using Water Power for Plant Operation or P0wer Generation	Government	Croatian Waters(CW) by W & S Cos.
3. Water Protection Charge	4. Protection of Water Resources (i) Preparation & Inplementation of Water Protection Plans (ii) Water Quality Control (iii) Bldg of Water Protection Facilities (Proportional Participation) 1. Expert, Admin & Other Activities in Water System Mangt (Public Service)	Persons Discharging Wastewater which pollute water Payment made on Quantity & Quality of effluent Amount can't be less than the price of Water Purification (unless user is purifying the wastewater water)	Government (Determined by CW)	1. CW by the Water Supply Companies, as per the Quantity of Water Distributed (CW Pay 5% collection fee) Collected from; Owners & Users of Apartments & Business Premises connected to the Water supply Industrial W/W & Apartments/Business not connected payCW direct
4. Extraction of Sand and Gravel	2.2. Regular Technical/Economical Maintenance of Water Courses, ameiloration Facilities, and Facilities for Protection from Water	Does not say - presumably by those who extract sand and gravel	CW Managing Board	Does not say
5. River Basin (Catchment) Fee	1. Expert, Admin & Other Activities in Water System Mangt (Public Service) 2.1. Planning of Flood Protection 2.2. Regular Technical/Economical Maintenance of Water Courses, 5 Magt/Maint of Land Reclaim Systems	Owners and Users of Land and other Real Estate - everything incl. Roads, parks etc.- there are some exemptions; the aged, failed crops etc	Rate per unit area is set County Assemblies - rate is set for 2-5 years based on Basin Mangt Plan - Government	Does not say
6. Budgets of Local Govt&Local Admin (if River Basin fee is not enough)	2. Mangt of Water Courses&Resources and Protection from Water 5 Magt/Maint of Land Reclaim Systems 2.3 Bldg Water Protection Facilities 5.3 Bldg Land Reclamation Systems	Owners & Holders of Agric/Forest Land etc.	County Assembly	Croatian Waters
7. Other Sources	Building of Water Managt Facilities or other works to Improve Water Regime	Legal and Physical Persons with own Funds	In Contract with CW, incl asset ownership	

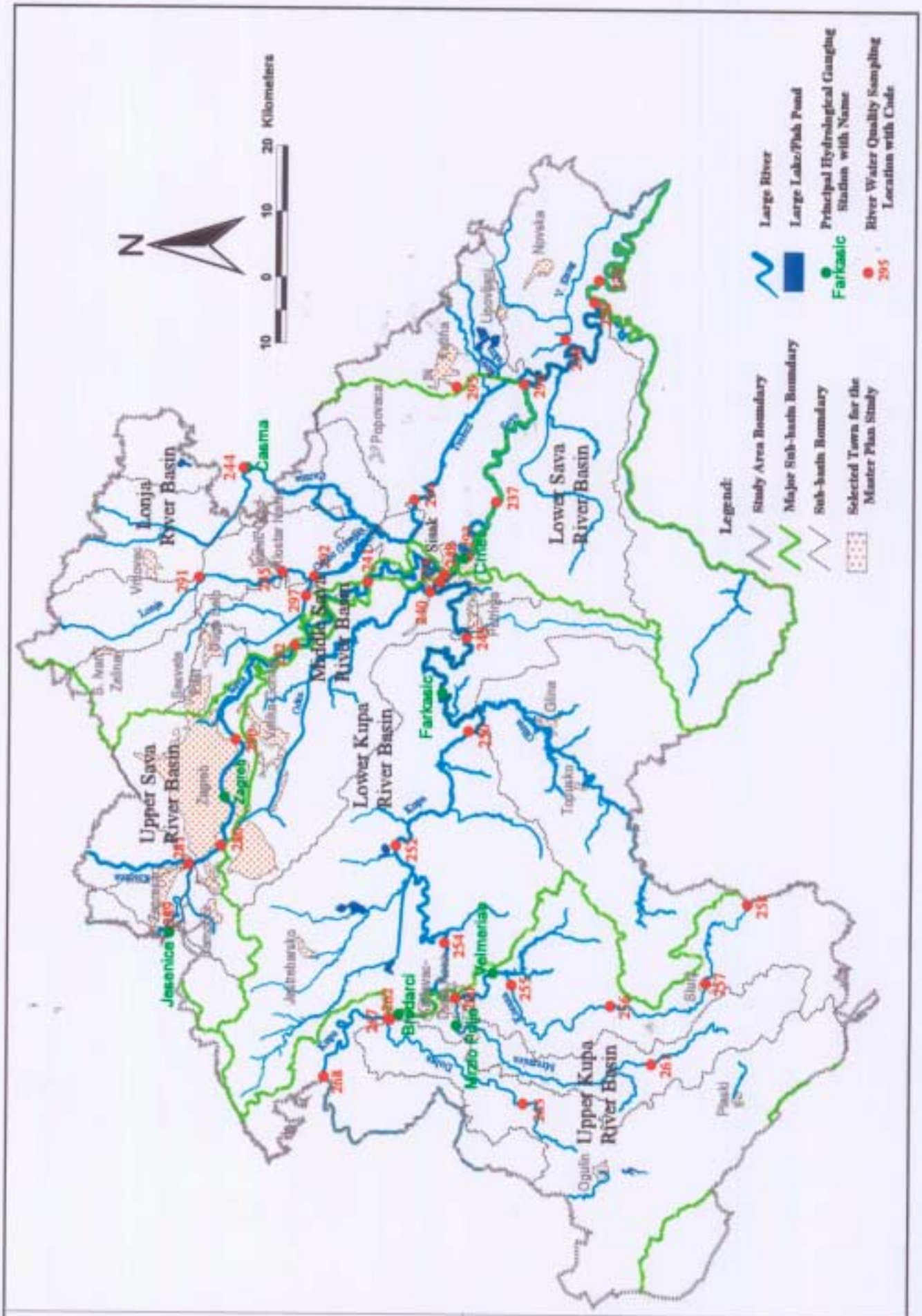
FIGURES







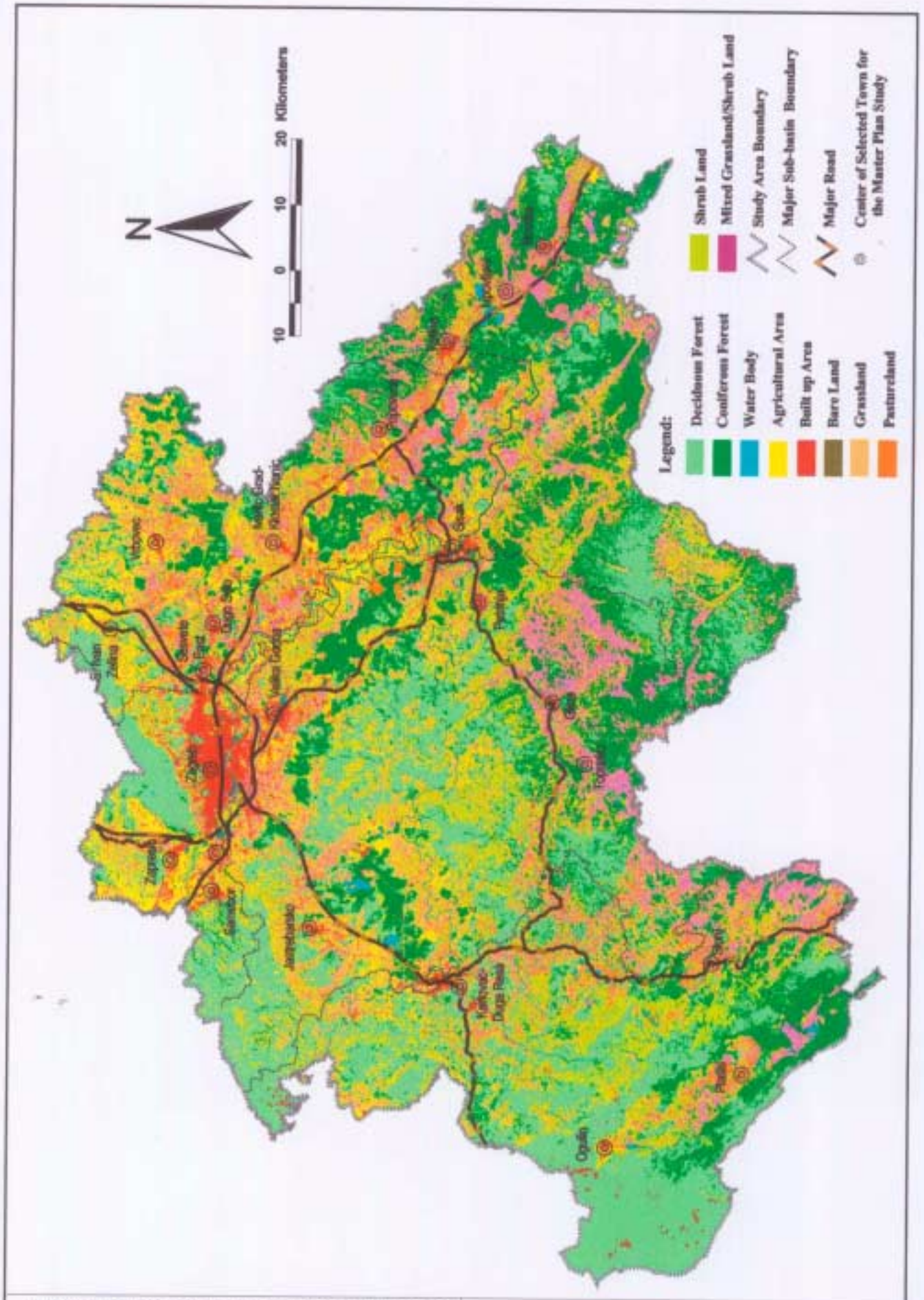
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.I-2.1 Seasonal Variation of Rainfall/Temperature/ River Flow Rate
JAPAN INTERNATIONAL COOPERATION AGENCY	



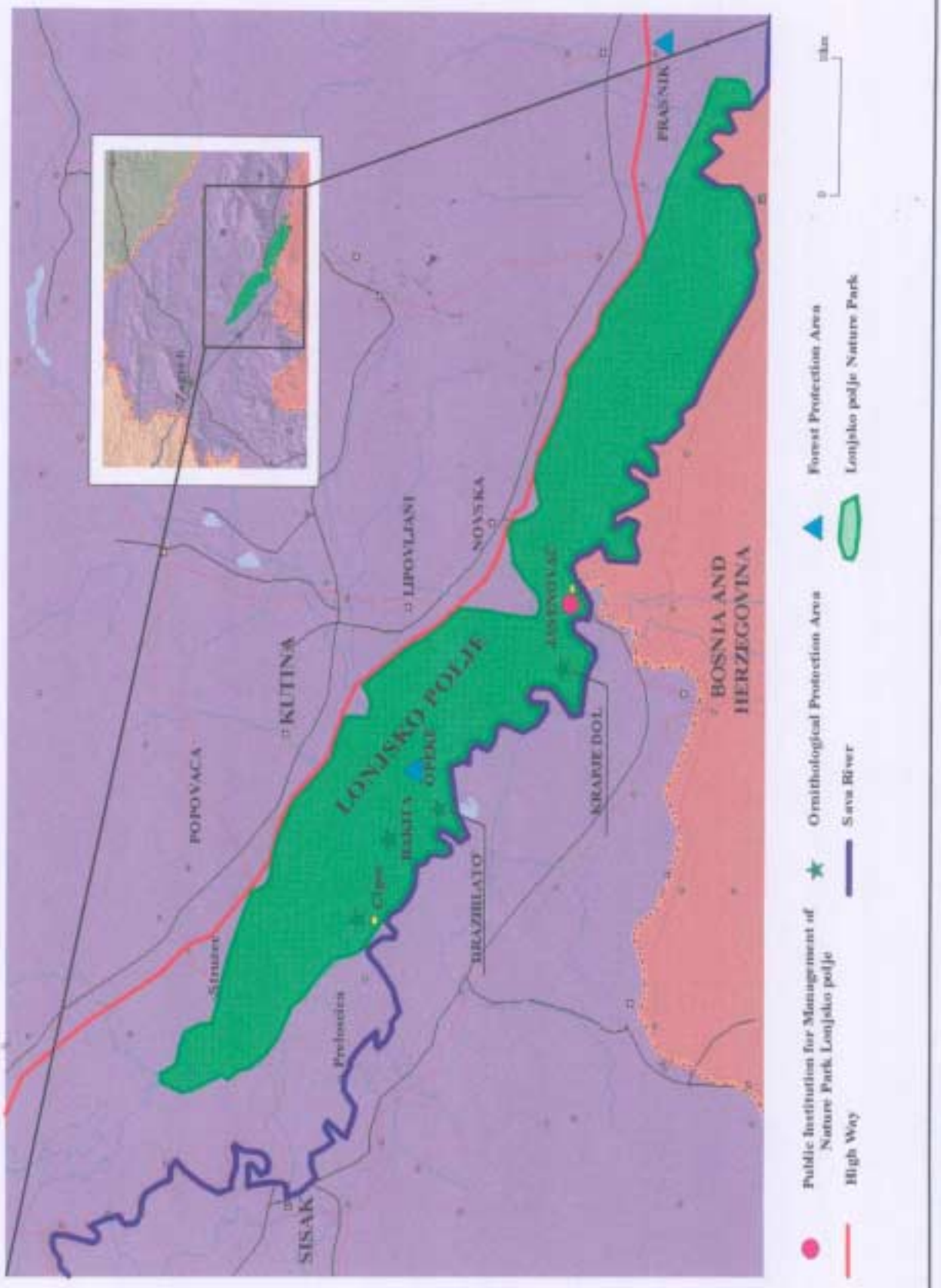
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

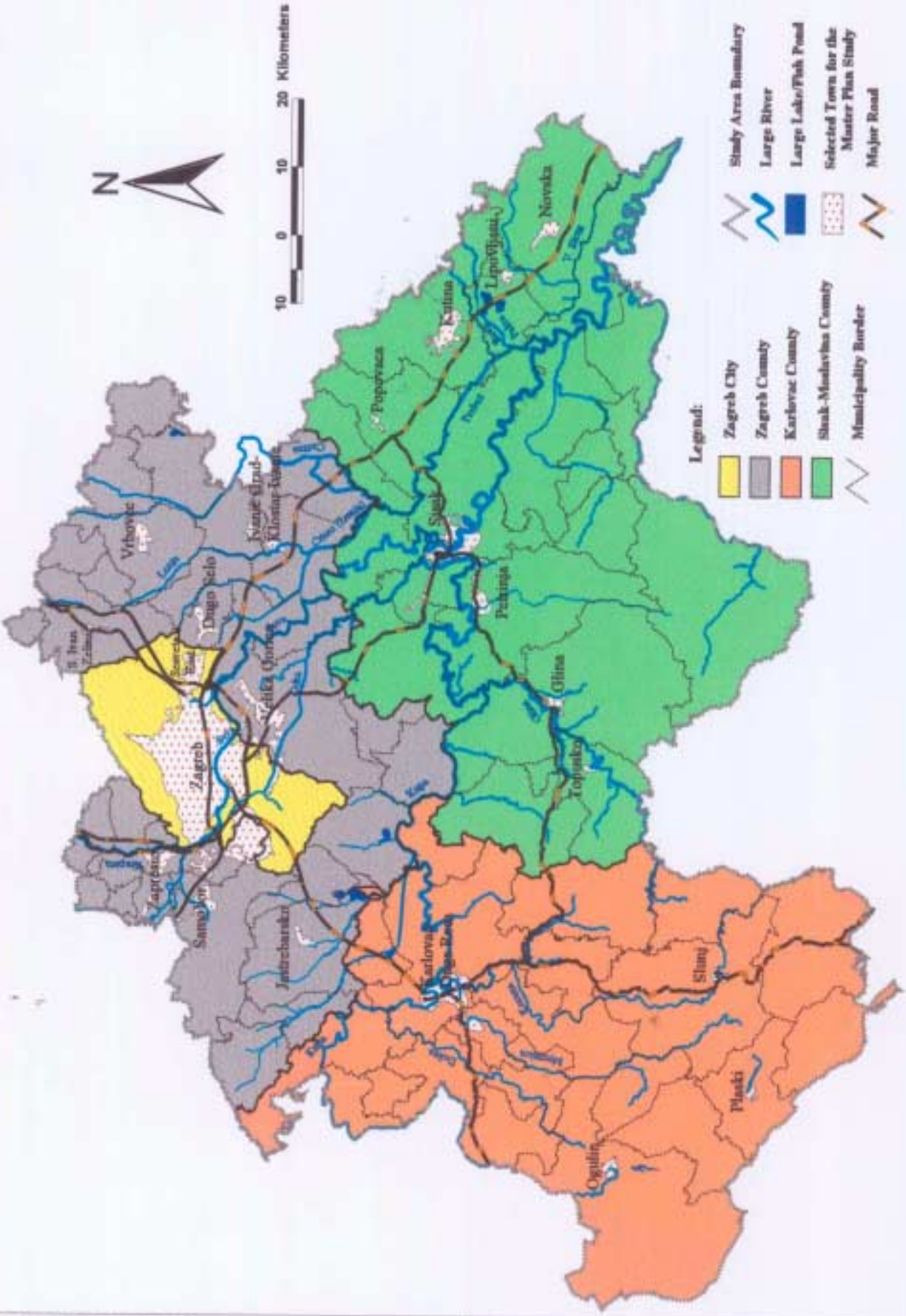
Fig.I-2.2 Basin Divisions in the Study Area



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.1-2.3 Land Use Map
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	**Fig.I-2.4** Location Map of the Lonjsko polje Natural Park
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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Fig.I-2.5 Distribution of Administrative Units in the Study Area

Phoxinus phoxinus
minnow

Pseudorasbora parva
false harlequin

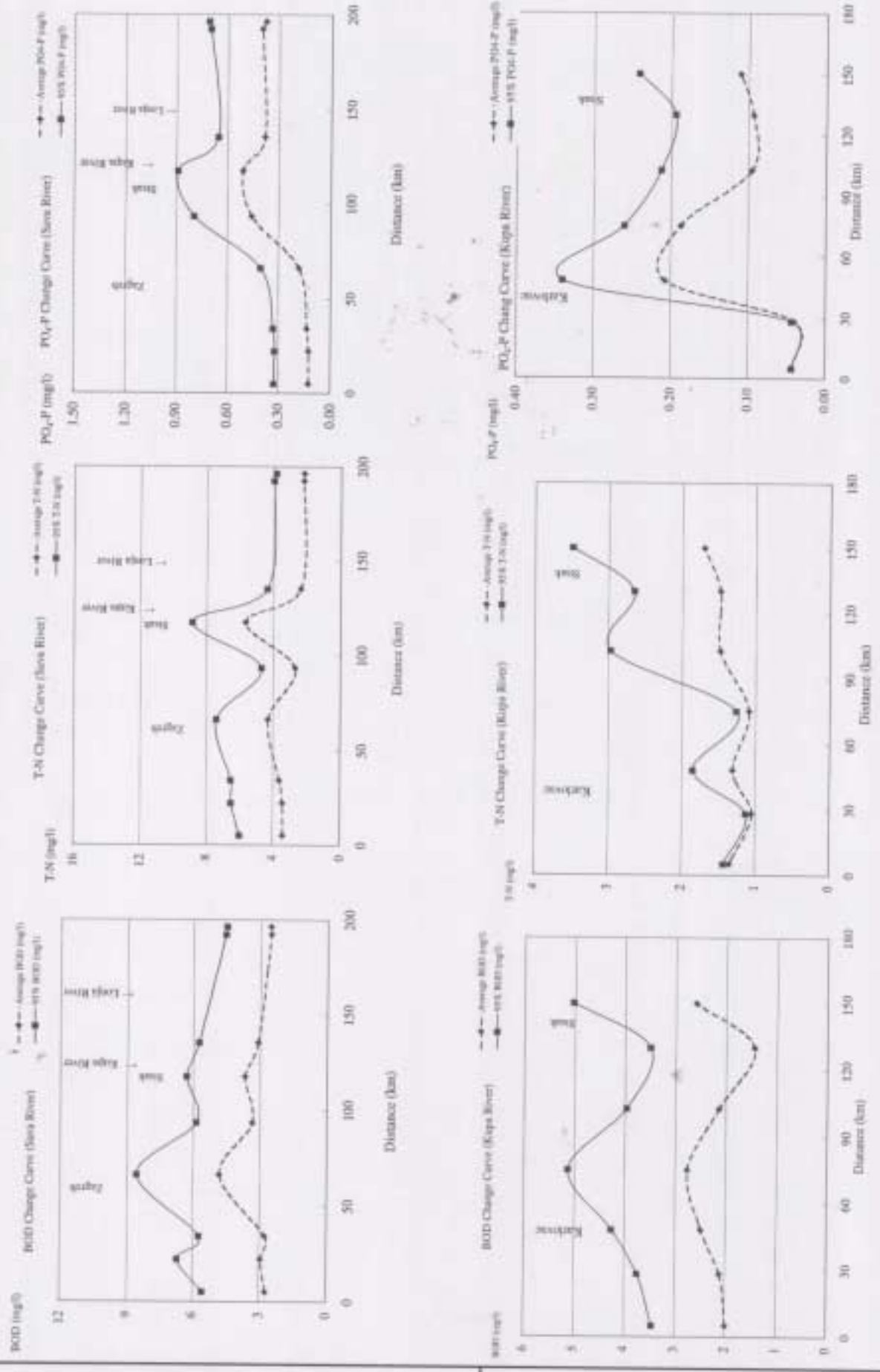
Leuciscus cephalus
chub

Carassius auratus gibelio
prussian carp

Alburnus alburnus
bleak

Rutilus rutilus
roach

THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	**Fig.I-3.1** Fishes in Sava River Basin
JAPAN INTERNATIONAL COOPERATION AGENCY	

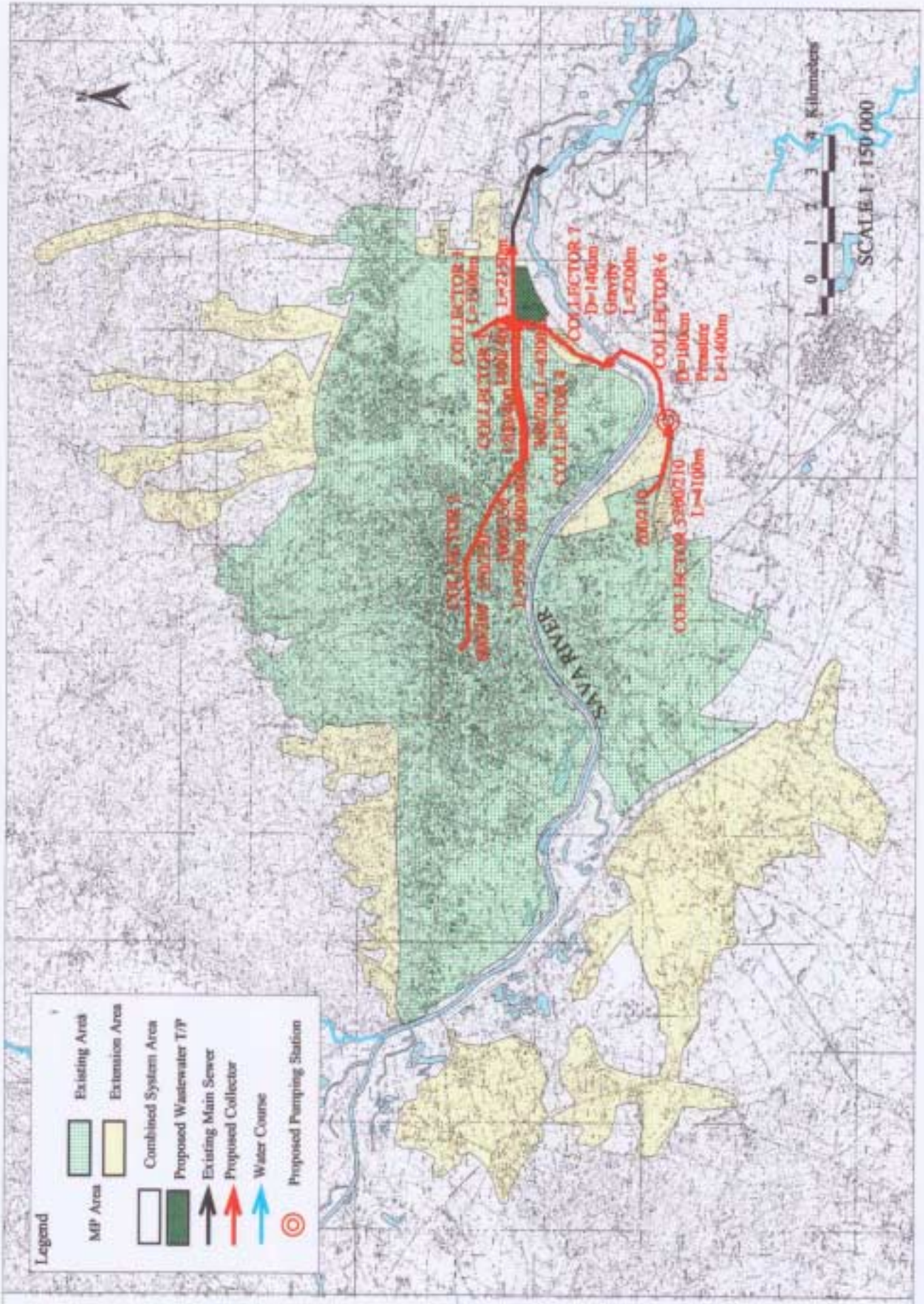


THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.I-3.2 Longitudinal Change of River Water Quality

Fig. I-5.1 Location of Selected Objective Urban Centers



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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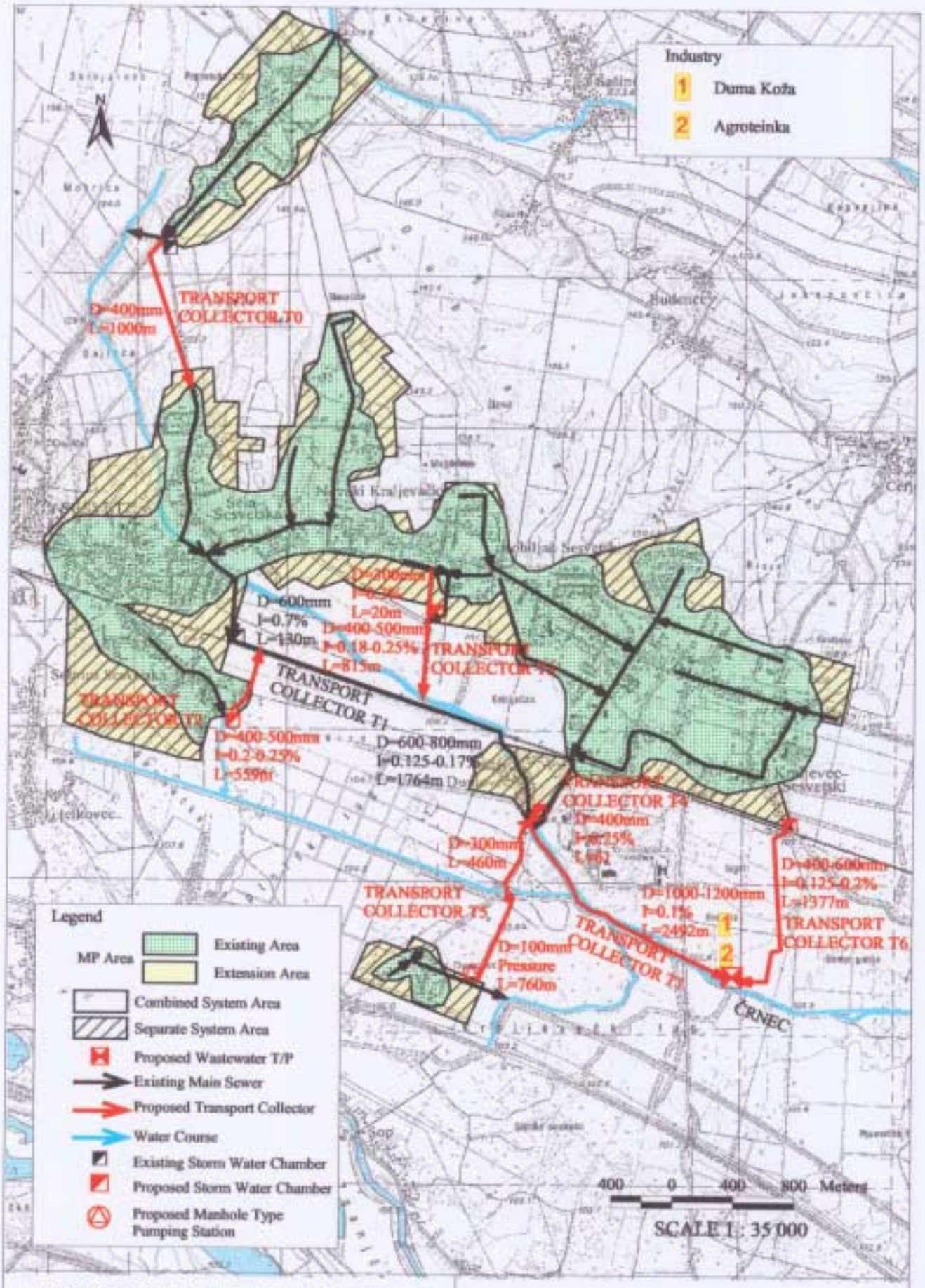
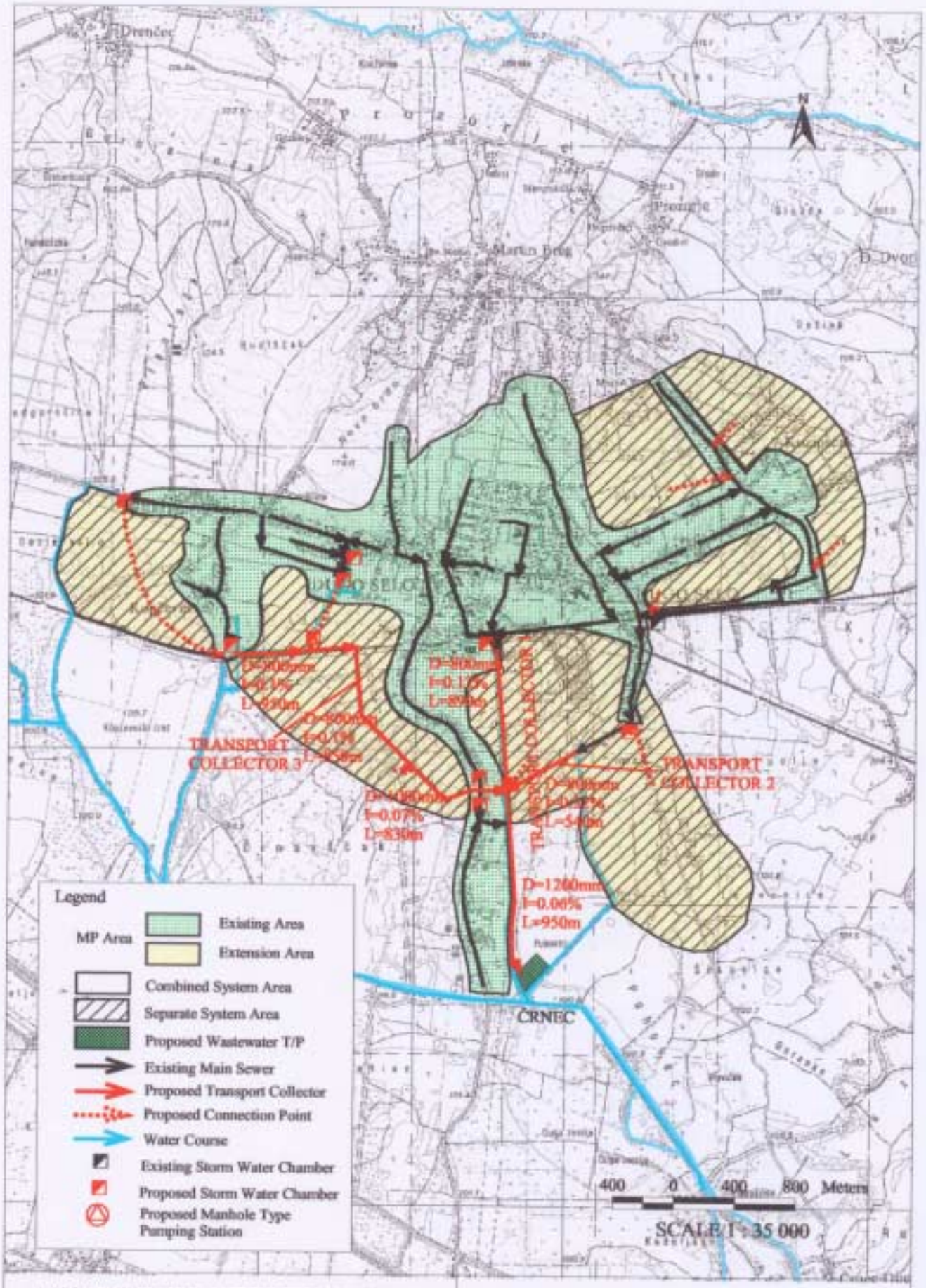
Fig. I-5.2 Sewerage Development System in Zagreb



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

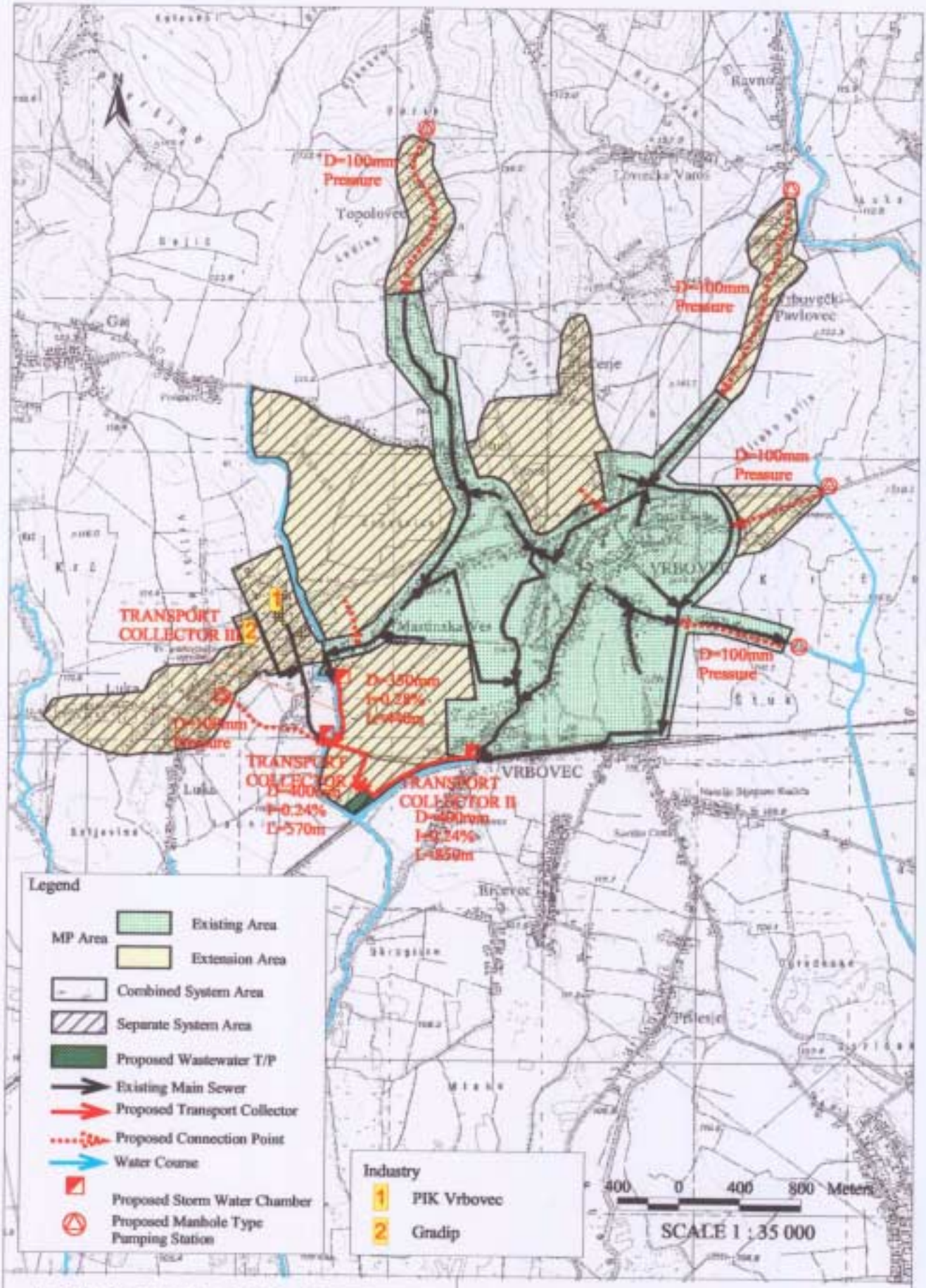
Fig. I-5.3 Sewerage Development System in Sesvete East



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

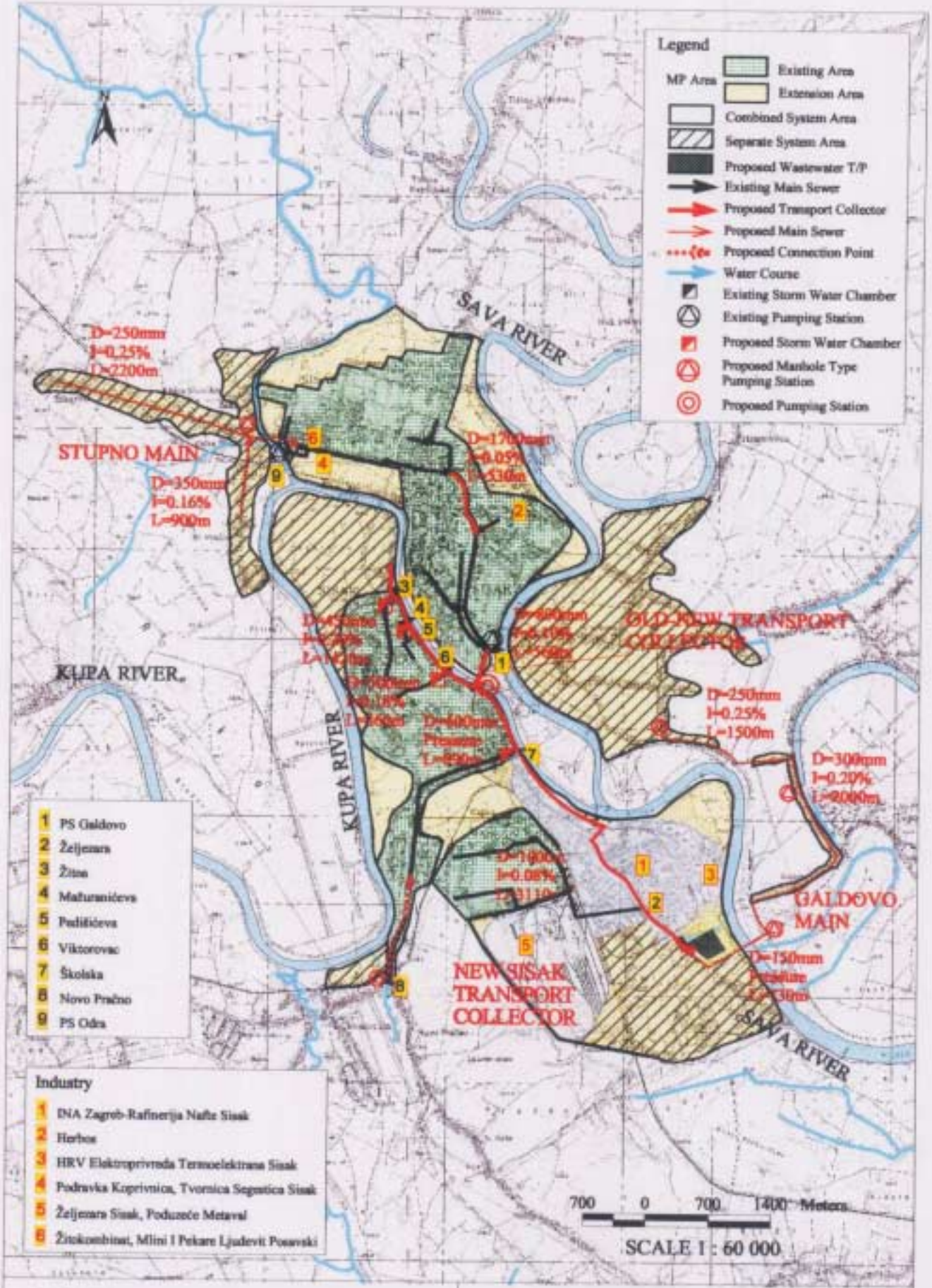
Fig. I-5.4 Sewerage Development System in Dugo Selo



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

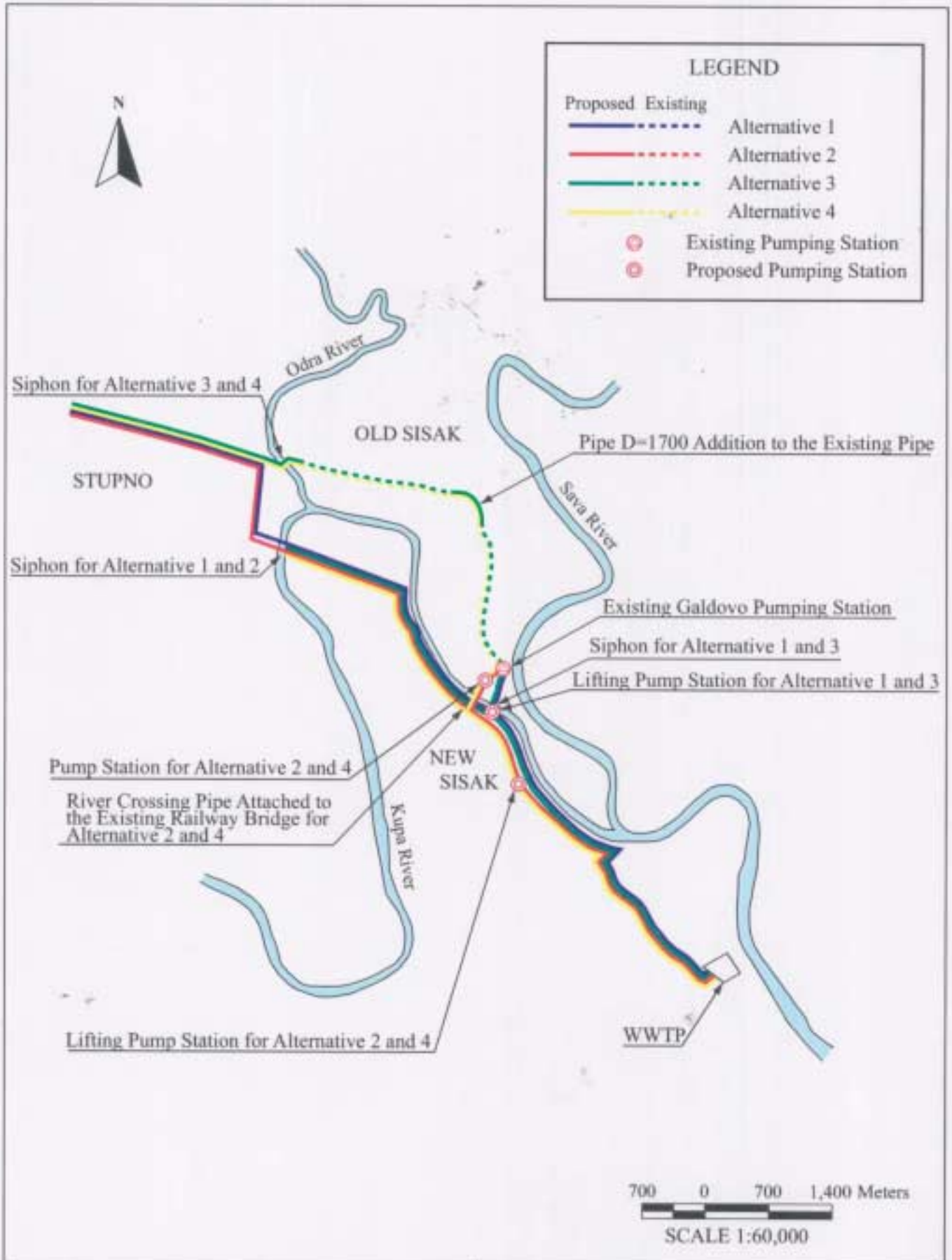
Fig. I-5.5 Sewerage Development System in Vrbovec



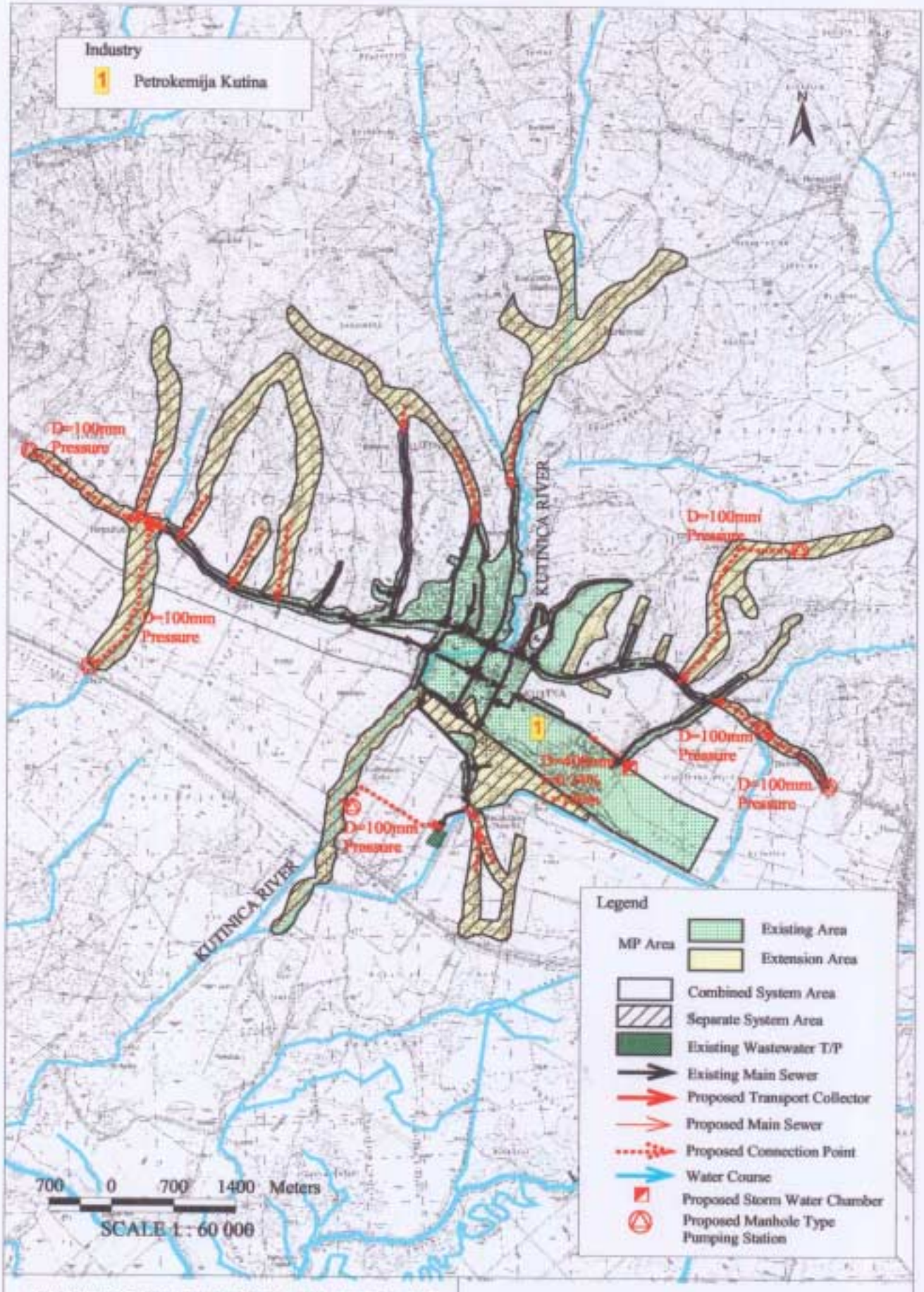
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.I-5.6(1) Sewerage Development System in Sisak



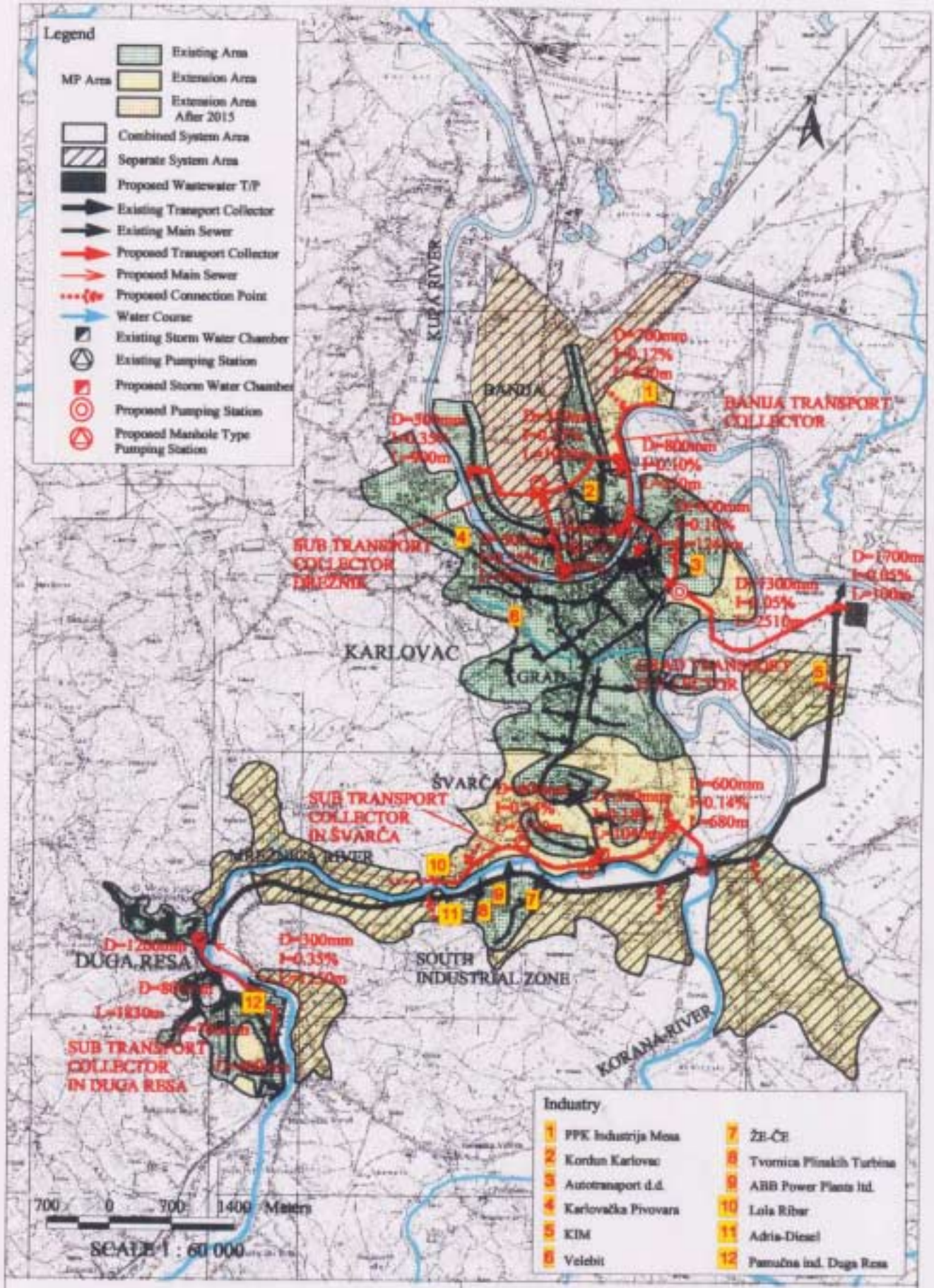
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.I- 5.6 (2) Alternatives of Collectors in Sisak
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

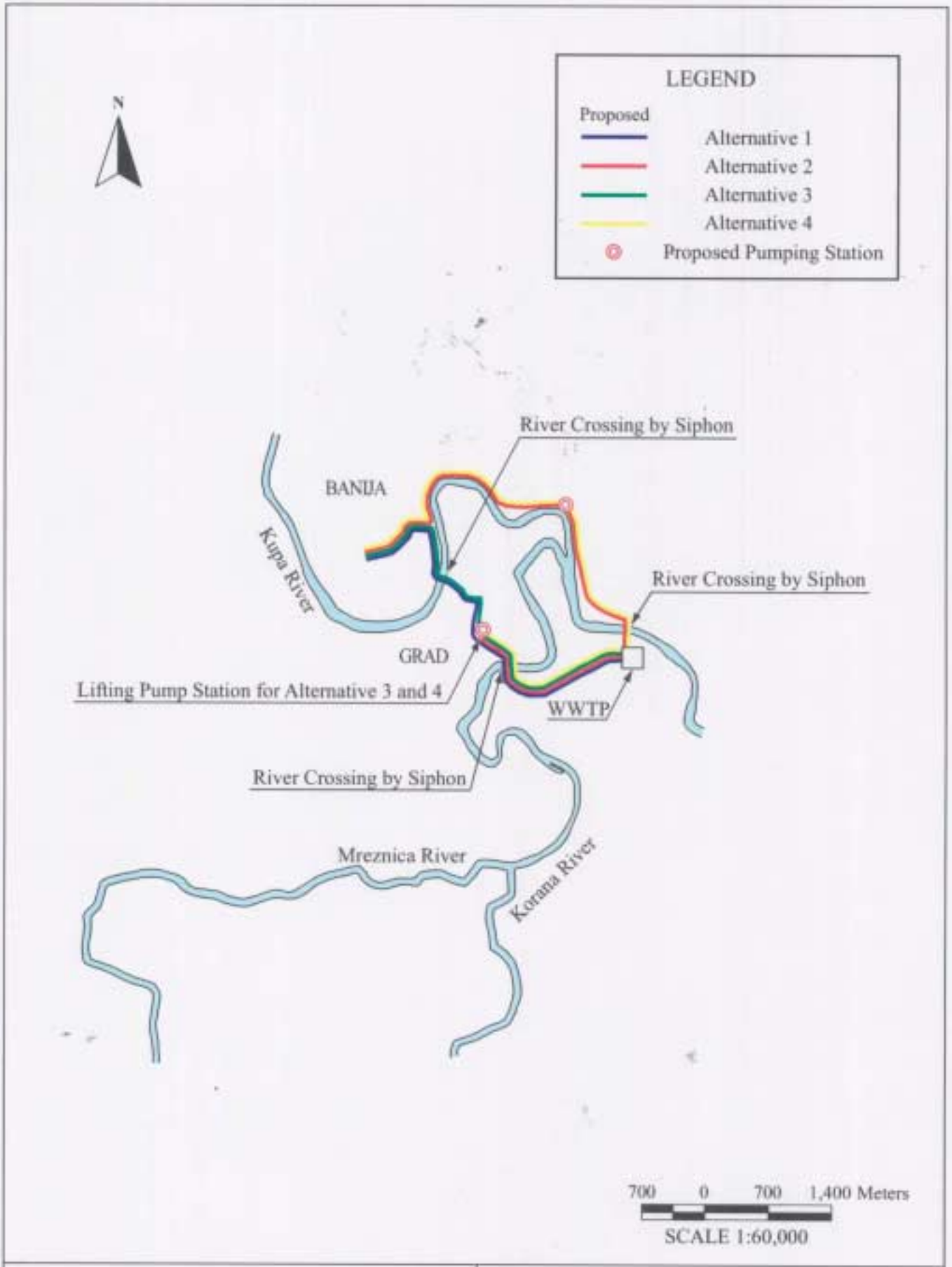
Fig. I-5.7 Sewerage Development System in Kutina



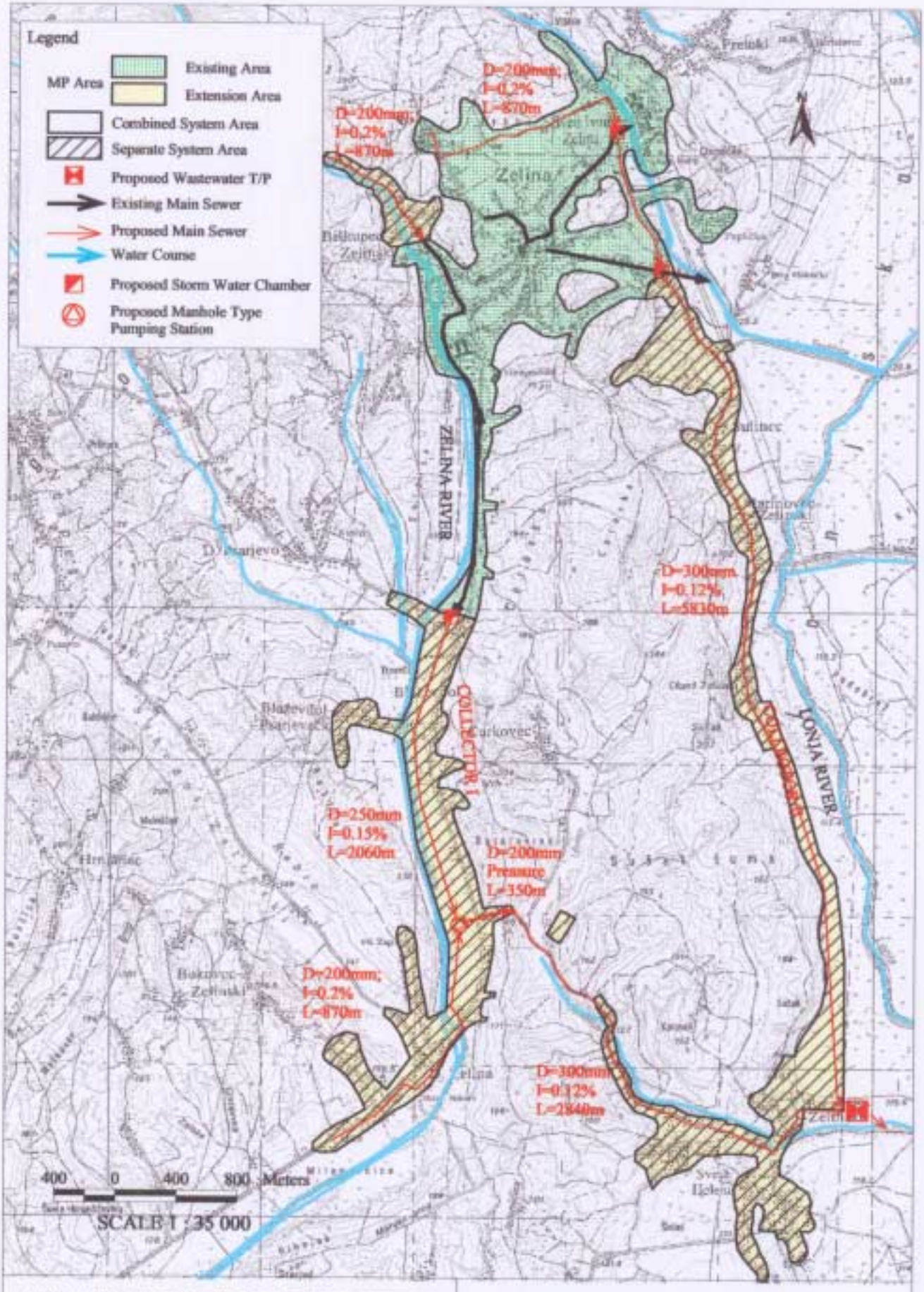
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I-5.8(1) Sewerage Development System in Karlovac and Duga Resa



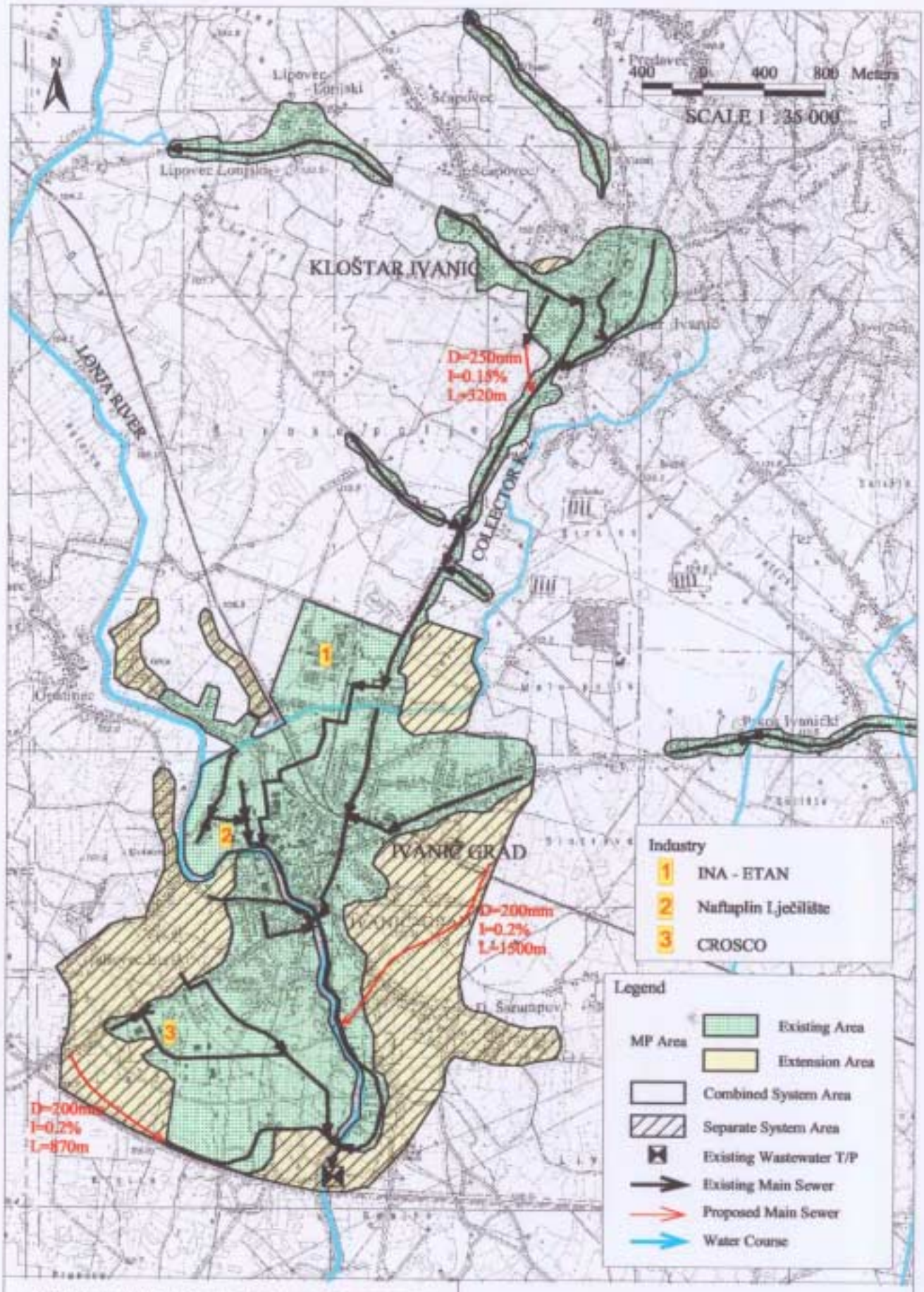
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.I- 5.8 (2) Alternatives of Collectors in Karlovac and Duga Resa
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

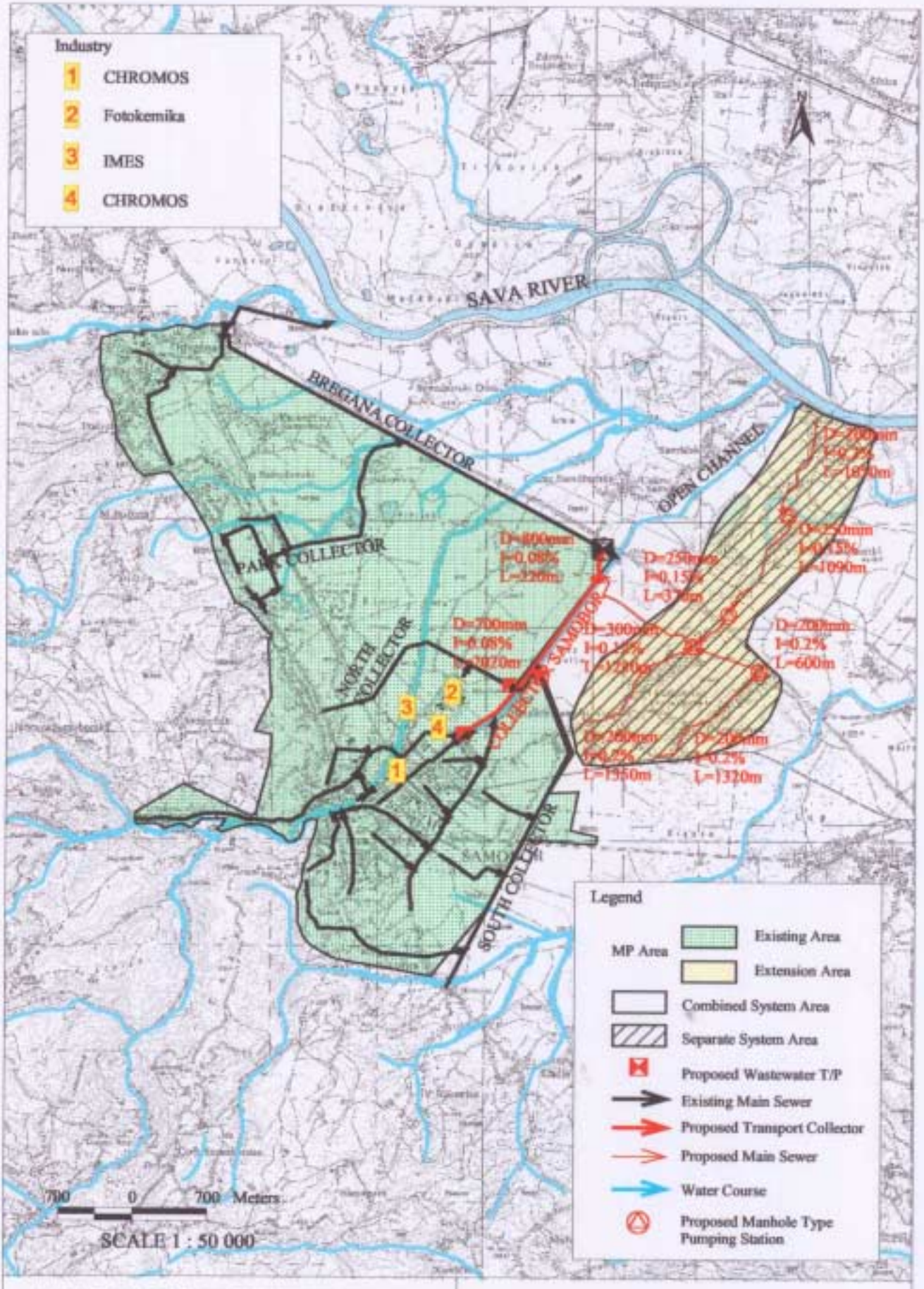
Fig. I-5.9 (1) Sewerage Development System in Sveti Ivan Zelina



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

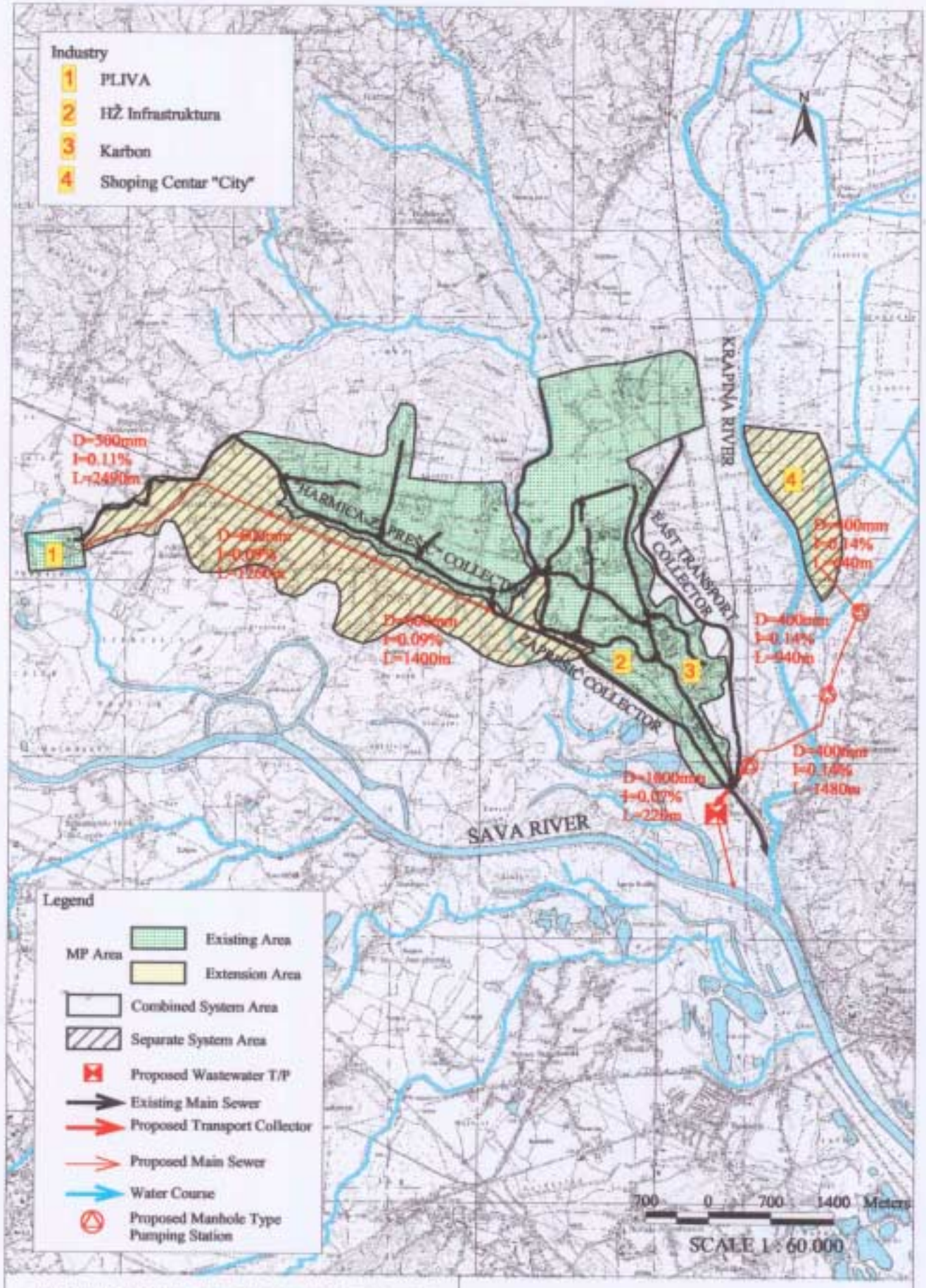
Fig. I-5.9 (2) Sewerage Development System in Ivanić Grad and Kloštar Ivanić



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

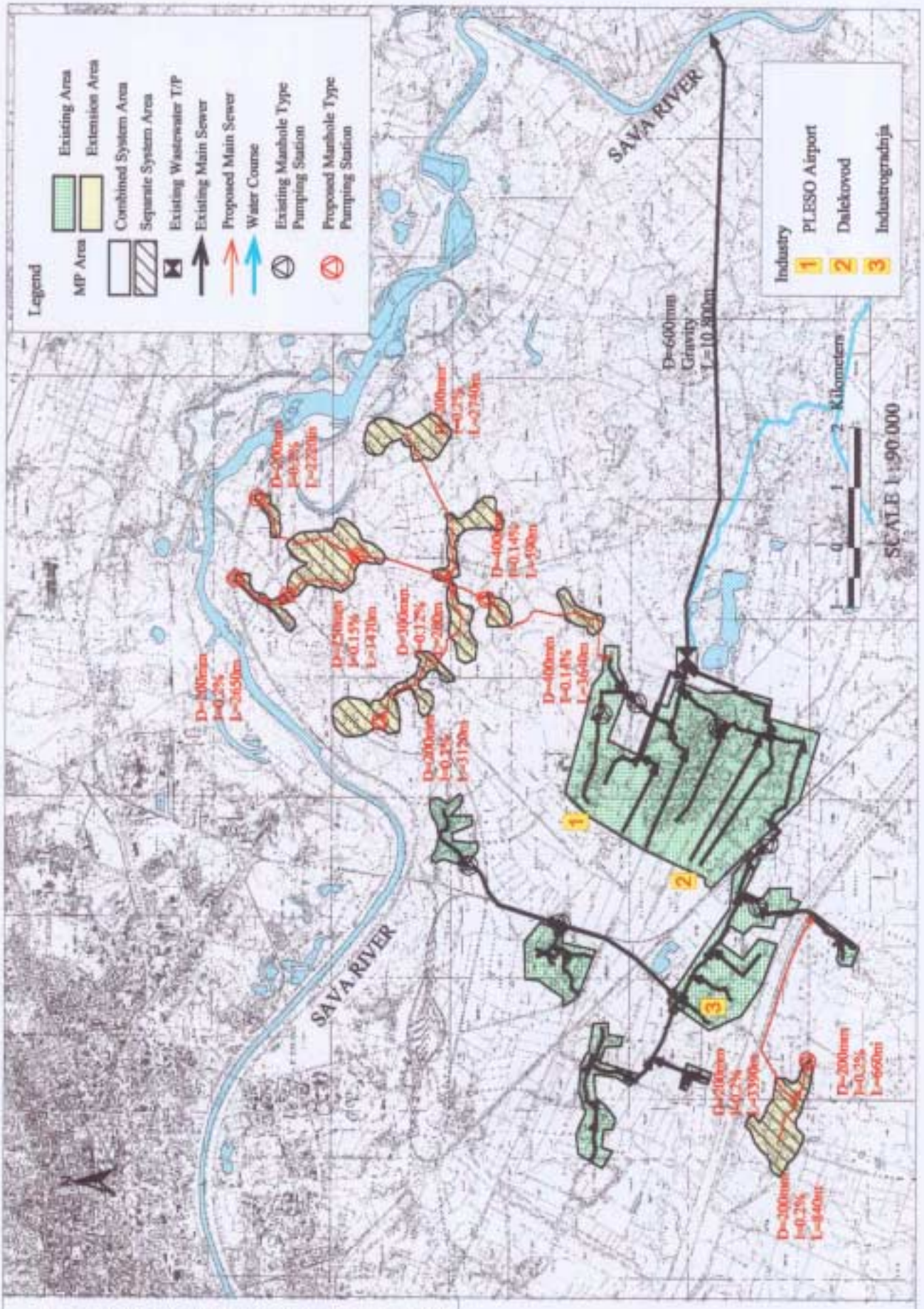
Fig. I-5.9 (3) Sewerage Development System in Samobor



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

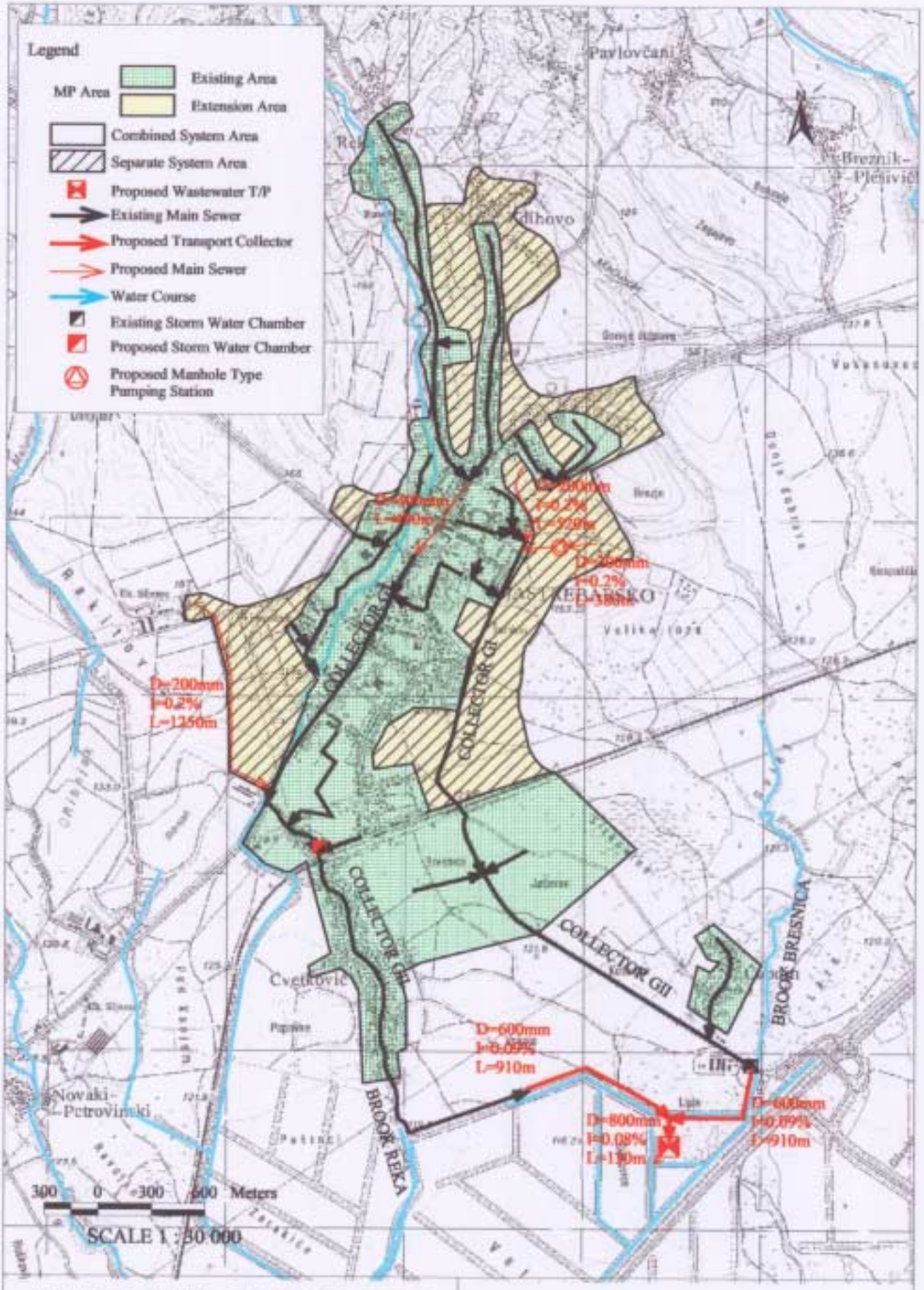
Fig. I-5.9 (4) Sewerage Development System in Zaprešić



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

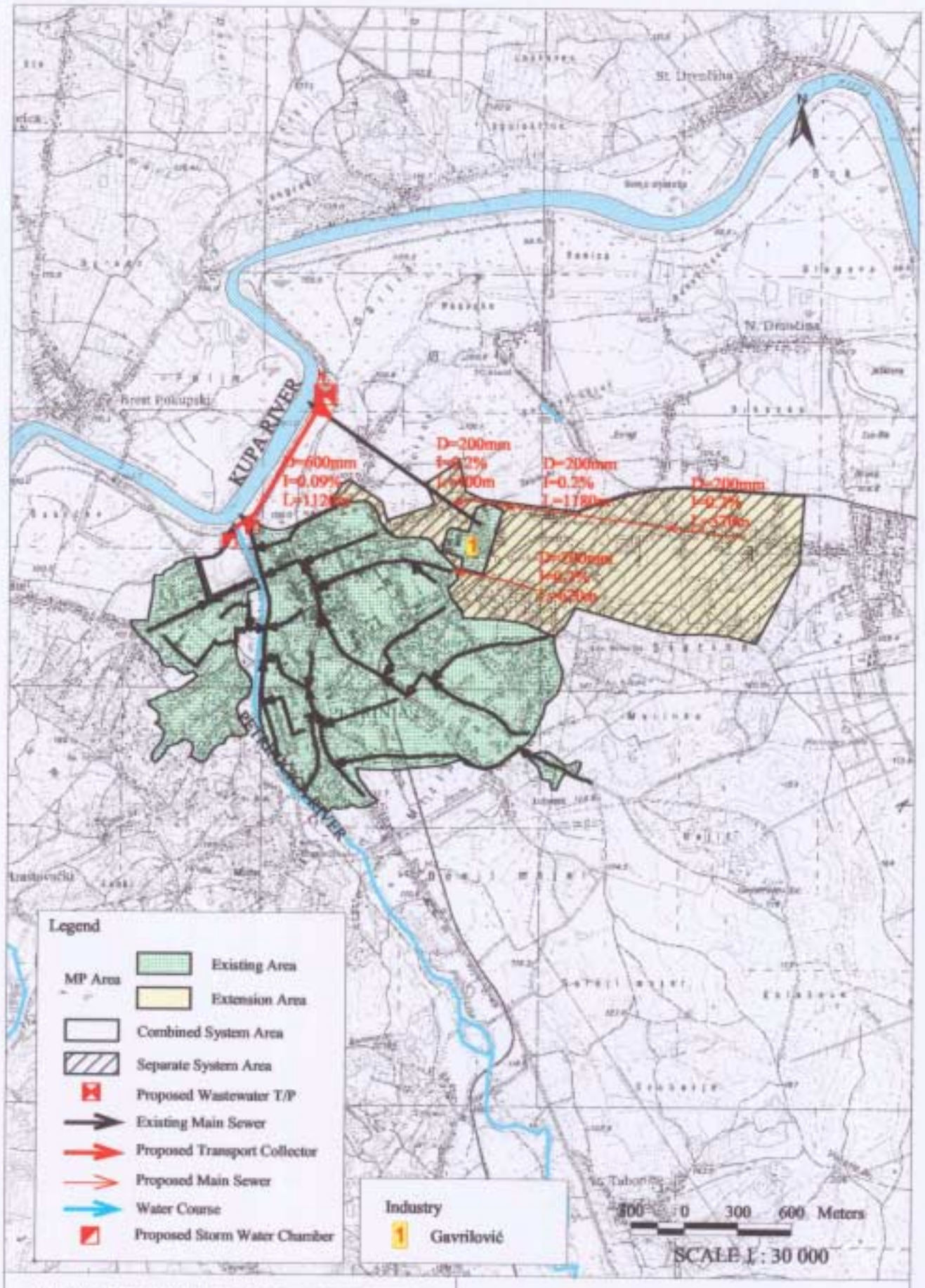
Fig. I-5.9 (5) Sewerage Development System in Velika Gorica



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I-5.9 (6) Sewerage Development System in Jastrebarsko



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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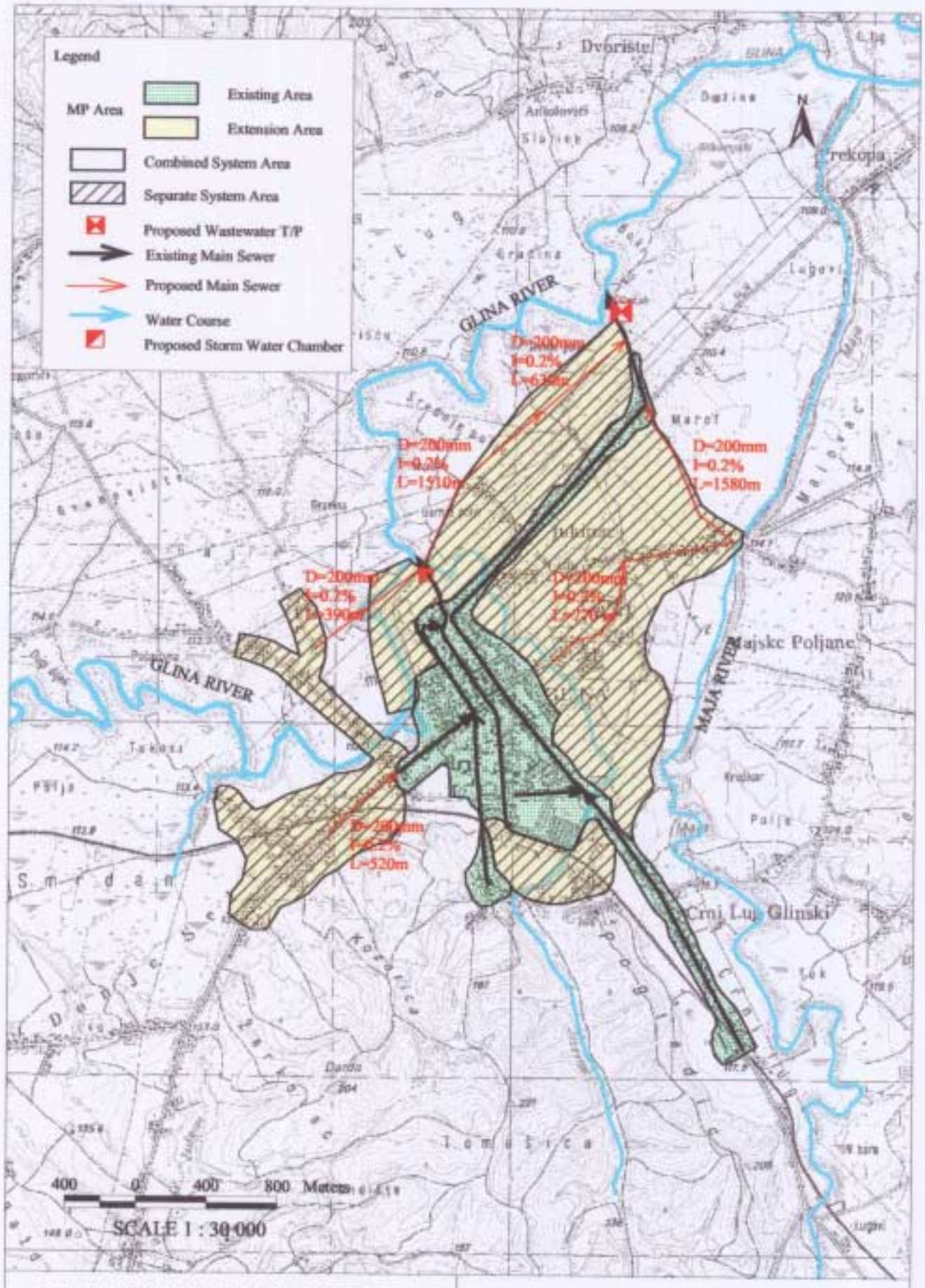
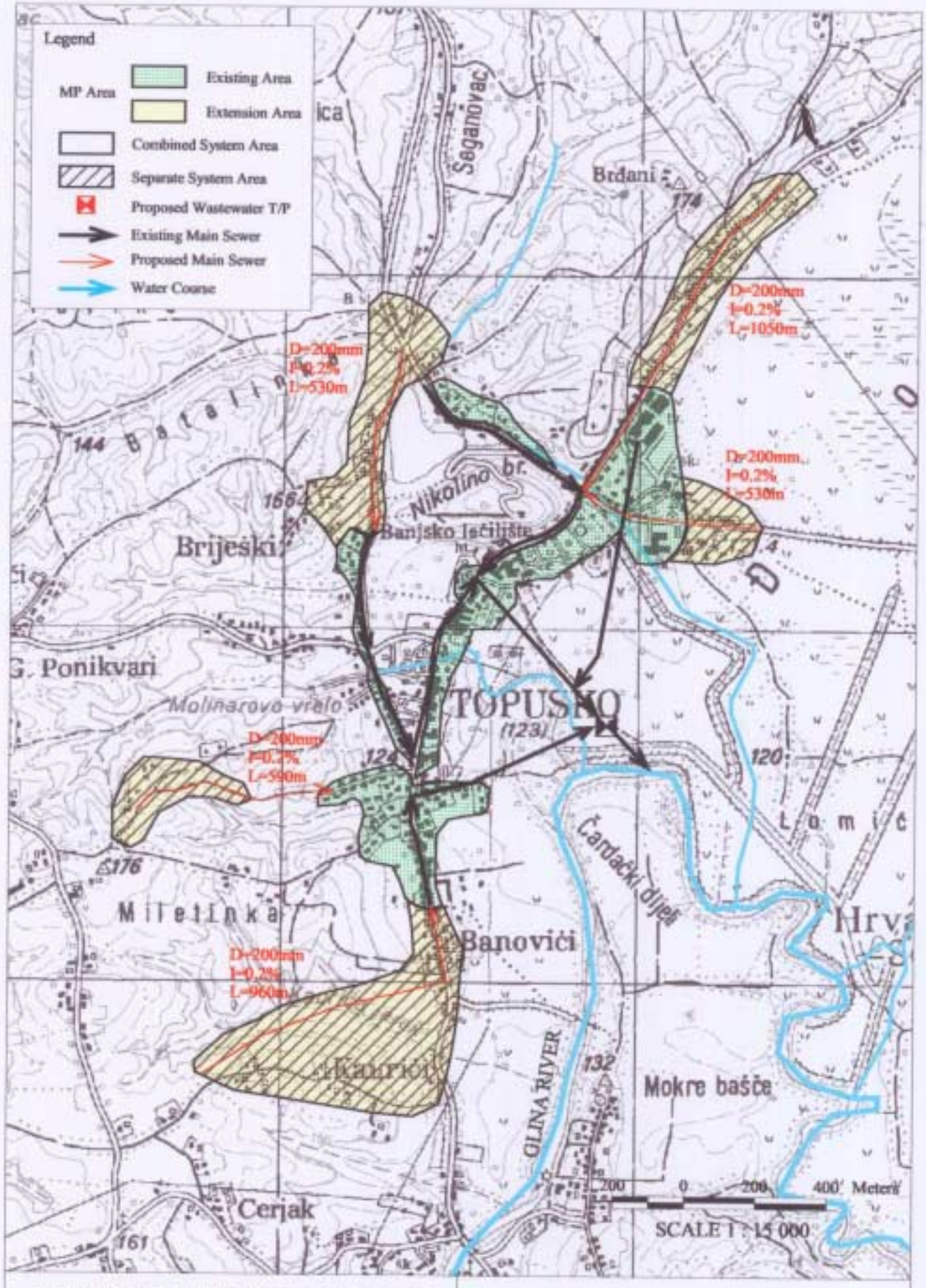
Fig. I-5.9 (7) Sewerage Development System in Petrinja



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I-5.9 (8) Sewerage Development System in Glina



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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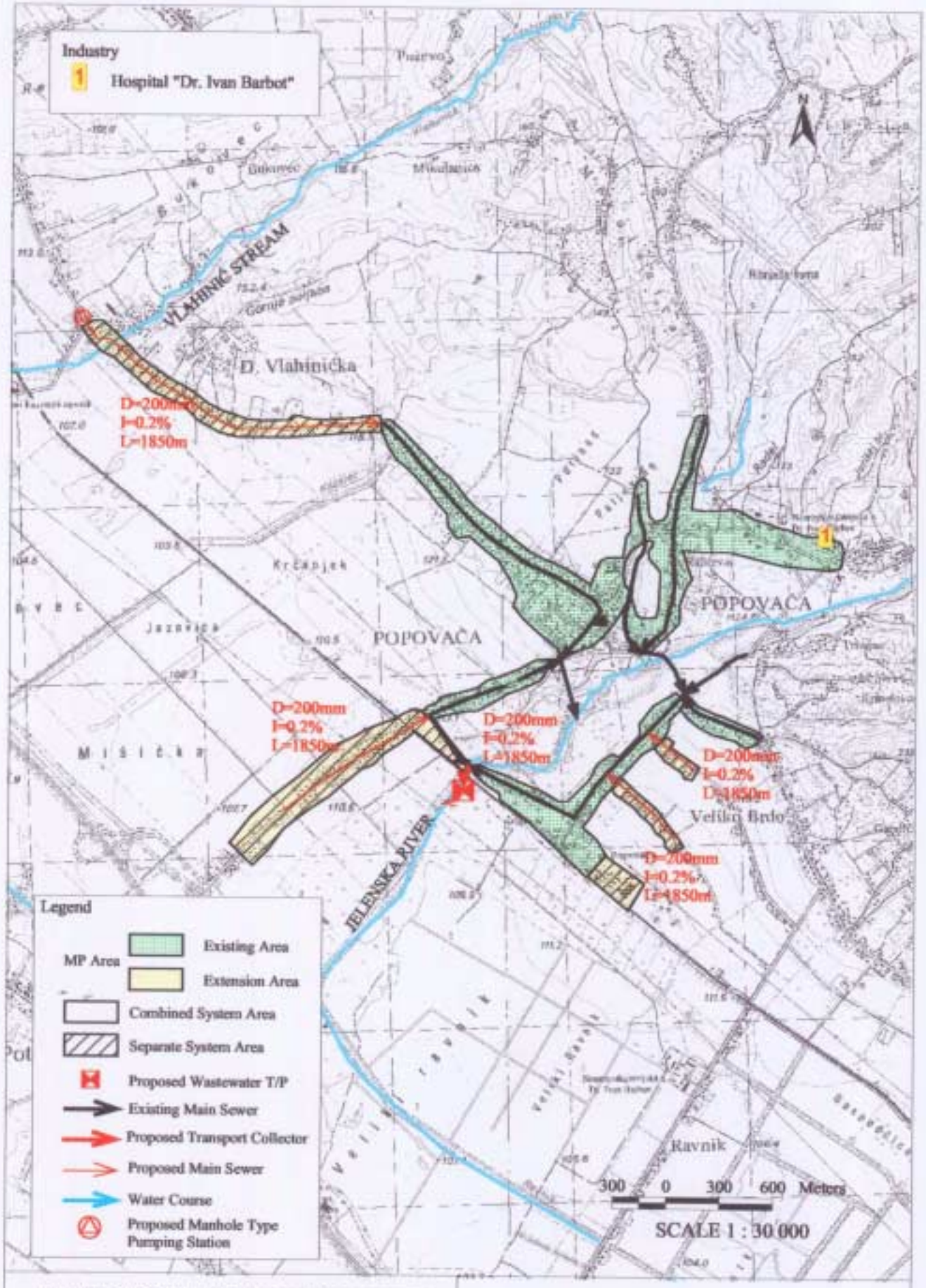
Fig. I-5.9 (9) Sewerage Development System in Topusko



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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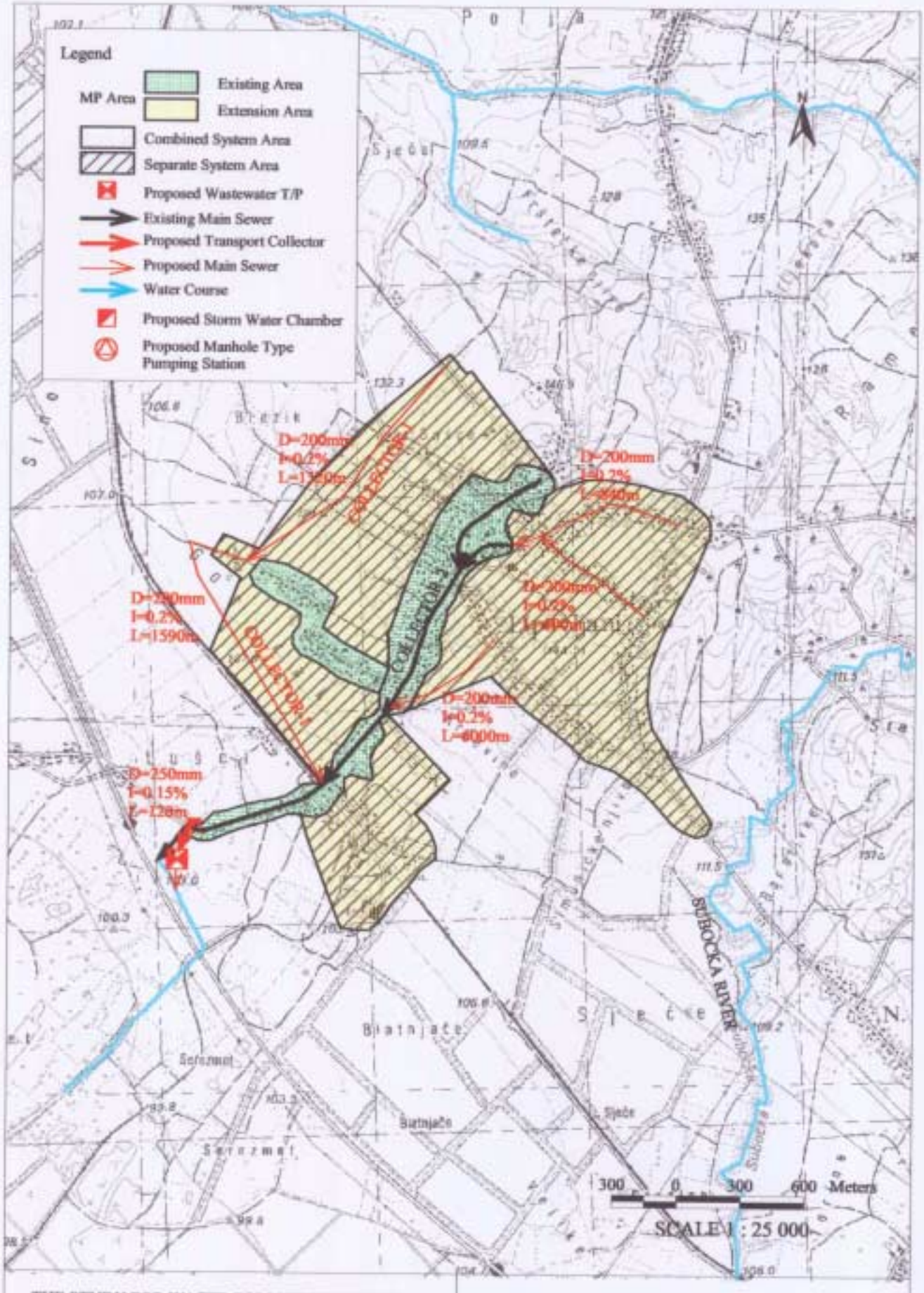
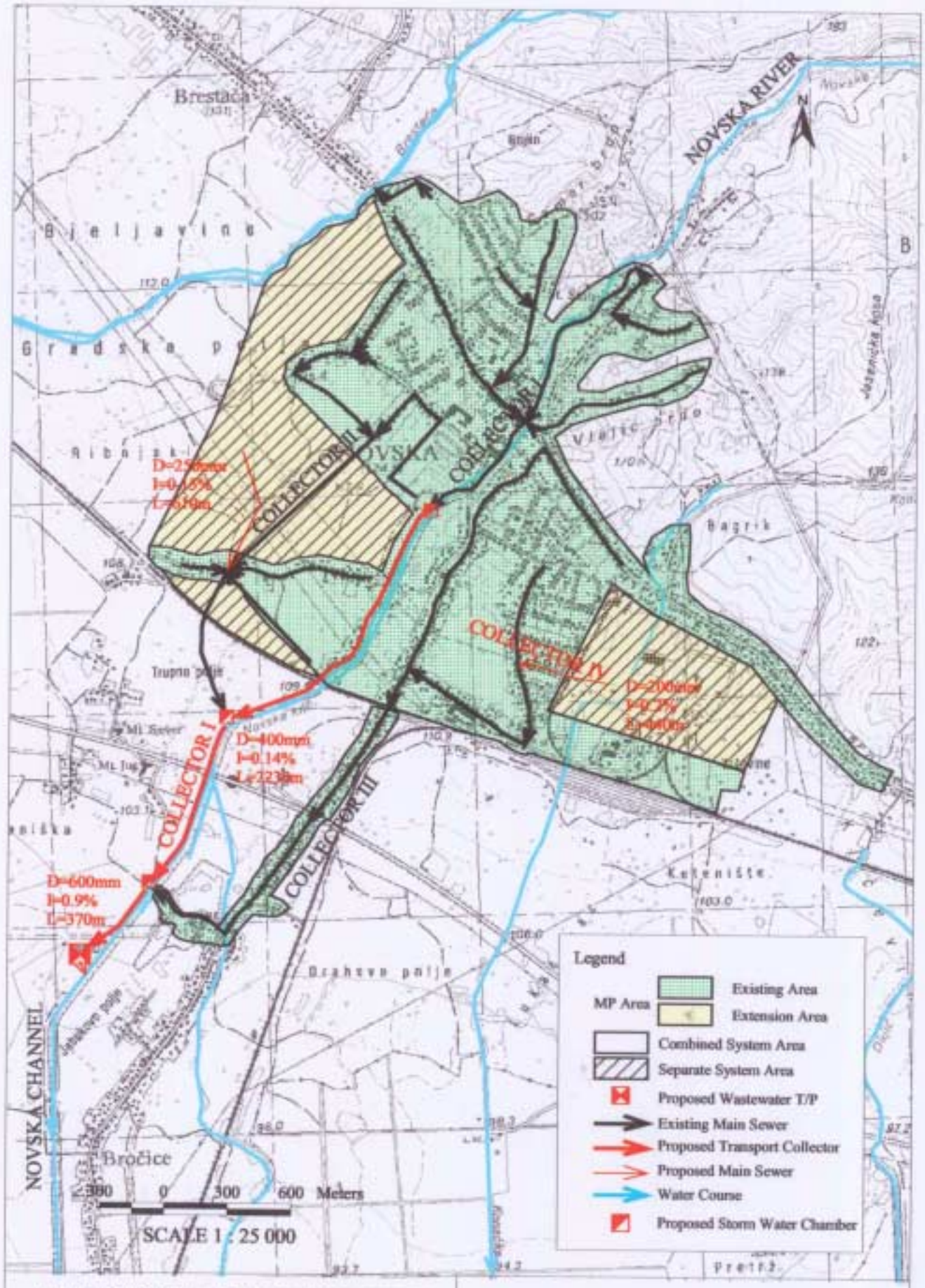
Fig. I-5.9 (10) Sewerage Development System in Popovača



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I-5.9 (11) Sewerage Development System in Lipovljani



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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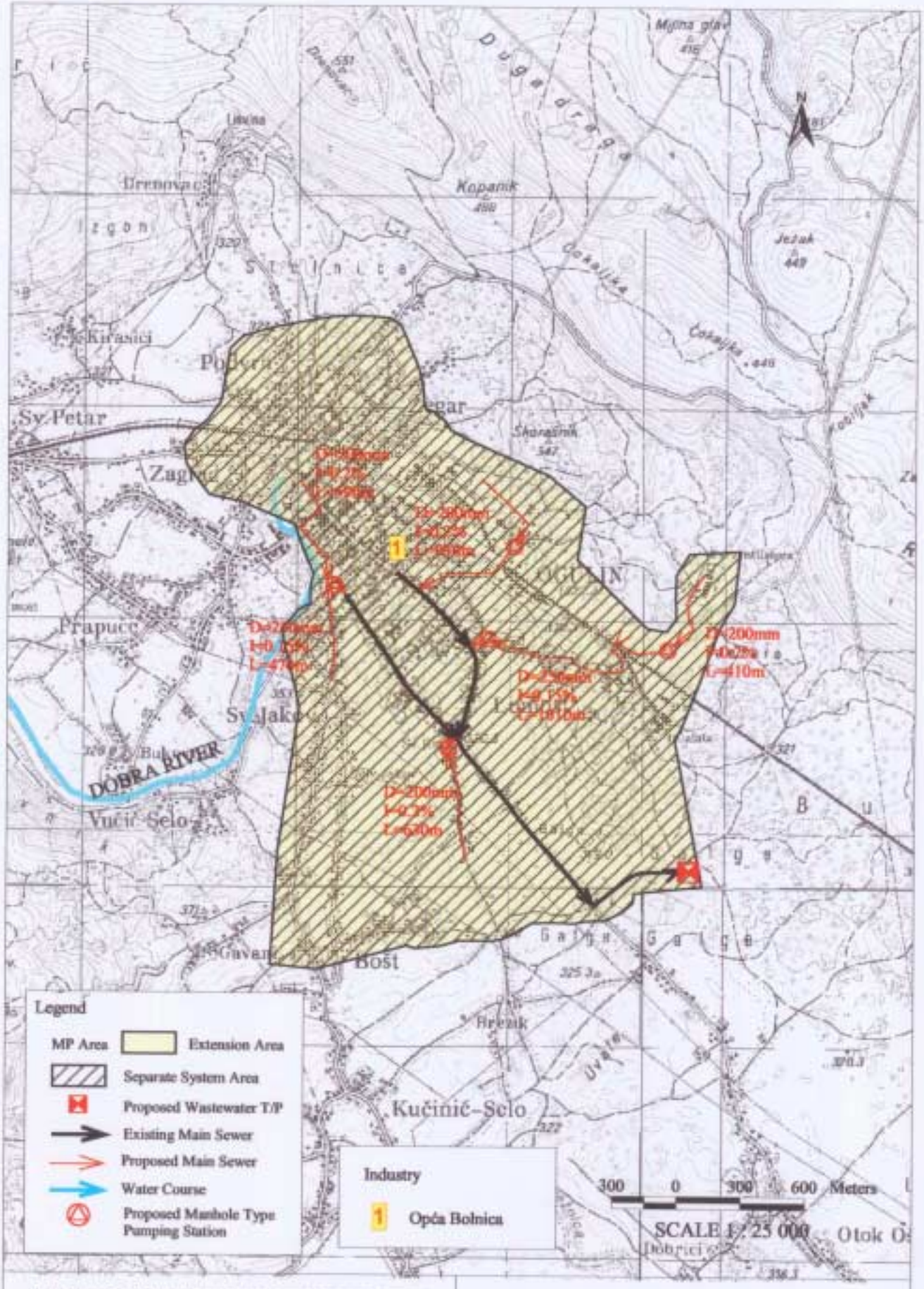
Fig. I-5.9 (12) Sewerage Development System in Novska



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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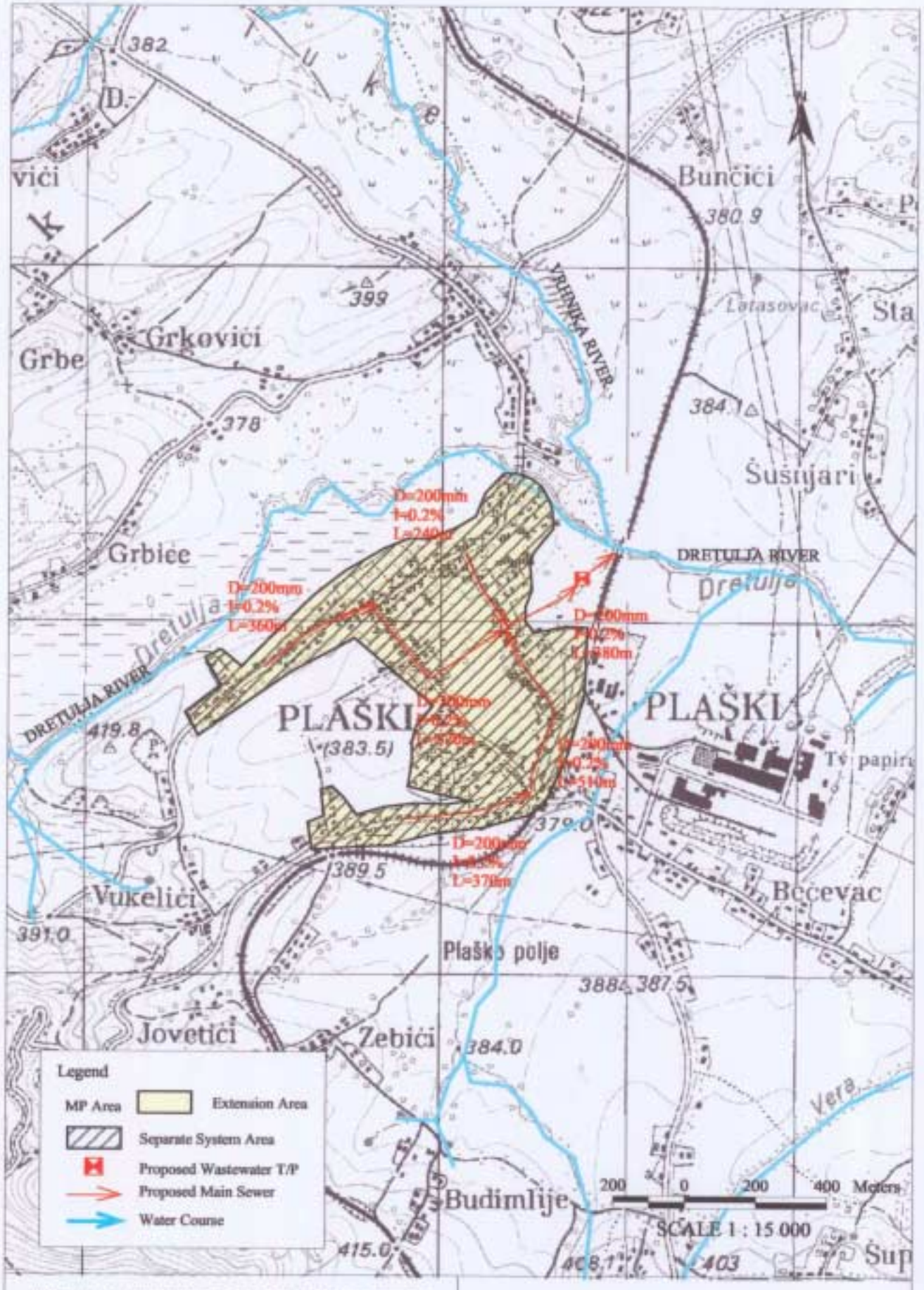
Fig. I-5.9 (13) Sewerage Development System in Ogulin



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

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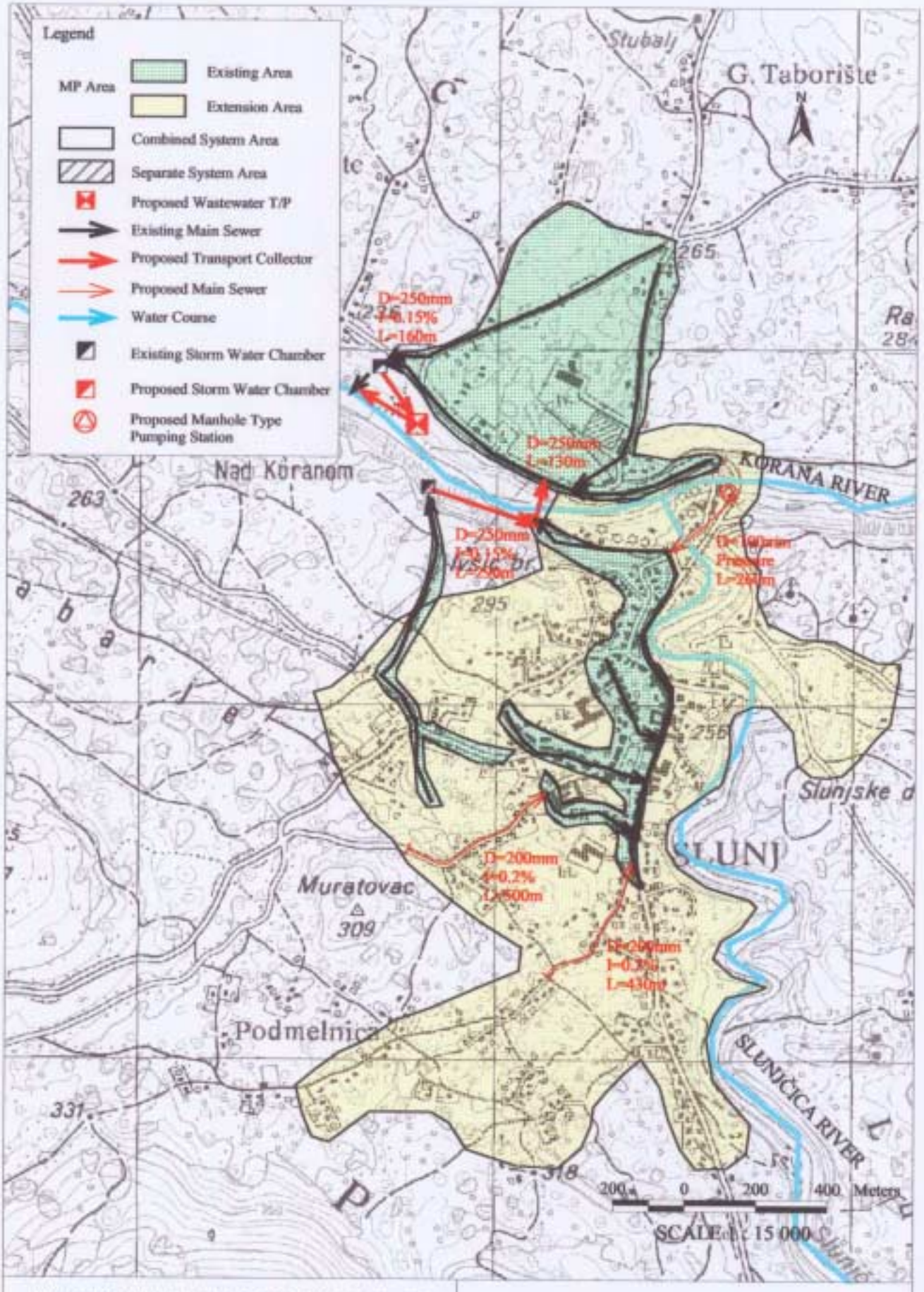
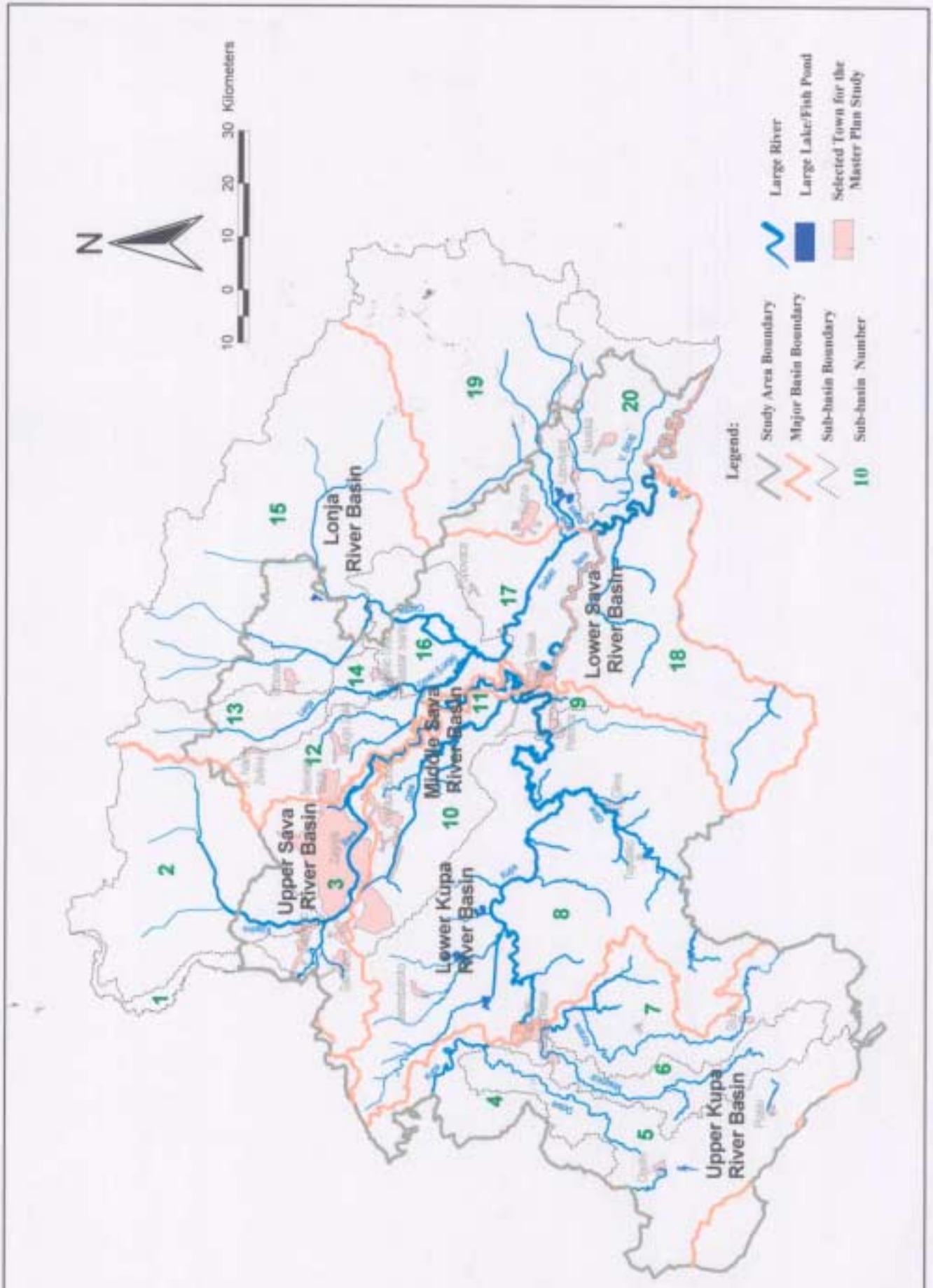
Fig. I-5.9 (14) Sewerage Development System in Plaški



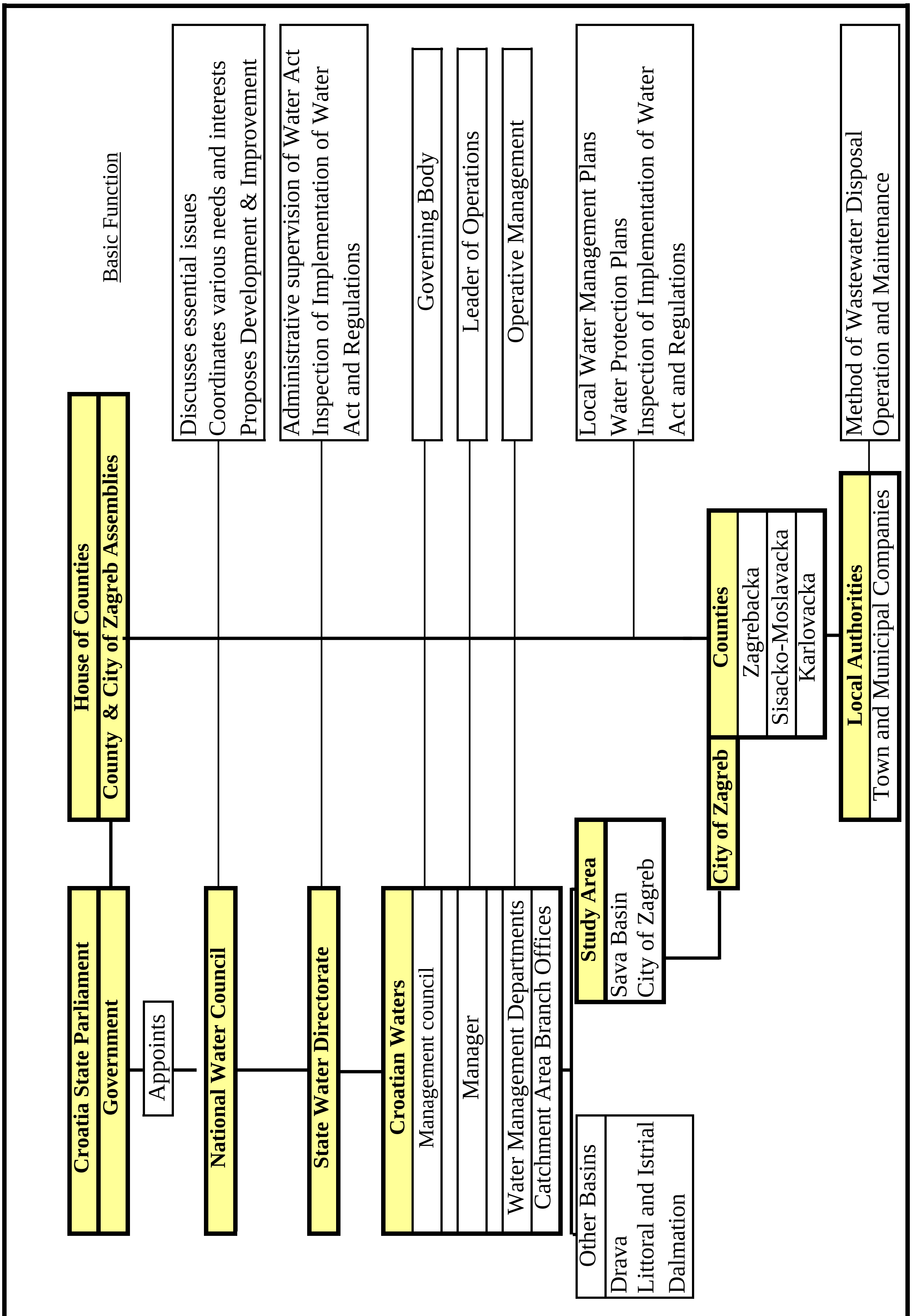
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. I-5.9 (15) Sewerage Development System in Slunj



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.I-6.1 Divided 20 Sub-basins for Simulation
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.I-.7.1 Institutional Framework for Water Management
JAPAN INTERNATIONAL COOPERATION AGENCY	

PART II

FEASIBILITY STUDY

PART II FEASIBILITY STUDY

CHAPTER I PLANNING BASIS

1.1 General

Among the 22 projects proposed in the Master Plan study, the following five (5) sewerage development projects were selected as the priority ones for the feasibility study through the detailed discussions with the State Water Directorate and the Croatian Waters:

(1) Dugo Selo Sewerage Development Project;

(2) Vrbovec Sewerage Development Project;

(3) Sisak Sewerage Development Project;

(4) Kutina Sewerage Development Project; and

(5) Karlovac-Duga Resa Sewerage Development Project

1.2 Target Year

The target year of projects in the Master Plan is set at the year 2015, and since the F/S projects are the first stage projects of the Master Plan, the target year of F/S projects is set at the year 2007. The proposed projects will treat a large quantity of industrial wastewater, so that the setting of a farther target year may cause a significant error in the estimation of industrial wastewater flow considering that the future economic growth of the country is still uncertain. This target year setup is considered reasonable also from the aspects of implementation schedule, which is normally expected as six (6) years for such kind of projects as shown below.

Year	Activities
2001	Approval of Project Plan
2002	Legal Procedures, Financial Arrangement
2003	Detailed Design and Land Acquisition
200 - 2006	Construction

1.3 Design Service Area and Population

The design sewerage service areas targeting the year 2007 are delineated based on the following policies:

(1) In urban centers of objective towns already covered or almost covered by a sewer network and wastewater is discharged into the neighboring river/canal with no treatment resulting in water pollution, the construction of treatment plant should be given priority, rather than the extension of sewerage service area, to attain the urgently required water pollution control within the limited financial resources.

(2) The extension of sewer networks should be planned at a minimum level.

(3) The design served population is set to be all the population living within the planned service area in 2007.

1.4 Design Wastewater Flow

The design sewerage wastewater flow is determined as the sum of municipal wastewater flow and large industry wastewater flow. The municipal wastewater consists of domestic, institutional, small industries and groundwater infiltration. The design municipal wastewater flow is estimated based on the assumed unit (wastewater per capita per day). On the other hand, the wastewater of large industries is estimated individually.

The design municipal wastewater flow is determined as follows:

(1) Design Unit Municipal Wastewater Quantity

In the same way as the master plan study, the existing municipal wastewater quantity is estimated from the water consumption. The unit municipal water consumption is assumed at 190 l/capita/day (lcd) for towns having the population smaller than 10,000, and 230 lcd for towns with population larger than 10,000. This unit water consumption is assumed to increase at the growth rate of 2% per annum. Further, the return rate of consumed municipal water is assumed at 80%.

Municipal wastewater fluctuates seasonally throughout the year, and fluctuates hourly in a day. In the same way as the master plan study, the daily maximum and hourly maximum ratios are assumed at 1.30 and 1.50, respectively.

Groundwater infiltration is also an important factor in designing a sewerage system including a treatment plant. The groundwater infiltration rate is assumed as 30% of the total wastewater of domestic, institutional and small industries in the same way as the master plan study.

The design unit municipal wastewater quantity for the feasibility study targeting the year 2007 is summarized below.

Population Size		<10,000 (l/capita/day)	≥10,000 (l/capita/day)
Daily Average	Domestic	160	160
	Institutional/Small Industry	20	60
	Groundwater Infiltration	60	60
	Total	240	280
Daily Maximum	Domestic	210	210
	Institutional/Small Industry	30	80
	Groundwater Infiltration	60	60
	Total	300	350
Hourly Maximum	Domestic	310	310
	Institutional/Small Industry	30	110
	Groundwater Infiltration	60	60
	Total	400	480

(2) Design Unit Pollution Load of Municipal Wastewater

In the same way as the master plan study, the design unit pollution load of domestic wastewater is as set below. By assuming pollution load concentrations, the design unit pollution load of institutional and small industrial wastewaters is also set below.

	BOD	COD-Cr	TSS	T-N	T-P
Domestic (g/capita/d)	60	120	70	11	2.5
Institutional/Small Industry (mg/l)	200	400	233.3	36.7	8.3

(3) Design Total Sewerage Wastewater

In the same way as the master plan study, the wastewater quantity and quality of large industrial wastewater is estimated individually. The total wastewater quantity and pollution loads into public sewerage are estimated by adding those of large industries to the municipal ones.

1.5 Wastewater Treatment Level

1.5.1 General

The proposed master plan of all the five (5) objective sewage treatment plants will treat the wastewater to BOD = 25 mg/l, COD-Cr = 125 mg/l, TSS = 35 mg/l, and T-P = 2.0 mg/l by the Anaerobic-Oxic Activated Sludge (AO) treatment process. The AO system consists of (i) preliminary treatment (grid chamber, oil trap, etc.); (ii) primary sedimentation; (iii) anaerobic process; (iv) aeration process; and (v) secondary sedimentation.

This feasibility study proposes the first stage treatment process of the master plan in due consideration of: (i) required improvement of river water quality, and (ii) required treatment cost.

1.5.2 River Water Quality Simulation

(1) General

For the above-mentioned purpose, the river water quality in the year 2007 at the following principal stations were simulated under without- and with-project situations. The simulation methodology is the same as in the master plan study.

River	Location of Simulation
Sava Main River	Oborovo (downstream of Zagreb), Utok Kupe Nizvodno (downstream of Sisak)
Kupa River	Recica (downstream of Karlovac), Brest (immediately upstream of Petrinja)
Lonja River	K. Lonja Strug (before joining Cesma River), Struzec (after joining Cesma River)
Kutina River	Kutina (downstream of treatment plant)

(2) Future Pollution Load Runoff in 2007 Without Project

The municipal wastewater will increase according to the growth of sewerage served population and per capita wastewater quantity. The industrial wastewater will also increase according to the growth of industrial production. The non-point pollution load generation is assumed as constant.

The future (2007) point and non-point pollution load runoff of the six (6) major sub-basins to the main rivers without project are as estimated below in terms of BOD in comparison with the existing ones (1999). In this calculation, the pollution load runoff from the outer drainage basins of the Study Area is also incorporated. For those of COD, T-P and T-N, see Appendix B, Section 6.3.

(Unit: BOD, kg/d)

Source	Upper Sava 2,035 km²	Middle Sava 77 km²	Lower Sava 3,807 km²	Upper Kupa 4,257 km²	Lower Kupa 3,784 km²	Lonja 4,321 km²	Total 18,281 km²	
Existing (1999)								
Municipal	50,594	0	1,734	2,208	3,878	2,862	61,308	(70%)
Industrial	10,942	0	159	1,639	906	1,540	15,196	(17%)
Sub-total	61,536	0	1,894	3,847	4,783	4,402	76,504	(88%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(12%)
Total	62,384	22	2,857	7,046	9,334	5,468	87,153	(100%)
Without (2007)								
Municipal	53,829	0	2,703	5,516	5,371	4,361	71,780	(66%)
Industrial	23,947	0	160	115	538	1,656	26,411	(24%)
Sub-total	77,773	0	2,862	5,630	5,909	6,017	97,237	(90%)
Non-point	848	22	963	3,199	4,550	1,066	10,649	(10%)
Total	78,621	22	3,826	8,829	10,459	7,084	108,840	(100%)

(3) Basic Assumptions for River Water Quality Simulation

The river water quality with F/S project was simulated under the following basic assumptions:

(a) In the above five (5) F/S towns, industries that directly discharge wastewater into rivers will also treat the wastewater in compliance with the government regulations. However, all industries in the other towns/municipalities are assumed to make no improvement on their existing treatment systems.

(b) Zagreb's ongoing sewerage project will treat the wastewater to the permissible limits of effluent (BOD = 25 mg/l, COD-Cr = 125 mg/l, TSS = 35 mg/l).

(c) Self-purification effects of main rivers are estimated based on the Streeter-Phelps Formula.

(4) Simulated Water Quality of Sava Main and Kupa River

Based on the results of the above pollution load runoff and self-purification estimates, the river water quality in 2007 without project was simulated for the river flow rate of 95% compared with the existing one. The results are as shown below.

(Unit: BOD mg/l)

River	Location	Existing (1999)	Without (2007)	With F/S (2007)	Remarks
Sava	Jesenice	(5.6)	(5.6)	(5.6)	Slovenian Border
	Oborovo	8.8 (8.6)	10.2	4.8*	After Zagreb
	Utok Kupe Nizvodno	5.6 (5.7)	6.5	3.1*	After Sisak
Kupa	Recica	4.3 (4.3)	5.0	4.0	After Karlovac
	Brest	3.5 (3.5)	3.9	3.5	Before Petrinja

Note: Values in parentheses are the observed quality; * including effects of Zagreb Project

The water quality of Sava Main River is expected to greatly improve with the ongoing Zagreb Project in 2007. The water quality of the Kupa River will not exceed the standard quality to a serious level even in the case of without-project as shown in the above table. Hence, the treatment level of primary sedimentation is considered applicable for the F/S projects of Sisak and Karlovac-Duga Resa.

The river water quality with primary sedimentation (treatment efficiency: 40%) of the F/S projects of Sisak and Karlovac-Duga Resa in 2007 was simulated at the river flow

rate of 95%. The results of simulation in above table show that the river water quality satisfies the required standards for a Category II watercourse in 2007.

(5) Simulated Water Quality of Lonja River

The water quality of Lonja River with the F/S projects of Dugo Selo and Vrbovec in 2007 was simulated for the principal river locations; namely, Crnec River at K. Lonja Strug and Lonja River (Lonjsko Polje) at Struzec, under the river flow rate of 95% probability. In this simulation, two (2) alternatives of treatment level; namely, (i) primary sedimentation (treatment efficiency: 40%), and (ii) biological treatment (BOD: 25 mg/l), were also compared. The results are summarized below.

(Unit: BOD, mg/l)

River Flow Rate	Treatment Level	K. Lonja Strug	Struzec
95% Probability	Existing (1999)	27.1	8.5
	Without Project (2007)	36.3	11.1
	Primary Sedimentation (2007)	33.5	10.6
	Biological Process (2007)	31.0	10.1

As shown in the above table, the improvement effects are small. Additional projects may be necessary to attain a significant water quality improvement of the Lonja River.

On the other hand, the implementation of Sesvete East project has already been approved, and the implementation of Ivanić Grad-Kloštar Ivanić project is expected to start in the near future. The river water quality of the Lonja River with the four (4) projects of Dugo Selo, Vrbovec, Sesvete East and Ivanić Grad-Kloštar Ivanić was simulated in the same way, and the results are as shown below.

(Unit: BOD, mg/l)

River Flow Rate	Treatment Level	K. Lonja Strug	Struzec
95 % Probability	Existing (1999)	27.1	8.5
	Without Project (2007)	36.3	11.1
	Primary Sedimentation (2007)	19.4	7.9
	Biological Process (2007)	7.6	5.2

In this case, the biological processes of the above-mentioned four (4) projects satisfy the standards of Category III at K. Lonja Strug of the Crnec River and nearly meet Category II at Struzec of Lonjsko Polje.

(6) Simulated Water Quality of Kutina River

The natural flow of Kutina River is negligible in the dry season. The river water is recharged by the wastewater of the sewerage system and the factories. Petrokemija Factory discharges a large quantity of wastewater into the Kutina River with a low BOD concentration, although the T-N content is high.

The river water quality with the Kutina F/S project is roughly estimated as follows, compared with the case without project.

(Unit: BOD, mg/l)

Treatment	1999	2007
Without	70	70
Primary Sedimentation	-	50
Biological Treatment	-	16

1.5.3 Conclusion

(1) The treatment plants of Sisak and Karlovac shall treat the wastewater to the level of primary sedimentation (treatment efficiency: 40%) to satisfy the standard river water quality in 2007.

(2) The treatment plants of Dugo Selo and Vrbovec shall treat the wastewater to BOD 25 mg/l to attain the target river water quality of Category III at the Crnec River and to nearly meet the standards of Category II at Lonjsko Polje along with the expected succeeding projects such as Sesvete East and Ivanić Grad-Kloštar Ivanić.

(3) The treatment plant of Kutina shall treat the wastewater to BOD 25 mg/l to improve the river water quality of Kutina up to the possible extent.

1.6 Wastewater and Sludge Treatment Processes

(1) Wastewater Treatment Process

As discussed in Part I, Master Plan Study, treatment plants larger than 10,000 PE shall treat phosphorus (P) as well as organic materials when the effluent is discharged into Category II rivers. The Anaerobic-Oxic treatment process (AO) is proposed as the optimum process for all the objective five (5) projects of the feasibility study. This AO system will treat the wastewater to BOD: 25 mg/l, COD-Cr: 125 mg/l, TSS: 35 mg/l and T-P: 2 mg/l by 2015.

The AO treatment process consists of the following sub-processes: (i) Preliminary Treatment, (ii) Primary Sedimentation, (iii) Anaerobic Process, (iv) Aeration Process, and (v) Secondary Sedimentation.

Part of the AO system is proposed as the first stage treatment system targeting the year 2007, based on the results of the simulation studies mentioned above. In the first stage, treatment of T-P is excluded in due consideration of the lower priority of nutrients removal and to maximize the cost effectiveness. The proposed first stage treatment processes of the objective five (5) projects of the F/S towns are as given below.

Project	Process	Sub-process
Sisak, Karlovac-Duga Resa	Primary Sedimentation	Preliminary Treatment, Primary Sedimentation
DugoSelo, Vrbovec, Kutina	Activated Sludge	Preliminary Treatment, Primary Sedimentation, Aeration, Secondary Sedimentation

(2) Sludge Treatment

In the master plan study, various combinations of thickening, digestion, drying bed and mechanical dewatering were compared in connection with the sludge treatment system. The treatment system with thickening and mechanical dewatering was proposed for the treatment plant with size larger than 10,000 PE, and with thickening and drying bed for the treatment plant with size of less than 10,000 PE.

In this Feasibility Study, the sludge treatment system with thickening and mechanical dewatering is applied for all the treatment plants of the F/S towns since their treatment capacities are larger than 10,000 PE.

1.7 Structural Design Principles

1.7.1 Transport Collector and Lift Pump

All the existing sewer networks of the objective towns are the combined type. The wastewater and storm water collected by secondary/tertiary sewers are discharged through the main sewers into the nearest water body. Hence, there are many outfalls on the main sewers.

Transport collectors are designed to intercept these outfalls and to transport the wastewater to the treatment plants. The capacity of a transport collector is designed to discharge two (2) times of the design hourly maximum wastewater quantity of the master plan (targeting 2015). The excess storm water is discharged into the water body through an overflow chamber at rainy time.

Further, some additional discharge is considered in designing the capacity of the transport collector for the areas where urban or industrial developments are expected beyond 2015. Lift pumps are provided at necessary intervals on the transport collector to minimize the installation cost. The capacity of lift pump is designed to meet the design discharge of the transport collector.

1.7.2 Treatment Plant

The treatment plant consists of preliminary treatment facilities, primary sedimentation tank, aeration tank and secondary sedimentation tank. The preliminary treatment facilities including inlet pumps are designed to meet the design hourly maximum wastewater quantity. The primary sedimentation tank, aeration tank and secondary sedimentation tank are further designed to meet the design daily maximum wastewater quantity. The design wastewater quantities are mentioned in Section 1.4.

Further, the treatment plant is designed to treat the inflow pollution load to the permissible limits. The design inflow pollution loads are also mentioned in Section 1.4.

The treatment plant is provided with some emergency works such as by-pass of inflow and emergency generator, and the plant is designed in double systems for emergency or periodical repair.

1.8 Bases of Cost Estimate

1.8.1 Conditions of Construction

Most of the resources of civil works are available in Croatia except special materials. However, the mechanical and electrical equipment of treatment plants are assumed in this Study as imported, referring to similar projects in the past.

Annual workable days are assumed as 278 days, considering the following suspension days: 53 days for Sunday, 7 days for national holiday and 27 days for rainy day.

1.8.2 Basis of Cost Estimate

(1) General

The construction and O&M costs are estimated based on the prevailing unit prices as of February 2001. The following currency conversion rates at the end of February 2001 are employed for the cost estimate: US$1.00 = Kn. 8.3 = JP¥ 116.

(2) Construction Cost

Construction cost consists of: (i) direct construction cost, (ii) land acquisition cost, (iii) engineering cost, (iv) government administration cost, (v) Customs Duties, (vi) VAT, and (vii) contingency.

Direct construction cost involves the three (3) main works: (i) transport collector/main sewer, (ii) secondary/tertiary sewer, and (iii) treatment plant.

Land acquisition cost is estimated individually; however, the other costs are estimated as lump sum based on assumptions, as follows.

Item	Assumption
Engineering Cost	10% of direct construction cost
Government Administration Cost	3% of direct construction cost
Customs Duties	10% of mechanical/electrical works
VAT	22% of direct construction and engineering costs
Contingency	10% of direct construction cost

(3) O&M Cost

The annual O&M cost for constructed collectors and sewers is estimated to be 0.5% of the direct construction cost. Those of the treatment plants are estimated individually, referring to the O&M cost of the treatment plant recently constructed in Croatia.

CHAPTER II DUGO SELO SEWERAGE DEVELOPMENT

2.1 Basis of Structural Design

2.1.1 Existing Conditions of Town

The town of Dugo Selo consisting of nine (9) settlements is located along the eastern suburbs of Zagreb City. The existing and future administrative area and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		300	4,922	5,222
Population	(1999)	10,570	4,756	15,326
	(2007)	11,406	5,132	16,538
	(2015)	12,301	5,535	17,836

The existing sewerage system serves not only the densely populated central urban area but also some surrounding areas at present. The existing sewerage service area and population are estimated to be approximately 516 ha and 9,100, respectively. For location of the existing service area, see Fig. II.2.1.

2.1.2 Design Service Area, Population and Industries

The proposed sewerage system will cover the existing service area of 516 ha, and serve the population of 10,300 within the service area in 2007. No extension of the existing service area is proposed. There is no large industry in the town at present; therefore, it is presumed that no large industry will be served by the sewerage system in 2007.

2.1.3 Design Wastewater Flow and Quality

The total design municipal wastewater flow and pollution load are determined as follows.

	Municipal Wastewater
Wastewater Quantity (m^3/d)	
Daily Average	2,884
Daily Maximum	3,605
Hourly Maximum (dry)	4,944
Hourly Maximum (rainy)	9,270
Pollution Load	
BOD Load (kg/d)	760 (12,700 PE)
BOD Concentration (mg/l)	211
COD-Cr Concentration (mg/l)	422
TSS Concentration (mg/l)	246

2.2 Preliminary Design of Transport Collector

The existing sewers are all of combined type with diameters of 30 to 120 cm for a total length of 16,541 m. The collected wastewater is discharged into the nearest canal through six (6) outfalls.

Three (3) transport collectors are proposed to intercept the six (6) outfalls and transport the wastewater to the treatment plant located on the left bank of the Crnec River. The transport collectors are provided with no pumps and siphons; however, the transport collector No. 3 crosses one (1) place under the railway. The main features are summarized below. For location of the transport collectors, see Fig. II.2.1.

Transport Collector	Length (km)	Diameter (mm)
T.C. 1	2.32	800 - 1,200
T.C. 2	0.54	800
T.C. 3	2.63	800 - 1,000
Total	5.49	

Secondary/tertiary sewers of combined type with the diameter of 400 mm are installed for a total length of 2.1 km in two (2) communities.

2.3 Preliminary Design of Treatment Plant

2.3.1 General

The treatment plant is proposed at a location on the left bank of the Crnec River, encompassed by two (2) drainage canals. The site is a bush land/forest with a ground elevation of approx. 100 m and free from floods. Inlet pumps lift up the wastewater transported to the plant, and the treated water is discharged into the Crnec River by gravity. For location of the treatment plant, see Fig. II.2.1.

2.3.2 Proposed Structural Design

The proposed treatment process is AS which is part of AO, only excluding the anaerobic tank from the AO system. The plant will treat the design influent concentration of BOD, COD-Cr and TSS to the permissible limits shown below. The generated sludge is treated with the thickening and mechanical dewatering system. The treated sludge is disposed at the municipal solid waste disposal site.

Parameter	Influent	Effluent
BOD (mg/l)	211	25
COD-Cr (mg/l)	422	125
TSS (mg/l)	246	35

The main structural features of the proposed treatment plant are summarized below, compared to the master plan. For layout of the treatment plant, see Fig. II.2.2.

Facilities	Specification	No. of Units	
		F/S	M/P
Influent Pumping Station and Screen	Coarse Screen, 2 m W	1	1
	Fine Screen, 1 m W	2	2
	Archimedical Screw Pump 3.6 m^3/min × 6m H × 6 kw	2	3
Grit Oil/Sand Removal	2 m W × 10 m L	2	2
Parshall flume	0.3048 m (1 ft)	1	1
Primary Sedimentation Tank	3.0 m W × 12.0 m L × 3.0 m D (Effective Depth)	3	4
Aeration Tank	5 m W × 20.0 m L × 5 m D	3	4
Secondary Sedimentation Tank	∅12 m × 3.5 m D (Effective Depth)	2	2
Sludge Thickener	∅5 m × 4.0 m D	1	1
Belt Press Filter	1.5 m W × 1.5 kw	2	2
Blower	Roots Blower, 10 m^3/min × 18.5 kw (Building, 7 m × 15 m)	3	3
Return Sludge	Archimedical Screw Pump 2 m^3/min × 3 m H × 3.0 kw	3	3
Administration Building	10 m W × 10 m L (m^2)	100	100

2.3.3 Appurtenant Works and Required Land Space

The treatment plant site is encompassed by the Crnec River and two (2) drainage canals. Hence, the construction of 150 m of access road is necessary. The required land space is estimated to be 1.39 ha.

2.4 Operation and Maintenance

The existing and proposed sewerage systems will be operated and maintained by the municipal service company (DUKOM d.o.o.) under the control of the Dugo Selo Town Council.

The company provides water supply, solid waste disposal, gas supply and cemetery, in addition to the sewerage services. It has 72 staff, 10 of which work for the O&M of water supply and sewerage. They are one (1) manager, one (1) foreman, two (2) independent fitters, three (3) assistant fitters, and three (3) general assistants.

Six (6) additional staffs are necessary for the operation and maintenance of the wastewater treatment plant; namely, Manager (1), Operator (4), and Water Quality Analyst (1).

2.5 Cost Estimate

(1) Construction Method

The geological formation of the treatment plant site consists of thick clay, but some ground improvement works are necessary for construction of the major treatment tanks. Although the transport collector will be installed by the normal open-cut method, some special temporary works may be necessary for crossing under the railway.

(2) Construction Cost

The total construction cost is estimated at Kn. 50.94 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)
Direct Cost	Pipe	Transport Collector/Main Sewer	8,770.7
		Secondary/Tertiary	1,651.9
		Sub-total	10,422.6
	Treatment Plant	Preliminary Treatment	4,084.4
		Biological Reactor	4,151.0
		Secondary Sedimentation	1,687.2
		Sludge Treatment	4,332.2
		Others	8,829.4
		Sub-total	23,084.2
	Total		33,506.8
Land Acquisition			186.8
Indirect Cost	Engineering		3,350.7
	Administration		1,005.2
	Customs Duties		1,432.5
	VAT		8,108.6
	Total		13,897.0
Contingency			3,350.7
Grand Total			50,941.2

(3) O&M Cost

The annual O&M Cost is estimated to be Kn. 1.59 million, broken down as follows.

Facilities	Items	Cost ($\times 10^3$ Kn)
Pipe	Maintenance	79.2
Wastewater Treatment Plant	Electrical Charges	350.4
	Personnel Expense	499.2
	Mechanical Maintenance	168.2
	Laboratory	154.2
	Others	336.4
	Sub-total	1,508.4
Total		1,587.6

2.6 Environmental Impact Assessment

There is yet no guideline for environmental impact assessment (EIA) of sewerage development projects in Croatia. In this Study, environmental components are taken up for EIA, referring to the guidelines of JICA and the comments given from the Ministry of Environmental Protection and Physical Planning (MEPP); namely, (i) land acquisition, (ii) noise, (iii) geology, (iv) flora and fauna, (v) air pollution/odor, (vi) water pollution, (vii) water use, and (viii) sludge disposal and groundwater.

The JICA Study Team carried out the EIA study for the proposed project by entrusting it to a qualified local consultant in order to evaluate the extent/degree of predicted negative impacts on the environment. The results are summarized below.

Survey Items	Survey Results	Evaluation
Land Acquisition	The proposed WWTP site is currently a private wasteland (bush/forest) and is designated as WWTP site in the physical plan of the local government.	O
Noise	The noise level at the nearest residential area caused by the construction of WWTP is estimated to be 57.2 dB(A), which is lower than Croatian standard [60 dB(A)]. Noise impact is not significant.	O
Geology	According to the boring tests, soil under the WWTP site is thick clay and is prone to compression by the construction of heavy structures. However, this problem is considered minor since the proposed structures are not heavy.	O
Flora and Fauna	No endangered flora and fauna were identified in/around and in the downstream of WWTP.	O
Air Pollution	During the construction stage of the project, the operation of construction equipment and earthwork would produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. During the operation stage, no significant odor will be emitted from the treatment plant since sludge is treated by the mechanical dewatering system and the treatment plant is located 250 m away from the nearest residences.	Δ
Water Pollution	According to the simulation analysis, the water quality of the Crnec River will much improve with this project. There are no large factories that discharge industrial wastewater into the sewerage system. Therefore, the impacts of industrial wastewater on the influent of WWTP will not be significant.	O
Water Use	No water intake and water recreation activities were identified in the vicinity and until 10 km downstream from the WWTP.	O
Sludge Disposal and Groundwater	According to the analyses of the wastewater effluent of the large industries in the Study Area, heavy metals were not detected or negligible. Hence, the quality of generated sludge from this project is considered as normal. On the other hand, the generated sludge of the existing biological treatment plants in Croatia contains heavy metals with a certain concentration. However, the concentration level is lower than Croatian permissible limits of sludge disposal. Hence, the dewatered sludge of this project can be disposed on the existing municipal solid waste disposal site (SWDS), which has enough space for disposing the sludge. According to the groundwater quality analysis, the groundwater around the existing Andrilovec SWDS has only been slightly polluted by organic matter. On the other hand, the town of Dugo Selo has a plan to install a leachate treatment system for the existing SWDS in the near future. Hence, the sludge disposal on the SWDS will cause no significant impact on the groundwater in the surrounding area.	Δ

O : Nothing or negligible Δ : Slight impact but acceptable

CHAPTER III VRBOVEC SEWERAGE DEVELOPMENT

3.1 Basis of Structural Design

3.1.1 Existing Conditions of Town

The town of Vrbovec, consisting of 41 settlements, is located in the catchment area between the Lonja and the Glogovnica River. The establishment of the food processing industry resulted in the present urban, industrial and commercial developments in the town.

The existing and future administrative areas and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		238	15,667	15,905
Population	(1999)	4,190	9,245	13,435
	(2007)	4,266	9,411	13,677
	(2015)	4,366	9,633	13,999

The sewerage system serves not only the densely populated central urban area (238 ha) but also some surrounding areas at present. The existing service area and population are estimated to be approximately 393 ha and 5,000, respectively.

There are three (3) large industries of which only one (1) industry, Gradip, is served by the sewerage system. Sewage of the other industry, PIK Vrbovec Farma Polijanski, is treated on land and that of the remaining one, PIK Vrbovec Mesna, is discharged directly into the canal with simple pre-treatment. PIK Vrbovec Mesna (food/beverage) is one of the largest industrial pollutant sources in the Sava River Basin.

3.1.2 Design Service Area, Population and Industries

PIK Vrbovec Mesna will change its recipient from the canal to public sewerage. Therefore, the proposed sewerage system will serve two (2) large industries: PIK Vrbovec Mesna and Gradip. Since the sewerage system is to be extended by 28 ha to cover the PIK Vrbovec Mesna, the total sewerage service area of the town will become 422 ha. All the population of 5,900 within the service area in 2007 will be served.

For location of the service extension area, see Fig. II.3.1.

3.1.3 Design Wastewater Flow and Quality

The total design municipal and industrial wastewater flow and pollution load are determined as follows.

	Municipal	Industrial	Total
Wastewater Quantity (m^3/d)			
Daily Average	1,416	2,769	4,185
Daily Maximum	1,770	2,769	4,539
Hourly Maximum (dry)	2,360	2,837	5,197
Hourly Maximum (rainy)	4,128	2,973	7,101
Pollution Load			
BOD Load (kg/d)	381	490	871 (14,600 PE)
BOD Concentration (mg/l)			198
COD-Cr Concentration (mg/l)			416
TSS Concentration (mg/l)			297

3.2 Preliminary Design of Transport Collector

The existing sewers are all of combined type with diameters of 30 to 120 cm for a total length of approximately 28 km. The collected wastewaters are discharged into the nearest canals through three (3) outfalls, but mostly into the Luka Canal through two (2) outfalls. PIK Vrbovec Mesna also discharges wastewater into the Luka Canal through its own outfall.

Three (3) transport collectors are proposed to intercept the above three (3) outfalls discharging into the Luka Canal and transport the wastewater to the treatment plant proposed at a location in the southern fringe of the town where wastewater is treated before discharge into the canal.

The transport collectors are not provided with pumps and siphons. The main features are summarized below. For location of the transport collectors, see Fig. II.3.1.

Transport Collector	Length (km)	Diameter (mm)
T.C. 1	0.59	400
T.C. 2	0.85	400
T.C. 3	0.44	350
Total	1.88	

A secondary pressured sewer of combined type with a diameter of 100 mm is installed for a total length of 0.75 km is installed to connect with the Stuk service area through the existing sewer network of Transport Collector II.

3.3 Preliminary Design of Treatment Plant

3.3.1 General

The treatment plant is proposed at a location west of the railway station in the southern fringe of the town to discharge into the Luka Canal. The site is at present a private wasteland (grassland) with a ground elevation of 111.0 m and free from floods. Inlet pumps will lift up the wastewater transported to the plant and the treated water is then discharged into the Luka Canal by gravity.

For location of the treatment plant, see Fig. II.3.1.

3.3.2 Proposed Structural Design

The proposed treatment process is AS which is part of AO, only excluding the anaerobic tank from the AO system. The plant will treat the design influent concentration of BOD, COD-Cr and TSS to the permissible limits shown below. The generated sludge is treated with the thickening and mechanical dewatering system, and the treated sludge is disposed at the municipal solid waste disposal site.

Parameter	Influent	Effluent
BOD (mg/l)	198	25
COD-Cr (mg/l)	416	125
TSS (mg/l)	297	35

The main structural features of the proposed treatment plant are summarized below, compared to the master plan. For layout of the treatment plant, see Fig. II.3.2

Facilities	Specification	No. of Units	
		F/S	M/P
Influent Pumping Station and Screen	Coarse Screen, 2 m W	1	1
	Fine Screen, 1 m W	2	2
	Archimedical Screw Pump 3.6 m^3/min × 6m H × 6 kw	2	3
Grit Oil/Sand Removal	2 m W × 10 m L	2	2
Parshall flume	0.3048 m (1 ft)	1	1
Primary Sedimentation Tank	3.0 m W × 14.0 m L × 3.0 m D (Effective Depth)	3	4
Aeration Tank	5 m W × 22.0 m L × 5 m D	3	4
Secondary Sedimentation Tank	∅13 m × 3.5 m D (Effective Depth)	2	2
Sludge Thickener	∅6 m × 4.0 m D	1	1
Belt Press Filter	1.5 m W × 1.5 kw	2	2
Blower	Roots Blower, 12 m^3/min × 18.5 kw (Building, 7 m × 15 m)	3	3
Return Sludge	Archimedical Screw Pump 2.3 m^3/min × 3 m H × 3.7 kw	4	4
Administration Building	10 m W × 10 m L (m^2)	100	100

3.3.3 Appurtenant Works and Required Land Space

A channel on the west and the railway on the south encompass the treatment plant site. Hence, the construction of access is necessary. The required land space is estimated to be 1.24 ha.

3.4 Operation and Maintenance

The existing and proposed sewerage systems will be operated and maintained by the municipal service company (KOMUNALAC VRBOVEC d.o.o.), which is controlled by the Vrbovec Town Council.

The company provides water supply, solid waste disposal, gas supply, and cemetery services, in addition to sewerage services. It has 106 staffs of which four (4) are presently assigned to the O&M of the sewerage system; namely, one (1) Sewerage Manager, one (1) engineer, one (1) qualified worker, and one (1) stoker. Six (6) more staffs are necessary for the operation and maintenance of the wastewater treatment plant; namely, Manager (1), Operator (4), and Water Quality Analyst (1).

3.5 Cost Estimate

(1) Construction Method

The geological formation at the treatment plant site consists of thick clay, which is considered stiff enough to support the treatment plant and hence no special ground improvement work is necessary. The transport collectors will be installed by the normal open-cut method. Although the transport collectors will cross the Luka Canal, no special temporary works may be necessary.

(2) Construction Cost

The total construction cost is estimated at Kn. 39.51 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)
Direct Cost	Pipe	Transport Collector/Main Sewer	2,100.8
		Secondary/Tertiary	316.7
		Sub-total	2,417.5
	Treatment Plant	Preliminary Treatment	4,122.7
		Biological Reactor	4,560.8
		Secondary Sedimentation	1,899.7
		Sludge Treatment	4,367.5
		Others	8,321.4
		Sub-total	23,272.2
	Total		25,689.6
Land Acquisition			199.2
Indirect Cost	Engineering		2,569.0
	Administration		770.7
	Customs Duties		1,491.4
	VAT		6,216.9
	Total		11,048.0
Contingency			2,569.0
Grand Total			39,505.8

(3) O&M Cost

The annual O&M Cost is estimated to be Kn. 1.53 million, broken down as follows.

Facilities	Items	Cost ($\times 10^3$ Kn)
Pipe	Maintenance	18.6
Wastewater Treatment Plant	Electric Charges	350.4
	Personnel Expense	499.2
	Mechanical Maintenance	168.2
	Laboratory	154.2
	Others	336.4
	Sub-total	1,508.4
Total		1,526.9

3.6 Environmental Impact Assessment

The JICA Study Team conducted the EIA study for the proposed project by entrusting it to a qualified local consultant in order to evaluate the extent/degree of the predicted negative impacts on the environment in the same way as the Dugo Selo sewerage development project. The results are summarized below.

Survey Items	Survey Results	Evaluation
Land Acquisition	The proposed WWTP site is at present a private wasteland (grassland) and is designated as WWTP site in the physical plan of the local government.	O
Noise	The noise level at the nearest residential area caused by the construction of WWTP is estimated to be 55.6 dB(A), which is lower than the Croatian standard [60 dB(A)]. Noise impact is not significant.	O
Geology	According to the boring test, soil at the WWTP site is thick clay and is prone to compression by the construction of heavy structures. However, this problem is considered minor since the proposed structures are not heavy.	O
Flora and Fauna	No endangered flora and fauna were identified in/around and in the downstream of WWTP.	O
Air Pollution	During the construction stage of the project, the operation of construction equipment and earthwork would produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. During the operation stage, no significant odor will be emitted from the treatment plant since sludge is treated by the mechanical dewatering system and the treatment plant is located 300 m away from the nearest residences.	Δ
Water Pollution	According to the simulation analysis, the water quality of the Lonja River will much improve with this project. There are two (2) large factories that discharge industrial wastewater into the sewerage system. They will discharge mainly organic materials that will be pre-treated before discharge into the sewerage system. Hence, the impacts on the proposed wastewater treatment system will not be significant.	O
Water Use	No water intake and water recreation activities were identified in the vicinity until 10 km downstream from the WWTP.	O
Sludge Disposal and Groundwater	According to the analyses of the wastewater effluent of the large industries in the Study Area, heavy metals were not detected or negligible. Hence, the quality of generated sludge from this project is considered as normal. On the other hand, the generated sludge of the existing biological treatment plants in Croatia contains heavy metals with a certain concentration. However, the concentration level is lower than the Croatian permissible limits of sludge disposal. Hence, the dewatered sludge of this project can be disposed on the existing municipal solid waste disposal site (SWDS), which has enough space for disposing the sludge. According to the groundwater quality analysis, the groundwater around the existing Lazarevac SWDS has only been slightly polluted by organic matter. On the other hand, the town of Vrbovec has a plan to install a leachate treatment system for the existing SWDS in the near future. Hence, the sludge disposal on the SWDS will cause no significant impact on the groundwater in the surrounding area.	Δ

O : Nothing or negligible Δ : Slight impact but acceptable

CHAPTER IV SISAK SEWERAGE DEVELOPMENT

4.1 Basis of Structural Design

4.1.1 Existing Conditions of Town

The town of Sisak, consisting of 31 settlements, had developed on the flood plains of the Sava, Kupa and Odra rivers. The Kupa River divides the urban center of the town into two (2) parts; namely, the central business area on the low-lying land encompassed by the right bank of the Sava River and the left bank of the Kupa River, and the industrial zone that developed on the southern end of the left bank of the Kupa River.

The existing and future administrative areas and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		1,770	40,373	42,143
Population	(1999)	44,175	25,108	69,283
	(2007)	44,507	25,297	69,804
	(2015)	44,842	25,487	70,328

The sewerage system covers almost all the urban area of the town. The sewerage service area and population are 944 ha and 39,400 persons, or 89% of the total urban population of 44,175 people. For location of the existing service area, see Fig. II.4.1.

There are six (6) large industries and three (3) of them are served by the sewerage system. Wastewater of the other three (3) industries is discharged directly into the rivers with necessary treatment. The industries served by the sewerage system are Herbos (chemical products), Tvornica Segestica (beverage products), and Ljudevit Posavski Mlin i Pekare (food products).

4.1.2 Design Service Area, Population and Industries

The proposed sewerage system is designed to cover the existing service area of 944 ha and serve all the population of 45,400 within the service area in 2007.

The three (3) industries currently served will be covered by the proposed sewerage system, but the three (3) industries that are not currently served will continue discharging wastewater directly into the rivers in the future.

4.1.3 Design Wastewater Flow and Quality

The total design municipal and industrial wastewater flow, as well as pollution load, are determined as follows.

	Municipal	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	12,712	1,083	13,795
Daily Maximum	15,890	1,083	16,973
Hourly Maximum (dry)	21,792	1,209	23,001
Hourly Maximum (rainy)	40,482	2,416	42,898
Pollution Load			
BOD Load (kg/d)	3,351	238	3,589 (59,900 PE)
BOD Concentration (mg/l)			211
COD-Cr Concentration (mg/l)			434
TSS Concentration (mg/l)			261

4.2 Preliminary Design of Transport Collector

The existing sewers are all of combined type for a total length of approx. 77 km; namely, 22 km of main sewer and 55 km of secondary/tertiary sewer. The maximum and minimum diameters of sewer are 200 cm and 20 cm, respectively.

The sewerage service area is divided into two (2) areas; namely, Old Sisak encompassed by the Sava, Kupa and Odra rivers, and New Sisak extending on the right bank of Kupa River. The entire area of Old Sisak is drained through two (2) outfalls, each one provided with a pumping station; namely, Galdovo PS (capacity: 5.9 m^3/s) into the Sava River, and Odra PS (capacity: 2.2 m^3/s) into the Odra River. The whole area of New Sisak is drained by gravity through seven (7) outfalls into the Kupa River.

Two (2) lines of transport collectors are proposed to intercept wastewater from the existing outfalls and convey the wastewater to the treatment plant. One of them is the New Sisak Transport Collector which will run from the Zitna outfall to the treatment plant along the right bank of the Kupa and Sava rivers. The other is the Old-New Sisak Transport Collector which will connect the Galdovo Pumping Station to New Sisak Transport Collector across the Kupa River to convey the wastewater of the Old Sisak area.

The Old-New Sisak Transport Collector will cross the Kupa River by siphon and a pumping station (22 kw $\times$ 2 units) will be installed at the connection point of the New Sisak and the Old-New Sisak transport collectors.

The main features of the proposed transport collectors are summarized below. For location of the transport collectors, see Fig. II.4.1. No secondary/tertiary sewer is proposed.

Transport Collector	Length (km)	Diameter (mm)
Old-New	0.37	800
Old-New (Siphon)	0.19	500 $\times$ 2
New Sisak (Zitna Outfall - Victorovac Outfall)	1.42	450
New Sisak (Victorovac Outfall - Railway Bridge)	0.36	500
New Sisak (Railway Bridge - Skolska Outfall)	0.89	900
New Sisak (Skolska Outfall - WWTP)	3.11	1,000
Total	6.34	

4.3 Preliminary Design of Treatment Plant

4.3.1 General

The treatment plant is proposed at the southern end of the urban center on the right bank of the Sava River to discharge into the Sava River. The site is wasteland (bush), owned by the town, with an average ground elevation of 97.5 m. However, the flood water level of the Sava River is estimated at 99.32 m for a 100-year return period and hence, some flood protection works are necessary.

Inlet pumps lift up the wastewater transported to the plant and the treated water is discharged into the Sava River by gravity. For location of the treatment plant, see Fig. II.4.1.

4.3.2 Proposed Structural Design

The proposed treatment process is primary sedimentation, consisting of preliminary treatment and primary sedimentation. The plant will treat the design influent concentration of BOD, COD-Cr and TSS to the permissible limits shown below. The generated sludge is treated with the thickening and mechanical dewatering system and the treated sludge is disposed at the municipal solid waste disposal site.

Parameter	Influent	Effluent	Treatment Efficiency
BOD (mg/l)	211	127	40%
COD-Cr (mg/l)	434	260	40%
TSS (mg/l)	261	157	40%

The main structural features of the proposed treatment plant are summarized below, compared to the master plan. For layout of the treatment plant, see Fig. II.4.2.

Facilities	Specification	No. of Units	
		F/S	M/P
Influent Pumping Station and Screen	Coarse Screen, 2 m W	1	1
	Fine Screen, 1 m W	2	2
	Archimedical Screw Pump 12 m^3/min × 10 m H × 19 kw	4	5
Grit Oil/Sand Removal	5 m W × 17 m L	2	2
Parshall Flume	0.3048 m (1 ft)	1	1
Primary Sedimentation Tank	4.0 m W × 18.0 m L × 3.0 m D (Effective Depth)	6	8
Aeration Tank	5 m W × 39.0 m L × 5 m D	0	8
Secondary Sedimentation Tank	∅17 m × 3.5 m D (Effective Depth)	0	4
Effluent Pumping Station	Vertical Axial Flow Pump 8 m^3/min × 6 m H × 6 kw (Building, 10 m × 13m)	4	5
Sludge Thickener	∅10 m × 4.0 m D	1	2
Belt Press Filter	2.0 m W × 2.2 kw	2	4
Blower	Roots Blower, 20 m^3/min × 37 kw (Building, 10 m × 25 m)	0	3
Return Sludge	Archimedical Screw Pump 6 m^3/min × 3 m H × 5.5 kw	0	4
Administration Building	10 m W × 15m L (m^2)	150	150

4.3.3 Appurtenant Works and Required Land Space

To protect the treatment plant from floods of the Sava River, dike of 2.5 m in height is constructed for a distance of 1,200 m. The required land space including the treatment plant and protection dike is estimated at approximately 6.34 ha.

4.4 Operation and Maintenance

The existing and proposed sewerage systems will be operated and maintained by the municipal service company (VODOVODO i KANALIZACIA SISAK d.o.o.), which is controlled by the Sisak Town Council.

The company provides water supply and sewerage services only. It has 145 staffs and 23 of them work in the Sewerage Section. These are one (1) manager, one (1) leader, one (1) foreman, eight (8) electrical engineers, five (5) drivers, six (6) sewerage workers, and one (1) assistant worker.

Six (6) additional staffs are necessary for the operation and maintenance of the wastewater treatment plant; namely, Manager (1), Operator (4), and Water Quality Analyst (1).

4.5 Cost Estimate

(1) Construction Method

The geological formation at the treatment plant site consists of thick clay. Some ground improvement works are necessary for the construction of major treatment tanks.

Although the transport collector is to be installed by the normal open-cut method, some special works will be necessary for it to cross the river by siphon, which will be constructed by the trenchless method. In this work, a vertical shaft 18 m in depth has to be installed on each bank.

(2) Construction Cost

The total construction cost is estimated at Kn. 68.95 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)
Direct Cost	Pipe	Transport Collector/Main Sewer	14,182.7
		Secondary/Tertiary	0.0
		Sub-total	14,182.7
	Treatment Plant	Preliminary Treatment	7,179.5
		Biological Reactor	0.0
		Secondary Sedimentation	0.0
		Sludge Treatment	8,201.5
		Others	15,951.8
		Sub-total	31,332.8
	Total		45,515.4
Land Acquisition			0.0
Indirect Cost	Engineering		4,551.5
	Administration		1,365.5
	Customs Duties		1,955.0
	VAT		11,014.7
	Total		18,886.7
Contingency			4,551.5
Grand Total			68,953.7

(3) O&M Cost

The annual O&M Cost is estimated to be Kn. 1.98 million, broken down as follows.

Facilities	Items	Cost ($\times 10^3$ Kn)
Pipe	Maintenance	46.1
Wastewater Treatment Plant	Electric Charges	499.3
	Personnel Expenses	499.2
	Equipment Maintenance	239.7
	Laboratory	219.7
	Others	479.3
	Sub-total	1,937.2
Total		1,983.4

4.6 Environmental Impact Assessment

The JICA Study Team conducted the EIA study for the proposed project by entrusting it to a qualified local consultant in order to evaluate the extent/degree of the predicted negative impacts on the environment in the same way as the Dugo Selo sewerage development project. The results are summarized below.

Survey Items	Survey Results	Evaluation
Land Acquisition	The proposed WWTP site is currently wasteland (grassland) owned by the town and is designated as WWTP site in the physical plan of the local government.	O
Noise	The noise level at the nearest residential area caused by the construction of transport collector is estimated to be 75 dB(A), which is over the Croatian standard [65 dB(A]]. Some measures should be taken to reduce the noise of the transport collector construction (for example, careful operation of equipment/dump truck, restriction of night time work). The residential area is far from the WWTP site (over 300 m). Noise impacts by the construction of the WWTP are negligible.	Δ
Geology	According to the boring tests, soils at the WWTP site consist of thick clay and are prone to compression by the construction of heavy structures. However, this problem is considered minor since the proposed structures are not heavy.	O
Flora and Fauna	No endangered flora and fauna were identified in/around and in the downstream of WWTP.	O
Air Pollution	During the construction stage of the project, the operation of construction equipment and earthwork would produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. During the operation stage, no significant odor will be emitted from the treatment plant since sludge is treated by the mechanical dewatering system and the treatment plant is located more than 300 m away from the nearest residences.	Δ
Water Pollution	According to the simulation analysis, the water quality of the Sava Main River will much improve with this project. Three (3) large industries will be served by the sewerage system. According to the analyses of the existing industrial effluent quality, the industries discharge no hazardous materials that may cause problems in the WWTP operation, and the industries will pre-treat the wastewater before discharging it into the sewerage. Hence, the impacts on the proposed wastewater treatment system will not be significant.	O
Water Use	No water intake and water recreation activities were identified in the vicinity and until 10 km downstream from the WWTP.	O
Sludge Disposal and Groundwater	According to the analyses of the wastewater effluent of the large industries in the Study Area, heavy metals were not detected or negligible. Hence, the quality of generated sludge from this project is considered as normal. On the other hand, the generated sludge of the existing biological treatment plants in Croatia contains heavy metals with a certain concentration. However, the concentration level is lower than the Croatian permissible limits of sludge disposal. Hence, the dewatered sludge of this project can be disposed on the existing municipal solid waste disposal site (SWDS), which has enough space for disposing the sludge. According to the groundwater quality analyses, the groundwater around the existing Gorieica SWDS has only been slightly polluted by organic matter. The sludge disposal on the SWDS will cause no significant impact on the groundwater in the surrounding area. However, the existing leachate treatment system is unsatisfactory. Hence, it should be improved to completely remove potential negative impacts on the surrounding groundwater.	Δ

O : Nothing or negligible Δ : Slight impact but acceptable

CHAPTER V KUTINA SEWERAGE DEVELOPMENT

5.1 Basis of Structural Design

5.1.1 Existing Conditions of Town

The town of Kutina, consisting of 23 settlements, is located midway of the main railway between Zagreb and Vinkovci. The establishment of the industrial complex of Petrokemija resulted in the urbanization of the town.

The existing and future administrative areas and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		902	28,616	29,518
Population	(1999)	16,800	6,252	23,052
	(2007)	18,188	6,768	24,956
	(2015)	19,679	7,323	27,002

The existing sewerage system serves 549 ha, covering the central urban area and some surrounding areas, and the served population is 16,100. The wastewater of the town is discharged into the Kutina River with preliminary treatment. For location of the existing service area, see Fig. II.5.1.

There is only one (1) large industry in the town (Petrokemija Kutina). Petrokemija Kutina is one of the largest pollution sources in the Sava River, but only sanitary wastewater is served by the existing sewerage system while a large quantity of process wastewater is discharged into the Kutina River.

5.1.2 Design Service Area, Population and Industries

Some extension of the existing sewer network is proposed to cover several communities located in the fringe areas of the urban center. The total extension area is estimated at 185 ha, hence the total service area in 2007 comes to 734 ha. The design served population in 2007 is set at 19,600. For location of the service extension area, see Fig. II.5.1.

No industrial wastewater will be covered under the sewerage system. Only the sanitary wastewater of Petrokemija Kutina will be served as at present.

5.1.3 Design Wastewater Flow and Quality

The total design municipal and industrial wastewater flow and pollution load are determined as follows.

	Municipal	Industry	Total
Wastewater Quantity (m^3/d)			
Daily Average	5,488	818	6,106
Daily Maximum	6,860	818	7,678
Hourly Maximum (dry)	9,408	818	10,226
Hourly Maximum (rainy)	17,052	1,635	18,687
Pollution Load			
BOD Load (kg/d)	1,447	15	1,462 (24,500 PE)
BOD Concentration (mg/l)			190
COD-Cr Concentration (mg/l)			383
TSS Concentration (mg/l)			262

5.2 Preliminary Design of Transport Collector

The existing sewers are mostly of combined type with diameters of 30 to 180 cm for a total length of approx. 45 km. There is one (1) outfall covering a small eastern fringe area of the urban center.

The wastewater of almost all of the service area is transported to the existing treatment plant (preliminary process) located on the right bank of the canal running through the southern fringe area of the urban center at present. The treated wastewater is discharged into this canal and finally into the Kutina River. The existing transport collector is not provided with pump or siphon. No transport collector is proposed.

One (1) main sewer with a diameter of 400 mm is proposed for a total length of 0.18 km to integrate the eastern fringe area that is not covered by the treatment plant at present. Further, secondary/tertiary sewers of 100 to 200 cm in diameter are proposed for a length of 9.0 km to collect the wastewater of extension service areas and to connect with the existing sewer network. For location of the proposed main sewer, see Fig. II.5.1.

5.3 Preliminary Design of Treatment Plant

5.3.1 General

The existing treatment plant is located at the southern fringe of the urban center. It is provided with only the preliminary treatment processes, which will be augmented with additional processes (primary sedimentation, aeration, secondary sedimentation and sludge treatment system). The existing treatment yard has enough space to accommodate the additional treatment processes. The site is on a ground level of 100.0 m and free from floods. For location of the treatment plant, see Fig. II.5.1.

5.3.2 Proposed Structural Design

The proposed treatment process is AS which is part of AO, only excluding the anaerobic tank from the AO system. The plant will treat the design influent concentration of BOD, COD-Cr and TSS to the permissible limits shown below. The generated sludge will be treated with the thickening and mechanical dewatering system, and disposed at the municipal solid waste disposal site.

Parameter	Influent	Effluent
BOD (mg/l)	190	25
COD-Cr (mg/l)	383	125
TSS (mg/l)	262	35

The main structural features of the proposed treatment plant are summarized below, compared to the master plan. For layout of the treatment plant, see Fig. II.5.2.

Facilities	Specification	No. of Units	
		F/S	M/P
Influent Pumping Station and Screen	Coarse Screen, 2 m W	(1)	(1)
	Fine Screen, 1 m W	(1)	(1)
	Archimedical Screw Pump 12 m^3/min × 6 m H × 19 kw 9 m^3/min × 6 m H × 14 kw	(2) (1)	(2) (1)
Grit Oil/Sand Removal	5 m W × 17 m L	(1)	(1)
Parshall Flume	0.3048 m (1 ft)	(1)	(1)
Primary Sedimentation Tank	4.0 m W × 18.0 m L × 3.0 m D (Effective Depth)	3	4
Aeration Tank	5 m W × 35.0 m L × 5 m D	3	4
Secondary Sedimentation Tank	∅17 m × 3.5 m D (Effective Depth)	2	2
Sludge Thickener	∅8 m × 4.0 m D	1	1
Belt Press Filter	1.5 m W × 1.5 kw	2	2
Blower	Roots Blower, 34 m^3/min × 60 kw (Building, 10 m × 25 m)	3	3
Return Sludge	Archimedical Screw Pump 9.0 m^3/min × 5 m H × 5.5 kw	3	3
Administration Building	10 m W × 15 m L (m^2)	150	150

Note: No. of Units in parentheses are existing facilities.

5.3.3 Appurtenant Works and Required Land Space

No special appurtenant works are necessary; however, the construction of access to the plant is required. The total required land space is estimated at 2.2 ha and thus, the proposed treatment plant improvement works can be accommodated within the existing treatment plant yard of 2.81 ha. No land acquisition is therefore necessary.

5.4 Operation and Maintenance

The existing and proposed sewerage systems will be operated and maintained by the municipal service company (MOSLAVINA d.o.o. KUTINA), which is controlled by the Kutina Town Council.

The company provides water supply, solid waste disposal, gas supply, market, and cemetery services, in addition to the sewerage services. The company has 187 staffs and 11 of them work for the O&M of the sewerage. These are one (1) sewerage manager, three (3) sewer maintenance officers, five (5) plant operation/maintenance officers, one (1) foreman, and one (1) cadastre officer.

Six (6) staffs are required for the operation and maintenance of the wastewater treatment plant including the existing five (5) staffs. The six required personnel are: Manager (1), Operator (4), and Water Quality Analyst (1).

5.5 Cost Estimate

(1) Construction Method

The geological formation at the treatment plant site consists of thick clay. Some ground improvement works are necessary for the construction of major treatment tanks. However, no special temporary works may be necessary.

(2) Construction Cost

The total construction cost is estimated at Kn. 41.16 million, broken down as follows.

Cost	Facilities		Cost ($\times 10^3$ Kn)
Direct Cost	Pipe	Main Sewer	175.6
		Secondary/Tertiary	5,905.4
		Sub-total	6,080.9
	Treatment Plant	Preliminary Treatment	1,151.4
		Biological Reactor	5,040.8
		Secondary Sedimentation	2,568.1
		Sludge Treatment	5,356.2
		Others	6,919.9
		Sub-total	21,036.4
	Total		27,117.3
Land Acquisition			0.0
Indirect Cost	Engineering		2,711.7
	Administration		813.5
	Customs Duties		1,239.9
	VAT		6,562.4
	Total		11,327.6
Contingency			2,711.7
Grand Total			41,156.6

(3) O&M Cost

The annual O&M Cost is estimated to be Kn. 2.52 million, broken down as follows.

Facilities	Items	Cost ($\times 10^3$ Kn)
Pipe	Maintenance	107.4
Wastewater Treatment Plant	Electric Charges	665.8
	Personnel Expense	499.2
	Mechanical Maintenance	319.6
	Laboratory	292.9
	Others	639.1
	Sub-total	2,416.6
Total		2,524.0

5.6 Environmental Impact Assessment

The JICA Study Team conducted the EIA study for the proposed project by entrusting it to a qualified local consultant in order to evaluate the extent/degree of the predicted negative impacts on the environment in the same way as the Dugo Selo sewerage development project. The results are summarized below.

Survey Items	Survey Results	Evaluation
Land Acquisition	The proposed WWTP improvement works are done within the existing plant site. No land acquisition is necessary.	O
Noise	The noise level at the nearest residential area caused by the construction of WWTP is estimated to be 55.6 dB(A), which is lower than the Croatian standard [60 dB(A)]. Noise impact is not significant.	O
Geology	According to the boring test, soils under the WWTP site are thick clay and are prone to compression by the construction of heavy structures. However, this problem is considered minor since the proposed structures are not heavy.	O
Flora and Fauna	No endangered flora and fauna were identified in/around and in the downstream of WWTP.	O
Air Pollution	During the construction stage of the project, the operation of construction equipment and earthwork would produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. During the operation stage, no significant odor will be emitted from the treatment plant since sludge is treated by the mechanical dewatering system and the treatment plant is located 300 m away from the nearest residences.	Δ
Water Pollution	According to the simulation analysis, the water quality of the Kutina River will much improve with this project. No industrial wastewater of large factories is discharged into the sewerage system. Only the sanitary wastewater of one (1) large industry is served by the sewerage system. No negative impact is expected with the operation of the WWTP.	O
Water Use	No water intake and water recreation activities were identified in the vicinity and until 10 km downstream from the WWTP.	O
Sludge Disposal and Groundwater	According to the analyses of the wastewater effluent of the large industries in the Study Area, heavy metals were not detected or negligible. Hence, the quality of generated sludge from this project is considered as normal. On the other hand, the generated sludge of the existing biological treatment plants in Croatia contains heavy metals with a certain concentration. However, the concentration level is lower than the Croatian permissible limits of sludge disposal. Hence, the dewatered sludge of this project can be disposed on the existing municipal solid waste disposal site (SWDS), which has enough space for disposing the sludge. According to the groundwater quality analysis, the groundwater around the existing Grads Olga SWDS has only been slightly polluted by organic matter. On the other hand, the town of Kutina has a plan to install a leachate treatment system for the existing SWDS during 2002 to 2003. Hence, the sludge disposal on the SWDS will cause no significant impact on the groundwater in the surrounding area.	Δ

O : Nothing or negligible Δ : Slight impact but acceptable

CHAPTER VI KARLOVAC – DUGA RESA SEWERAGE DEVELOPMENT

6.1 Basis of Structural Design

6.1.1 Existing Conditions of Town

(1) Karlovac

The town of Karlovac, consisting of 56 settlements, has developed on the flood plains of the Kupa, Korana and Mrežnica rivers. It links with Zagreb City through the superhighway and railway, and this resulted in the intensive urbanization and development of industries.

The existing and future administrative areas and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		952	39,203	40,155
Population	(1999)	52,000	8,000	60,000
	(2007)	52,000	8,000	60,000
	(2015)	53,000	7,000	60,000

The existing sewerage system serves 966 ha covering the central urban area (Grad Area: 952 ha) and some surrounding areas. The served settlements and industrial zone are Grad, Banija, Švarča and the South Industrial Zone. The served population is 28,200 people. For the existing sewerage service area, see Fig. II.6.1.

There are 12 large industries in the whole town area and seven (7) of them are served by the sewerage system while the remaining five (5) discharge wastewater into the rivers/canals, as shown below.

Classification	Industry
Served by Sewerage	Karlovack Pivovara, Kordun Karlovac, Ze-Ce, Tvornica Plinski Turbuna, Adria-Diesel, ABB Alstom Power, Autotransport
Discharge to River	PPK Karlovacka Industrija Mesna, Velebit, Lola Ribar, Karlovacka Industrija Mlijeka, Linde Plin

(2) Duga Resa

The town of Duga Resa, consisting of 28 settlements, is located immediately upstream of Karlovac along the Mrežnica River.

The existing and future administrative areas and population are estimated as follows.

Item		Urban Center	Rural Area	Total
Area (ha)		185	5,979	6,164
Population	(1999)	8,266	7,234	15,500
	(2007)	8,106	6,980	15,086
	(2015)	8,425	7,075	15,500

The sewerage system serves not only the densely populated central urban area (185 ha) but also some surrounding areas at present. The existing sewerage service area and population are estimated to be approximately 133 ha and 3,800, respectively. For the existing sewerage service area, see Fig. II.6.1.

There is only one (1) large industry (Pamučna Industrija Duga Resa), which discharges wastewater into the Mrežnica River at present.

6.1.2 Design Service Area, Population and Industries

(1) Karlovac

In the proposed sewerage system, the existing service area of 966 ha will be extended to 1,009 ha to include the PPK industry, which is a large pollutant source, and serve the population of 38,200 within the extended service area in 2007.

Two (2) of the five (5) large industries currently discharging into the rivers will be covered under the sewerage system development. As a result, the following nine (9) large industries will be served by the sewerage system by 2007.

Served Industry in 2007
Karlovack Pivovara, Kordun Karlovac, Ze-Ce, Tvornica Plinski Turbuna, Adria-Diesel, ABB Alstom Power, Autotransport, PPK Karlovacka Industrija Mesna, Velebit

(2) Duga Resa

The proposed sewerage development will cover the existing service area of 133 ha, and serve the population of 5,600 within the service area in 2007. Pamučna Industrija, which is currently discharging wastewater into the river, will also be served by the sewerage system.

For location of the extended service area in Karlovac-Duga Resa, see Fig. II.6.1.

6.1.3 Design Wastewater Flow and Quality

The total design municipal and industrial wastewater flow and pollution load are determined as follows.

Item	Municipal		Industry		Total
	Karlovac	Duga Resa	Karlovac	Duga Resa	
Wastewater Quantity (m^3/d)					
Daily Average	10,696	1,568	4,871	2,984	20,119
Daily Maximum	13,470	1,960	4,871	2,984	23,285
Hourly Maximum (dry)	18,336	2,680	5,885	2,984	29,885
Hourly Maximum (rainy)	34,380	5,040	11,770	3,992	55,182
Pollution Load					
BOD Load (kg/d)	2,819	413	893	358	4,484 (74,800 PE)
BOD Concentration (mg/l)					193
COD-Cr Concentration (mg/l)					419
TSS Concentration (mg/l)					247

6.2 Preliminary Design of Transport Collector

6.2.1 Existing Sewer and Outfall

(1) Karlovac

The existing sewers are all of combined type with diameters of 30 to 300 cm for a total length of approx. 90 km. The collected wastewater is discharged into the Kupa and Mrežnica rivers through the five (5) major outfalls of Grad, Drežnik, Banija I, Banija II and Švarča.

The outfalls of Grad, Banija I and Banija II discharge both domestic and industrial wastewater. On the other hand, Drežnik and Švarča drain only domestic wastewater.

(2) Duga Resa

Duga Resa has the sewerage system of combined type with a total length of 9,200 m. The collected wastewater is discharged into the Mrežnica River through the seven (7) major outfalls.

6.2.2 Transport Collector

The largest transport collector serving both towns is the completed South Transport Collector, which connects with Duga Resa. Midway, the transport collector joins the collectors of Švarča and the South Industrial Zone in Karlovac. The collector will be connected to the central treatment plant proposed at the right bank of the Kupa River east of Karlovac.

The second largest is the transport collector that conveys wastewater of the Banija and Grad areas to the treatment plant after crossing the Kupa and Korana rivers by siphon. Further, the Drežnik Transport Collector (sub-transport collector) is connected to the Banija Transport Collector to intercept wastewater of the Drežnik area. The Švarča Transport Collector (sub-transport collector) is connected to the South Transport Collector to intercept wastewater of the Švarča area. The Duga Resa Transport Collector is also connected to the South Transport Collector to intercept wastewater of the Duga Resa area.

The main features of the proposed transport collectors are summarized below. For location of the transport collectors, see Fig. II.6.1.

Transport Collector	Length (km)	Dia. (mm)	Remarks
Drežnik - Banija	2.88	300 - 350	
Banija - Grad	2.63	700 - 800	Including Kupa River siphon (0.17 km, ∅500mm × 2)
Grad - Treatment Plant	2.61	1,300 - 1,700	Including Korana River siphon (0.13 km, ∅750mm × 2)
Švarča - South Transport Collector	1.72	500 - 600	Including Mrežnica River siphon (0.13 km, ∅400mm × 2)
Duga Resa, Left Bank	1.83	400 - 1,200	
Total	11.67		

Secondary sewers with diameter of 400 mm are proposed for a total length of 1.0 km to serve the area of PPK industry.

6.3 Preliminary Design of Treatment Plant

6.3.1 General

The treatment plant is proposed on the right bank of the Kupa River to discharge into the Kupa River. The treatment site is a private wasteland (bush) with an average ground elevation of 107.8 m. Since the flood water level of the Sava River is estimated at 111.10 m for a 100-year return period, some flood protection works are necessary.

Inlet pumps lift up the wastewater transported to the plant and then the treated water is discharged into the Kupa River by gravity. For location of the treatment plant, see Fig. II.6.1.

6.3.2 Proposed Structural Design

The proposed treatment process is the primary sedimentation, consisting of preliminary treatment and primary sedimentation. The plant will treat the design influent concentration of BOD, COD-Cr and TSS to the permissible limits shown below. The generated sludge will be treated with the thickening and mechanical dewatering system, and the treated sludge is disposed at the municipal solid waste disposal site.

Parameter	Influent	Effluent	Treatment Efficiency
BOD (mg/l)	193	116	40%
COD-Cr (mg/l)	419	251	40%
TSS (mg/l)	247	148	40%

The main structural features of the proposed treatment plant are summarized below, compared to the master plan. For layout of the treatment plant, see Fig. II.6.2.

Facilities	Specification	No. of Units	
		F/S	M/P
Influent Pumping Station and Screen	Coarse Screen, 2 m W	1	1
	Fine Screen, 1 m W	3	3
	Archimedical Screw Pump 12 m^3/min × 10 m H × 19 kw	4	5
Grit Oil/Sand Removal	2 m W × 10 m L	2	2
Parshall flume	1.2192 m (4 ft)	1	1
Primary Sedimentation Tank	6.5 m W × 19.0 m L × 3.0 m D (Effective Depth)	5	8
Aeration Tank	5 m W × 64.0 m L × 5 m D	0	8
Secondary Sedimentation Tank	∅22 m × 3.5 m D (Effective Depth)	0	4
Effluent Pumping Station	Vertical Axial Flow Pump 15 m^3/min × 6 m H × 22 kw	4	5
Sludge Thickener	∅10 m × 4.0 m D	1	2
Belt Press Filter	2.0 m W × 2.2 kw	2	6
Blower	Roots Blower, 34 m^3/min × 60 kw (Building, 10 m × 25 m)	0	5
Return Sludge	Archimedical Screw Pump 9 m^3/min × 3 m H × 5.5 kw	0	4
Administration Building	13 m W × 20 m L (m^2)	260	260

6.3.3 Appurtenant Works and Required Land Space

To protect the treatment plant from floods of the Kupa River, dike of 4.0 m in height will be constructed for a length of 1,200 m. The required land space including the treatment plant and protection dike is estimated at approximately 6.9 ha.

6.4 Operation and Maintenance

The existing sewerage systems of Karlovac and Duga Resa are managed respectively by the municipal service companies (VODOVODO i KANALIZACIA d.o.o. and KOMULANO DUGA RESA), which are controlled by the town council of each town. The municipal service company in Karlovac provides water supply and sewerage services only, while the company in Duga Resa extends its services to include water supply, sewerage, solid waste disposal, gas supply, cemetery, park and open market.

The company in Karlovac has a total staff of 188 and 43 of them work in its Sewerage Section. These consist of one (1) manager, one (1) secretary, two (2) engineers, nine (9) drainage workers, 17 sewerage workers, and 13 drivers (shared with the Water Supply Section). The company in Duga Resa has a total staff of 49; however, there is no full time staff at its Sewerage Section.

The existing and proposed sewerage systems will be jointly operated and maintained by the two municipal service companies in the future. Six (6) additional staffs are necessary for the operation and maintenance of the wastewater treatment plant; namely, Manager (1), Operator (4), and Water Quality Analyst (1).

6.5 Cost Estimate

(1) Construction Method

The geological formation at the treatment plant site consists of thick clay overlaying gravel and sand layers. Some ground improvement works are necessary for the construction of major treatment tanks. The transport collector will be installed by the normal open-cut method; however, some special works are necessary to make it cross the rivers by siphon. One of the trenchless methods shall be applied for the construction of three (3) siphons: Kupa, Korana and Mrežnica. For these works, a vertical shaft of 16 m in depth for Kupa, 15 m for Korana and 8 m for Mrežnica has to be constructed on each bank.

(2) Construction Cost

The total construction cost is estimated at Kn. 129.76 million, broken down as follows.

Cost		Facilities	Cost ($\times 10^3$ Kn)
Direct Cost	Pipe	Transport Collector/Main Sewer	40,864.3
		Secondary/Tertiary	865.4
		Sub-total	41,729.7
	Treatment Plant	Preliminary Treatment	8,637.3
		Biological Reactor	0.0
		Secondary Sedimentation	0.0
		Sludge Treatment	15,737.1
		Others	19,284.6
		Sub-total	43,659.1
	Total		85,388.7
Land Acquisition			1,452.5
Indirect Cost	Engineering		8,538.9
	Administration		2,561.7
	Customs Duties		2,610.4
	VAT		20,664.1
	Total		34,375.1
Contingency			8,538.9
Grand Total			129,755.2

(3) O&M Cost

The annual O&M Cost is estimated to be Kn. 2.33 million, broken down as follows.

Facilities	Items	Cost ($\times 10^3$ Kn)
Pipe	Maintenance	317.1
Wastewater Treatment Plant	Electric Charges	525.6
	Personnel Expenses	499.2
	Mechanical Maintenance	252.3
	Laboratory	231.3
	Others	504.6
	Sub-total	2,012.9
Total		2,330.0

6.6 Environmental Impact Assessment

The JICA Study Team conducted the EIA study for the proposed project by entrusting it to a qualified local consultant in order to evaluate the extent/degree of the predicted negative

impacts on the environment in the same way as the Dugo Selo sewerage development project. The results are summarized below.

Survey Items	Survey Results	Evaluation
Land Acquisition	The proposed WWTP site is currently private wasteland (grassland) and is designated as WWTP site in the physical plan of the local governments.	O
Noise	The noise level at the nearest residential area caused by the construction of WWTP is estimated to be 57.2 dB(A), which is lower than the Croatian standard [60 dB(A)]. Noise impact is not significant.	O
Geology	According to the boring test, soils at the WWTP site are thick clay and are prone to compression by the construction of heavy structures. However, this problem is considered minor since the proposed structures are not heavy.	O
Flora and Fauna	Some endangered fish species *(Danubian roach, Danubian and Kessler's gudgeon)* have been identified in the Kupa River. This project will give positive impacts for the protection of such fish species.	O
Air Pollution	During the construction stage of the project, the operation of construction equipment and earthwork would produce dust. Although the impacts are temporary, some control measures (such as covering) should be taken. During the operation stage, no significant odor will be emitted from the treatment plant since sludge is treated by the mechanical dewatering system and the treatment plant is located more than 300 m away from the nearest residences.	Δ
Water Pollution	According to the simulation analysis, the water quality of the Kupa River will much improve with this project. Ten (10) large industries will be served by the sewerage system. According to the analyses of the existing industrial effluent quality, the industries discharge no hazardous materials that may cause problems in the WWTP operation, and the industries will pre-treat the wastewater before discharging it into the sewerage. Hence, the impacts on the proposed wastewater treatment system will not be significant.	O
Water Use	No water intake and water recreation activities were identified in the vicinity and until 10 km downstream from the WWTP.	O
Sludge Disposal and Groundwater	According to the analyses of the wastewater effluent of the large industries in the Study Area, heavy metals were either not detected or negligible. Hence, the quality of generated sludge from this project is considered as normal. On the other hand, the generated sludge of the existing biological treatment plants in Croatia contains heavy metals with a certain concentration. However, the concentration level is lower than the Croatian permissible limits of sludge disposal. Hence, the dewatered sludge of this project can be disposed on the existing municipal solid waste disposal site (SWDS), which has enough space for disposing the sludge. However, the existing SWDS of Ilovac-Pojatono may be closed in the near future due to lack of capacity. Karlovac County has a plan to install an SWDS that will comply with EU standards in the near future. Hence, the dewatered sludge of this project can be disposed on this SWDS with no significant impact on the surrounding environment.	Δ

O : Nothing or negligible Δ : Slight impact but acceptable

6.7 Replacement of Major Damaged Sewers in Karlovac

Some sewers in the central part of Karlovac Town are damaged to a considerable extent and they need to be replaced. The major damaged sewers are approximately 5 km long, 800 mm to 1,400 mm in diameter and 7 m in depth on average. However, this replacement project is dealt with separately from the sewerage development projects proposed by this Study. The replacement cost is therefore not included in the cost of the proposed sewerage development project for Karlovac-Duga Resa. The required replacement cost is estimated at Kn. 58.88 million including direct construction cost, indirect construction cost and contingencies.

CHAPTER VII FINANCIAL ANALYSIS

7.1 General

At present, the sewerage systems of the six (6) towns (Dugo Selo, Vrbovec, Sisak, Kutina, Karlovac and Duga Resa) are managed by their respective municipal service companies. However, the sewerage systems of Karlovac and Duga Resa are to be integrated into one system, and jointly operated and maintained by their respective service companies as planned by the Croatian authorities concerned.

The municipal service companies of Dugo Selo, Vrbovec, Sisak and Kutina, as well as the integrated Karlovac-Duga Resa, should be able to perform a financially sound management for the five (5) sewerage development projects proposed by this Study. The financial feasibility of each project has been confirmed through the evaluation of financial statement of each municipal service company and further checked through the calculation of financial internal rate of return (FIRR). The financial analyses were made for both the existing and the proposed ones, including the integrated Karlovac-Duga Resa.

In connection with the financial analysis for Karlovac-Duga Resa municipal service company, the replacement cost of damaged sewers in Karlovac Town is considered separately from the construction and O&M costs of the sewerage development project proposed in this Study.

The financial feasibility of the proposed projects much depends on the future growth of GDP. It is because the affordable sewerage charges and personnel expense for operation/maintenance will increase in proportion to the growth of per capita GDP and further, the industrial wastewater quantity will also increase according to the growth of GDP. On the other hand, the growth rate of per capita GDP can be assumed as equal to the growth rate of GDP since the population growth of the country is negligible.

In this Study, two (2) alternatives are considered for the annual growth rate of GDP. Alternative A adopts the original growth rate proposed for engineering studies (see, Chapter II, Subsection 2.3.3). Alternative B (one-half of growth rate in Alternative A) is proposed to ensure the reliability of the financial evaluation since the future economic development of the country is still uncertain. The growth rates adopted for the two (2) alternatives are shown below.

Year	2001 - 2005	2006 - 20010	2011 - 2015
Alternative A (Origial Proposal)	3.6%	5.5%	4.5%
Alternative B (Half of Original One)	1.8%	2.75%	2.25%

7.2 Implementation Schedule

The implementation schedule of the five (5) sewerage development projects proposed is prepared, based on the following assumptions:

(1) The projects are implemented through external funds. Accordingly, a certain period for the arrangement of funds is necessary after the government approval of the projects, including environmental assessment.

(2) One (1) year is required for the land acquisition and detailed design of the projects before the commencement of construction works.

(3) The treatment plants of Dugo Selo, Vrbovec and Kutina are constructed in two (2) stages involving two (2) treatment processes: (i) primary treatment and (ii) biological treatment. In the first stage, the primary sedimentation tank, sludge treatment system and appurtenant works are constructed along with the transport collectors and other sewers. Then the biological treatment tank is installed in the second stage. After

completion of the first stage works, the influent/effluent quantity and quality into/from the primary sedimentation tanks are monitored for one (1) year to check the original detailed design of the biological treatment system.

(4) Only the primary treatment process is applied to the wastewater of Sisak and Karlovac-Duga Resa. Hence, the transport collectors and other sewers, primary sedimentation tank, sludge treatment system, and appurtenant works are constructed simultaneously in one construction period.

The proposed implementation schedule of the five (5) sewerage development projects is as summarized in the table below. The replacement of existing damaged sewers in Karlovac Town should be implemented apart from the above sewerage development projects during five (5) years from 2003 to 2007 upon the decision of the local government concerned.

Item of Work		Schedule
(1) Governmental Approval of Five (5) Projects	:	Within 2001
(2) Financial Arrangement for Five (5) Projects	:	2002
(3) Detailed Design and Land Acquisition for Five (5) Projects	:	2003
(4) Construction of Dugo Selo, Vrbovec and Kutina Sewerage Projects	:	2004 ~ 2007
(a) Stage I Construction (Collectors, Primary Treatment, Sludge Treatment, etc.)	:	2004 ~ Mid 2005
(b) Monitoring	:	Mid 2005 ~ Mid 2006
(c) Stage II Construction (Biological Treatment)	:	Mid 2006 ~ 2007
(5) Construction of Sisak and Karlovac-Duga Resa (Collectors, Primary Treatment, Sludge Treatment, etc.)	:	2004 ~ 2006

7.3 Disbursement Schedule of Construction and O&M Costs

7.3.1 Disbursement Schedule of Construction Cost

(1) Construction Cost of Proposed Sewerage Development

The construction cost includes costs for transport collector/main sewer, secondary/tertiary sewer, treatment plant, land acquisition, engineering, administration, Customs Duties, VAT and contingencies. The construction cost disbursement schedule for the five (5) projects are given below at the price of 2001. The detailed disbursement schedule of each project is shown in Table II.7.1.

(Unit: 10^3 Kn, 2001 Price)

Sewerage Project	2003	2004	2005	2006	2007	Total
Dugo Selo	1,058	26,414	13,643	3,566	6,261	50,941
Vrbovec	867	18,616	9,642	3,683	6,698	39,506
Sisak	1,479	8,027	29,724	29,724	-	68,954
Kutina	705	18,753	9,729	4,225	7,744	41,157
Karlovac-Duga Resa	4,228	21,867	51,830	51,830	-	129,755
Total	8,337	93,677	114,567	93,028	20,703	330,312

(2) Replacement Cost of Damaged Sewers in Karlovac

The disbursement schedule of sewer replacement cost of damaged sewers in Karlovac Town is shown below at the price of 2001. The cost includes direct construction cost, engineering cost, administration cost, VAT and contingencies.

(Unit: 10^3 Kn, 2001 Price)

Sewerage System	2003	2004	2005	2006	2007	Total
Karlovac – Duga Resa	11,776	11,776	11,776	11,776	11,776	58,880

7.3.2 Disbursement Schedule of O&M Cost

(1) Annual O&M Cost of Existing Sewerage System

The annual O&M cost of the existing sewerage system in 2001 at the price of 2001 is estimated from the actual expenditures during 1997-1999. The estimated annual O&M costs of the five (5) sewerage systems are shown below, broken down into personnel and other expenses. The annual O&M cost includes not only the operation and maintenance costs in the field but also management costs in the head office.

(Unit: 10^3 Kn/year, 2001 Price)

Sewerage Project	Personnel Expense	Other Expenses	Total
Dugo Selo	71	47	118
Vrbovec	451	301	751
Sisak	4,291	2,861	7,152
Kutina	1,322	881	2,204
Karlovac-Duga Resa	4,751	3,167	7,918
Total	10,886	7,257	1,8143

Note: Breakdown is by JICA Study Team.

(2) Annual O&M Cost of Proposed Projects

The annual O&M costs are estimated for the five (5) proposed projects (excluding the existing sewerage system). The O&M works of the Dugo Selo, Vrbovec and Kutina projects will start in 2005 after completion of the Stage I construction works and will be fully implemented in 2008 after completion of the Stage II construction works. On the other hand, the O&M works of the Sisak and Karlovac-Duga Resa projects will start in 2007 after completion of the proposed construction works.

The annual O&M costs of the five (5) proposed projects at the time of full operation are estimated at the price of 2001 under the economic condition of 2001 (no GDP growth is considered) as follows.

(Unit: 10^3 Kn/year, 2001 Price)

Project	Personnel Expense	Other Expenses	Total
Dugo Selo	563	1,602	2,165
Vrbovec	514	1,595	2,109
Sisak	536	1,973	2,509
Kutina	585	2,723	3,308
Karlovac-Duga Resa	753	2,669	3,422
Total	2,951	10,562	13,513

(3) Disbursement Schedule of Total O&M Cost

From the above discussions, the total annual O&M costs in the future are estimated for the five (5) sewerage systems. In this estimation, personnel expense is assumed to

increase in proportion to the growth of GDP, while the other expenses are considered to remain constant.

The disbursement schedule of total O&M cost under the GDP growth rate of Alternative A (original proposal) is shown below at the price of 2001. For details, see Appendix H, Chapter II, Tables H.2.1 to H.2.5.

(Unit: 10^3 Kn/year, 2001 Price)

Year	2003	2004	2005	2006	2007	2008	2010	2015	2016 -
Dugo Selo	123	126	713	1,323	1,348	2,506	2,603	2,838	2,838
Existing	123	126	129	133	138	143	154	180	180
Proposed	-	-	585	1,189	1,210	2,363	2,449	2,658	2,658
Vrbovec	784	802	1,372	1,969	2,017	3,200	3,348	3,705	3,705
Existing	784	802	820	848	879	910	979	1,146	1,146
Proposed	-	-	552	1,121	1,138	2,290	2,368	2,559	2,559
Sisak	7,466	7,632	7,804	8,076	11,023	11,364	12,102	13,891	13,891
Existing	7,466	7,632	7,804	8,076	8,363	8,665	9,321	10,912	10,912
Proposed	-	-	-	-	2,660	2,698	2,780	2,979	2,979
Kutina	2,300	2,352	3,284	4,268	4,379	6,184	6,475	7,182	7,182
Existing	2,300	2,352	2,404	2,488	2,577	2,670	2,872	3,362	3,362
Proposed	-	-	879	1,780	1,802	3,514	3,603	3,820	3,820
Karlovac-DR*	8,267	8,450	8,640	8,941	12,893	13,281	14,123	16,163	16,163
Existing	8,267	8,450	8,640	8,941	9,259	9,594	10,320	12,081	12,081
Proposed	-	-	-	-	3,634	3,687	3,803	4,082	4,082

Note: Existing means O&M cost for the existing sewerage system; Proposed means additional O&M cost for the proposed sewerage system; * DR means Duga Resa

Similarly, the disbursement schedule of total O&M cost under the GDP growth rate of Alternative B (half of original one) is shown below also at the price of 2001. For details, see Appendix H, Chapter II, Tables H.2.6 to H.2.10.

(Unit: 10^3 Kn/year, 2001 Price)

Year	2003	2004	2005	2006	2007	2008	2010	2015	2016 -
Dugo Selo	120	122	696	1,280	1,291	2,387	2,428	2,520	2,520
Existing	120	122	123	125	127	130	134	144	144
Proposed	-	-	573	1,154	1,164	2,258	2,294	2,376	2,376
Vrbovec	768	776	1,326	1,889	1,911	3,019	3,082	3,222	3,222
Existing	768	776	785	798	812	826	855	920	920
Proposed	-	-	542	1,091	1,099	2,193	2,227	2,301	2,301
Sisak	7,308	7,388	7,469	7,596	10,307	10,458	10,771	11,470	11,470
Existing	7,308	7,388	7,469	7,596	7,726	7,860	8,139	8,760	8,760
Proposed	-	-	-	-	2,581	2,598	2,633	2,710	2,710
Kutina	2,252	2,276	3,167	4,082	4,133	5,826	5,950	6,226	6,226
Existing	2,252	2,276	2,301	2,340	2,380	2,422	2,508	2,699	2,699
Proposed	-	-	866	1,742	1,752	3,404	3,442	3,527	3,527
Karlovac-DR*	8,091	8,180	8,270	8,410	12,077	12,248	12,606	13,403	13,403
Existing	8,091	8,180	8,270	8,410	8,554	8,702	9,011	9,699	9,699
Proposed	-	-	-	-	3,523	3,546	3,595	3,704	3,704

Note: Existing means O&M cost for the existing sewerage system; Proposed means additional O&M cost for the proposed sewerage system; * DR means Duga Resa

7.4 Revenue from Sewerage Charge

7.4.1 Existing Unit Sewerage Charge

At present, municipal service companies in the respective towns collect sewerage charges from users of the sewerage system based on water consumption. Two (2) kinds of unit charges are set in each of the six (6) towns, one for domestic users and another for other users (institutional and small/large industries).

The unit sewerage charge in the year 2001, including VAT (22%) , is summarized below. The unit sewerage charge based on wastewater quantity is also estimated on the assumption that the return rate of sewage wastewater is 80%.

(Unit: Kn/m^3, 2001 Price)

Town	Water Consumption Basis		Wastewater Quantity Basis	
	Domestic User	Other Users	Domestic User	Other Users
Dugo Selo	0.29	0.59	0.36	0.74
Vrbovec	0.48	0.65	0.59	0.81
Sisak	1.07	3.20	1.34	4.00
Kutina	3.29	3.29	4.12	4.12
Karlovac	1.16	2.14	1.45	2.67
Duga Resa	0.43	0.43	0.54	0.54
Average	1.12	1.72	1.40	2.15

7.4.2 Affordable Unit Sewerage Charge

(1) Household Income

The average household income in the six (6) towns in 2001 are as estimated in the table below based on the interview survey, data of municipal service companies, and data from the Central Bureau of Statistics. Since the average household income at present is not much different among the towns, the average income of 3,600 Kn/month was applied for the financial analysis of each town.

(Unit: Kn/month, 2001 Price)

Town	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac	Duga Resa	Average
Household Income	3,700	3,800	3,700	3,600	3,400	3,400	3,600

(2) Ratio of Existing Sewerage Charge to Household Income

According to data from municipal service companies, the average per capita domestic water consumption is 5.0 m^3/person/month in the objective towns. Hence, the average per capita domestic wastewater quantity is estimated to be 4.0 m^3/person/month by assuming a return rate of 80%. The average domestic wastewater quantity of households comes to 12 m^3/household/month when the family size is assumed at 3 persons.

The ratio of existing domestic sewerage charge to household income in 2001 is calculated for the six (6) towns as follows. As shown in the table, the domestic sewerage charge per household is very different among towns.

Town	Household Income (Kn/month/house)	Unit Domestic Charge (Kn/m^3)	Household Domestic Charge (Kn/month/house)	Domestic Charge Ratio to Household Income (%)
Dugo Selo	3,600	0.36	4.32	0.12
Vrbovec	3,600	0.59	7.08	0.20
Sisak	3,600	1.34	16.08	0.45
Kutina	3,600	4.12	49.44	1.37
Karlovac	3,600	1.45	17.40	0.48
Duga Resa	3,600	0.54	6.48	0.18
Average	3,600	1.40	16.80	0.47

Note: Table estimated at 2001 prices

(3) Ratio of People's Willingness to Pay to Household Income

The Study Team conducted a survey on inhabitants's willingness to pay domestic sewerage charges and the results are summarized below, including the ratios to average household income (3,600 Kn/month/house).

Town	Household Domestic Charge (Kn/month/house)	Domestic Charge Ratio to Household Income (%)
Dugo Selo	28	0.78
Vrbovec	20	0.56
Sisak	18	0.50
Kutina	34	0.94
Karlovac	20	0.56
Duga Resa	27	0.75
Average	24.5	0.68

(4) Affordable Sewerage Charge

From the above survey results, the affordable domestic sewerage charge is considered to be in the range of 0.5% and 0.9%, averaging 0.7% of household income. It is approximately 1.5 times the current actual charge on average (0.68% ÷ 0.47% = 1.5).

7.4.3 Wastewater Quantity

In the engineering studies in Chapter I to Chapter VI of this Part II, wastewater to the proposed sewerage system is classified into two (2) categories: municipal wastewater (domestic, institutional and small industry) and industrial wastewater (large industry). However, in this financial study, it is reclassified into domestic wastewater and other wastewater (institutional, small industry and large industry), corresponding to the classification of sewerage charge collection.

As mentioned in Chapter I, the domestic wastewater will increase according to the growth of population and per capita water consumption, and the institutional and small industrial wastewater is assumed to increase at the same rate as the domestic wastewater. These wastewaters will increase at a constant rate regardless of the growth of GDP.

On the other hand, the large industrial wastewater is assumed to increase according to the growth of GDP (refer to Part I, Chapter IV). Accordingly, the large industrial wastewater in the future is projected for the two (2) alternatives of GDP growth rate mentioned above.

The wastewater quantity for this financial study is projected based on the following assumptions:

(1) The connection rate to the sewerage system is assumed at 90% for domestic users and 100% for other users.

(2) The large industries to be newly served by the proposed sewerage system (PIK Vrbovec, PPK Industrija Karlovac, Pamučna Industrija Duga Resa, etc.) are connected immediately before completion of the treatment plant.

(3) The wastewater will increase at a certain rate until 2007 as mentioned above and thereafter assumed to remain constant. It is because the proposed treatment plant is designed to meet the wastewater in 2007 as the fist stage project and treatment of the excess wastewater generated after 2007 is regarded as the second stage project.

The annual wastewater quantity to be discharged into the five (5) proposed sewerage systems under Alternative A (original proposal of GDP growth rate) is estimated as follows.

(Unit: m^3/year)

Year	2003	2004	2005	2006	2007	2008 -
Dugo Selo	741,680	797,525	853,005	908,485	974,185	974,185
Domestic	520,490	558,450	596,410	634,370	682,185	682,185
Others	221,190	239,075	256,595	274,115	292,000	292,000
Vrbovec	348,210	375,950	884,395	1,405,250	1,456,715	1,456,715
Domestic	303,680	326,675	349,670	372,665	395,660	395,660
Others	44,530	49,275	534,725	1,032,585	1,061,055	1,061,055
Sisak	3,684,675	3,943,825	4,203,705	4,463,585	4,723,100	4,723,100
Domestic	2,360,455	2,531,640	2,703,190	2,874,740	3,046,290	3,046,290
Others	1,324,220	1,412,185	1,500,515	1,588,845	1,676,810	1,676,810
Kutina	1,672,065	1,794,340	1,916,980	2,039,255	2,161,895	2,161,895
Domestic	996,085	1,075,290	1,154,495	1,233,335	1,312,540	1,312,540
Others	675,980	719,050	762,485	805,920	849,355	849,355
Karlovac-Duga Resa	4,345,690	4,670,175	4,994,660	5,983,445	6,988,655	6,988,655
Domestic	2,126,125	2,325,050	2,523,975	2,722,900	2,921,825	2,921,825
Others	2,219,565	2,345,125	2,470,685	3,260,545	4,066,830	4,066,830

Similarly, the annual wastewater quantity of the five (5) proposed sewerage systems is estimated for Alternative B (one-half of original proposal of GDP growth rate) as follows.

(Unit: m^3/year)

Year	2003	2004	2005	2006	2007	2008 -
Dugo Selo	741,680	797,525	853,005	908,485	974,185	974,185
Domestic	520,490	558,450	596,410	634,370	682,185	682,185
Others	221,190	239,075	256,595	274,115	292,000	292,000
Vrbovec	348,210	375,950	834,755	1,297,575	1,332,615	1,332,615
Domestic	303,680	326,675	349,670	372,665	395,660	395,660
Others	44,530	49,275	485,085	924,910	936,955	936,955
Sisak	3,661,680	3,914,625	4,167,935	4,420,880	4,674,190	4,674,190
Domestic	2,360,455	2,531,640	2,703,190	2,874,740	3,046,290	3,046,290
Others	1,301,225	1,382,985	1,464,745	1,546,140	1,627,900	1,627,900
Kutina	1,662,940	1,783,025	1,903,110	2,022,465	2,142,550	2,142,550
Domestic	996,085	1,075,290	1,154,495	1,233,335	1,312,540	1,312,540
Others	666,855	707,735	748,615	789,130	830,010	830,010
Karlovac-Duga Resa	4,259,550	4,559,215	4,859,245	5,745,465	6,636,795	6,636,795
Domestic	2,126,125	2,325,050	2,523,975	2,722,900	2,921,825	2,921,825
Others	2,133,425	2,234,165	2,335,270	3,022,565	3,714,970	3,714,970

7.4.4 Estimate of Sewerage Revenue

The sewerage revenue of towns is calculated as the product of wastewater quantity and assumed unit sewerage charge. However, it may be difficult to collect 100% of the sewerage charge from the users.

Collection rates also vary at present. The average collection rate of domestic and other users in 2001 (existing) is as estimated below according to the results of interview with the municipal service companies. The collection rates are assumed to gradually increase to 90% during 2003 to 2007 and thereafter become constant.

Town	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Collection Rate (%)	65	80	80	80	80

7.5 Financial Evaluation

7.5.1 General

Each municipal service company should be able to perform a sound sewerage business by collecting sewerage charges set within the users' affordability. For this purpose, a considerable amount of financial assistance from the Central Government (including Croatian Waters) is considered necessary for the construction of proposed projects. The possible financial assistance includes Grant, local soft loan (Water Management Fund), and external soft loan (foreign currency soft loan by ODA).

In this financial evaluation, the required sewerage charges and financial assistance from the Central Government are estimated by analyzing the financial status of each municipal service company. However, the financial limitation of the Central Government is not considered.

7.5.2 Existing Financing System

At present, the initial cost of sewerage projects in Croatia is financed as below.

(1) Twenty percent (20%) from the Central Government (Grant)

(2) Forty percent (40%) from the Water Management Fund (loan accorded by Croatian Waters to sewerage companies, repayable in 50 years with no interest)

(3) Forty percent (40%) from the Local Government/municipal sewerage company

(4) O&M and depreciation costs are fully covered by sewerage charges in principle.

7.5.3 Preparation of Alternatives

Various alternatives for the financial evaluation are prepared by combining the following assumptions concerning GDP growth rate, financial assistance of the Central Government for construction cost (Grant and Water Management Fund Loan), and financing by external loan for construction cost (ODA).

(1) Growth Rate of GDP

As mentioned before, the following two (2) cases of GDP growth rate are assumed:

(a) Originally proposed growth rates for engineering studies:

3.6% for 2001-2005, 5.5% for 2006-2010 and 4.5% for 2011-2015

(b) One-half of the originally proposed growth rates:

1.8% for 2001-2005, 2.75% for 2006-2010 and 2.25% for 2011-2015

(2) Financial Assistance of Central Government

The following two (2) cases of financial assistance are assumed:

(a) The financial assistance is extended based on the current financing system (Grant: 20%, Water Management Fund Loan: 40%). In this case, the loan conditions of the Water Management Fund are assumed to be: (i) no interest and (ii) 50-year repayment including 7-year grace period.

(b) All the financial assistance is assumed as Grant since the loan conditions of the Water Management Fund are very soft and nearly equivalent to Grant. Two (2) grant rates are assumed; namely, 40% and 60% of the construction cost.

(3) External Loan

The remaning construction cost is financed by external loan through the Central Government. The loan conditions are assumed at either 2% or 6% of interest rate, both with 25-year repayment including 7-year grace period.

From the above assumptions, four (4) typical alternatives for the lower GDP growth rate (one-half of originally proposed rate) are proposed to ensure the reliability of financial evaluation. Further, two (2) alternatives for the originally proposed GDP growth rate are supplementarily proposed. The six (6) alternatives are summarized below.

Case	GDP Growth Rate	Financial Assistance for Construction Cost		
		Central Gov't. (Grant)	Water Management Fund	External Loan
Alternative 1	Half of Original	20%	40% (no interest)	40% (interest: 2%)
Alternative 2	Half of Original	20%	40% (no interest)	40% (interest: 6%)
Alternative 3	Half of Original	40%	-	60% (interest: 2%)
Alternative 4	Half of Original	60%	-	40% (interest: 2%)
Alternative 5	Original	20%	40% (no interest)	40% (interest: 2%)
Alternative 6	Original	20%	40% (no interest)	40% (interest: 6%)

7.5.4 Sewerage Charge Calculation

(1) General

The above Water Management Fund loan (local currency) and external loan (foreign currency) should be repaid from sewerage charges. Further, the O&M and depreciation costs should be fully covered also by sewerage charges. The required sewerage charge for each municipal service company to perform a sound sewerage business is estimated by analyzing the financial statement including income statement and cash flow statement. To perform a sound sewerage business:

(a) Annual net income should be almost positive throughout the entire period of 25 years (2003-2027);

(b) External loan liability should be zero in 25 years; and

(c) Necessary cash should be reserved before the replacement of mechanical and electrical equipment.

(2) Required Sewerage Charge for Six (6) Alternatives

The required sewerage charge for each municipal service company is estimated for the above six (6) alternatives under the following additional assumptions:

(a) Sewerage Charges

(i) Unit sewerage charges vary in towns at present. The unit sewerage charge required to repay the loan for construction cost and to cover O&M and depreciation costs is set for each town.

(ii) The ratio between unit domestic charge and unit other charges vary in towns at present, and the existing ratio is maintained in the future.

(b) Depreciation Cost

The life of proposed facilities is assumed at 50 years for civil works and 20 years for mechanical/electrical equipment, referring to similar projects in Croatia.

The replacement cost of mechanical/electrical equipment in each sewerage system is as estimated below at the price of 2001. The annual depreciation cost of equipment is also shown at the price of 2001.

Project	ReplacementCost (10^3 Kn)	Annual Depreciation Cost (10^3 Kn/year)
Dugo Selo	11,542	577
Vrbovec	11,636	582
Sisak	10,518	526
Kutina	15,666	783
Karlovac - Duga Resa	21,830	1,091

Note: Table estimated at 2001 prices.

(c) Profit Tax

Profit Tax is assumed at 20%.

(d) Price Escalation

In the calculation of the financial statement, price escalation is not considered in Alternative 3 and Alternative 4 because the external loan is to be repaid in foreign currency and the exchange rate will change corresponding to the price escalation of local currency. However, some price escalation is considered for the other alternatives since the Water Management Fund loan is to be repaid in local currency. The annual average price escalation rate is assumed at 3%.

(e) Financing of Sewer Replacement Cost in Karlovac Town

The replacement cost of the existing damaged sewers in Karlovac Town is different from the construction cost of the proposed sewerage development projects but similar to the O/M cost. Hence, all the cost is to be borne by the local government/municipal service company. In this financial analysis, it is assumed that 60% of the sewer replacement cost is granted from the Local Government (Karlovac Town) and the remaining 40% is covered by sewerage charge.

The required sewerage charge of each municipal service company is as calculated in the following table in comparison with the existing sewerage charge. The calculated financial internal rate of return (FIRR) is shown in the table as well. The sewerage charges in the table are the values in 2001 at 2001 prices.

	Dugo Selo	Vrbovec	Sisak	Kutina	Karlovac-Duga Resa
Existing					
Rate to Household Income (%)	0.12	0.20	0.45	1.37	0.48 (0.18)
Domestic Charge (Kn/m^3)	0.36	0.59	1.34	4.12	1.45 (0.54)
Other Charge (Kn/m^3)	0.74	0.81	4.00	4.12	2.67 (0.54)
FIRR (%)					
Alternative 1					
Rate to Household Income (%)	0.95	0.80	0.48	1.37	0.63
Domestic Charge (Kn/m^3)	2.85	2.40	1.44	4.12	1.89
Other Charge (Kn/m^3)	5.86	3.29	4.30	4.12	2.92
FIRR (%)	4.81	4.69	3.67	24.23	4.87
Alternative 2					
Rate to Household Income (%)	1.02	0.85	0.51	1.37	0.66
Domestic Charge (Kn/m^3)	3.06	2.55	1.53	4.12	1.98
Other Charge (Kn/m^3)	6.29	3.50	4.57	4.12	3.06
FIRR (%)	6.54	6.51	6.75	24.23	6.20
Alternative 3					
Rate to Household Income (%)	0.98	0.84	0.50	1.37	0.67
Domestic Charge (Kn/m^3)	2.94	2.52	1.50	4.12	2.01
Other Charge (Kn/m^3)	6.04	3.46	4.48	4.12	3.11
FIRR (%)	5.54	5.70	5.35	40.67	5.55
Alternative 4					
Rate to Household Income (%)	0.85	0.75	0.47	1.37	0.62
Domestic Charge (Kn/m^3)	2.55	2.25	1.41	4.12	1.86
Other Charge (Kn/m^3)	5.24	3.09	4.21	4.12	2.87
FIRR (%)	6.58	5.98	5.48	Large	5.91
Alternative 5					
Rate to Household Income (%)	0.75	0.60	0.42	1.37	0.51
Domestic Charge (Kn/m^3)	2.25	1.80	1.26	4.12	1.53
Other Charge (Kn/m^3)	4.63	2.47	3.76	4.12	2.36
FIRR (%)	4.05	4.55	4.43	34.91	4.93
Alternative 6					
Rate to Household Income (%)	0.85	0.65	0.45	1.37	0.53
Domestic Charge (Kn/m^3)	2.55	1.95	1.35	4.12	1.59
Other Charge (Kn/m^3)	5.24	2.68	4.03	4.12	2.46
FIRR (%)	6.98	6.88	7.78	34.91	6.03

Note: Table estimated at 2001 prices. Values not in parentheses are existing charges in Karlovac, while those in parentheses are for Duga Resa.

7.5.5 Proposed Sewerage Charge and Financial Assistance

The industrial activities in the Study Area have not fully recovered and the future economic growth is still uncertain. Hence, a lower GDP growth rate should be assumed to ensure the reliability of financial evaluation.

Based on the questionnaire survey, the inhabitant's willingness to pay domestic sewerage charge is in the range of 0.5% to 0.9% of household income, or 0.7% on the average. Hence, the proposed domestic sewerage charge should not exceed 0.9% of household income.

The main beneficiaries of the proposed projects will be the people living downstream. The projects will enhance the water environment nationwide and are therefore of national importance. Hence, the financial assistance of the Central Government for each of the five (5) projects should be set higher than has been usually extended.

From the above considerations, the sewerage charges of Alternative 4 are proposed. In this case, sixty percent (60%) of the construction cost is to be extended as Grant by the Central Government and the remaining forty percent (40%) is to be financed by an external loan made available through the Central Government. The loan conditions are to be 2.0% interest and 25-year repayment including a 7-year grace period.

It should be noted that the above external loan (40% of construction cost) does not mean the actual amount of loan to be obtained by the Central Government but only the loan amount to be repaid from sewerage charges. In case the financial resources of the Central Government are limited, it may need to obtain more external loan to be able to extend the necessary grant (60% of construction cost) to the municipal service companies.

The proposed sewerage charge will increase according to the assumed growth of GDP in the future, as shown below.

(Unit: Kn/m^3, 2001 price)

Project	Existing (2001)	Proposed				
		2001	2003	2005	2010	2015 ~
Dugo Selo						
Domestic	0.36	2.55	2.64	2.74	3.14	3.51
Others	0.74	5.24	5.43	5.63	6.45	7.20
Vrbovec						
Domestic	0.59	2.25	2.33	2.42	2.77	3.09
Others	0.81	3.09	3.20	3.32	3.80	4.25
Sisak						
Domestic	1.34	1.41	1.46	1.51	1.73	1.94
Others	4.00	4.21	4.36	4.52	5.18	5.79
Kutina						
Domestic	4.12	4.12	4.27	4.42	5.07	5.66
Others	4.12	4.12	4.27	4.42	5.07	5.66
Karlovac-Duga Resa						
Domestic	1.45 (0.54)*	1.86	1.93	2.00	2.29	2.56
Others	2.67 (0.54)*	2.87	2.98	3.09	3.54	3.95

* Values not in parentheses are existing charges in Karlovac, while those in parentheses are for Duga Resa

7.5.6 Evaluation of Financial Statement

The prepared financial statements, consisting of income statements and cash flow statements of the five (5) municipal service companies in connection with the proposed sewerage charges are shown in Table II.7.2 to Table II.7.6. Judging from the financial statements, all municipal service companies will be able to conduct a sound sewerage business; namely,

(1) Annual net income is positive throughout the entire period of 25 years (2003 to 2027) except a very small deficit in the initial stage in Vrbovec and Sisak;

(2) In Karlovac-Duga Resa, the net cash flow is negative in the initial stage due to a high cost expenditure for the sewer replacement. However, this could be offset by a small local loan.

(3) Loan liability of all the municipal service companies becomes zero in 25 years; and

(4) Necessary cash is reserved before the replacement of mechanical/electrical equipment.

CHAPTER VIII RECOMMENDATIONS

(1) The proposed five (5) sewerage development projects consisting of Dugo Selo, Vrbovec, Sisak, Kutina and Karlovac-Duga Resa are technically feasible and financially viable. The early implementation of these projects is necessary to cope with the existing water pollution in the Sava River Basin.

(2) For this purpose, the Central Government/State Water Directorate/Croatian Waters and the local governments concerned should immediately proceed with the necessary legal procedures and financial arrangements.

(3) Water pollution of the Lonja River is the worst in the entire Sava River Basin. Early implementation of the Sesvete East and Ivanić Grad-Kloštar Ivanić sewerage development projects is also awaited to attain a satisfactory water pollution control of the Lonja River.

(4) Since the available data on river water quantity and quality in the Lonja River are limited, the necessary monitoring of river water quantity and quality should be commenced immediately.

TABLES

Table II-7.1 Disbursement Schedule of Construction Cost

(Unit: x 10^3 Kn)

Work Item	2003	2004	2005	2006	2007	2008	Total
Dugo Selo							
Direct Construction Cost	0	18,446	9,223	1,946	3,892	0	33,507
Transport/Main Collector	0	5,847	2,924	0	0	0	8,771
Secondary/Tertiary Pipe	0	1,101	551	0	0	0	1,652
WWTP Primary Treatment	0	11,497	5,749	0	0	0	17,246
Biological Treatment	0	0	0	1,946	3,892	0	5,838
Land Acquisition Cost	187	0	0	0	0	0	187
Indirect Construction Cost	871	6,124	3,497	1,425	1,979	0	13,897
Engineering + Administration	871	871	871	871	871	0	4,356
Custom Duties + VAT	0	5,252	2,626	554	1,108	0	9,541
Contingency	0	1,845	922	195	389	0	3,351
Total	1,929	32,538	17,140	4,991	8,240	0	64,838
Vrbovec							
Direct Construction Cost	0	12,819	6,410	2,154	4,307	0	25,690
Transport/Main Collector	0	1,401	700	0	0	0	2,101
Secondary/Tertiary Pipe	0	211	106	0	0	0	317
WWTP Primary Treatment	0	11,208	5,604	0	0	0	16,812
Biological Treatment	0	0	0	2,154	4,307	0	6,461
Land Acquisition Cost	199	0	0	0	0	0	199
Indirect Construction Cost	668	4,514	2,591	1,314	1,960	0	11,048
Engineering + Administration	668	668	668	668	668	0	3,340
Custom Duties + VAT	0	3,847	1,923	646	1,292	0	7,708
Contingency	0	1,282	641	215	431	0	2,569
Total	1,535	23,130	12,233	4,997	8,658	0	50,554
Sisak							
Direct Construction Cost	0	4,728	20,394	20,394	0	0	45,515
Transport/Main Collector	0	4,728	4,728	4,728	0	0	14,183
Secondary/Tertiary Pipe	0	0	0	0	0	0	0
WWTP Primary Treatment	0	0	15,666	15,666	0	0	31,333
Biological Treatment	0	0	0	0	0	0	0
Land Acquisition Cost	0	0	0	0	0	0	0
Indirect Construction Cost	1,479	2,826	7,291	7,291	0	0	18,887
Engineering + Administration	1,479	1,479	1,479	1,479	0	0	5,917
Custom Duties + VAT	0	1,347	5,811	5,811	0	0	12,970
Contingency	0	473	2,039	2,039	0	0	4,552
Total	2,959	10,853	37,014	37,014	0	0	87,840
Kutina							
Direct Construction Cost	0	13,006	6,503	2,536	5,073	0	27,117
Transport/Main Collector	0	117	59	0	0	0	176
Secondary/Tertiary Pipe	0	3,937	1,968	0	0	0	5,905
WWTP Primary Treatment	0	8,952	4,476	0	0	0	13,427
Biological Treatment	0	0	0	2,536	5,073	0	7,609
Land Acquisition Cost	0	0	0	0	0	0	0
Indirect Construction Cost	705	4,447	2,576	1,435	2,165	0	11,328
Engineering + Administration	705	705	705	705	705	0	3,525
Custom Duties + VAT	0	3,742	1,871	730	1,460	0	7,802
Contingency	0	1,301	650	254	507	0	2,712
Total	1,410	23,200	12,305	5,660	9,909	0	52,484
Karlovac-Duga Resa							
Direct Construction Cost	0	13,910	35,739	35,739	0	0	85,389
Transport/Main Collector	0	13,621	13,621	13,621	0	0	40,864
Secondary/Tertiary Pipe	0	288	288	288	0	0	865
WWTP Primary Treatment	0	0	21,830	21,830	0	0	43,659
Biological Treatment	0	0	0	0	0	0	0
Land Acquisition Cost	1,453	0	0	0	0	0	1,453
Indirect Construction Cost	2,775	6,567	12,517	12,517	0	0	34,375
Engineering + Administration	2,775	2,775	2,775	2,775	0	0	11,101
Custom Duties + VAT	0	3,791	9,742	9,742	0	0	23,275
Contingency	0	1,391	3,574	3,574	0	0	8,539
Total	7,003	28,434	64,347	64,347	0	0	164,130
Grand Total	14,836	118,155	143,039	117,009	26,808	0	419,847

Table II-7.2 Financial Statement of Dugo Selo Municipal Company

Income Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Revenue	1,675	2,012	2,385	2,822	3,337	3,428	3,523	3,619	3,701	3,784	3,869	3,956	4,045	4,045	4,045	4,045	4,045
a- Charge Revenue	1,675	2,012	2,385	2,822	3,337	3,428	3,523	3,619	3,701	3,784	3,869	3,956	4,045	4,045	4,045	4,045	4,045
-Domestic users	894	1,070	1,266	1,495	1,775	1,824	1,874	1,926	1,969	2,013	2,059	2,105	2,152	2,152	2,152	2,152	2,152
-Other users	781	942	1,119	1,327	1,561	1,604	1,648	1,694	1,732	1,771	1,811	1,851	1,893	1,893	1,893	1,893	1,893
II. Expense	120	130	915	1,609	1,649	3,372	3,392	3,413	3,408	3,403	3,399	3,395	3,391	3,278	3,165	3,142	3,120
a-O&M	120	122	696	1,280	1,291	2,387	2,407	2,428	2,446	2,464	2,482	2,501	2,520	2,520	2,520	2,520	2,520
b- Depreciation						577	577	577	577	577	577	577	577	577	577	577	577
c- Interest	0	8	220	329	357	408	408	408	385	362	340	317	294	181	68	45	23
III. Income before tax	1,554	1,882	1,469	1,214	1,688	57	131	207	293	381	471	562	654	767	880	903	926
Tax	311	376	294	243	338	11	26	41	59	76	94	112	131	153	176	181	185
IV. Net Income	1,243	1,505	1,176	971	1,350	45	104	165	234	305	376	449	523	614	704	722	741

Cash Flow Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Cash Inflow	2,733	28,426	16,028	6,388	9,597	3,428	3,523	3,619	3,701	3,784	3,869	3,956	4,045	4,045	4,045	4,045	4,045
a- Charge Revenue	1,675	2,012	2,385	2,822	3,337	3,428	3,523	3,619	3,701	3,784	3,869	3,956	4,045	4,045	4,045	4,045	4,045
-Domestic users	894	1,070	1,266	1,495	1,775	1,824	1,874	1,926	1,969	2,013	2,059	2,105	2,152	2,152	2,152	2,152	2,152
-Other users	781	942	1,119	1,327	1,561	1,604	1,648	1,694	1,732	1,771	1,811	1,851	1,893	1,893	1,893	1,893	1,893
b- Grant	635	15,848	8,186	2,140	3,756	0	0	0	0	0	0	0	0	0	0	0	0
c- Loan	423	10,566	5,457	1,426	2,504	0	0	0	0	0	0	0	0	0	0	0	0
II. Cash Outflow	1,489	26,921	14,852	5,417	8,247	2,806	2,841	4,009	4,021	4,034	4,048	4,062	4,077	3,987	3,896	3,878	15,402
a-O&M	120	122	696	1,280	1,291	2,387	2,407	2,428	2,446	2,464	2,482	2,501	2,520	2,520	2,520	2,520	2,520
b-Capital Investment	1,058	26,414	13,643	3,566	6,261	0	0	0	0	0	0	0	0	0	0	0	11,542
-Initial investment	1,058	26,414	13,643	3,566	6,261	0	0	0	0	0	0	0	0	0	0	0	0
-Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,542
c-Debt Service	0	8	220	329	357	408	408	1,540	1,517	1,494	1,472	1,449	1,426	1,313	1,200	1,177	1,155
- Interest	0	8	220	329	357	408	408	408	385	362	340	317	294	181	68	45	23
- Loan Repayment	0	0	0	0	0	0	0	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132	1,132
d- Tax	311	376	294	243	338	11	26	41	59	76	94	112	131	153	176	181	185
III. Net Cash Flow	1,243	1,505	1,176	971	1,350	622	682	-390	-320	-250	-178	-106	-32	59	149	168	-11,356
IV. Cash Reserve	1,243	2,749	3,924	4,896	6,246	6,868	7,550	7,160	6,840	6,590	6,411	6,306	6,274	6,387	6,953	7,121	-4,236
V. Net Debt	820	-8,240	-12,521	-12,977	-14,131	-13,508	-12,827	-12,084	-11,273	-10,391	-9,437	-8,411	-7,311	-1,537	4,689	5,989	-4,236
a- Debt Outstanding	423	10,989	16,446	17,872	20,376	20,376	20,376	19,244	18,112	16,980	15,848	14,716	13,584	7,924	2,264	1,132	0
b- Cash Reserve	1,243	2,749	3,924	4,896	6,246	6,868	7,550	7,160	6,840	6,590	6,411	6,306	6,274	6,387	6,953	7,121	-4,236

Table II-7.3 Financial Statement of Vrbovec Municipal Company

Income Statement

(Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Revenue	681	777	2,087	3,590	3,863	3,969	4,078	4,190	4,285	4,381	4,480	4,580	4,684	4,684	4,684	4,684	4,684
a- Charge Revenue	681	777	2,087	3,590	3,863	3,969	4,078	4,190	4,285	4,381	4,480	4,580	4,684	4,684	4,684	4,684	4,684
-Domestic users	566	644	718	814	908	933	959	985	1,008	1,030	1,054	1,077	1,101	1,101	1,101	1,101	1,101
-Other users	114	133	1,368	2,775	2,954	3,036	3,119	3,205	3,277	3,351	3,426	3,503	3,582	3,582	3,582	3,582	3,582
II. Expense	768	783	1,482	2,122	2,173	3,917	3,948	3,980	3,989	3,999	4,009	4,020	4,032	3,944	3,856	3,839	3,821
a-O&M	768	776	1,326	1,889	1,911	3,019	3,050	3,082	3,109	3,136	3,164	3,193	3,222	3,222	3,222	3,222	3,222
b- Depreciation						582	582	582	582	582	582	582	582	582	582	582	582
c- Interest	0	7	156	233	262	316	316	316	298	281	263	246	228	140	53	35	18
III. Income before tax	-87	-6	604	1,467	1,690	52	130	211	296	382	471	560	652	740	827	845	862
Tax	0	0	121	293	338	10	26	42	59	76	94	112	130	148	165	169	172
IV. Net Income	-87	-6	483	1,174	1,352	42	104	168	237	306	376	448	521	592	662	676	690

Cash Flow Statement

(Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Cash Inflow	1,548	19,393	11,728	7,273	10,561	3,969	4,078	4,190	4,285	4,381	4,480	4,580	4,684	4,684	4,684	4,684	4,684
a- Charge Revenue	681	777	2,087	3,590	3,863	3,969	4,078	4,190	4,285	4,381	4,480	4,580	4,684	4,684	4,684	4,684	4,684
-Domestic users	566	644	718	814	908	933	959	985	1,008	1,030	1,054	1,077	1,101	1,101	1,101	1,101	1,101
-Other users	114	133	1,368	2,775	2,954	3,036	3,119	3,205	3,277	3,351	3,426	3,503	3,582	3,582	3,582	3,582	3,582
b- Grant	520	11,169	5,785	2,210	4,019	0	0	0	0	0	0	0	0	0	0	0	0
c- Loan	347	7,446	3,857	1,473	2,679	0	0	0	0	0	0	0	0	0	0	0	0
II. Cash Outflow	1,635	19,399	11,245	6,099	9,209	3,346	3,392	4,318	4,344	4,371	4,399	4,428	4,458	4,388	4,318	4,304	15,926
a-O&M	768	776	1,326	1,889	1,911	3,019	3,050	3,082	3,109	3,136	3,164	3,193	3,222	3,222	3,222	3,222	3,222
b-Capital Investment	867	18,616	9,642	3,683	6,698	0	0	0	0	0	0	0	0	0	0	0	11,636
-Initial investment	867	18,616	9,642	3,683	6,698	0	0	0	0	0	0	0	0	0	0	0	0
-Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11,636
c-Debt Service	0	7	156	233	262	316	316	1,194	1,176	1,159	1,141	1,124	1,106	1,018	931	913	895
- Interest	0	7	156	233	262	316	316	316	298	281	263	246	228	140	53	35	18
- Loan Repayment	0	0	0	0	0	0	0	878	878	878	878	878	878	878	878	878	878
d- Tax	0	0	121	293	338	10	26	42	59	76	94	112	130	148	165	169	172
III. Net Cash Flow	-87	-6	483	1,174	1,352	623	686	-128	-60	10	80	152	225	296	366	380	-11,242
IV. Cash Reserve	-87	-93	390	1,564	2,916	3,539	4,225	4,097	4,038	4,047	4,128	4,280	4,505	5,843	7,531	7,911	-3,331
V. Net Debt	-434	-7,887	-11,260	-11,559	-12,887	-12,263	-11,577	-10,827	-10,009	-9,121	-8,163	-7,133	-6,030	-303	5,775	7,033	-3,331
a- Debt Outstanding	347	7,793	11,650	13,123	15,802	15,802	15,802	14,924	14,046	13,169	12,291	11,413	10,535	6,145	1,756	878	-0
b- Cash Reserve	-87	-93	390	1,564	2,916	3,539	4,225	4,097	4,038	4,047	4,128	4,280	4,505	5,843	7,531	7,911	-3,331

Table II-7.4 Financial Statement of Sisak Municipal Company

Income Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Revenue	7,301	8,174	9,109	10,199	11,377	11,690	12,011	12,342	12,619	12,903	13,193	13,490	13,794	13,794	13,794	13,794	13,794
a- Charge Revenue	7,301	8,174	9,109	10,199	11,377	11,690	12,011	12,342	12,619	12,903	13,193	13,490	13,794	13,794	13,794	13,794	13,794
-Domestic users	2,759	3,107	3,479	3,914	4,383	4,504	4,628	4,755	4,862	4,971	5,083	5,197	5,314	5,314	5,314	5,314	5,314
-Other users	4,542	5,068	5,629	6,285	6,994	7,186	7,384	7,587	7,757	7,932	8,110	8,293	8,479	8,479	8,479	8,479	8,479
II. Expense	7,308	7,400	7,545	7,910	11,385	11,535	11,690	11,849	11,952	12,058	12,167	12,279	12,395	12,241	12,088	12,057	12,027
a-O&M	7,308	7,388	7,469	7,596	10,307	10,458	10,613	10,771	10,905	11,042	11,181	11,324	11,470	11,470	11,470	11,470	11,470
b- Depreciation					526	526	526	526	526	526	526	526	526	526	526	526	526
c- Interest	0	12	76	314	552	552	552	552	521	490	460	429	398	245	92	61	31
III. Income before tax	-7	775	1,563	2,289	-8	154	321	492	667	845	1,026	1,211	1,399	1,553	1,706	1,736	1,767
Tax	0	0	313	458	0	31	64	98	133	169	205	242	280	311	341	347	353
IV. Net Income	-7	775	1,251	1,831	-8	154	321	492	667	845	821	969	1,119	1,242	1,365	1,389	1,414

Cash Flow Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Cash Inflow	8,780	16,201	38,833	39,923	11,377	11,690	12,011	12,342	12,619	12,903	13,193	13,490	13,794	13,794	13,794	13,794	13,794
a- Charge Revenue	7,301	8,174	9,109	10,199	11,377	11,690	12,011	12,342	12,619	12,903	13,193	13,490	13,794	13,794	13,794	13,794	13,794
-Domestic users	2,759	3,107	3,479	3,914	4,383	4,504	4,628	4,755	4,862	4,971	5,083	5,197	5,314	5,314	5,314	5,314	5,314
-Other users	4,542	5,068	5,629	6,285	6,994	7,186	7,384	7,587	7,757	7,932	8,110	8,293	8,479	8,479	8,479	8,479	8,479
b- Grant	888	4,816	17,834	17,834	0	0	0	0	0	0	0	0	0	0	0	0	0
c- Loan	592	3,211	11,890	11,890	0	0	0	0	0	0	0	0	0	0	0	0	0
II. Cash Outflow	8,787	15,426	37,582	38,092	10,859	11,040	11,228	12,954	13,092	13,233	13,379	13,528	13,681	13,558	13,436	23,929	13,387
a-O&M	7,308	7,388	7,469	7,596	10,307	10,458	10,613	10,771	10,905	11,042	11,181	11,324	11,470	11,470	11,470	11,470	11,470
b-Capital Investment	1,479	8,027	29,724	29,724	0	0	0	0	0	0	0	0	0	0	0	10,518	0
-Initial investment	1,479	8,027	29,724	29,724	0	0	0	0	0	0	0	0	0	0	0	0	0
-Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10,518	0
c-Debt Service	0	12	76	314	552	552	552	2,084	2,053	2,023	1,992	1,961	1,931	1,777	1,624	1,594	1,563
- Interest	0	12	76	314	552	552	552	552	521	490	460	429	398	245	92	61	31
- Loan Repayment	0	0	0	0	0	0	0	1,532	1,532	1,532	1,532	1,532	1,532	1,532	1,532	1,532	1,532
d- Tax	0	0	313	458	0	31	64	98	133	169	205	242	280	311	341	347	353
III. Net Cash Flow	-7	775	1,251	1,831	518	649	783	-612	-473	-330	-185	-37	113	236	358	-10,135	407
IV. Cash Reserve	-7	768	2,018	3,850	4,367	5,017	5,800	5,187	4,715	4,384	4,199	4,162	4,275	5,208	6,754	-3,382	-2,974
V. Net Debt	-599	-3,035	-13,673	-23,732	-23,214	-22,565	-21,782	-20,862	-19,802	-18,600	-17,253	-15,758	-14,113	-5,518	3,689	-4,914	-2,974
a- Debt Outstanding	592	3,802	15,692	27,581	27,581	27,581	27,581	26,049	24,517	22,985	21,452	19,920	18,388	10,726	3,065	1,532	0
b- Cash Reserve	-7	768	2,018	3,850	4,367	5,017	5,800	5,187	4,715	4,384	4,199	4,162	4,275	5,208	6,754	-3,382	-2,974

Table II-7.5 Financial Statement of Kutina Municipal Company

Income Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I Revenue	5,680	6,432	7,158	8,092	9,008	9,256	9,510	9,772	9,992	10,216	10,446	10,681	10,922	10,922	10,922	10,922	10,922
a- Charge Revenue	5,680	6,432	7,158	8,092	9,008	9,256	9,510	9,772	9,992	10,216	10,446	10,681	10,922	10,922	10,922	10,922	10,922
-Domestic users	3,402	3,879	4,342	4,934	5,518	5,670	5,826	5,986	6,121	6,259	6,399	6,543	6,691	6,691	6,691	6,691	6,691
-Other users	2,278	2,553	2,816	3,157	3,490	3,586	3,684	3,786	3,871	3,958	4,047	4,138	4,231	4,231	4,231	4,231	4,231
II Expense	2,252	2,282	3,323	4,316	4,400	6,938	6,999	7,062	7,097	7,132	7,169	7,207	7,247	7,155	7,064	7,045	7,027
a-O&M	2,252	2,276	3,167	4,082	4,133	5,826	5,887	5,949	6,002	6,056	6,111	6,168	6,226	6,226	6,226	6,226	6,226
c- Depreciation						783	783	783	783	783	783	783	783	783	783	783	783
b- Interest	0	6	156	233	267	329	329	329	311	293	274	256	238	146	55	37	18
III Income before tax	3,429	4,151	3,835	3,776	4,608	2,317	2,511	2,710	2,895	3,084	3,277	3,474	3,675	3,766	3,858	3,876	3,894
Tax	686	830	767	755	922	463	502	542	579	617	655	695	735	753	772	775	779
IV Net Income	2,743	3,320	3,068	3,020	3,686	2,317	2,511	2,710	2,895	3,084	2,622	2,779	2,940	3,013	3,086	3,101	3,116

Cash Flow Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Cash Inflow	6,385	25,186	16,887	12,316	16,752	9,256	9,510	9,772	9,992	10,216	10,446	10,681	10,922	10,922	10,922	10,922	10,922
a- Charge Revenue	5,680	6,432	7,158	8,092	9,008	9,256	9,510	9,772	9,992	10,216	10,446	10,681	10,922	10,922	10,922	10,922	10,922
-Domestic users	3,402	3,879	4,342	4,934	5,518	5,670	5,826	5,986	6,121	6,259	6,399	6,543	6,691	6,691	6,691	6,691	6,691
-Other users	2,278	2,553	2,816	3,157	3,490	3,586	3,684	3,786	3,871	3,958	4,047	4,138	4,231	4,231	4,231	4,231	4,231
b- Grant	423	11,252	5,837	2,535	4,647	0	0	0	0	0	0	0	0	0	0	0	0
c- Loan	282	7,501	3,892	1,690	3,098	0	0	0	0	0	0	0	0	0	0	0	0
II. Cash Outflow	3,642	21,865	13,819	9,296	13,066	6,618	6,718	7,735	7,807	7,880	7,956	8,033	8,113	8,040	7,967	7,952	23,604
a-O&M	2,252	2,276	3,167	4,082	4,133	5,826	5,887	5,949	6,002	6,056	6,111	6,168	6,226	6,226	6,226	6,226	6,226
b-Capital Investment	705	18,753	9,729	4,225	7,744	0	0	0	0	0	0	0	0	0	0	0	15,666
-Initial investment	705	18,753	9,729	4,225	7,744	0	0	0	0	0	0	0	0	0	0	0	0
-Replacement	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15,666
c-Debt Service	0	6	156	233	267	329	329	1,244	1,226	1,207	1,189	1,171	1,152	1,061	969	951	933
- Interest	0	6	156	233	267	329	329	329	311	293	274	256	238	146	55	37	18
- Loan Repayment	0	0	0	0	0	0	0	915	915	915	915	915	915	915	915	915	915
d- Tax	686	830	767	755	922	463	502	542	579	617	655	695	735	753	772	775	779
III. Net Cash Flow	2,743	3,320	3,068	3,020	3,686	2,637	2,792	2,036	2,185	2,336	2,490	2,648	2,809	2,882	2,955	2,970	-12,682
IV. Cash Reserve	2,743	6,063	9,131	12,152	15,838	18,475	21,267	23,304	25,488	27,824	30,315	32,963	35,771	50,034	64,663	67,633	54,951
V. Net Debt	2,461	-1,720	-2,544	-1,213	-625	2,012	4,805	7,756	10,855	14,106	17,511	21,073	24,796	43,632	62,834	66,718	54,951
a- Debt Outstanding	282	7,783	11,675	13,365	16,463	16,463	16,463	15,548	14,633	13,719	12,804	11,890	10,975	6,402	1,829	915	0
b- Cash Reserve	2,743	6,063	9,131	12,152	15,838	18,475	21,267	23,304	25,488	27,824	30,315	32,963	35,771	50,034	64,663	67,633	54,951

Table II-7.6 Financial Statement of Karlovac- Duga Resa Municipal Company

Income Statement (Unit: 10^3 Kn)

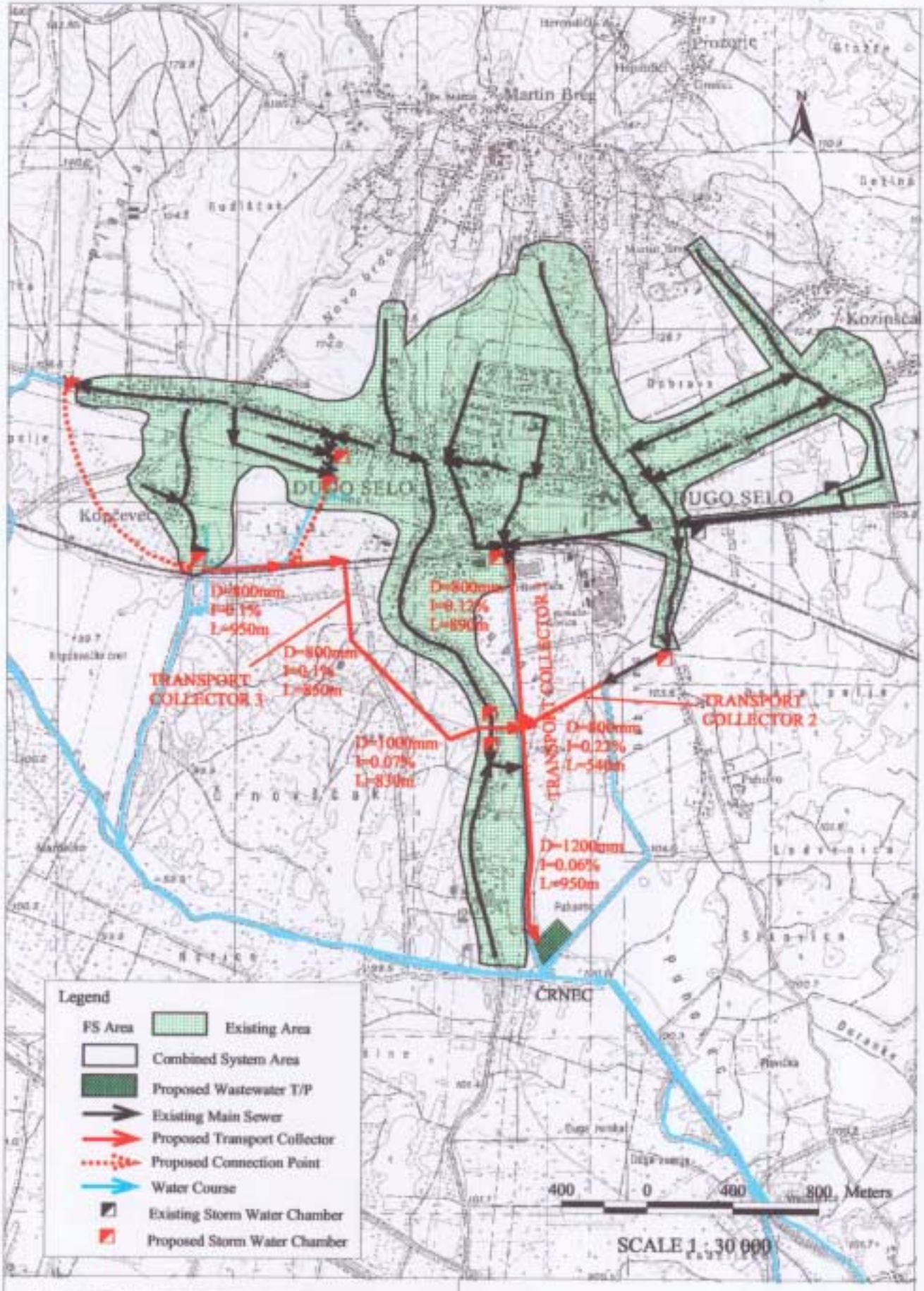
Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Revenue	8,362	9,353	10,413	13,278	16,442	16,894	17,359	17,836	18,237	18,648	19,067	19,496	19,935	19,935	19,935	19,935	19,935
a- Charge Revenue	8,362	9,353	10,413	13,278	16,442	16,894	17,359	17,836	18,237	18,648	19,067	19,496	19,935	19,935	19,935	19,935	19,935
-Domestic users	3,279	3,764	4,286	4,890	5,546	5,698	5,855	6,016	6,151	6,290	6,431	6,576	6,724	6,724	6,724	6,724	6,724
-Other users	5,084	5,589	6,127	8,388	10,896	11,196	11,504	11,820	12,086	12,358	12,636	12,920	13,211	13,211	13,211	13,211	13,211
II. Expense	8,091	8,213	8,479	9,034	14,206	14,378	14,554	14,735	14,830	14,928	15,030	15,135	15,243	14,955	14,667	14,609	14,551
a-O&M	8,091	8,180	8,270	8,410	12,077	12,248	12,424	12,606	12,758	12,914	13,073	13,236	13,402	13,402	13,402	13,402	13,402
b- Depreciation					1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091	1,091
c- Interest	0	34	209	623	1,038	1,038	1,038	1,038	980	923	865	807	750	461	173	115	58
III. Income before tax	271	1,139	1,934	4,245	2,236	2,516	2,805	3,101	3,407	3,720	4,038	4,361	4,691	4,980	5,268	5,326	5,383
Tax	54	228	387	849	447	503	561	620	681	744	808	872	938	996	1,054	1,065	1,077
IV. Net Income	217	912	1,547	3,396	1,789	2,516	2,805	3,101	3,407	3,720	3,230	3,489	3,753	3,984	4,214	4,261	4,307

Cash Flow Statement (Unit: 10^3 Kn)

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2020	2025	2026	2027
I. Cash Inflow	12,590	31,220	62,243	65,108	16,442	16,894	17,359	17,836	18,237	18,648	19,067	19,496	19,935	19,935	19,935	19,935	19,935
a- Charge Revenue	8,362	9,353	10,413	13,278	16,442	16,894	17,359	17,836	18,237	18,648	19,067	19,496	19,935	19,935	19,935	19,935	19,935
-Domestic users	3,279	3,764	4,286	4,890	5,546	5,698	5,855	6,016	6,151	6,290	6,431	6,576	6,724	6,724	6,724	6,724	6,724
-Other users	5,084	5,589	6,127	8,388	10,896	11,196	11,504	11,820	12,086	12,358	12,636	12,920	13,211	13,211	13,211	13,211	13,211
b- Grant	2,537	13,120	31,098	31,098	0	0	0	0	0	0	0	0	0	0	0	0	0
c- Loan	1,691	8,747	20,732	20,732	0	0	0	0	0	0	0	0	0	0	0	0	0
II. Cash Outflow	17,083	35,019	65,406	66,423	18,272	13,789	14,023	17,147	17,303	17,464	17,629	17,799	17,974	17,743	17,512	39,296	17,420
a-O&M	8,091	8,180	8,270	8,410	12,077	12,248	12,424	12,606	12,758	12,914	13,073	13,236	13,402	13,402	13,402	13,402	13,402
b-Capital Investment	8,938	26,578	56,540	56,540	4,710	0	0	0	0	0	0	0	0	0	0	21,830	0
-Initial investment	4,228	21,867	51,830	51,830	0	0	0	0	0	0	0	0	0	0	0	0	0
-Replacement (1)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	21,830	0
-Replacement (2)	4,710	4,710	4,710	4,710	4,710	0	0	0	0	0	0	0	0	0	0	0	0
c-Debt Service	0	34	209	623	1,038	1,038	1,038	3,921	3,864	3,806	3,748	3,691	3,633	3,345	3,056	2,999	2,941
- Interest	0	34	209	623	1,038	1,038	1,038	1,038	980	923	865	807	750	461	173	115	58
- Loan Repayment	0	0	0	0	0	0	0	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883	2,883
d- Tax	54	228	387	849	447	503	561	620	681	744	808	872	938	996	1,054	1,065	1,077
III. Net Cash Flow	-4,493	-3,799	-3,163	-1,314	-1,830	3,105	3,335	689	934	1,184	1,438	1,697	1,961	2,192	2,422	-19,361	2,515
IV. Cash Reserve	-4,493	-8,292	-11,455	-12,770	-14,600	-11,496	-8,160	-7,472	-6,538	-5,354	-3,916	-2,219	-258	10,240	21,890	2,529	5,044
V. Net Debt	-6,184	-18,730	-42,625	-64,672	-66,502	-63,398	-60,063	-56,490	-52,673	-48,606	-44,284	-39,704	-34,859	-9,945	16,123	-354	5,044
a- Debt Outstanding	1,691	10,438	31,170	51,902	51,902	51,902	51,902	49,019	46,135	43,252	40,368	37,485	34,601	20,184	5,767	2,883	-0
b- Cash Reserve	-4,493	-8,292	-11,455	-12,770	-14,600	-11,496	-8,160	-7,472	-6,538	-5,354	-3,916	-2,219	-258	10,240	21,890	2,529	5,044

Note: Replacement (1): damaged sewer replacement, Replacement (2): equipment replacement

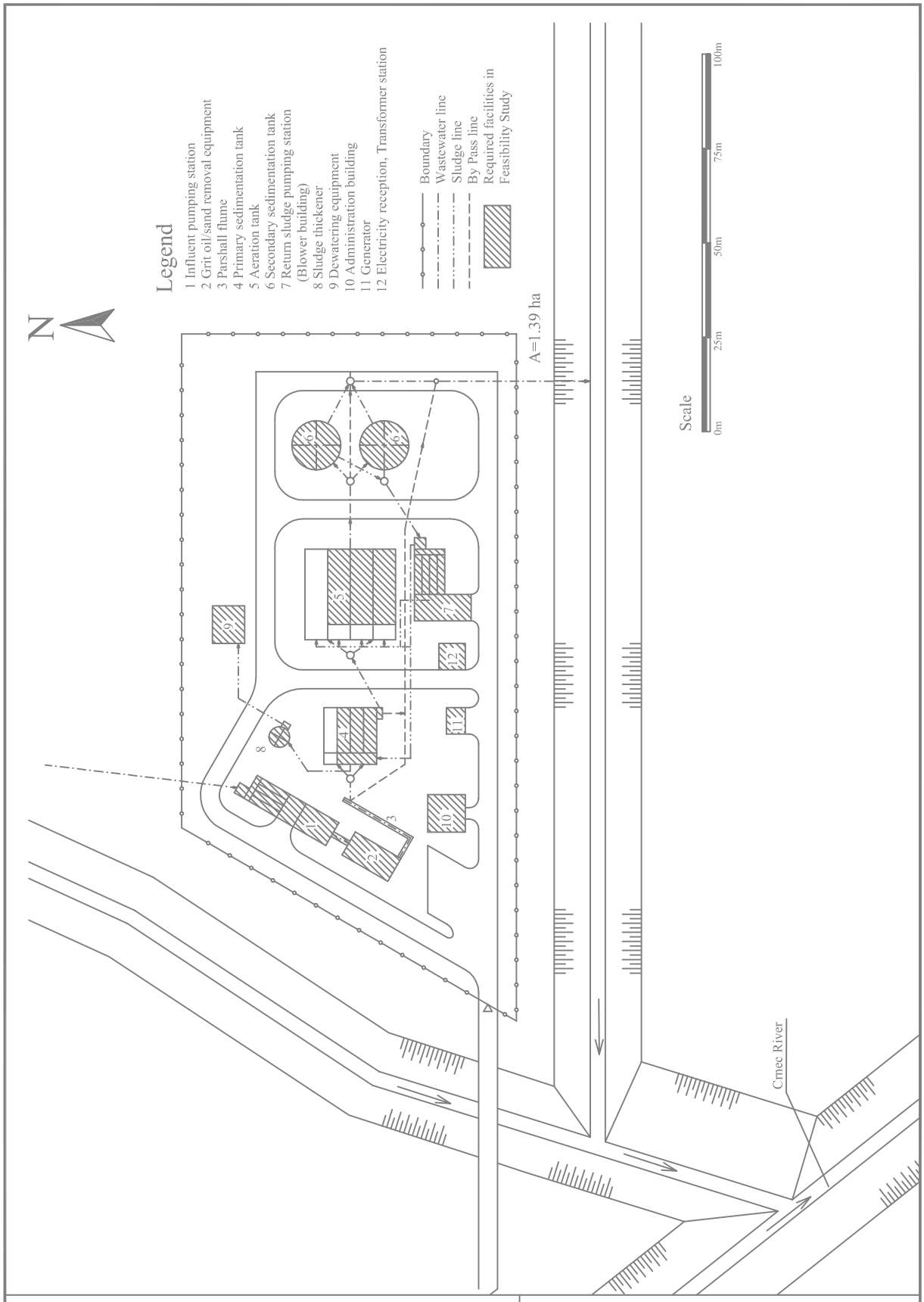
FIGURES



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

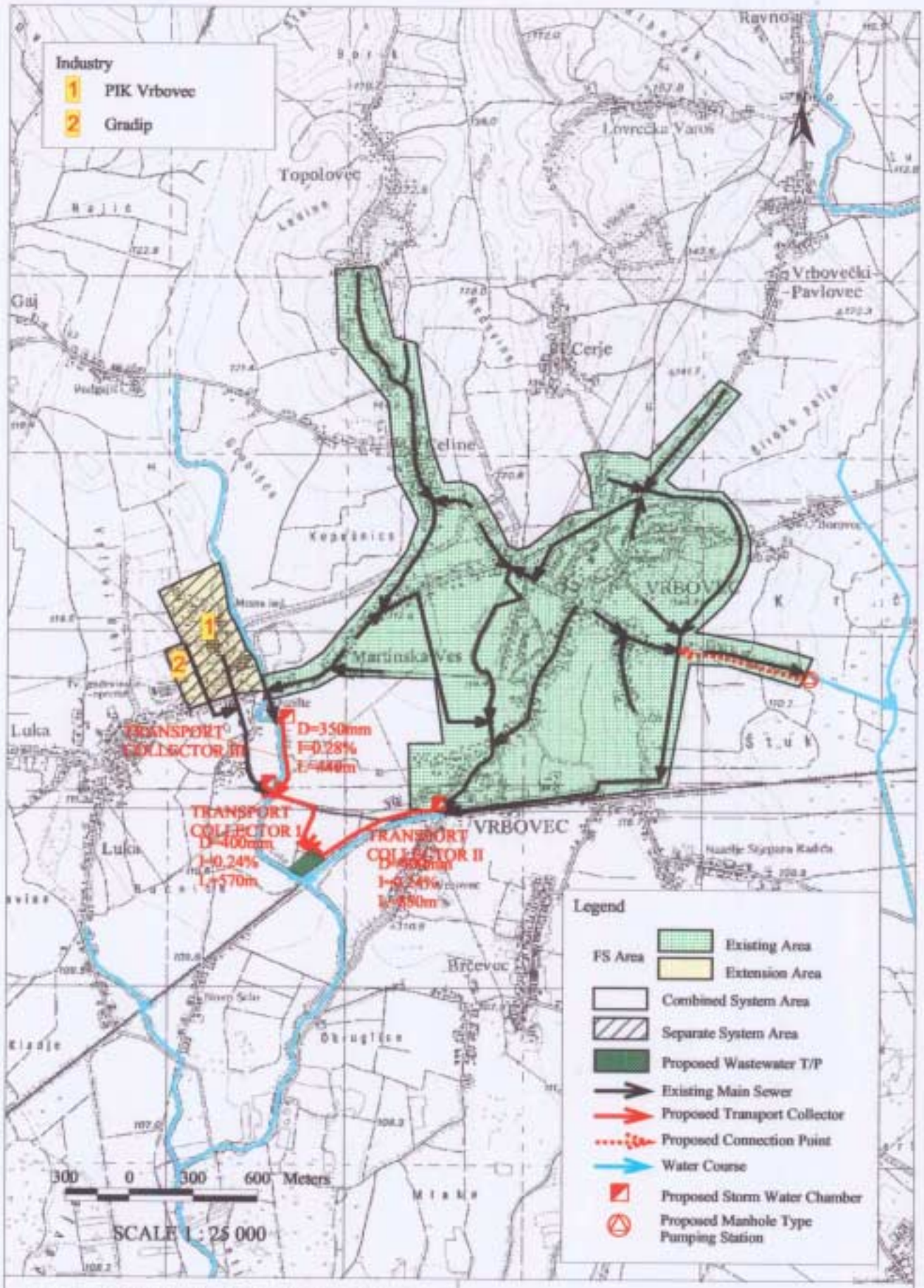
Fig. II-2.1 Sewerage Development System in Dugo Selo



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

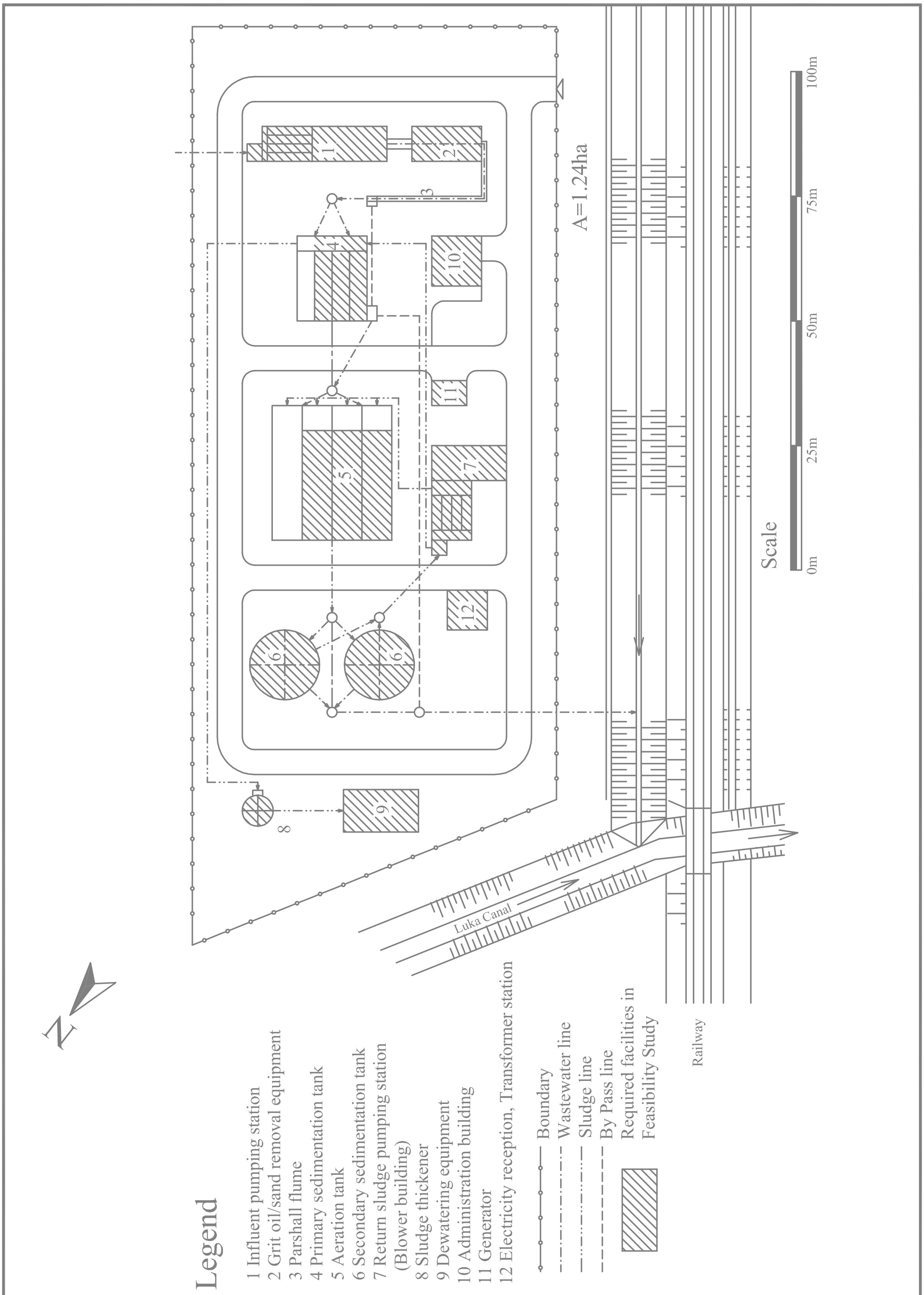
Fig.II-2.2
Layout of Wastewater Treatment Plant in Dugo Selo



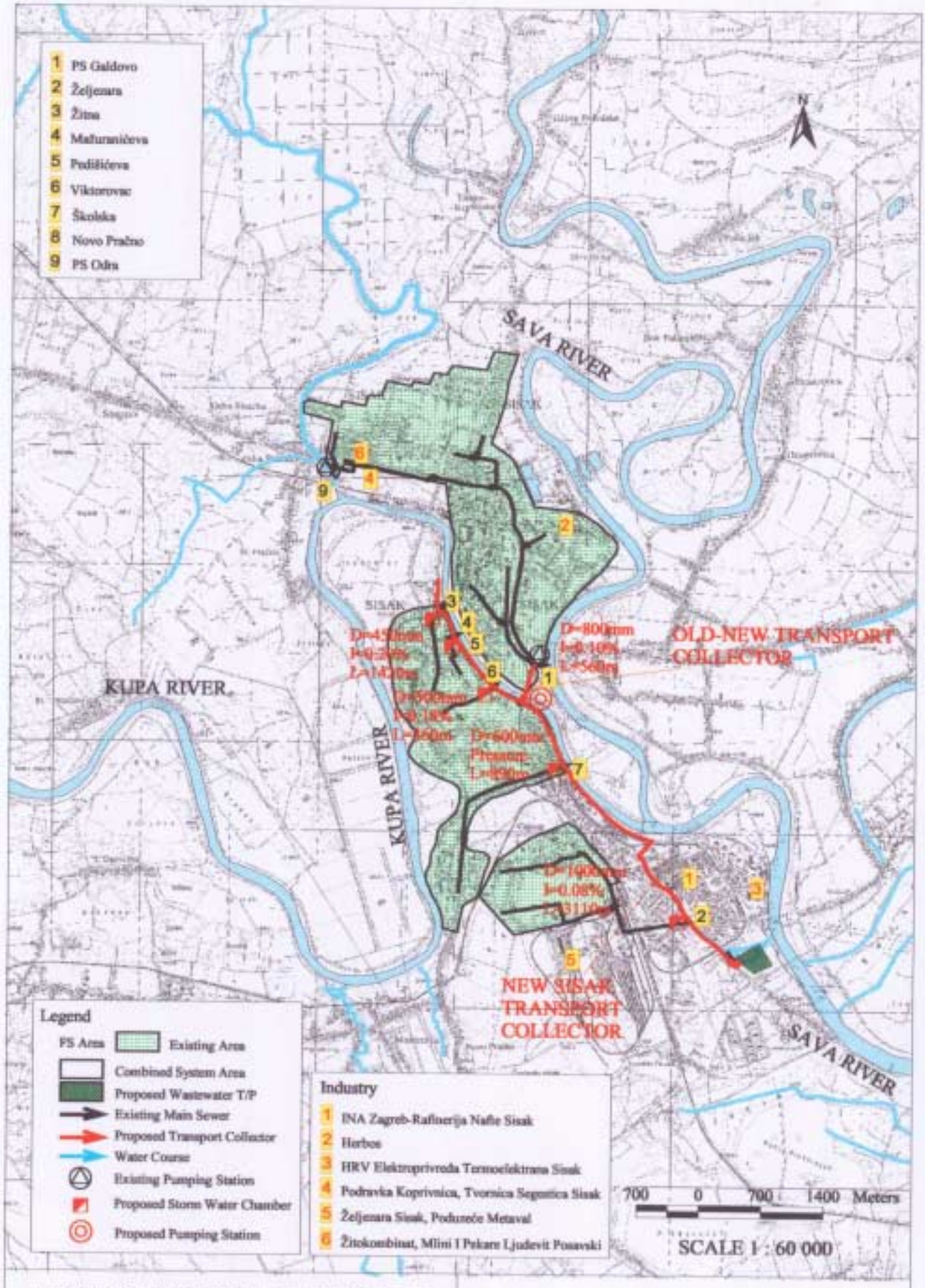
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-3.1 Sewerage Development System in Vrbovec



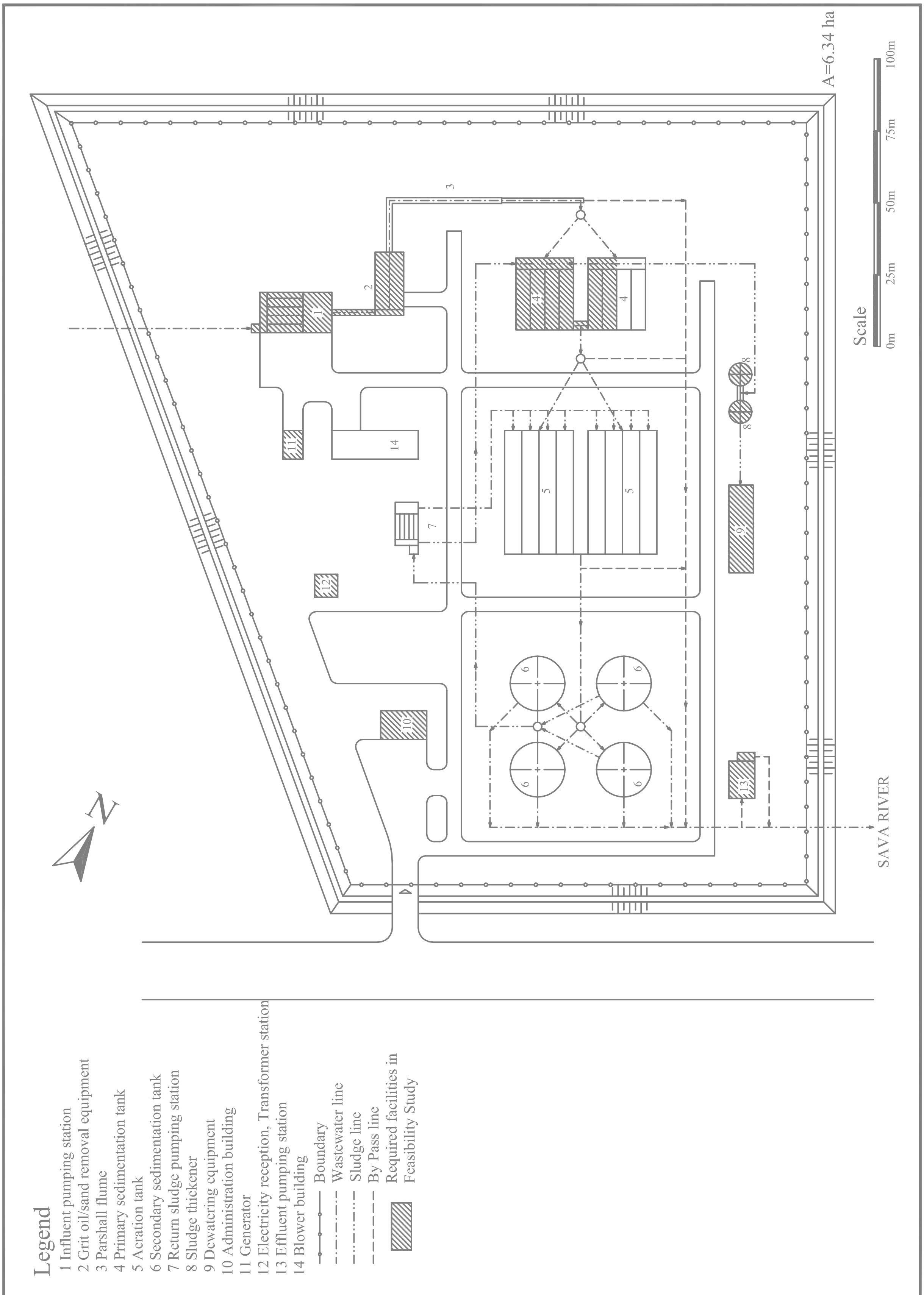
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.II-3.2 Layout of Wastewater Treatment Plant in Vrbovec
JAPAN INTERNATIONAL COOPERATION AGENCY	



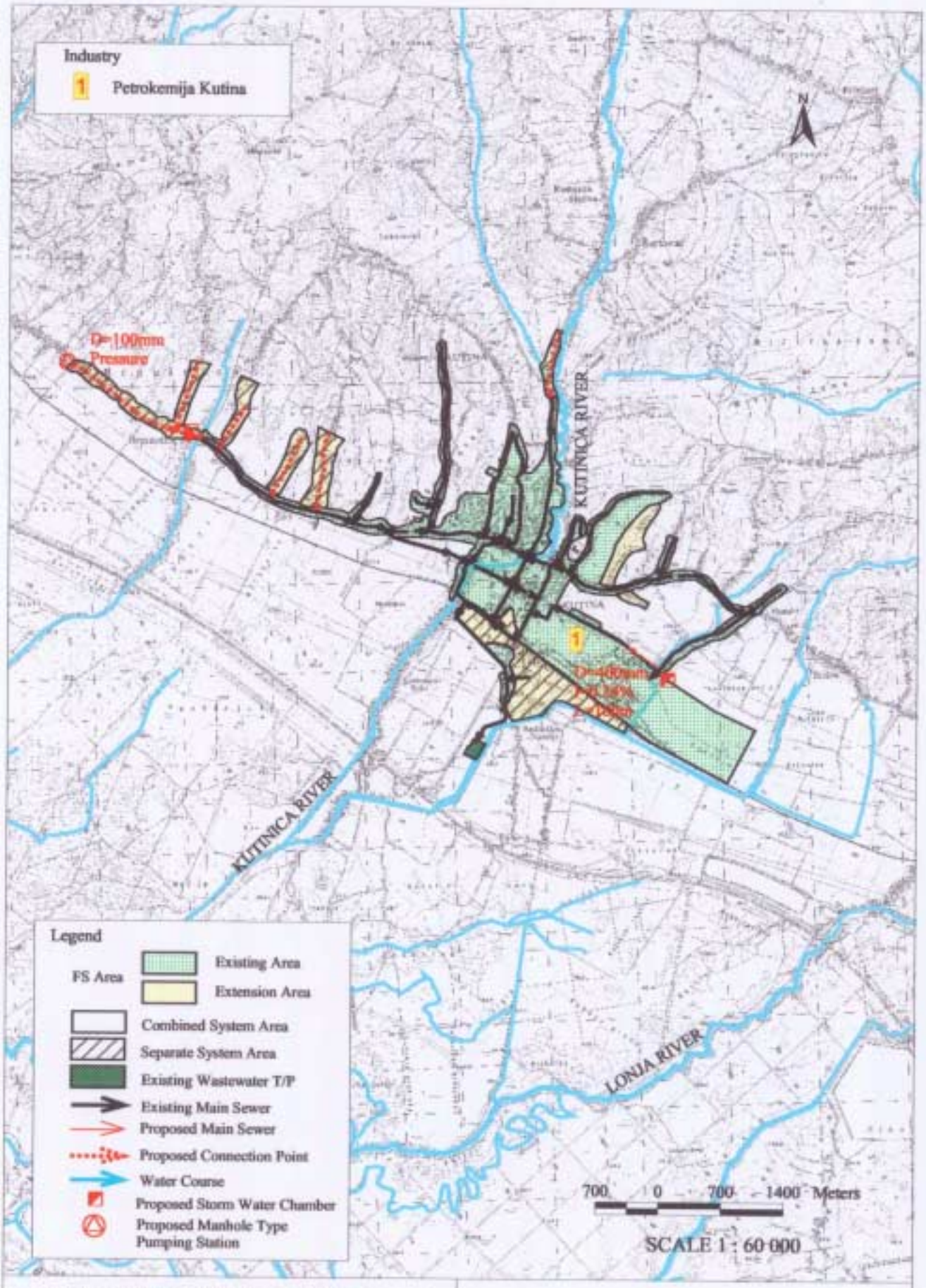
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. II-4.1 Sewerage Development System in Sisak



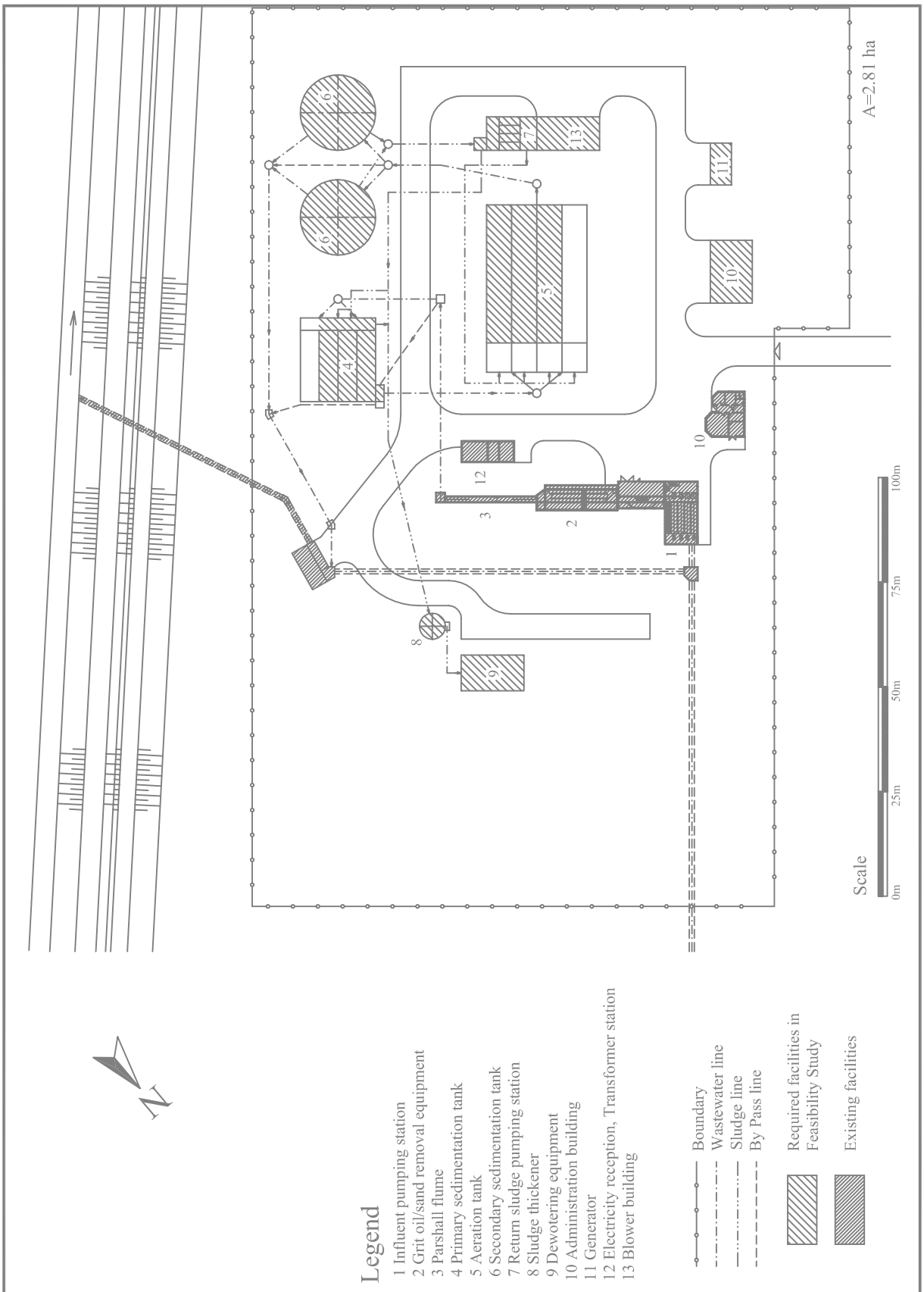
THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN	Fig.II-4.2 Layout of Wastewater Treatment Plant in Sisak
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

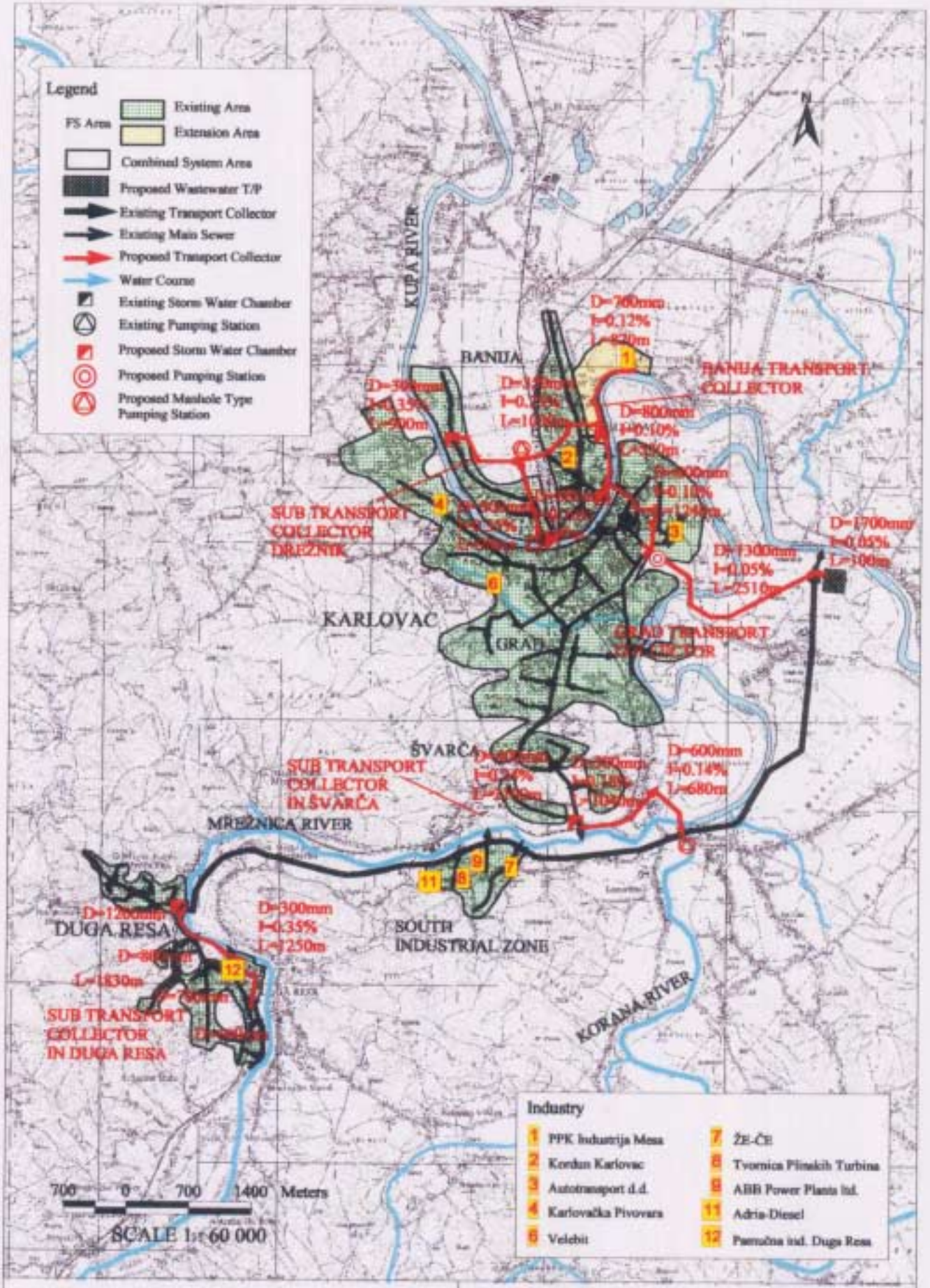
Fig. II-5.1 Sewerage Development System in Kutina



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

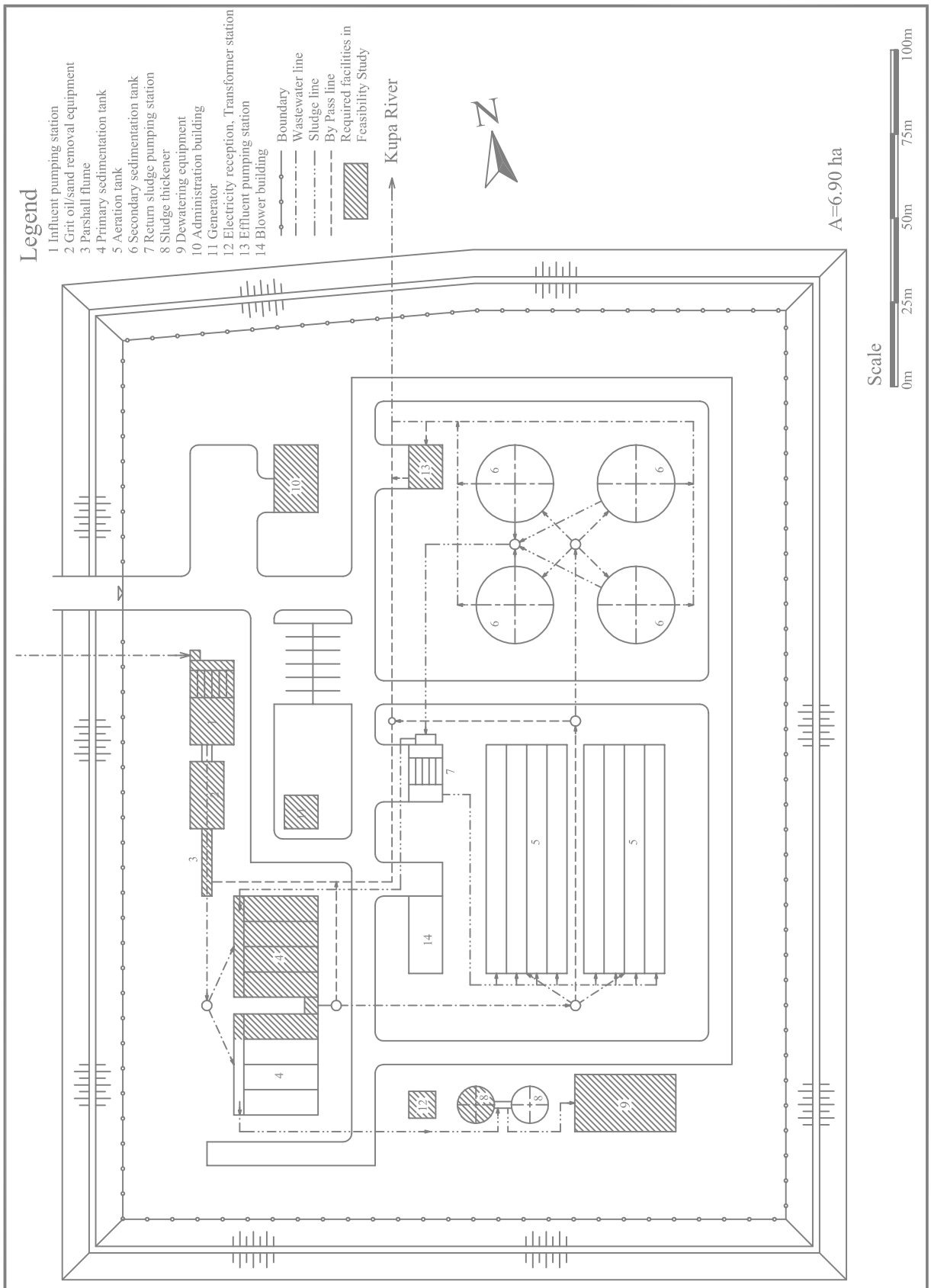
Fig.II-5.2
Layout of Wastewater Treatment Plant in Kutina



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.II -6.1 Sewerage Development System in Karlovac and Duga Resa



THE STUDY FOR WATER POLLUTION REDUCTION ON THE SAVA RIVER BASIN

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.II-6.2
Layout of Wastewater Treatment Plant in Karlovac - Duga Resa