社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY

No. 2

MINISTRY OF AGRICULTURE, WATER MANAGEMENT AND FORESTRY
BOSNIA AND HERZEGOVINA

THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO CITY IN BOSNIA AND HERZEGOVINA

FINAL REPORT

VOLUME I : SUMMARY REPORT

NOVEMBER 1999

TOKYO ENGINEERING CONSULTANTS CO., LTD.
NIHON SUIDO CONSULTANTS CO., LTD.

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OF
SARAJEVO CITY
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FINAL REPORT

CONSTITUENT VOLUMES

VOLUME Ⅰ	**SUMMARY REPORT**
VOLUME Ⅱ	**MAIN REPORT**
VOLUME Ⅲ	**ASSESSMENT WORK REPORT**
VOLUME Ⅳ	**APPENDIX**

EXCHANGE RATE

KM 1.00 = DEM 1.00 = JPY 71.20

(Status as of 24 May 1999)

PREFACE

In response to a request from the Government of Bosnia and Herzegovina, the Government of Japan decided to conduct The Feasibility Study on the Wastewater Treatment Plant of Sarajevo City in Bosnia and Herzegovina and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Kaoru Suzuki of Tokyo Engineering Consultants Co., Ltd. and consist of Tokyo Engineering Consultants Co. Ltd. and Nihon Suido Consultants Co. Ltd. to Bosnia and Herzegovina, 3 times between February 1999 and September 1999. In addition, JICA set up an advisory committee headed by Mr. Kazunori Koinuma, Sewerage Bureau, Tokyo Metropolitan Government, between January 1999 and November 1999, which examined the study from specialist and technical points of view.

The team held discussions with the officials concerned of the Government of Bosnia and Herzegovina 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 this 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 Bosnia and Herzegovina for their close cooperation extended to the Team.

November 1999

Kimio Fujita
President
Japan International Cooperation Agency

THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO CITY IN BOSNIA AND HERZEGOVINA

November 1999

Mr. Kimio Fujita
President,
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

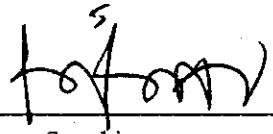
We are pleased to submit you the final report entitled "THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO CITY IN BOSNIA AND HERZEGOVINA". This report has been prepared by the Study Team in accordance with the contracts signed on 22 January 1999, between Japan International Cooperation Agency and Tokyo Engineering Consultants Co., Ltd. and Nihon Suido Consultants Co., Ltd.

The report examines the existing conditions concerning wastewater systems in Sarajevo, and presents a feasibility study on a priority project selected from the reconstruction program.

The report consists of the Summary Report, Main Report, Assessment Report and Appendix. The Summary Report summarizes the results of all studies. The Main Report presents the results of the whole study including background conditions, formulation of the master plan, selection of the priority project and the feasibility study on the priority project. The Assessment Report included all the assessment work of Sarajevo wastewater treatment plant and the Appendix describes in detail the same contents of the Main Report.

All the members of the Study Team wish to acknowledge gratefully to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Agriculture, Water Management and Forests, and Embassy of Japan in Bosnia and Herzegovina, and also to the officials and individuals of the Government of Bosnia and Herzegovina for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study contribute to the improvement of the wastewater systems and the social and economic development in Bosnia and Herzegovina.

Yours faithfully,



Kaoru Suzuki
Team Leader

EXECUTIVE SUMMARY

OBJECTIVES OF THE STUDY

The objectives of the Study are the following:

(1) To conduct a feasibility study for the rehabilitation of the Sarajevo WWTP that contributes to the recovery of the sanitary and environmental conditions.

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

The study area will cover the present urbanised area to include the sewerage planning area and the Sarajevo WWTP. However, the Kuwaiti Fund financed on-going project, "Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in the Canton of Sarajevo" will serve as basis for the Study. The target year for the urgent rehabilitation works is year 2000 and for the long term planning is year 2015.

THE EXISTING SEWERAGE SYSTEM

The Central Sarajevo Sewerage System managed by ViK, serves about 90 % of the population of Canton Sarajevo. Some parts of the collection system (particularly in Stari Grad and Centar) were constructed some 100 years ago; collecting both combined sanitary and storm water drainage. This system causes problems such as, overloading of sewers and accumulation of large amount of grit and foreign materials especially during heavy rains. However, ViK started reconstruction of the collection system to separate sewerage from storm water drainage. Basically before the war, sewage collected in this zone is treated by the Sarajevo WWTP before disposal into Bosna River.

REVIEW OF THE PREVIOUS STUDIES AND PROJECTS

Out of the 49 countries and 13 international agencies, Japan is the 4th largest donor for the reconstruction and development program of BiH. Out of the total US $ 386 million pledged by the government of Japan, US $ 111 million have already been completed and US $ 119 million are in implementation. The rehabilitation of the Sarajevo WWTP is among the projects funded by the government of Japan. Other projects by donor countries include the "Norwegian People's Aid Demining Program", "Kuwaiti Fund - Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in the Canton of Sarajevo", and others.

The Kuwaiti funded project serves as the basis for this Feasibility Study, especially in examining the framework plan of the project. Aside from the demining project, the government of Finland also carried out reinstallation of about 500 m of diameter 300-800 mm sewer line in Sarajevo valued at DEM 0.48 million. The World Bank loaned approximately US $ 3 million for the rehabilitation of the trunk sewers. The International Red Cross donated vehicles to ViK, which include a vehicle for sewer maintenance.

ASSESSMENT OF SARAJEVO WWTP

The second field survey and assessment of the Sarajevo WWTP was carried out on the 25th May to 3rd August 1999. The major purpose of the fieldwork is to assess the present condition of the existing facilities in order to formulate the most feasible alternative for the plant's rehabilitation.

Several tests and appropriate actions were performed during that period, which were mainly categorised into aspects such as civil, architectural, mechanical and electrical. The detailed appraisal of each existing treatment facilities and auxiliaries does not limit only to the visual condition survey and photo-documentation, but also include testing of the present condition on important items in order to assess the capacity, stability and a sound operability of the plant for the long term period.

NEW PRELIMINARY TREATMENT FACILITIES

The very serious problem that had caused trouble to the WWTP operation not only to the aerated grit chamber but also caused blockages to the screw pumps and the screens are the very large volume of coarse grit present in the raw wastewater. Improving the grit removal facility will not solve the problem since blockages also occur upstream at the screens and screw pumps.

Therefore, the only logical solution is to install pre-treatment and pre-screening facilities upstream of the Raw Water Pumping Station. These facilities will consist of rectangular, horizontal flow grit channels to remove heavier grit particles and sets of coarse and medium screens.

URGENT REHABILITATION WORK

Primarily, the Feasibility Study was done on the concept of rehabilitating the WWTP by bringing it back to the pre-war condition. Hence, the assessment works have done in order to bring the each facility, including mechanical and electrical equipment, back to the pre-war capacity. Based on the result of assessment works, the preliminary design has done.

As previously discussed in the previous sections, the same basic design data will be used in the rehabilitation plan of the WWTP. For urgent rehabilitation in the year 2000, the urgent works include the following:

(1) Pre-treatment Facilities
(2) Existing Inlet Works
(3) Secondary Treatment Facilities
(4) Sludge Treatment Facilities
(5) Building Facilities

OPERATION AND MAINTENANCE

Serious operational and maintenance problems previously encountered during the operational period of the WWTP will be rectified with the proposed rehabilitation plan. However, the operation of the WWTP requires well-trained and efficient operators familiar not only with the peculiarities of the sewer system, but also with the characteristics of the wastewater.

Regular monitoring of the treatment processes is imperative to effectively attain the required quality and quantity of the effluent as well as the sludge. More importantly, good housekeeping and following the required operational procedures for each facility will make the Sarajevo WWTP less troublesome and environmentally friendly.

PRELIMINARY COST ESTIMATE

The total project cost is estimated at DEM 76 million. The construction cost amounted to DEM 64 million mostly on mechanical and electrical equipment, which are foreign supplied. The local component will cover mostly the cost on labour and materials. Ten percent (10 %) of the cost is allocated to contingency at DEM 6.9 million and engineering services at DEM 5.0 million.

The operation and maintenance cost, which includes the cost on salaries, chemicals, power consumption, depreciation and spare parts is estimated at DEM 5.8 million annually.

FINANCIAL EVALUATION

The financial viability of the project was represented by the FIRR which was computed at 5.9 %. This indicates that the project will be financially viable if the cost of capital (cost of capital = interest cost of foreign loan + interest cost of domestic loan) is less than 5.9 %.

A capital investment consisting of 85 % foreign loan with interest rate of 1 % + 15 % domestic loan with interest rate of 10 % will give a FIRR of 2.35 %, therefore financially viable. However, if the project will be fully financed by grant, there would be no cost of capital.

ECONOMIC EVALUATION

The economic benefit of the project was computed based on the amount of willingness to pay for the WWTP (consumer surplus) of both the domestic and non-domestic users in Sarajevo. The survey resulted to a consumer surplus of KM 3.0 to KM 4.1 for domestic users and 42 % more on top of the current sewage bill for the non-domestic users.

Due to insufficient economic data in computing for the coefficient factor in conversion, the value of economic cost is regarded same as that of the financial cost. The calculation of the economic evaluation resulted to EIRR = 17.4 %. A realization of the project can be justified due to the much higher EIRR compared to the 5.9 % FIRR.

WASTEWATER TARIFF AND COLLECTION RATE

With the consideration of financial and economic evaluation, and the cost of estimated operation and maintenance, it is recommended to raise the wastewater tariff rate gradually by the year 2002 to the following level.

Domestic Users	: 0.7 + 0.2 (for WWTP) KM/m3
Non-domestic Users	: 1.2 + 0.3 (for WWTP) KM/m3

The collection rate is currently about 50% for domestic users and 70 % for non-domestic users. As the socio-economic situation is to be rehabilitated, the collection rate should be improved up to 70% and 90 % respectively by the year 2003.

ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

The major impacts and countermeasures identified with the implementation of the WWTP are the following:

(1) Pollutant load reduction (positive impact) – water quality of the receiving water body will improve provided that effluent quality criteria, such as BOD at 20 mg/l and SS at 30 mg/l are maintained.

(2) Sewage sludge generation and disposal – large volume of sludge cake (107 m^3/day for year 2000 and 180 m^3/day for year 2015) will be added to the current solid waste volume disposed into the landfill site at Buca Potok. Drier sludge cakes are to be maintained and monitored.

(3) Industrial wastewater discharge into sewerage system – danger of toxic materials discharge into the sewerage system can be expected unless stringent measures and standards on industrial waste disposal are implemented.

(4) Odour generation – the odour generated from the plant facilities can be reduced and/or eliminated if good housekeeping and proper operational procedures are followed. The planned odour control facilities can be built when stricter controls become necessary in the future.

The rehabilitation and re-commissioning of the WWTP will greatly improve the environmental conditions not only in Sarajevo but also the countries downstream of Bosna River and the surrounding environs. By taking the countermeasures very seriously will reduce negative impacts.

CONCLUSION

(1) Basic Concept of the Project

Primarily, this Feasibility Study was conducted on the concept of rehabilitating the WWTP by bringing it back to the pre-war condition. Therefore, each facility including mechanical and electrical equipment was assessed in order to bring back these to the pre-war capacity or condition. Based on the results of assessment, preliminary designs have been done.

(2) The WWTP Rehabilitation Project and Costs

Based on the assessment work, the fundamentals of the WWTP rehabilitation project are the following;

1) Installation of new pre-treatment and pre-screening grit-removal chamber would take measures for sand and small gravel during the rain in the influent.
2) Existing facilities would be basically rehabilitated and improved to bring back these to the pre-war condition.
3) All plant-machine and electric facilities, except a section of the clarifiers would be newly established.
4) As an architectural work, boiler room and generator building would be newly constructed, and the others would be rehabilitated.
5) Contract construction cost of the rehabilitation is estimated at about 64 million DEM, and the total Project cost is estimated at about 76 million DEM.
6) Annual O&M cost is estimated at about 5.8 million DEM.

(3) Economical and Financial Evaluation

Economical and financial evaluation is done with some assumptions in consideration with preliminary design and estimation, and O&M cost. As a result, Financial Internal Rate of Return (FIRR) shows 5.9 % and it is feasible as a loan project if the financial condition improved by such as the raise of wastewater tariff rate. The economic value of the implementation of the project is also justified by Economic Internal Rate of Return (EIRR), which is 17.6 %. According to the result of questionnaire survey done by this study, the recognition for the improvement of Mirijaka river's environment was considerably high, and also the Willingness To Pay (WTP) was relatively high (3.0-4.1KM per household per month).

NECESSITY AND EFFECT OF THE REALIZATION OF PROJECT

(1) Co-ordination with the Bosnian Development Plan

The role of Japanese Official Development Assistance (ODA) is clear in "Priority Reconstruction Projects". Based on the framework of the plans, it is also become clear that the WWPT rehabilitation plan is effective projects in cooperation with related-projects implemented by other donor countries. Since other international organizations and donor countries have also indicated the same recognition, the implementation of the rehabilitation is highly desired.

(2) Environmental Regulation

The population is expected to increase up to 40% and the economic situation to be recovered toward the pre-war level by year 2000. In such a situation, it is possible to be obligated by law to follow the European standard even for the wastewater discharge public watershed. Hence, the adaptable total plan toward 2015 is proposed in this report.

(3) Effect of Sewage Treatment on Environment Improvement

After completion of the Project, treated effluent would have about 20 mg/l of BOD_5 and about 30 mg/l of SS, which are values of discharging standards to the Bosna River so that it can contribute toward environmental preservation of the Danube River.

RECOMMENDATIONS

(1) Recommendation for Total Plan

In order to meet the requirement of environment and wastewater policy of 2015, it expected to be necessary the treatment to be up-graded. This plan does not include the following design but it is recommended to have the followings as a total plan in future.

1) The expansion of the final sedimentation tank
2) chlorination system
3) Anti-odour measurement

(2) Human Development

It is strongly recommended to assign process engineers, maintenance engineers and water quality specialist after the implementation of the Project. The consistent program for human development and seminar is indispensable based on the mid-term plan.

(3) Outsourcing of Operation and Maintenance

The contract with constructors should include the training program for operation and maintenance for the local staffs for the first year of the WWTP operation. Thereafter it is recommended to have partial outsourcing contract or operation and maintenance contract. Since the WWTP operate as a system, the daily routine work and follow-up of operation manual is especially important for improvement of the treatment efficiency.

(4) Promotion for the Implementation of the Project

This study project is a part of the Japan ODA pledged in 1996 in order to support the reconstruction of BiH. The realization of this WWTP rehabilitation project is highly desired for supporting and promoting the effort of reconstruction. It is indispensable for the responsible institutions to have necessary reactions for the realization of the projects basing on the strong requirement from BiH.

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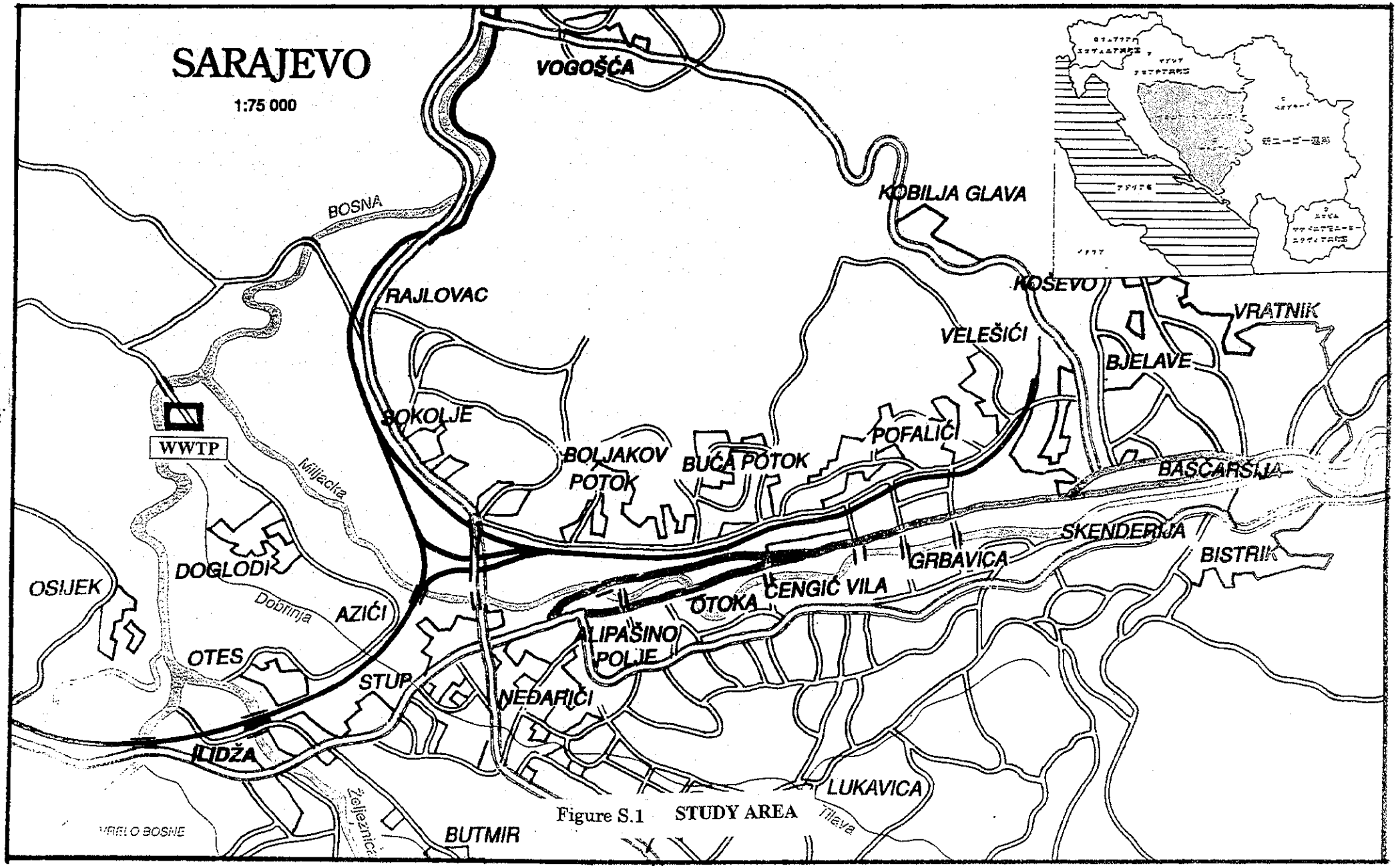


Figure S.1 STUDY AREA

Photo S - 1 A BIRD'S-EYE PHOTO OF WHOLE WWTP

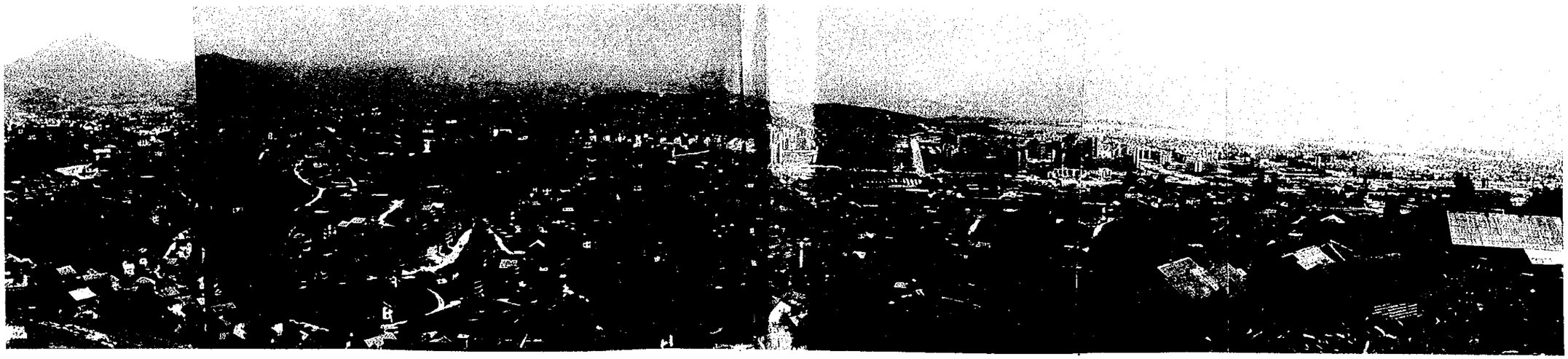
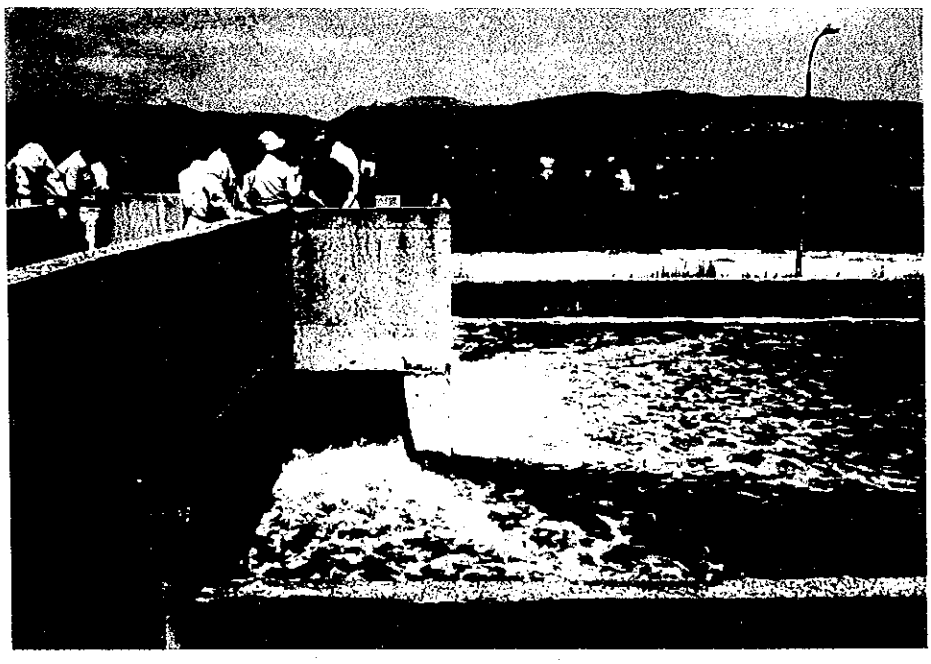


Photo. S-1 THE SEWERAGE AREA OF GREATER SARAJEVO

Date : Nov. 99 Scale: Not to Scale	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO SEWERAGE AREA OF GREATER SARAJEVO	PHOTO S – 2



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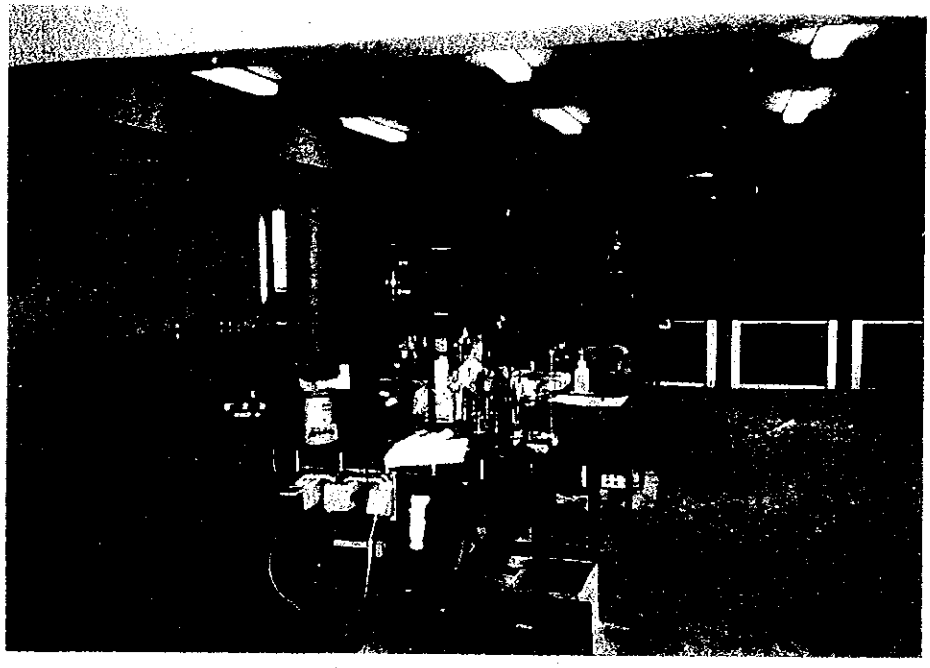
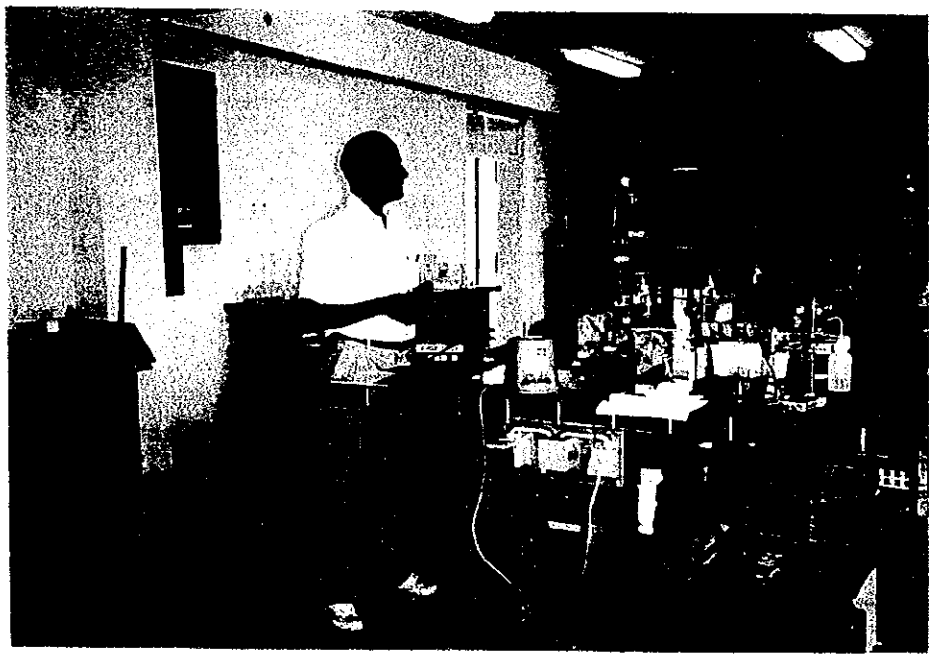
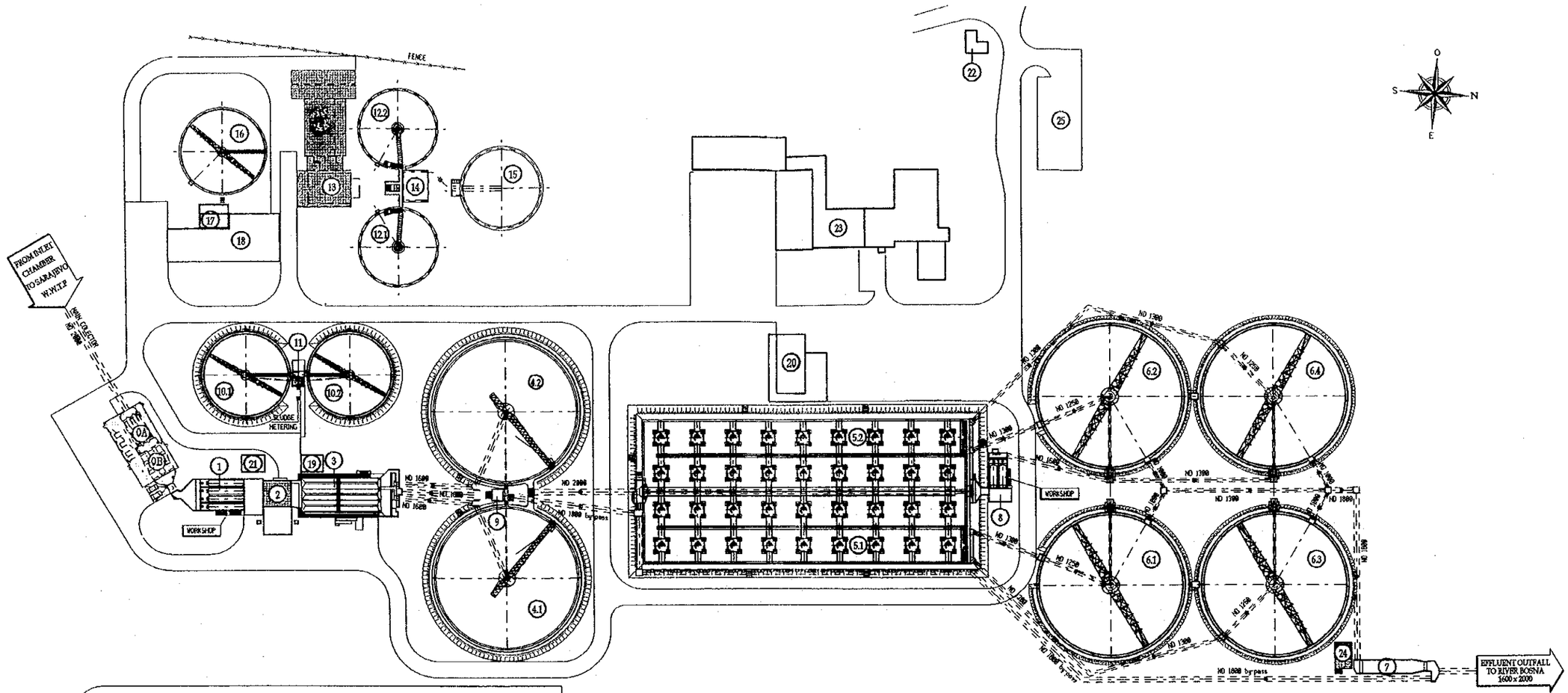




Date : Nov. 99 Scale: Not to scale	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO	PHOTO
	NEWLY REHABILITATED LABORATORY WITH EQUIPMENT DONATED BY JICA	S – 4



- LEGEND -

0A	PRE-TREATMENT	17	SLUDGE PUMPING STATION
0B	PRE-SCREENING STATION	18	SLUDGE DEHYDRATION
1	RAW WATER PUMPING STATION	19	AIR BLOWER ROOM
(2)	SCREENING STATION	(20)	POWER STATION
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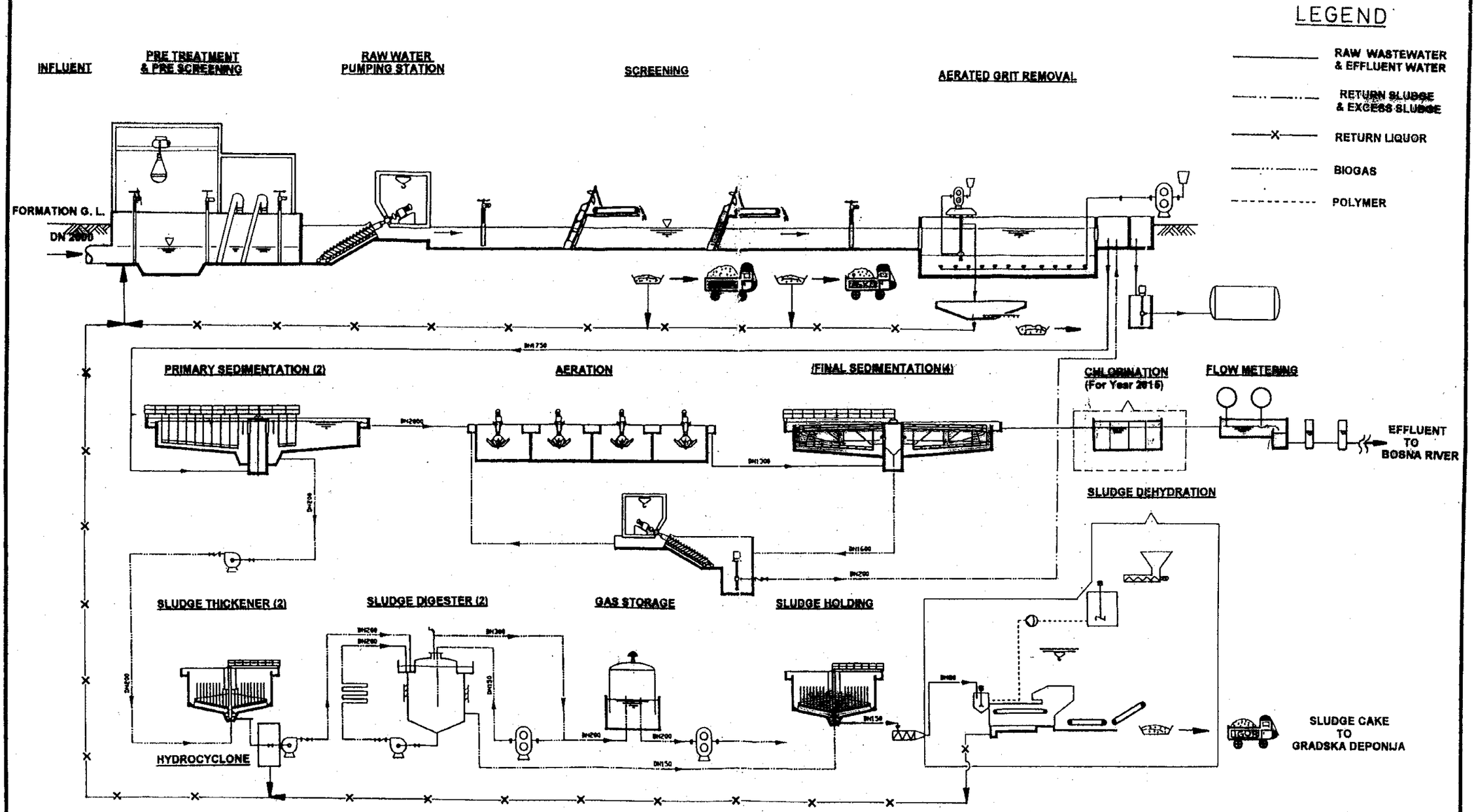
Date : Nov. 99 Scale: As shown	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO PROPOSED SITE PLAN – YEAR 2000	FIGURE S.2



Date : Nov. 1999 Scale : Not to Scale	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO	FIGURE S.3
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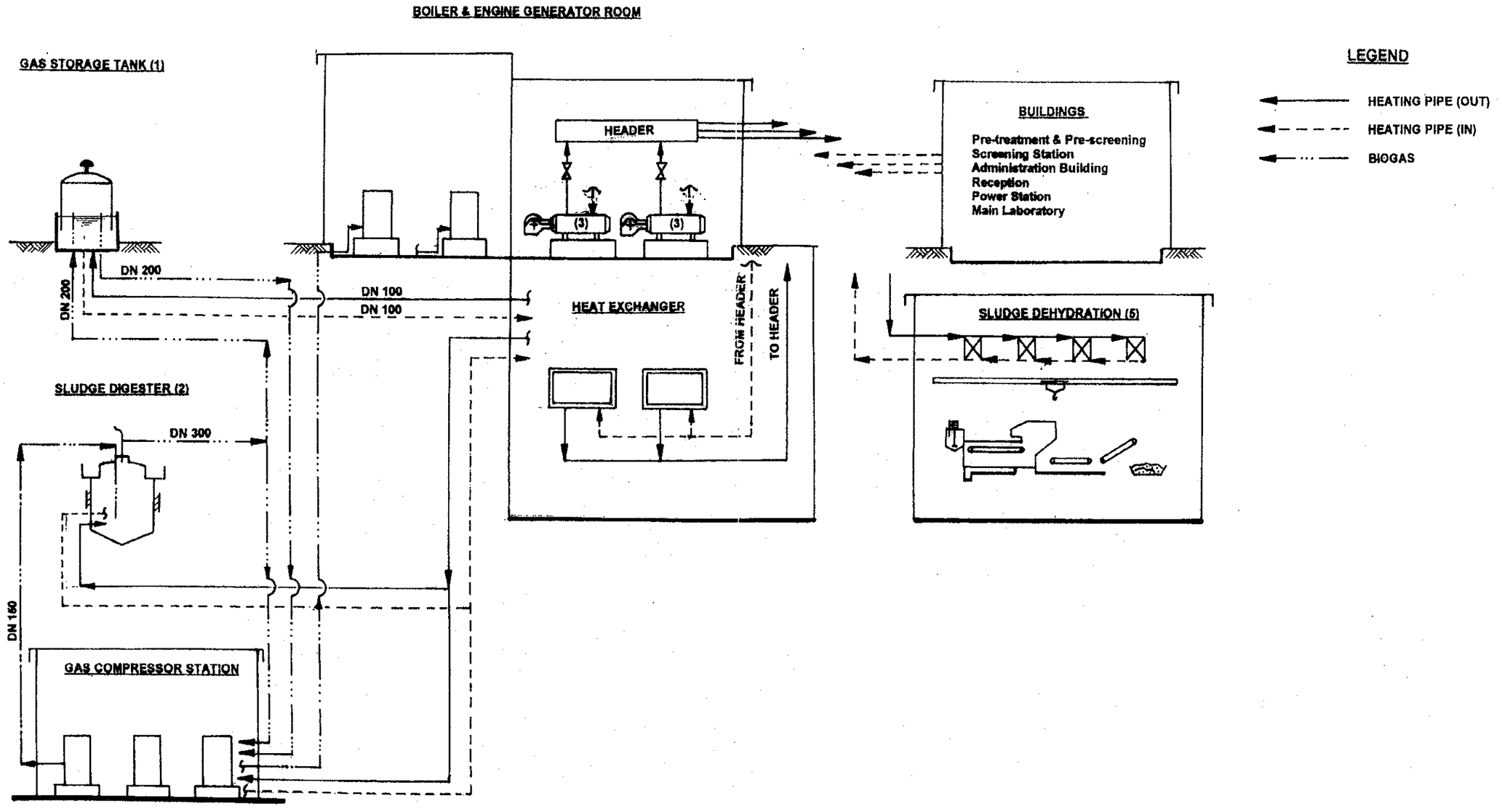
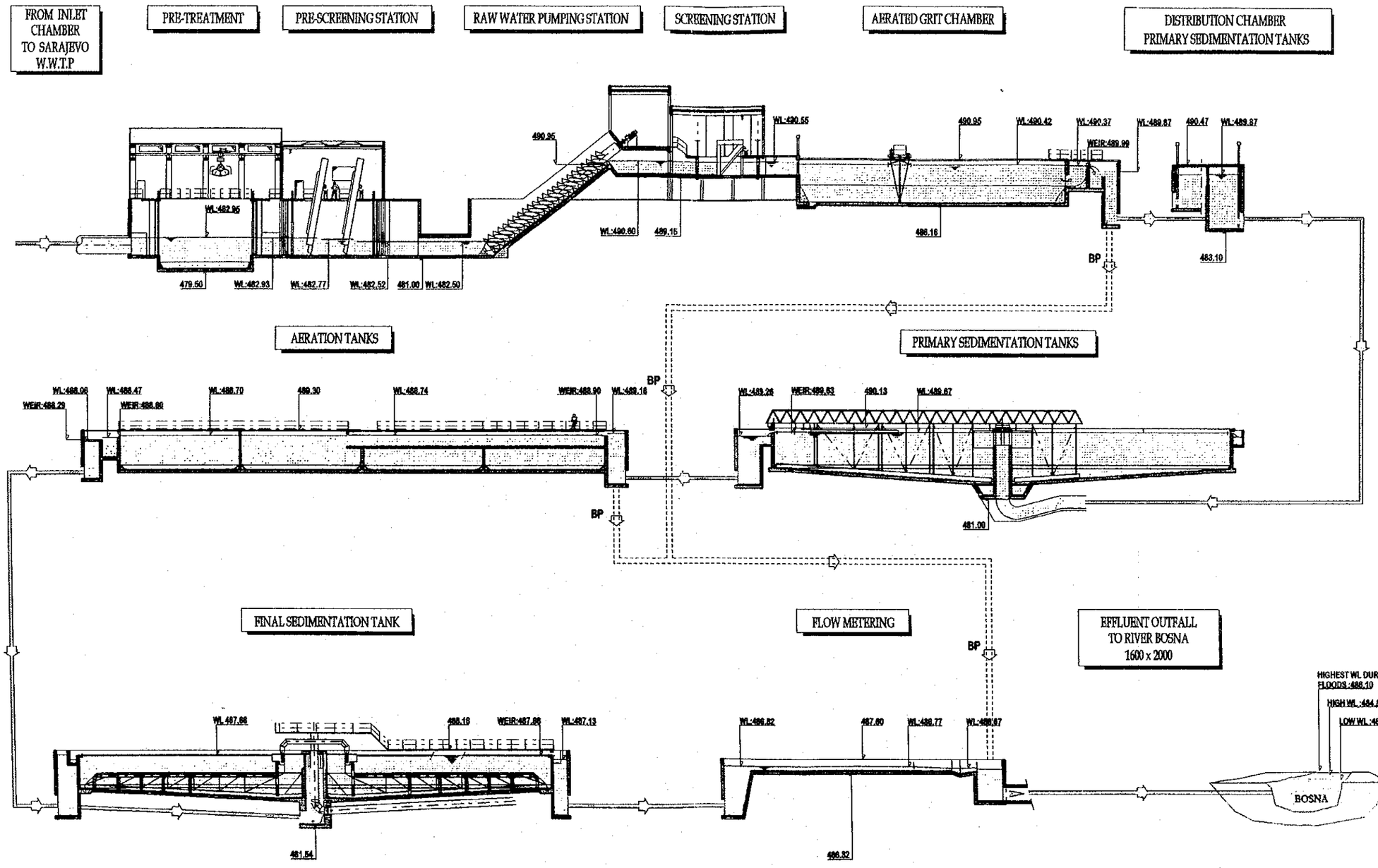


Date : Nov. 99 Scale: Not to Scale	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO PROCESS SCHEMATIC 2 (BIOGAS)	FIGURE S.4



Date : Nov. 99 Scale: Not to Scale	THE FEASIBILITY STUDY ON THE WASTEWATER TREATMENT PLANT OF SARAJEVO WASTEWATER HYDRAULIC PROFILE	FIGURE S.5

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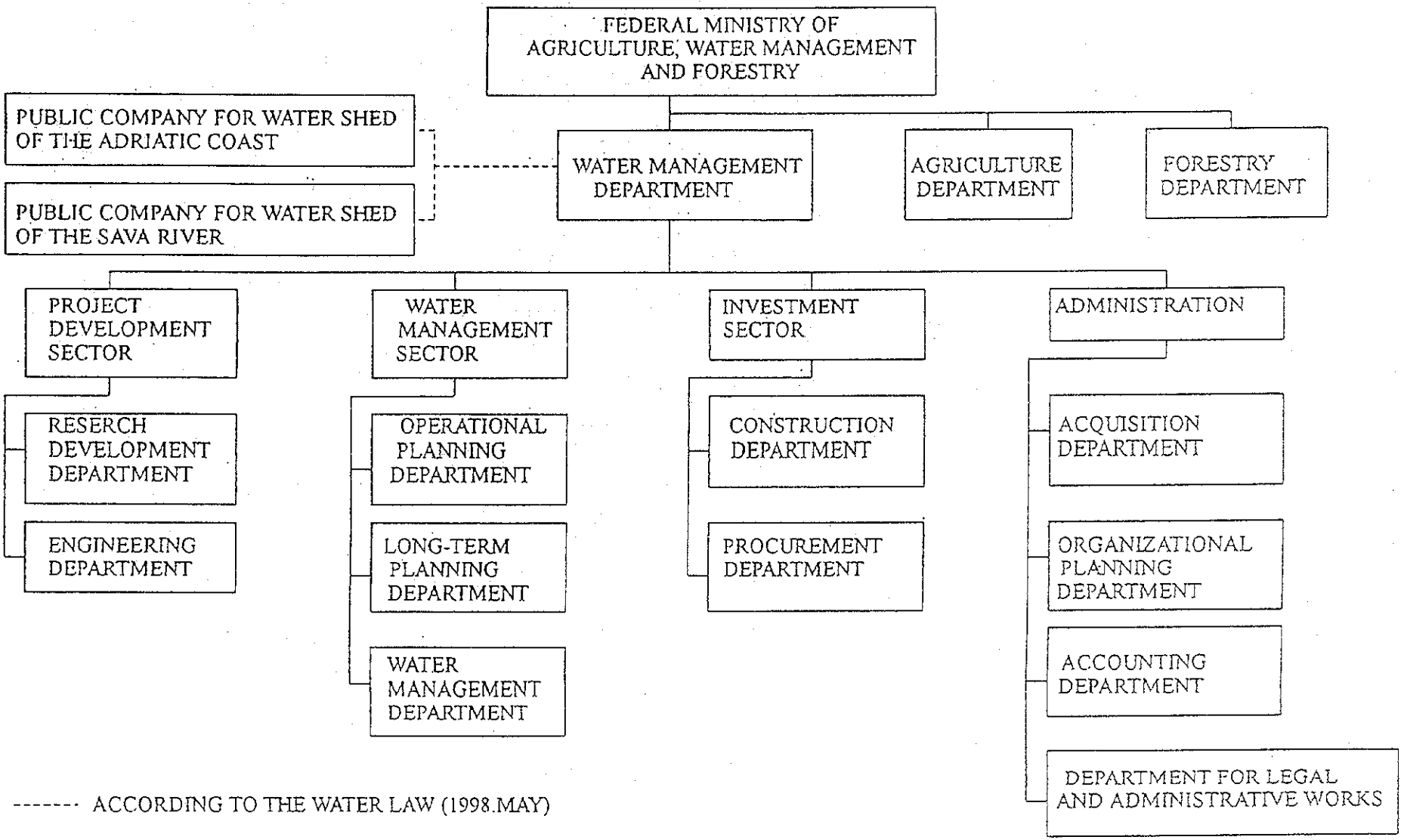
- THE FEDERTATION OF BOSNIA AND HERZEGOVINA –



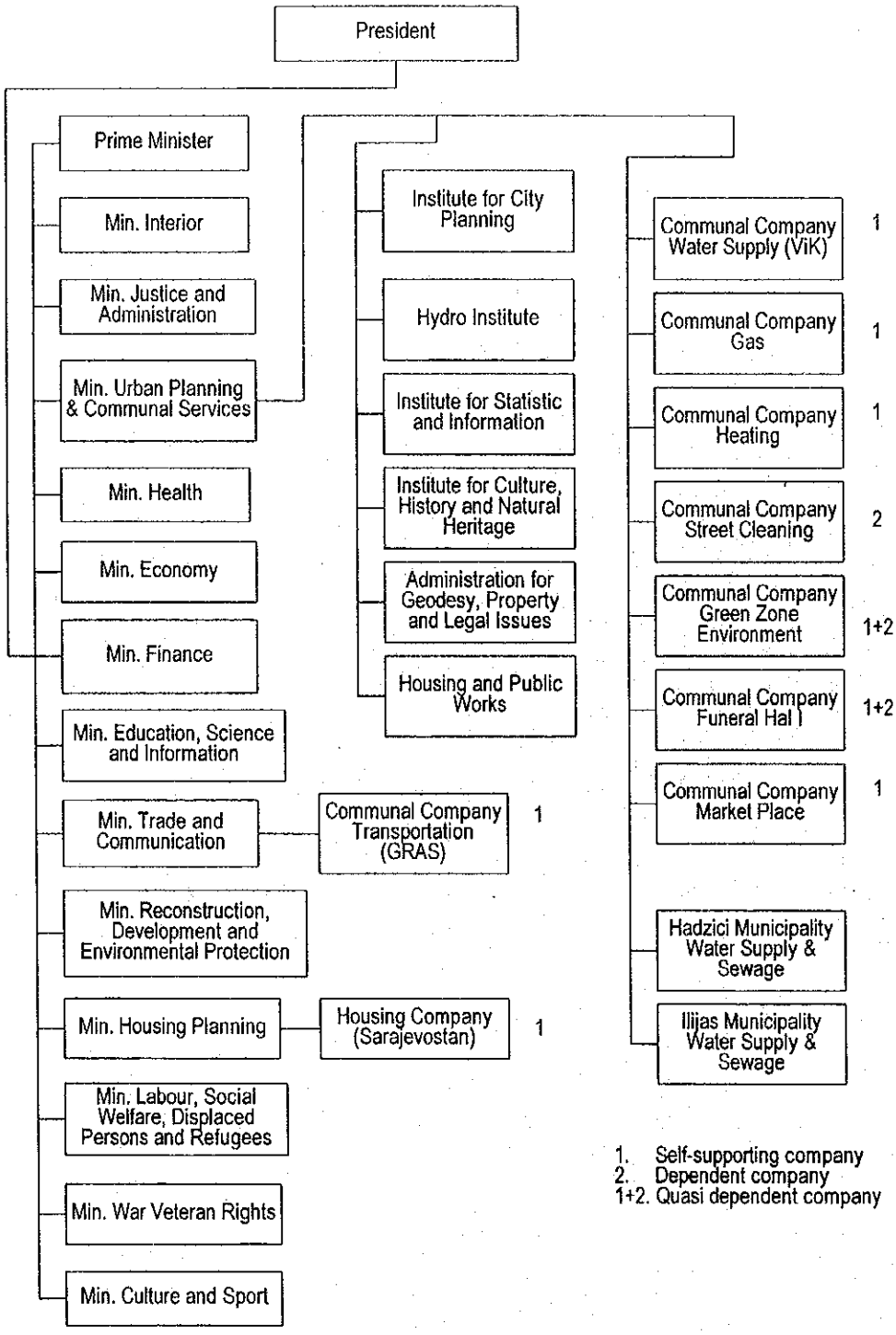


Figure S.7 MAJOR ADMINISTRATIVE FUNCTIONS OF SARAJEVO CANTON

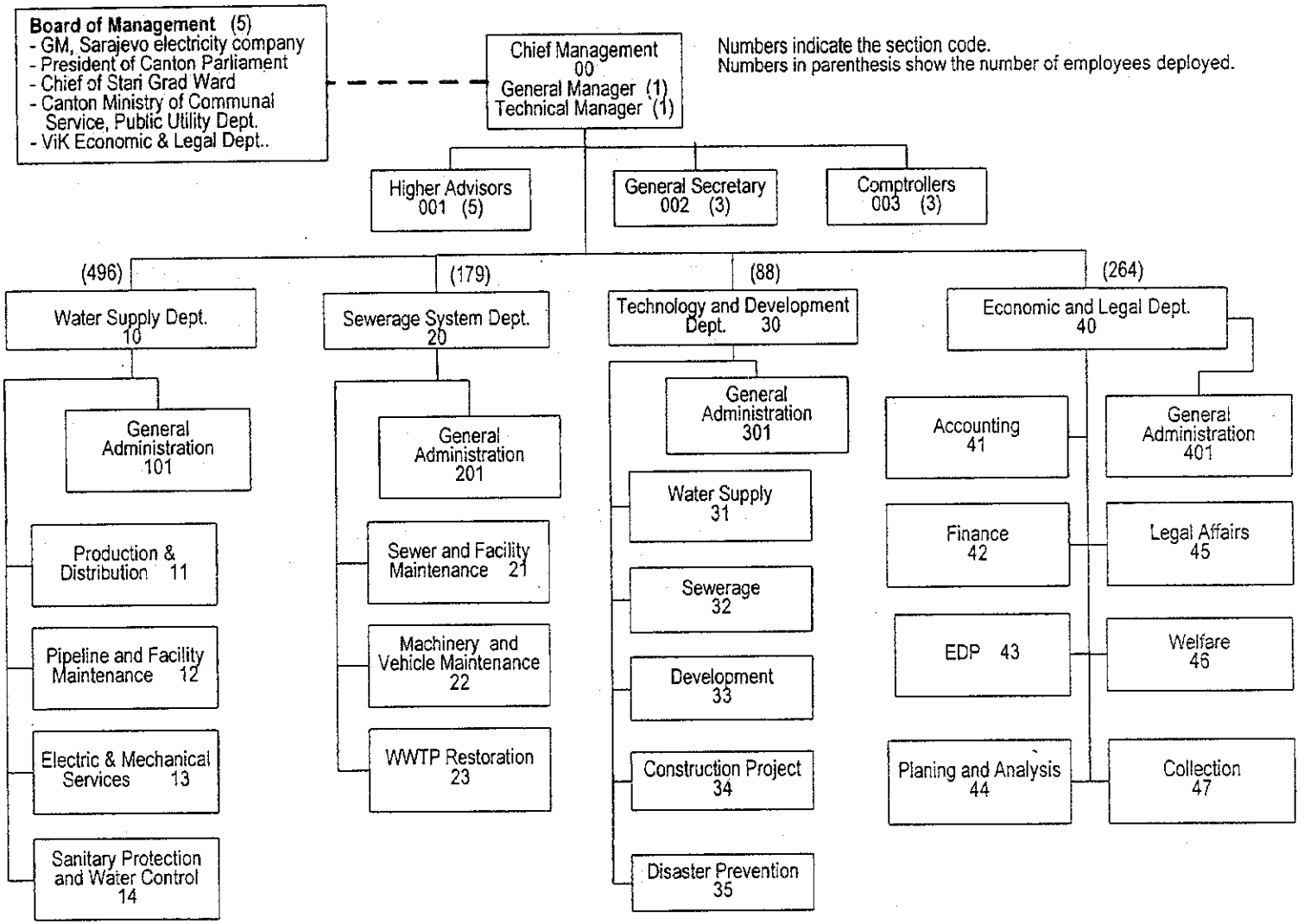


Figure S.8 VIK ORANIZATIONAL CHART

CHAPTER S1. INTRODUCTION

S1.1 BACKGROUND

The peace fulfilment conference held right after the war in Bosnia and Herzegovina was concluded in December 1995, with the international community's program of reconstruction the war damages that includes the Sarajevo WWTP.

Currently, the plant, which stopped operation since the war is inoperative due to extensive damages caused by the war and natural deterioration due to the absence of maintenance works. As a result, raw wastewater is being discharged into rivers without treatment. Therefore, to improve the environmental conditions and the quality of the receiving rivers, rehabilitation works by bringing back the Sarajevo WWTP into operation is imperative.

S1.2 OBJECTIVES OF THE STUDY

The objectives of the Study are the following:

(1) To conduct a feasibility study for the rehabilitation of the Sarajevo WWTP that contributes to the recovery of the sanitary and environmental conditions.
(2) To transfer technology on planning methods and skills to counterpart personnel in the course of the Study.

S1.3 SCOPE OF THE STUDY

The study area will cover the present urbanized area to include the sewerage planning area and the Sarajevo WWTP. However, the Kuwaiti Fund financed on-going project, "Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in the Canton of Sarajevo" will serve as basis for the Study. The target year for the urgent rehabilitation works is year 2000 and for the long term planning is year 2015. The Study will include the following:

(1) Collection and analysis of existing data and information.
(2) Assessment and analysis of the existing conditions of the WWTP and the sewerage system.
(3) Field survey on the quality and quantity of wastewater, receiving rivers, and natural conditions.
(4) Feasibility study and formulation of urgent rehabilitation plan for the WWTP.
(5) Feasibility study for the long-term planning of the WWTP.

CHAPTER S2. PRESENT CONDITIONS OF THE STUDY AREA

S2.1 NATURAL CONDITIONS

The Canton Sarajevo is located in the Southeast region of the Federation of Bosnia and Herzegovina (FBiH) at latitude 43.52° N and 18.26° E. It is the center of political, economic, educational and cultural activities in FBiH.

Gentle slopes at the city center, surrounded by mountains and rolling terrain characterize the geography of the study area. Two major rivers, Miljacka and Bosna drain the valley of Sarajevo. The average elevation in the midland valley area is about 500 m above mean sea level, while the mountain ranges are as high as 1,500 m.

Sarajevo has a very cold and snowy climate as low as minus 15° C experienced during November to March. Then, the temperature starts to rise in mid-year to as high as 30° C, especially during summer. The average precipitation in the city is about 900 mm annually.

S2.2 SOCIO-ECONOMIC CONDITIONS

The State of Bosnia and Herzegovina (BiH) is composed of two entities and one district, namely: the Federation of Bosnia & Herzegovina (FBiH) and the Serb Republic (RS), and the Brcko District. BiH is composed of 5 major institutions such as, three-member Presidency, the Council of Ministers, a bicameral Parliament, the Central Bank, and the Constitutional Court. Both the FBiH and RS have their own government.

The 1997 socio-economic condition of Canton Sarajevo is compared to the federal government as shown in the table below.

	BiH	FBiH	Sarajevo	Sarajevo/FBiH
Area (km^2)	51,197	26,111	1,277	5 %
Population (000 person)	3,600	2,200	326	15 %
GDP (KM Million)	5,803	4,189	1,379	33 %

The nominal GDP of Sarajevo represented as added value, grew 52 % in 1997, which signifies that most industries have grown dramatically since the end of the war. Principal industries of Sarajevo are manufacturing and mining, trade, public administration, education and culture, traffic and communication, and banking.

S2.3 POPULATION AND LAND USE

The historical and projected population of Canton Sarajevo, comprising of 9 municipalities and grouped into 3 sewerage zones is presented in the table below.

Based on the City Development Plan for the year 1986-2015 prepared by the City Planning, the land use of Sarajevo is categorized into 29 zones describing its usage. The residential zones are subdivided into 5 categories, namely: collective, mixed, individual, individual urban, and vacation houses. About 30 % of the developed areas of Canton Sarajevo are categorized as forest zone, with a few percentages as agricultural zones.

Municipality	Sewerage Zone	1981	1991	1996	1997	1998	2000	2010	2015
Stari Grad	Central Sarajevo	56,181	50,744	43,129	43,562	42,379	49,971	55,738	60,000
Centar		72,762	79,286	66,286	64,374	68,097	72,314	87,612	96,250
Novo S'jevo.		94,200	95,089	48,799	59,664	67,737	68,700	87,612	98,750
Novi Grad		80,559	136,616	95,399	101,090	103,115	120,271	151,188	167,500
Ilidza		57,243	67,937	31,755	40,107	41,442	37,500	51,963	58,750
Hadzici		20,952	24,200	23,870	17,684	19,653	22,814	23,675	25,000
Sub-total		381,867	453,872	309,238	326,481	342,423	371,570	457,788	506,250
Vogosca	Vogosca/ Ilijas	18,663	24,647	13,118	16,536	17,662	11,214	18,250	21,250
Ilijas		24,316	25,184	11,540	12,766	13,463	3,914	13,813	17,500
Trnovo	Trnovo	8,161	6,991	767	719	748	600	2,538	3,250
Sub-total		51,140	56,822	25,425	30,021	31,873	15,728	34,601	42,000
Total of Canton		433,037	510,694	334,663	356,502	374,296	387,298	492,389	548,250

S2.4 INSTITUTIONAL SET-UP

The BiH central government is officially called the Council of Ministers. Its role is confined to matters of foreign affairs, foreign trade, customs and monetary policy, civil affairs and communications. The Ministry of Foreign Affairs has a function of executing external borrowings as BiH. The Ministry of Economic Relations and Foreign Trade coordinates activities with both entities (FBiH and RS) in defining program of reconstruction in BiH.

The constitution of BiH provides substantial power on both entities. Accordingly, FBiH has its own president, bicameral parliament and government. FBiH also has responsibility for matters such as defense, internal affairs, police, economic and social sector policies, industry, environmental policies, reconstruction program, refugees and displaced persons, justice, tax and customs administration.

The Ministry of Agriculture, Water Management and Forestry is the competent ministry for water supply and wastewater management within FBiH. Under this ministry, and on the basis of FBiH's two watershed areas, two Public Companies for Watershed Area (PCWA) have been established. In terms of general environmental issues at the federal level, the Ministry of Urban Planning and Environment has the jurisdictional power.

Sarajevo Canton is economically and politically central among ten cantons of FBiH. Each canton has its own president, cantonal assembly and government. The cantons are responsible for all other matters not granted explicitly to FBiH, such as public services, housing, education, culture and social transfer expenditures.

Financial assistance to water supply and wastewater management operations is provided primarily by the local government, which are implies at cantonal and municipal levels. Contributions from the FBiH government also exist to certain extent through transfers to the cantons and municipalities.

S2.5 THE EXISTING WATER SUPPLY AND ITS DEVELOPMENT PLAN

The service area of the Sarajevo Water Supply comprises of 4 independent systems owned and operated by ViK, namely: Sarajevo Central System, Ilidza, Hadzici, and Trnovo.

Out of the total water production (2.62 m^3/s), about 97 % (2.55 m^3/s) of the water sources are groundwater from springs and wells and 3 % (0.07 m^3/s) is abstracted from streams. The Sarajevo Central System is supplied mostly from the Bacevo wellfield. A typical groundwater collection center consists of wells (boreholes) and a collection reservoir at ground level. Groundwater is of good quality, so only disinfection is applied before it is pumped to service reservoirs. Source from surface water is treated by chemical addition, coagulation, flocculation, filtration and chlorination. The 40 pumping stations including water collection centers are not equipped with emergency generators for use in case of power outages.

The transmission and distribution mains in Sarajevo is approximately 1,000 km comprising of cast iron, ductile iron and asbestos cement pipes. Majority of the pipes are old and with minimal maintenance that result to a large amount of leakage (about 65 % of total production) in the system. ViK replaced about 10 km of old leaking mains for each year in 1997 & 1998. A program for replacement of transmission and distribution mains is targeted at 20 km/year.

As of 1998, the 48,800 customers of ViK (92.5 % domestic and 7.5 % non-domestic users) are basically metered with diameters ranging from 13 mm to 150 mm. ViK does their own repair of the water meters.

The new Water Law (No. 1811) provides the formation of an integrated water management on a river basin wide basis. A single institution will be formed to develop, construct, operate and manage irrigation system, water supply and sewerage system. Although enacted in March 1998, there has been no material development on this law.

S2.6 THE EXISTING SEWERAGE SYSTEM

Majority of the canton population has access to the reticulated sewerage system. Based on the 1986–2015 Urban Development Plan for the Sewerage System of Canton Sarajevo, the population is serviced by three independent systems geographically divided into 3 sewerage zones, namely: Central Sarajevo, Vogosca/Ilijas, and Trnovo.

The Central Sarajevo Sewerage System managed by ViK, serves about 90 % of the population of Canton Sarajevo. Some parts of the collection system (particularly in Stari Grad and Centar) were constructed some 100 years ago; collecting both combined sanitary and storm water drainage. This system causes problems such as, overloading of sewers and accumulation of large amount of grit and foreign materials especially during heavy rains. However, ViK started reconstruction of the collection system to separate sewerage from storm water drainage. Basically before the war, sewage collected in this zone is treated by the Sarajevo WWTP before disposal into Bosna River.

The total length of the Central Sarajevo trunk sewer (collector) network as per the survey made is approximately 45.33 km with diameters ranging from 500 mm to a maximum of 2,000 mm. About 90 % of the collectors are of asbestos cement pipes, with 10 % constructed of concrete bricks some centuries ago. Generally, the trunk sewers are in good condition since no signs of leakage due to neither incrustation nor broken portion were sighted during the survey. However, accumulation of grit, sand and stones was noted several hundred meters upstream of the WWTP, which was one of the causes of the sewer blockages resulting to overflowing manholes in Butila. This excessive amount of grit was also noted as one of the

major problems during the operational years of the WWTP. Further discussion of the treatment plant will be done in **Chapter 4 of Main Report, Volume II.**

The Vogosca & Ilijas Sewerage Systems operated independently by the local enterprise of each municipality, serve mainly the population of the town centers. The unsewered areas dispose their sewage into septic tanks. Both systems collect a combined storm and sanitary wastewater that are disposed into the nearby rivers.

The Trnovo Sewerage Zone is beyond our scope due to the current political and geographical situation of the area.

S2.7 WATER QUALITY AND ENVIRONMENTAL CONDITIONS

The Miljacka and Bosna rivers are the main watercourses seriously affected by wastewater disposal in Sarajevo. The confluence of both rivers is several hundred meters from the WWTP. Due to the wastewater disposal upstream of the WWTP, both rivers are classified as Class II category and downstream as water quality deteriorates both are classified as Class III.

From the east, where it originates the Miljacka River flows through Sarajevo City where discharges into the river and pollution, generally takes place. The Bosna River originates at Vrelo Bosna (Bosna Springs) as crystal clear and beautiful stream. It becomes polluted with wastewater discharges from Sarajevo City drained by Miljacka River.

The result of the water quality survey indicates that the water quality of both rivers deteriorates further as they come close to the WWTP. As the flow rates in the river decreases, the water quality deteriorates further. Generally, the water quality of Miljacka River is not only affected by direct discharges from domestic and industrial waste but also from other Potoks (streams). According to the survey conducted in May 1990, these 33 Potok discharges into Miljacka River amount to a population equivalent of 127,133. The survey indicates that these Potoks are grossly polluted.

S2.8 OVERALL OPERATION OF VIK

On top of the ViK organization is the Board of Management, which is the decision making body of ViK. The day-to-day operation of ViK is managed by the General Manager assisted by his advisors and technical managers. The current organization of ViK is basically formed on functional basis, wherein 4 functional departments are existing, such as Water Supply, Sewerage System, Technology & Development, and Economic & Legal Matters.

As of December 1998, the total employee strength of ViK is 1,036, deployed to the different department, such as Water Supply (496), Sewerage (179), Technical (88), Economic (264) and waiting list (9). The WWTP is under the Sewerage System Dept. The current number of employees is about 20 % less than the pre-war level.

"Staff per thousand connection" is the indicator used to measure the staff productivity. Currently, ViK has 20 staff per thousand connections, which is more than the preferred 10. Therefore, it indicates possible redundancy of employees.

A typical household connected to both water and sewerage is charge at 1 KM/m^3 plus 10 % tax. Households that have damaged pipe or meter by war are charged flat rate at 20 KM/m^3 plus 10 % tax. Non-domestic users are charged at 2.6 KM/m^3. The tariff include both water and sewerage (WWTP charge is included) charges which has a ratio of 70:30.

Depending on direct costs incurred by ViK such as pipe material and excavation cost, the connection charge varies between KM 260 and KM 5,000. The same connection charge applies to sewerage, except for the direct costs that are usually 30 % higher than water connection fee.

Based on the financial records of ViK for the year 1996 to 1998, the key financial indicators, such as profitability – return on capital and assets are in the negative level. This is due to the post-war recovery stage of ViK, Canton Sarajevo, and BiH as a whole. Although, ViK still enjoys a strong financial support from the cantonal government.

S2.9 USER SURVEYS

A survey was conducted on the domestic and non-domestic users in Sarajevo to collect information such as, household income, company revenue, specific utility cost and more importantly in order to estimate the price of "willingness to pay" (WTP) by the users/consumers for the benefit of the WWTP. The WTP can be used as a measure to gauge the economic benefit of the project.

The surveys were based on the sampling approach in order for the results to be considered reasonable and sufficient to provide a general outline for economic analysis. The door to door and street surveys for domestic users, resulted to a very encouraging value of WTP in the amount of KM 3.0 to KM 4.1 per month.

For the non-domestic users, major non-domestic consumers of ViK water supply plus non-ViK water users but big wastewater discharger into the sewerage system were selected as sample candidates. Out of the 33 respondents, the average value in terms of the maximum additional increase in wastewater tariff rate their company/institution could afford to pay in case rehabilitation works of the WWTP is done is 42 %.

CHAPTER S3. REVIEW OF THE PREVIOUS STUDIES, PROJECTS AND REPORTS

Out of the 49 countries and 13 international agencies, Japan is the 4th largest donor for the reconstruction and development program of BiH. Out of the total US $ 386 million pledged by the government of Japan, US $ 111 million have already been completed and US $ 119 million are in implementation. The rehabilitation of the Sarajevo WWTP is among the projects funded by the government of Japan. Other projects by donor countries include the "Norwegian People's Aid Demining Program", "Kuwaiti Fund - Long Term Solutions of Water Supply and Wastewater Drainage and Treatment in the Canton of Sarajevo", and others.

The Kuwaiti funded project serves as the basis for this Feasibility Study, especially in examining the framework plan of the project. Aside from the demining project, the government of Finland also carried out reinstallation of about 500 m of diameter 300-800 mm sewer line in Sarajevo valued at DEM 0.48 million. The World Bank loaned approximately US $ 3 million for the rehabilitation of the trunk sewers. The International Red Cross donated vehicles to ViK, which include a vehicle for sewer maintenance.

Under the ViK funds the following are the projects being implemented/completed:

(1) Report "Elaborate on Restoration of the Sarajevo WWTP", which includes a detailed description and restoration concept for the treatment plant facility.
(2) Sewer Cleaning Project.
(3) On-going Cleaning Project of the WWTP.
(4) Independent Surface Development Project for the districts of Vogosca and Alipasno.

The Canton Sarajevo also subsidized a project at a cost of DEM 1.1 million for the surface development in the districts of Ilidza and Faletici.

The original loan for the Sarajevo WWTP was extended by the World Bank for the amount of US$ 35 million, out of which roughly US$ 25 million is still outstanding as of 1997. The present borrower is not ViK, but BiH.

CHAPTER S4. ASSESSMENT OF SARAJEVO WWTP

The second field survey and assessment of the Sarajevo WWTP was carried out on the 25th May to 3rd August 1999. The major purpose of the fieldwork is to assess the present condition of the existing facilities in order to formulate the most feasible alternative for the plant's rehabilitation.

Several tests and appropriate actions were performed during that period, which were mainly categorized into aspects such as civil, architectural, mechanical and electrical. The detailed appraisal of each existing treatment facilities and auxiliaries does not limit only to the visual condition survey and photo-documentation, but also include testing of the present condition on important items in order to assess the capacity, stability and a sound operability of the plant for the long term period.

S4.1 DESCRIPTION AND ASSESSMENT OF EXISTING TREATMENT PROCESS

The parameters used in the 1979 original design of the treatment process is assessed and compared by the JICA Study Team to the forecasted scenario in the year 2000 and 2015. Table S4.1 below shows the comparative analysis of the design parameters.

Table S4.1 COMPARATIVE ANALYSIS OF BASIC DESIGN PARAMETERS

DESIGN CRITERIA	ORIGINAL DESIGN			JICA STUDY TEAM FORECAST		
	Influent		Effluent for Stage 1 & 2	Influent		Effluent for Year 2000 & 2015
	Stage 1 – 1979	Provision for Stage 2		Year 2000	Year 2015	
Population	600,000	900,000		371,600	506,300	
Average dry weather flow (ADWF)	186,000 m^3/d 2.15 m^3/s	300,000 m^3/d 3.47 m^3/s		120,000 m^3/d 1.39 m^3/s	196,200 m^3/d 2.27 m^3/s	
Peak wet weather flow (PWWF)	12,180 m^3/h 3.55 m^3/s			7,136 m^3/h 1.98 m^3/s	11,667 m^3/h 3.2 m^3/s	
BOD load (kg/day)	36,000	54,000		22,294	37,969	
BOD concentration (mg/l)	194	180	20	186	200	20
TSS load (kg/day)	48,000	72,000		29,726	48,094	
TSS load (mg/l)	270		30	248	245	30
Fecal coliforms (MPN/100 ml)						200

The above comparison indicates that the forecasted scenario of the Study Team is much more conservative than the original data used in 1979 design in terms of flows and loads. Although there is a 5 % increase in the forecasted ADWF and BOD load for the year 2015, generally all the existing treatment process and facilities is sufficient enough to deal with the expected raw water quality and quantity up to the year 2015, except for the secondary clarifiers. Additional 2 tanks and effluent disinfection will be required to deal with the expected increase in flow and stricter water quality regulations on fecal coliform.

The most notable problem that had caused trouble to the WWTP operation not only to the aerated grit chamber but to the treatment process as a whole is the very large volume of grit present in the raw wastewater. The existing aerated grit chamber is unable to deal with the very large quantities of sand and gravel especially during peak wet weather flows. This

phenomenon, which may have been overlooked during the original design calculation of the treatment process, was also one of the factors that contributed to the plant breakdown during the operational period of the WWTP.

S4.2 CIVIL WORKS

The liquid retaining structures of the WWTP did not sustain any major damage caused by the war. However, signs of deterioration to the structures were mainly due to the following:

(a) weathering of all exposed surfaces,
(b) extensive cracking in walls with signs of leakage and previous repairs,
(c) poor workmanship in construction joints and concrete finishes,
(d) insufficient concrete cover to the reinforcement and rust stains, and
(e) exposed reinforcement that leads to corrosion.

Several tests were carried out to the concrete structures in order to assess its strength and durability and to evaluate leakage that include the following:

(a) Carbonation Depth – done by treatment of the concrete surface with phenolphthalein indicator on the freshly exposed surface on site. Results indicate a high risk of steel corrosion in areas where the concrete cover is less than 20mm.
(b) Concrete Hardness – done by the use of the Schmidt Rebound Hammer on site. The results show that the concrete has an average rebound number, R = 41, which corresponds to a cylinder compressive strength of about 350 kg/cm^2.
(c) Concrete Compressive Strength Test – concrete core samples were taken and subjected to compression test in the laboratory of IMK. The test indicates that concrete has an average compressive strength of about 320 kg/cm^2.
(d) Tensile Stress Test on Steel – specimen samples of the reinforcement were taken and subjected to ultimate tensile strength at failure in the laboratory of IMK. The test shows that the steel is of acceptable quality, in good condition and the corrosion is insignificant even in areas where it is exposed without concrete cover.
(e) Sludge (Underground) Piping Material Test – cut section samples were tested using the Brinell method to evaluate the ultimate strength. The test shows that the ultimate strength of the pipe is about 5,500 kg/cm^2, a general use structural steel with middle stiffness. The pipe samples from 4 locations are in excellent condition.
(f) Leakage Test – the liquid retaining structures were filled with water where the drop in water level was monitored after 2 days of stabilization. The results show that leakage in all structures tested was substantially more than the acceptable standard and coming mostly from the expansion and construction joints and from the crack repairs previously done to the structures.

S4.3 ARCHITECTURAL WORKS

The general assessment on the architectural aspect of the building and facilities can be summarized as follows:

(a) The existing strength of the concrete super structure can be classified as in good condition.
(b) Most of the exterior and interior finish have floated, stained and corroded.

(c) Leakage on the roof can be seen from inside of the building and through the traces of water leakage.
(d) Most of the fittings are missing while those that are existing are either broken or corroded.
(e) Heating, ventilation and lighting equipment are almost entirely broken, corroded or missing.
(f) Sanitary equipment is only available to a few building.
(g) Fire fighting equipment available to some buildings are corroded or broken.
(h) Traces of flooding can be seen on the walls of the building.

S4.4 MECHANICAL WORKS

The assessment for the mechanical aspect of the WWTP can be summarized according to the facilities as follows:

(a) Main Inlet Chamber (Facility 0) – the entire sluice gate facility is to be reconstructed since most of the parts are either broken or missing.
(b) Raw Water Pumping Station (Facility 1) – all 4 pumps can be rehabilitated by replacing the parts, except for the screws and shaft. The screws and shafts require anti-rust protective painting and readjustment.
(c) Screening Station (Facility 2) – all 4 set of coarse and fine screens are heavily damaged and most parts are missing that complete replacement will be necessary.
(d) Aerated Grit Chamber (Facility 3) – the whole grit removal and aeration system is heavily damaged and corroded that complete replacement will be necessary.
(e) Primary Sedimentation Tank (Facility 4) - the mechanism for sludge collection and scum skimmer are both damaged that replacement will be required. The corroded parts of the diagonal beams need replacement. All bolts and nuts have to be replaced with stainless steel to avoid corrosion.
(f) Aeration Tank (Facility 5) – out of the 36 aeration turbines, 3 are without drive motors, 2 are in unstable installation, 2 have broken oil piping and 10 have broken coupling. Therefore, only 19 units of aeration turbines were tested for continuous 2 hours load test. The result indicates that all 19 tested aeration turbines can be used.
(g) Final Sedimentation Tank (Facility 6) – the drive motors of 4 tanks are missing while the existing drive heads are partially damaged. The structure's mechanisms are partially rusted with all bolts and nuts heavily corroded. The structure's mechanism can be used provided that appropriate protective measures are done to include cleaning, application of anti-rust protection painting, and replacement of all steel bolts & nuts with stainless steel. The central sliding sleeves and the drive units are to be replaced with new one.
(h) Recycled Sludge Pumping Station (Facility 8) – the screws and shaft of both pumps are in good condition except that it will require readjustment and application of anti-rust protection painting especially at the edges. The drive units and foot bearings need to be replaced with new one.
(i) Primary Sludge Pumping Station (Facility 9) – the pumps are heavily damaged and no drive motors exists. All pumps including drive motors and auxiliaries are to be replaced with new one.
(j) Sludge Thickener (Facility 10) – the drive motors of both tanks are missing while the existing drive heads are partially damaged. The structure's mechanisms are partially rusted with all bolts and nuts heavily corroded. The structure's mechanism can be used

provided that appropriate protective measures are done to include cleaning, application of anti-rust protection painting, and replacement of all steel bolts & nuts with stainless steel. The drive units are to be replaced with new one.

(k) Thickened Sludge Pumping Station (Facility 11) – the pumps are heavily damaged and no drive motors exists. All pumps including drive motors and auxiliaries are to be replaced with new one.

(l) Sludge Digester (Facility 12) – the heat exchangers used in heating the sludge are heavily damaged that replacement with new units is imperative.

(m) Boiler House (Facility 13) – the 3 pumps that are installed in the boiler house for sludge re-circulation are heavily damaged. All 3 pumps including drive motors and auxiliaries need to be replaced.

(n) Gas Compressor Station (Facility 14) – a total of 6 gas compressors are installed in this building. Three are used for re-circulation in sludge mixing and 3 for transporting digested gas from storage tank to the power generator. Since all 6 gas compressors are heavily damaged replacement will be necessary.

(o) Gas Storage Tank (Facility 15) – the roof and floating guide assembly require application of anti-rust protection painting. Service piping and auxiliaries need new replacement.

(p) Homogenised Sludge Holding Tank (Facility 16) - the drive motor of this tank is missing while the existing drive head is partially damaged. The structure's mechanism is partially rusted with all bolts and nuts heavily corroded. The structure's mechanism can be used provided that appropriate protective measures are done to include cleaning, application of anti-rust protection painting, and replacement of all steel bolts & nuts with stainless steel. The drive unit needs replacement.

(q) Sludge Pumping Station (Facility 17) – all the 5 pumps including accessories except for the casing are missing. Part of the transmission mechanism and reducers were also dismounted. All 5 sets of pumps need to be replaced.

(r) Sludge Dehydration (Facility 18) – all the 5 filter presses to include electrical motors and transmission mechanisms, automatic system, filter clothes and auxiliaries require new replacement due to severe damage. The overhead crane can be utilised provided that appropriate measure to include cleaning, application of anti-rust protective painting and readjustments are done. The cables and controls need new replacement.

(s) Air Blower Room (Facility 19) – three complete sets of diffused aeration system for the grit removal facilities are heavily damaged/missing and require new replacement.

(t) Power Station (Facility 20) – due to the long standstill condition and disastrous damage of the diesel engine generators, new replacement will be necessary.

(u) Service Water Pumping Station (Facility 24) – the 2 smaller capacity pumps need new 22 kW motors. The 2 other bigger capacity pumps with 37 kW motors can be used provided that appropriate repairs, such as cleaning, replacement of bearings and rewinding are done. All other accessories such as wiring and controls are to be replaced.

S4.5 ELECTRICAL WORKS

The assessment of the electrical aspect of the WWTP is summarised as follows:

(a) Electric Power Supply System

From the Electric Distribution Sarajevo (EDS), the power to the WWTP is supplied through the Azici and Rajlovac Substation. The electric power supply system within the plant consists of the Power Station (Facility 20) and Substation (Facility 21).

Two generators in the power station are heavily damaged and require new replacement. All other equipment and auxiliaries such as transformers, switch gears, control panels, cables, etc. need new replacement, too. At the substation, all electrical equipment to include transformers, control panels and cables must be newly replaced.

(b) Electric Motor

Out of the 47 total motors that were found existing in the plant facilities, only the 19 motors for the aeration turbines qualified for continuous 2 hours on-load test. All the rests failed the criteria for testing, such as structural stability, and eletro-mechanical soundness of the motors. Therefore, the remainder of the non-tested existing motors are to be newly replaced due to corrosion and damages inflected on the machines. All other electric motors that were found missing in the facilities such as the pumping stations, compressor/blower stations, screening stations, etc. are to be replaced.

(c) Control Facilities

Due to the severe damage inflected to the Central Control Equipment and 9 Local Control Panels, replacements to these equipment including accessories will be necessary.

(d) Measuring Equipment

The plant facilities need new measuring equipment since the units previously installed are either missing or heavily damaged. The Flow Metering (Facility 7) requires new measuring instruments, too.

(e) Cabling

All high tension (HT) and low tension (LT) cables are to be newly replaced due to severe damage.

CHAPTER S5. TREATMENT PROCESS ALTERNATIVES

S5.1 REHABILITATION COMPARED TO RECONSTRUCTION

Obviously, the cost of building a new treatment plant serving a population of about 600,000 people would be more costly than rehabilitating the existing WWTP.

Based on the preliminary cost estimate, the total cost for the plant rehabilitation to include repair/reconstruct of civil structures, replacement of most of the M&E facilities and construction of new pre-treatment and boiler facilities is estimated at about 76 million DEM. The cost for a new treatment plant of this size (excluding demolition cost) is roughly about 400 million DEM.

S5.2 NEW PRELIMINARY TREATMENT FACILITIES

The very serious problem that had caused trouble to the WWTP operation not only to the aerated grit chamber but also caused blockages to the screw pumps and the screens are the very large volume of coarse grit present in the raw wastewater. Improving the grit removal facility will not solve the problem since blockages also occur upstream at the screens and screw pumps.

Therefore, the only logical solution is to install pre-treatment and pre-screening facilities upstream of the Raw Water Pumping Station. These facilities will consist of rectangular, horizontal flow grit channels to remove heavier grit particles and sets of coarse and medium screens.

S5.3 COMPARISON BETWEEN SURFACE AERATORS AND DIFFUSED AIR SYSTEM

The option for providing air to the activated sludge treatment process was evaluated between the choice of rehabilitating and using the existing surface aerators and construction/installation of a new diffused aeration system. Several criteria were used in the comparative evaluation, such as cost-effectiveness, system compatibility, operational flexibility and reliability, environmental quality and power requirement.

The result of the comparison indicates that it is more technically and financially viable to use the existing surface aerators.

S5.4 SLUDGE TREATMENT ALTERNATIVES

Due to the damage of its facilities, the view of replacing the existing sludge treatment process with a better technologically advanced and cost effective alternative was evaluated using the same criteria as above.

Among the different sludge treatment methods, the option of lime stabilization was closely considered as an alternative replacement. However, due to the environmental regulations on sludge volume for disposal to landfill sites, the generated volume of sludge plus lime makes it prohibitive for disposal. Therefore, the existing anaerobic digestion process must be rehabilitated.

S5.5 SLUDGE DEWATERING ALTERNATIVES

Due to the damage of the sludge dewatering facilities and environmental regulations on sludge disposal, alternative sludge dewatering options were evaluated.

Among the sludge dewatering methods, the option of using centrifuge was considered as an alternative replacement to the damaged belt filter presses. Although, the centrifuge produces drier sludge cake with a cleaner operating environment, the result indicates that it is more feasible (in terms of capital investment and power requirement) to rehabilitate the existing belt filter presses.

CHAPTER S6. REHABILITATION PLAN OF THE WWTP

S6.1 URGENT REHABILITATION WORK

Primarily, the Feasibility Study was done on the concept of rehabilitating the WWTP by bringing it back to the pre-war condition. Hence, the assessment works have done in order to bring the each facility, including mechanical and electrical equipment, back to the pre-war capacity. Based on the result of assessment works, the preliminary design has done.

As previously discussed in the previous sections, the same basic design data presented in **Table S4.1** will be used in the rehabilitation plan of the WWTP. For urgent rehabilitation in the year 2000, the urgent works include the following:

(a) Pre-treatment Facilities – this includes the construction of 3 rectangular, horizontal flow grit channels to remove heavier grit particles and 3 sets of coarse and medium screens.

(b) Existing Inlet Works – rehabilitation to the civil structures are necessary, such as repair of the expansion/construction joints, sealing of the cracks, appropriate protective layer to the exposed reinforcing bars and coating of the inside walls. Most of the electrical and mechanical equipment are to be newly replaced to include the screens, aeration and grit removal facilities. The screw pumps and motors can be rehabilitated by cleaning, overhauling and application of protective measures.

(c) Secondary Treatment Facilities – the same method of rehabilitation works as above will be required for the civil structures of these facilities. However, new supplemental concrete slab and walls is essential to reinforce the deteriorated portion. Seventeen new motors including gear boxes will be required for the surface aeration turbine and the rest of the 19 can be used. New drive motors are essential for the sedimentation tanks scrapper mechanisms.

(d) Sludge Treatment Facilities – the same manner of rehabilitation works as above will be done for the civil structures of these facilities. Appropriate heat-retaining insulation and anti frozen materials will be required for the digestion tanks and other sludge treatment facilities. New mechanical & electrical equipment for sludge dehydration, recirculation and gas collection systems are necessary to replace the heavily damaged existing equipment.

(e) Building Facilities – rehabilitation works on the buildings should continue to complete what the ViK had started. A new building for the boilers & engine generators will be constructed close to the sludge digesters.

S6.2 PRELIMINARY DESIGN FOR CIVIL WORK

The proposed plant layout for the year 2000 is shown in **Figure S.1** with the process schematic shown in **Figure S.2 and S.3**. The preliminary design for the year 2000 include new pre-treatment facilities with road extensions and new boiler & engine generation building. For the year 2015, includes 2 additional final sedimentation tanks and optional disinfection and odour control facilities.

The most significant rehabilitation works to civil structures are the concrete structure repairs, which include the following activities:

(1) Sealing of cracks and construction joints.
(2) Repair of expansion joints.
(3) Treatment of corrosion and reinforcement protection.
(4) Rehabilitation of weathered surfaces.

S6.3 PRELIMINARY DESIGN FOR ARCHITECTURAL WORK

As discussed in the previous sections, new facilities will be constructed for the pre-treatment and boiler & engine generators. The basic architectural plan and section of these facilities and all other facilities are shown in **Drawings A-1** to **A-20, Vol. IV**.

Due to the absence of the Bosnian Architectural Standard, the German Standard will be used in the design. Basic design criteria, such as snowfall, wind velocity soil capacity and type of subsoil, temperature and frost data prevailing in Sarajevo will be used. A reconstruction plan for each facility in terms of architectural aspect is presented in **Table 8.3.3, Vol. II**.

S6.4 PRELIMINARY DESIGN FOR MECHANICAL WORK

The preliminary design for mechanical work can be summarized as follows:

(1) Proposed Pre-treatment (Facility 0): Grit Channels & Screens – installation consists of 3 horizontal flow grit channels equipped with grab bucket having a capacity of 0.30 m^3, and followed by 3 sets of 50 mm automatic coarse screens and 25 mm automatic medium screens of 2.0 m width each.
(2) Raw Water Pumping Station (Facility 1): Drive Units – the 4 sets of drive units including auxiliaries for lubrication are to be replaced. The screws and shafts require complete anti-rust protection painting and readjustment.
(3) Screening Station (Facility 2): Fine Screens – the 4 existing sets of coarse and fine screens will be replaced with 4 sets of fine screens with 6 mm bar opening of 1.5 m width and alternately arranged for easier maintenance.
(4) Aerated Grit Chamber (Facility 3): Sand Trap Bridge & Aeration System – a new sand trap bridge equipped with mammoth pumps having "jet mix suction" is recommended. Anti-frozen countermeasure along the concrete rails of the bridge with the installation of electric heater sheets is necessary during winter. The aeration system will be replaced with new one.
(5) Primary Sedimentation Tank (Facility 4): Drive Motors – two new sets of drive motors with 1.5 kW traction type thickeners are required. The structure's mechanism needs cleaning and application of anti-rust protective painting. All bolts and nuts shall be replaced with stainless steel.
(6) Aeration Tank (Facility 5): Surface Aeration Turbines – seventeen motors for surface aeration turbines of 37 kW capacity are required. All 36 turbines will be reinstalled properly in a steel channel beam structure, accurately leveled and rigidly fastened to avoid excessive vibration.
(7) Final Sedimentation Tank (Facility 6): Drive Motors – four new sets of drive motors with 0.75 kW center drive thickeners are required. The structure's mechanism needs cleaning and application of anti-rust protective painting. All bolts and nuts shall be replaced with stainless steel.
(8) Flow Metering (Facility 7): Flow Meter – new installation of flow meter with transducer is required.

(9) Recycled Sludge Pumping Station (Facility 8): Drive Units – two new sets of drive units with capacity of 200 m^3/hrs. * 100 kW and foot bearings including auxiliaries for lubrication are to be replaced. The screws and shafts require complete anti-rust protection painting and readjustment.

(10) Primary Sludge Pumping Station (Facility 9): Torque Flow Type Pumps – two new sets of pumps with motors of capacity 5.0 m^3/min * 15 kW and auxiliaries are necessary.

(11) Sludge Thickener (Facility 10): Drive Motors - two new sets of drive motors with 1.5 kW center drive thickeners are required. The structure's mechanism needs cleaning and application of anti-rust protective painting. All bolts and nuts shall be replaced with stainless steel.

(12) Thickened Sludge Pumping Station (Facility 11): Torque Flow Type Pumps – two new sets of pumps with motors of capacity 1.0 m^3/min * 22 kW and auxiliaries are necessary.

(13) Sludge Digester (Facility 12): Gas Mixing – three sets of gas mixing facilities with 3.75 m^3/min * 11 kW sludge pump and auxiliaries are to be replaced.

(14) Boiler House (Facility 13): Boilers and Auxiliaries – two sets of boiler with capacity of 1,300,000 kcal/hrs. * 110 °C * 6 bars including sludge recirculation pumps, heat exchangers and all auxiliaries are required.

(15) Gas Compressor Station (Facility 14): Compressors – six sets of new compressors are necessary with the following specifications:

3 sets for mixing digested gas:	582 N-m^3/hrs. * 2.0 bars * 37 kW
3 sets for transporting digested gas:	400 N-m^3/hrs. * 2.2 bars * 30 kW

(16) Gas Storage Tank (Facility 15): Service Piping – new service pipes and auxiliaries are to be installed. The roof and floating guide mechanism need repairs and application of anti-rust protective painting.

(17) Homogenized Sludge Holding Tank (Facility 16): Drive Motors - one set of new drive motors with 1.5 kW center drive thickener and picket are required. The structure's mechanism needs cleaning and application of anti-rust protective painting. All bolts and nuts shall be replaced with stainless steel.

(18) Sludge Pumping Station (Facility 17): Moineau Pumps – five new sets of 28 m^3/hrs. * 1.5 kW capacity pumps are necessary.

(19) Sludge Dehydration (Facility 18): Belt Filter Press – five new sets of filter presses, 3 m width * 140 kg/m-hrs. filter capacity * 1.5 kW and accessories are required.

(20) Air Blower Room (Facility 19): Blowers – three sets of blowers, 13 N-m^3/min * 1 bar * 10 kW including accessories are required.

(21) Power Station (Facility 20): Diesel Engine for Power Generation – two sets of generators with 640 kW capacity diesel engine are required.

(22) Service Water Pumping Station (Facility 24): Centrifugal Pumps – two sets of motors for the centrifugal pumps of capacity 0.84 m^3/min * 22 kW and auxiliaries are required. The motors of the 2.1 m^3/min * 37 kW pumps need repairs to include replacement of bearings and rewinding.

S6.5 PELIMINARY DESIGN FOR ELECTRICAL WORK

Taking into account the maximum excess gas available for electric power generation during summer at 12,600 N-m^3/day, which is equivalent to about 1,140 kW generating capacity, will

require two units of engine generators at 640 kW each. This corresponds to the existing engine generators at the Power Station that needs new replacement.

During winter when the excess gas available is lesser equivalent to 22,750 kW-hrs. the engine generators could only supply about 40 % of the total power requirement of the WWTP (55,000 kW-hrs.). Thus, the shortage will be supplied by EDS.

Since the power demand for the rehabilitation plan is almost the same as during the operational period, new replacement of the damaged electrical equipment and facilities including the generators, HT switch gears, transformers, cables controls and measuring equipment will be sufficient using the previous design idea.

S6.6 IMPLEMENTATION PLAN

From the conclusion of this feasibility study, the implementation programme will take approximately 2 ½ years to complete the rehabilitation works of the WWTP, starting from detail design up to commissioning. Sufficient time will be necessary in the procurement of the mechanical and electrical equipment, since these are not locally available.

S6.7 OPERATION AND MAINTENANCE

Serious operational and maintenance problems previously encountered during the operational period of the WWTP will be rectified with the proposed rehabilitation plan. However, the operation of the WWTP requires well-trained and efficient operators familiar not only with the peculiarities of the sewer system, but also with the characteristics of the wastewater.

Regular monitoring of the treatment processes is imperative to effectively attain the required quality and quantity of the effluent as well as the sludge. More importantly, good housekeeping and following the required operational procedures for each facility will make the Sarajevo WWTP less troublesome and environmentally friendly.

S6.8 ORGANIZATIONAL PLAN

ViK is supposed to execute the Project. The proposed organizational structure for the WWTP is depicted in **Figure S6.1**. The number of staff to perform the required functions, either of WWTP's own or of external contractors totals to 40.

It is anticipated that difficulties may arise in the recruitment or the outsourcing process since qualified professionals in the field of wastewater treatment are neither sufficiently available within the existing ViK's organization nor in the local labor market. Thus, it is vital for the ViK staff, especially key personnel to go through proper training and acquire necessary skills and knowledge.

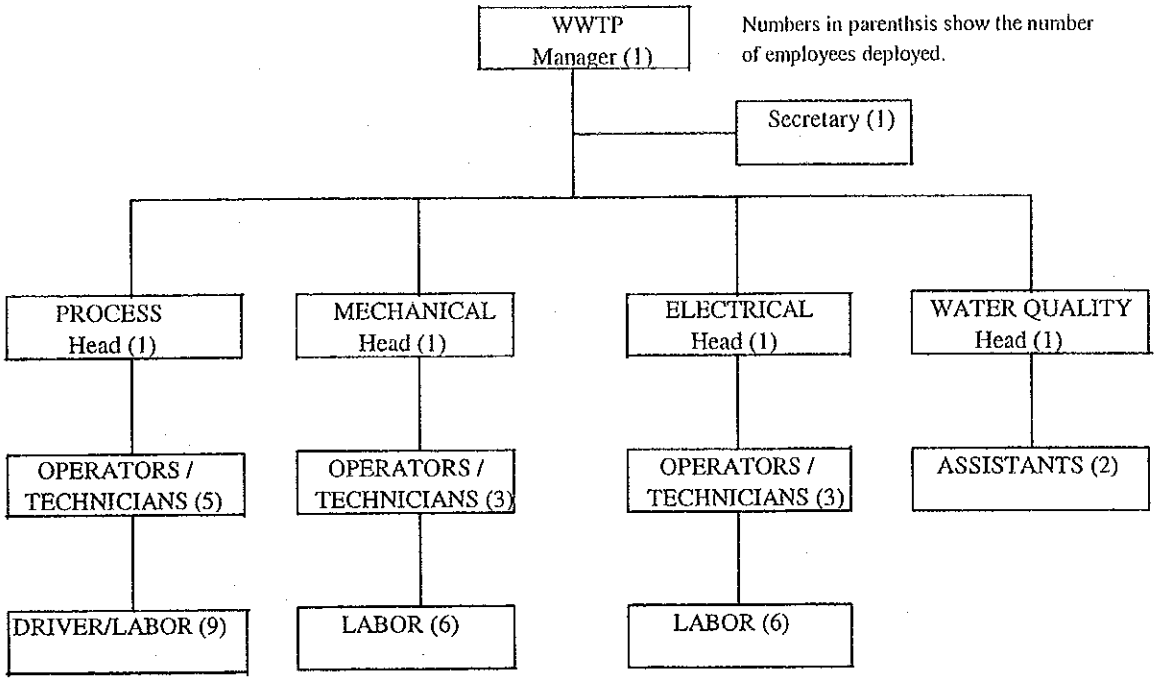


Figure S6.1 PROPOSED WWTP ORGANIZATIONAL STRUCTURE

That knowledge can be transferred to the ViK staff by foreign experts through training courses provided normally by bilateral technical assistance programs. It is therefore recommended that key WWTP operators be sent for training, for the agreed period of time in foreign countries.

The actual operation skills can be also provided in situ, through direct contact with personnel sufficiently experienced in the operation of WWTP. Use of external contractors/suppliers who can dispatch such capable engineers or technicians to the Project for a certain period is considered realistic for such objective.

S6.9 PRELIMINARY COST ESTIMATE

The total project cost is estimated at DEM 76 million. The construction cost amounted to DEM 64 million mostly on mechanical and electrical equipment, which are foreign supplied. The local component will cover mostly the cost on labor and materials. Ten percent (10 %) of the cost is allocated to contingency at DEM 6.9 million and engineering services at DEM 5.0 million.

The operation and maintenance cost, which includes the cost on salaries, chemicals, power consumption, depreciation and spare parts is estimated at DEM 5.8 million annually.

S6.10 FINANCIAL PLAN

In the financial planning for the proposed rehabilitation project, the following major assumptions are employed

(1) 85 % - foreign loan with interest rate at 1 % per annum payable in 40 years with 10 years grace period.

(2) 15 % - domestic loan with interest rate at 10 % per annum payable in 12 years with 2 years grace period
(3) The exchange rate of relevant currencies are set at DEM 1.00 = KM 1.00 = JPY 71.20.
(4) No foreign exchange loss or gain is expected.
(5) Income tax to the profits on the wastewater treatment operation will be levied at 30 %.
(6) During the construction period when the shortage of cash will inevitably occur due to the interest payments for loans, another bridge finance will be provided by other business accounts of ViK.

As a result, the Project is expected to maintain a positive cash balance throughout the project period.

CHAPTER S7. FINANCIAL AND ECONOMIC EVALUATION

S7.1 FINANCIAL EVALUATION

The financial viability of the project was analyzed using the discounted cash method by computing the financial rate of return (FIRR). The financial evaluation was done using the assumptions as follows:

(a) The capital investment cost excludes contingency cost but includes engineering cost.

(b) The operational life of the facilities and equipment is from year 2002 to 2026 (25 years).

(c) The wastewater treatment (WWT) rate revenues will be calculated on the basis of water consumption.

(d) The collection efficiency will improve as follows:

Year	1998 actual	1999	2000	2001	2002	2003 - 2026
Domestic user	50%	54%	58%	62%	66%	70%
Non domestic user	80%	82%	84%	86%	88%	90%

(e) A new tariff system will be introduced by the year 2002 to include the wastewater treatment rate. The proposed rate is as follows:

Year	1999	2000	2001	2002-2026
Domestic user				
Water	0.70	0.90	1.20	1.50
Sewage	0.30	0.40	0.55	0.70
Wastewater treatment	—	—	—	0.20
Total	1.00	1.30	1.75	2.40
Non domestic user				
Water	1.82	2.00	2.20	2.50
Sewage	0.78	0.90	1.05	1.20
Wastewater treatment	—	—	—	0.30
Total	2.60	2.90	3.25	4.00

(KM/m^3)

(f) The gap between the increase in net wage and other prices will diminish, but in real term the increase in net wage will continue until 2010.

(g) The average household size used for the project is 3.70 and 6 % of the household income is allocated for water and sewerage bills.

The FIRR of the Project was computed at 5.9 %. This indicates that the project will be financially viable if the cost of capital is less than 5.9 %. A capital investment consisting of 85 % foreign loan with interest rate of 1 % plus 15 % domestic loan with interest rate of 10 % will give a cost of capital of 2.35 %. Therefore the Project is financially viable.

The result of the sensitivity analysis indicates that the financial viability of the project is most sensitive to changes in rate revenue. And even if the rate revenue decreases by 20 %, the Project will be still viable.

S7.2 ECONOMIC EVALUATION

The economic benefit of the project was computed based on the amount of willingness to pay for the WWTP (consumer surplus) of both the domestic and non-domestic users in Sarajevo. The survey resulted to a consumer surplus of KM 3.0 to KM 4.1 for domestic users and 42 % more on top of the current sewage bill for the non-domestic users.

Due to insufficient economic data in computing for the coefficient factor in conversion, the value of economic cost is regarded same as that of the financial cost. The calculation of the economic evaluation resulted to EIRR = 17.4 %. A realization of the project can be justified due to the much higher EIRR compared to the 5.9 % FIRR.

S7.3 Wastewater Tariff and Collection Rate

With the consideration of financial and economic evaluation, and the cost of estimated operation and maintenance, it is recommended to raise the tariff rate gradually to the following level.

Domestic Users		
Water Tariff	1.5	KM/m3
Wastewater Tariff	0.7 + 0.2(for WWTP)	KM/m3
Non-domestic Users		
Water Tariff	2.5	KM/m3
Wastewater Tariff	1.2 + 0.3(for WWTP)	KM/m3

As described in section **7.1.1(8)**, the collection rate is currently about 50%. As the socio-economic situation is to be rehabilitated, the collection rate should be improved up to 70% by the year 2003.

CHAPTER S8. ENVIRONMENTAL IMPACT ASSESSMENT (EIA)

S8.1 GENERAL

Environmental impacts and countermeasures are described for the proposed plan for rehabilitation of the WWTP in respect to the relevant laws and regulations.

S8.2 LEGISLATIVE FRAMEWORK AND FUTURE DIRECTION

Currently, there are no laws or regulations on environment, which deals specifically with environmental impact assessment. However, several laws relative to environment were used as guidelines in the design/assessment of the WWTP project. The existing laws in BiH with details compiled in **Appendix N** include the following:

(a) Water Law
(b) Classification of Rivers
(c) Industrial Effluent Standard for Discharge to Public Sewerage System, and
(d) Air Pollution and Noise

Other proposed laws and environmental regulations, such as Environmental Protection Law, Solid Waste Management, governmental and EC directives and standards were also considered especially in the projections for future planning.

S8.3 MAJOR IMPACTS AND COUNTERMEASURES

The major impacts and countermeasures identified with the implementation of the WWTP are the following:

(a) Pollutant load reduction (positive impact) – water quality of the receiving water body will improve provided that effluent quality criteria, such as BOD at 20 mg/l and SS at 30 mg/l are maintained.
(b) Sewage sludge generation and disposal – large volume of sludge cake (107 m^3/day for year 2000 and 180 m^3/day for year 2015) will be added to the current solid waste volume disposed into the landfill site at Buca Potok. Drier sludge cakes are to be maintained and monitored.
(c) Industrial wastewater discharge into sewerage system – danger of toxic materials discharge into the sewerage system can be expected unless stringent measures and standards on industrial waste disposal are implemented.
(d) Odour generation – the odour generated from the plant facilities can be reduced and/or eliminated if good housekeeping and proper operational procedures are followed. The planned odour control facilities can be built when stricter controls become necessary in the future.

S8.4 RECOMMENDATION

The rehabilitation and re-commissioning of the WWTP will greatly improve the environmental conditions not only in Sarajevo but also the countries downstream of Bosna River and the surrounding environs. By taking the countermeasures very seriously will reduce negative impacts.

CHAPTER S9. CONCLUSION AND RECOMMENDATION

S9.1 CONCLUSION

(1) Basic Concept of the Project

Primarily, this Feasibility Study was conducted on the concept of rehabilitating the WWTP by bringing it back to the pre-war condition. Therefore, each facility including mechanical and electrical equipment was assessed to check the pre-war capacity and operating condition. Based on the results of assessment, preliminary designs have been done.

(2) Assessment Works

The first and second field assessment survey of the WWTP has identified the following matters:

1) If the Project is implemented, the treatment capacity of the WWTP may return to the condition before the War and can correspond to the planned sewage volume in 2015.
2) It became clear after applying calculation model that the civil and architectural structure of the wastewater treatment facilities has sufficient capacity. Repairs of construction joints, expansion joints, reinforced concrete protection, partial structural reinforcement are required. It is also concluded that most of the existing mechanical equipment can be used provided that cleaning, overhauling, and replacement of damaged and missing arts are done. Moreover, it is impossible to use electric facilities at all.
3) From the point of view of structural aspects, the sludge treatment facilities can be utilized provided that appropriate repair measures are applied in the same manner as the wastewater treatment facilities. Except for a total replacement of the sludge dehydration and boiler facilities, most of the existing mechanical equipment can be used provided that cleaning, overhauling and replacement of damaged and missing parts are done. However, total replacement of the electrical equipment is required.

(3) Alternative Rehabilitation Plan

Based on the assessment work, alternative rehabilitation plans are discussed and the most appropriate method was selected as follows:

1) Aeration Method Alternative
   In order to determine the most appropriate aeration method of an activated sludge treatment process, aeration system using surface aerators and diffused air system were compared. The great difference in both the methods is the electric power consumption. Although the higher power consumption of the surface aerators could be offset by the biogas available for power generation, the cost of retrofitting the existing aeration tank to accommodate the diffused air system is prohibitive. Therefore, the use of the existing surface aerator is the most suitable option for the Project.
2) Comparison of Sludge Treatment Process Alternatives
   A comparison between the existing anaerobic digestion and the direct sludge-dewatering process is carried out. In terms of the volume of the generated sludge cake for disposal in consideration with the existing condition of the landfill and

future regulations, the existing method is preferable. Besides, anaerobic digestion generates electricity, which is utilized in the operation of the WWTP.

(4) The WWTP Rehabilitation Project and Costs

Based on the assessment work, the fundamentals for WWTP rehabilitation were formulated as follows:

1) Installation of new pre-treatment and pre-screening facilities that will remove heavier grit particles before they are lifted by the screw pumps.
2) Existing facilities would be basically rehabilitated and improved to bring them back to the pre-war condition.
3) All mechanical equipment and electric facilities, except some parts of the clarifiers would be newly replaced.
4) As an architectural work, a new boiler room and generator building will be constructed, and the others will be rehabilitated.

Based on these improvement fundamentals, the preliminary design of the Project is formulated with the estimated cost as follows:

a) The Total Project Cost is estimated at DEM 76 million, consisting of the construction cost, and engineering plus contingency cost at DEM 64 million and DEM 12 million, respectively.
b) Annual O&M cost is estimated at about DEM 6.1 million.

(5) Economic and Financial Evaluation

Economic and financial evaluation is done with some assumptions in consideration with preliminary design and estimation, and O&M cost. The calculation shows Financial Internal Rate of Return (FIRR) of 5.9 %. The result indicates that the Project is feasible as a loan project, provided that revenue collection will be improved by raising tariff rates. The economic benefit of the Project is justified by the calculation of the Economic Internal Rate of Return (EIRR), which is 17.6 %. According to the result of questionnaire survey done on the domestic and non-domestic water uses in Sarajevo, recognition on the improvement of the environment and the water quality of Bosna and Miljacka Rivers was considerably high. The survey resulted to a relatively high amount of Willingness To Pay (WTP) at KM 3.0 to 4.1per household per month.

(6) Environmental Impact Assessment (EIA)

The start up of the rehabilitated WWTP may give some environmental impact, with the following countermeasure will be effective.

1) It is important to reduce the quantity and weight of precipitated sand and dewatered sludge cake for disposal. The compost treatment is a good option.
2) To discharge the industrial wastewater into the sewerage system would require the establishment of discharging standards and necessity pre-treatment facilities before disposal into the system.
3) Disinfection by chlorination is designed to satisfy future environmental regulation on fecal coliform.

S9.2 JUSTIFICATION

(1) Co-ordination with the Bosnian Development Plan

As mentioned in **Chapter 3**, the role of Japan's Official Development Assistance (ODA) is clear in "Priority Reconstruction Projects". Based on the framework of the plans, it is also clear that the WWTP rehabilitation plan is effective projects in cooperation with related projects implemented by other donor countries. Since other international organizations and donor countries have also indicated the same recognition, the implementation of the WWTP Rehabilitation is highly desired.

(2) Effect of Sewage Treatment on Environment Improvement

After completion of the Project, treated effluent will generate about 20 mg/l of BOD_5 and about 30 mg/l of SS, which are the discharging standards into the Bosna River. This condition will contribute towards the environmental of the Danube River.

The implementation of the project will likewise improve the water quality of the Milijaka River and the sanitary and environmental conditions of Srajevo. It would be possible that more houses and industries will be connected to the system as the sewerage area expands.

(3) Environmental Regulation

The population is expected to increase up to 40% and the economic situation to recover back to the pre-war level by year 2000. In such a situation, it is possible for BiH to be obligated to follow the strict European Standards on wastewater discharge into receiving waters. Hence, the a long-term project plan toward 2015 is proposed in this report.

S9.3 RECOMMENDATION

(1) Recommendation for Total Plan

In order to meet the environmental requirement and wastewater quality and volume for 2015 upgrading of the treatment plant facilities will be necessary. The followings are recommended for the Long - Term Plan.

1) Expansion of the Final Sedimentation Tank
   By the year 2015, two additional Final Sedimentation Tank will be necessary to follow the German Standard for surface loading rate, which attains its peak during rainy season. The capacity and other technical data on the two proposed tanks will be the same as the existing one. These will be constructed north of the existing facility as shown on **Drawing G-1**, of the Preliminary Design Drawings.

2) Chlorination System
   The fecal coliform count on the effluent will be possibly regulated by year 2015. Therefore, disinfection by chlorination is proposed as a countermeasure. This future standard (FC = 200/100 ml) can be attained by a chlorine dosage of 8 mg/l

3) Odour Control Measure
   Considering a safe, sanitary and environmentally friendly working condition, Odour treatment will be necessary in the existing and proposed preliminary treatment facilities.

(2) Human Development

It is strongly recommended to assign process engineers, maintenance engineers and water quality specialist in the operation of the WWTP. A consistent program for human resources development and training is indispensable based on the Mid-Term Plan.

(3) Outsourcing of Operation and Maintenance

The contract with constructors of the Project should include the training program of local staffs for operation and maintenance during the first year of the WWTP operation. Thereafter, it is recommended to have partial outsourcing on manpower contract for the operation and maintenance.

Since the WWTP operate as a system, following strongly the daily routine work and schedule, operation and maintenance manual are especially important for improvement of the treatment efficiency.

(4) Increase in Tariff and Collection Rate

With the consideration of financial and economic evaluation, and the cost of estimated operation and maintenance, it is recommended to raise the wastewater tariff rate gradually by the year 2002 to the following level.

Domestic Users : 0.7 + 0.2 (for WWTP) KM/m^3

Non-Domestic Users : 1.2 + 0.3 (for WWTP) KM/m^3

The collection rate is currently about 50% for domestic users and 70% for non-domestic users. As the socio-economic situation is to be rehabilitated, the collection rate should be improved up to 70% and 90% respectively by the year 2003.

(5) Promotion for the Implementation of the Project

This study project is a part of the Japan ODA pledged in 1996 to support the reconstruction of BiH. The realization of this WWTP rehabilitation project is highly desired for supporting and promoting the effort of reconstruction.

It is indispensable for the responsible institutions to take necessary actions for the realization of the projects.

JICA