REPUBLIC OF SERBIA
THE CITY OF BELGRADE
BELGRADE LAND DEVELOPMENT PUBLIC AGENCY (LDA)
BELGRADE WATERWORKS AND SEWERAGE (BVK)

PREPARATORY SURVEY REPORT ON THE SEWERAGE SYSTEM IMPROVEMENT PROJECT FOR THE CITY OF BELGRADE IN REPUBLIC OF SERBIA

VOLUME I SUMMARY & MAIN REPORT

MAY 2013

JAPAN INTERNATIONAL COOPERATION AGENCY

TEC INTERNATIONAL CO., LTD.

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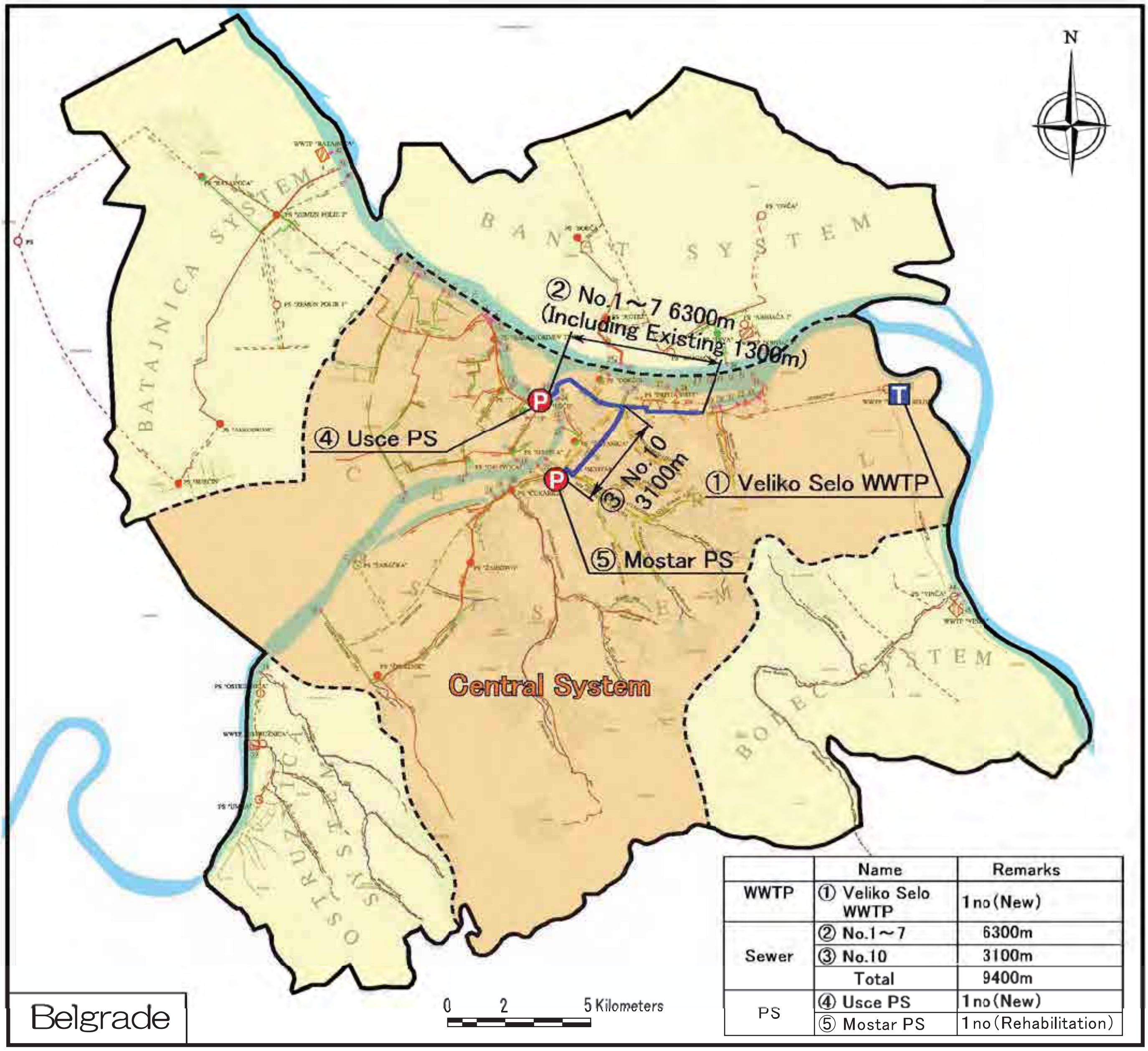

	Name	Remarks
WWTP	① Veliko Selo WWTP	1 no (New)
Sewer	② No.1～7	6300m
	③ No.10	3100m
	Total	9400m
PS	④ Usce PS	1 no (New)
	⑤ Mostar PS	1 no (Rehabilitation)

Location Map of Sewerage Facilities of the Survey

S1. **Introduction**

(1) Background of the Survey

The Republic of Serbia sets the first priority on joining the EU, hence securing the river water quality which meets the EU standards is absolutely imperative for this realization. The Government of Serbia formulated “National Physical Plan of the Republic of Serbia” and the City of Belgrade prepared a city master plan, “Master Plan of Belgrade to 2021” which was approved in September 2003 by the city council. Following the city master plan, Belgrade Waterworks and Sewerage prepared “Master Plan of the Belgrade Sewerage System to 2021” for its sewerage development.

The Government of Serbia requested the Japanese Government to extend Japanese ODA Loans for a sewerage project, Sewerage System Improvement Project for the City of Belgrade (the Project), which is to implement a part of the said sewerage master plan.

In response to the request of the Government of Serbia, the Government of Japan decided to conduct the Preparatory Survey on the Sewerage System Improvement Project for the City of Belgrade (the Survey) and the Japan International Cooperation Agency (JICA) was assigned to undertake the Survey. Minutes of Discussion for the Survey was agreed on February 3, 2012 between the City of Belgrade and JICA.

(2) Objective of the Survey

The objective of the Survey is to provide information in order to prepare an appropriate project implementation plan. Such information includes project objectives, facilities planning, project costs, implementation schedule, procurement and implementation methods, implementation structure for the construction and O&M, economic and financial evaluation, and environmental and social considerations.

(3) Survey Area and Facilities Covered by the Survey

The Project is to construct the sewerage facilities for the Central System of the Belgrade Sewerage Master Plan. Figure S 1 shows the Central System of the Belgrade Sewerage Master Plan and the location of its major facilities. The major facilities to be covered by the Survey are as follows:

- Veliko Selo Wastewater Treatment Plant (WWTP)
- Interceptors (No.1 to 7 and 10 indicated in the figure below)
- Ušće and Mostar pumping stations
- Sludge treatment facilities (in Veliko Selo WWTP)

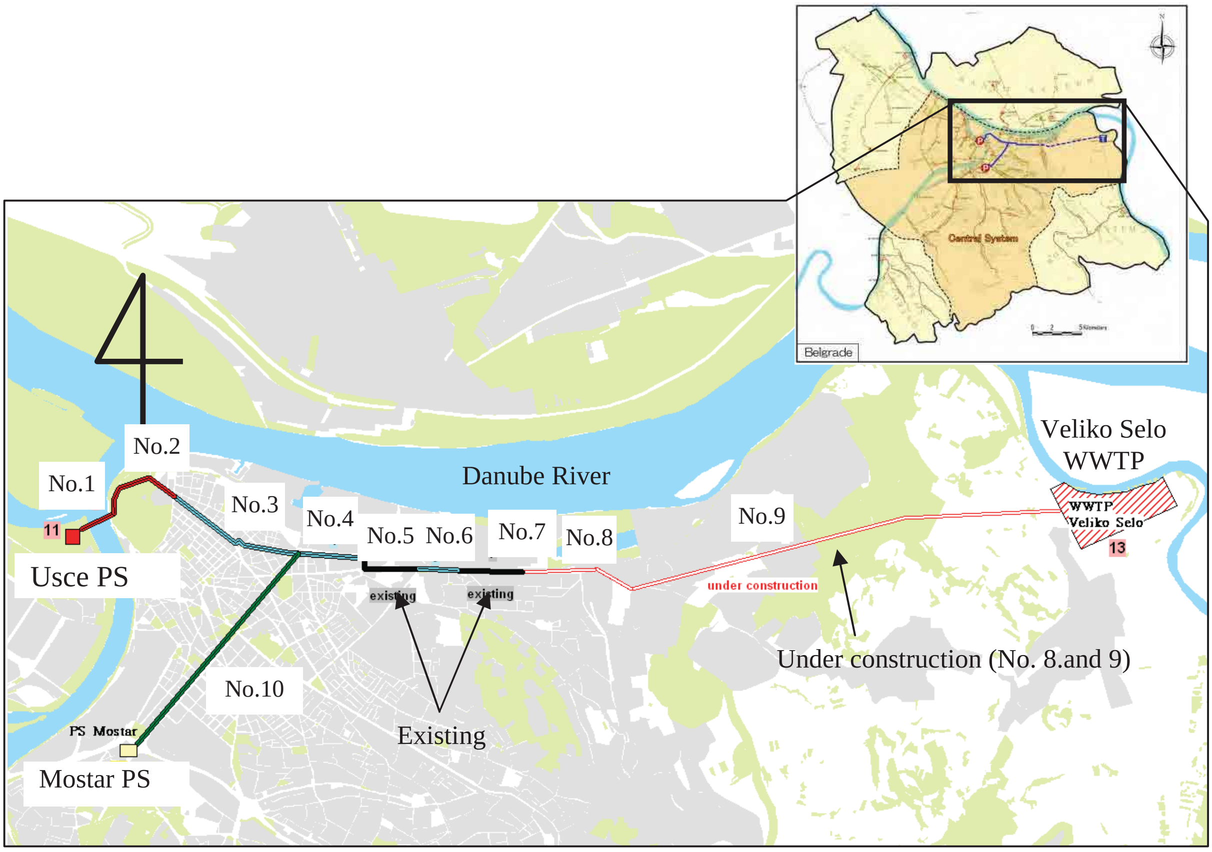

Figure S 1 Central System of the Belgrade Sewerage Master Plan and Its Major Facilities

(4) Survey Organizations

The implementing organizations of the Serbian side of this Survey are the City of Belgrade, Belgrade Land Development Public Agency (LDA), and Belgrade Waterworks and Sewerage (BVK). Of these agencies, LDA works as a counterpart organization to the JICA Study Team.

S2. Planning Frame

Planning frame, such as population, hydraulic load and pollutant load, etc. are principally adopted based on the Belgrade Sewerage Master Plan. These are as follow:

(1) Population

Table S 1 shows the population estimation by system of the Belgrade Sewerage Master Plan (as for the central system, the data is given by subbasin). The population adopted for the facilities planning in the Survey is 1,297,900, which is summation of the Central system and Bolec system in 2031, since the Master Plan proposes to treat the sewage from the Bolec system in Veliko Selo WWTP by conveying it through an interceptor to be constructed separately from the interceptors of the Central system.

Table S 1 Population by System and Subbasin

Name of System		Subbasin	2007		2010	2012	2015	2021	2031
			Number of Population	%	Number of Population				
Central System	Ušće PS Catchment Area	1. Gornji Zemun	110,499	7.85	110,900	111,200	111,600	112,450	113,800
		2. Karađorđev trg	62,892	4.47	63,200	63,300	63,550	64,000	64,800
		3. Nova Nova	56,179	3.99	56,400	56,500	56,750	57,150	57,900
		4. Galovica	105,351	7.49	105,700	106,000	106,400	107,200	108,550
		5. Gazela	16,693	1.19	16,800	16,800	16,850	17,000	17,200
		6. Ušće immediate basin	6,182	0.44	6,200	6,200	6,250	6,300	6,350
		Sub-total	357,796	25.42	359,200	360,000	361,400	364,100	368,600
	Mostar PS Catchment Area	14. Topčider collector	133,093	9.46	133,600	134,000	134,450	135,400	137,100
		15. Senjak	5,950	0.42	5,950	6,000	6,050	6,100	6,150
		16. Železnik	104,804	7.45	105,250	105,450	105,850	106,650	108,000
		17. Banovo Brdo	53,847	3.83	54,050	54,200	54,400	54,800	55,500
		Sub-total	297,694	21.16	298,850	299,650	300,750	302950	306,750
	Mokrolug Catchment Area	9. Duboki creek	48,225	3.43	48,400	48,500	48,700	49,100	49,700
		10. Čubura collector	37,289	2.65	37,450	37,500	37,650	37,950	38,400
		11. Mokrolug collector	48,443	3.44	48,600	48,750	48,900	49,300	49,900
		12. Kumodraž collector	51,492	3.66	51,700	51,800	52,000	52,400	53,050
		13. Banjica collector	45,430	3.23	45,600	45,700	45,900	46,200	46,800
		Sub-total	230,879	16.41	231,750	232,250	233,150	234,950	237,850
	Danube Catchment Area	7. Bulbuder collector	124,566	8.85	126,250	125,350	125,800	126,750	128,350
		8. Mirijevo	60,699	4.31	61,400	61,100	61,300	61,800	62,550
		18. Danube immediate basin	131,348	9.33	130,150	132,150	132,700	133,650	135,300
		Sub-total	316,613	22.49	317,800	318,600	319,800	322,200	326,200
	Sub-total of Central system		1,202,982	85.47	1,207,600	1,210,500	1,215,100	1,224,200	1,239,400
Batajnica system			64,724	4.6	65,000	65,100	65,350	65,900	66,700
Banat system			63,063	4.48	63,300	63,500	63,700	64,200	65,000
Bolec system			56,816	4.04	57,000	57,200	57,400	57,800	58,500
Ostruznica system			19,833	1.41	19,900	20,000	20,050	20,200	20,400
TOTAL			1,407,418	100	1,412,800	1,416,300	1,421,600	1,432,300	1,450,000

Source: Belgrade Sewerage Master Plan

(2) Hydraulic Load

Daily average hydraulic load is calculated by population, unit water consumption rates, ratio of sewage to water consumption and water infiltration as shown in Table S 2.

Table S 2 Basis of Hydraulic Load Calculation

Item		Description
Water Consumption Rate	Domestic	220 lpcd
	Leagal entities (per Emproyee)	200 lpcd
Ratio of sewage to water consumption rate		0.80
Water infiltration rate		0.05～0.12 l/s/ha

Source: Belgrade Sewerage Master Plan.

Average hydraulic load to each interceptor is calculated adopting the above figures, using the population of corresponding subbasins. Average hydraulic load to Veliko Selo WWTP is calculated based on the population of the Central system and Bolec system. As for the interceptors, daily maximum flow, hourly maximum flow and wet weather flow are calculated from the average load and coefficients specific to the corresponding subbasins. Table S 3 shows the various flows to Veliko Selo WWTP.

Table S 3 Projected Influent Flow

Year	2015	2021	2031
Daily average flow	394,000 m^3/day	409,000 m^3/day	448,700 m^3/day
Daily maximum flow	464,000 m^3/day	474,000 m^3/day	521,200 m^3/day
Hourly maximum flow	696,000 m^3/day	717,100 m^3/day	788,800 m^3/day
Wet weather flow	1,209,600 m^3/day	1,252,800 m^3/day	1,341,100 m^3/day

Note: Adopted value of Hourly max/Daily max ratio is 1.5 for the Central system, and Wet weather flow/Hourly max ratio is 1.75.
Hydraulic load in 2031 includes the load from Bolec subsystem.
Source: Belgrade Sewerage Master Plan

(3) Pollutants Load

Pollutant loads to the Veliko Selo WWTP are calculated based on the population equivalent unit pollutant load and population as shown in Table S 4.

Table S 4 Projected Pollutant Load

Item		2015	2021	2031
Population Equivalent Unit Pollutant Load (PE)		1,301,000	1,347,000	1,439,000
BOD_5	60 g/PE/day	78,060 kg/day	80,820 kg/day	86,340 kg/day
CODcr	120 g/PE/day	156,120 kg/day	161,640 kg/day	172,680 kg/day
TSS	70 g/PE/day	91,070 kg/day	94,290 kg/day	100,730 kg/day
T-kN	11 g/PE/day	14,311 kg/day	14,817 kg/day	15,829 kg/day
T-P	2.5 g/PE/day	3,253 kg/day	3,368 kg/day	3,598 kg/day

Note: Pollutant loads in 2031 include the one from Bolec system.

S3. **Facilities Planning**

Intending the implementation of the Project, several design works for each facility (Preliminary design) had been conducted. The facilities planning in this study was carried out by referring to the latest versions of Preliminary design of each facility, verifying them and proposing necessary modifications.

(1) Interceptors

10 sectors of interceptor exist in the Central system. Among them 4 interceptors have been either constructed (No. 5 and 7) or under construction (No. 8 and No. 9) as shown in Figure S 1.

For the remaining interceptors, the Survey reviewed the existing Preliminary designs and found them acceptable with minor modifications except No. 1 interceptor, which is a section of the Sava River crossing.

For the existing Preliminary design of the No.1 interceptor, which is a single pipe without protection structure, problems with respect to maintenance work and risks of disruptive accidents are concerned. The Survey conducted an alternative study from safety, maintenance, economic view points and concluded the structure with dual pipe each of 1000 mm diameter placed in a large protection pipe of 3500 mm diameter.

Figure S 2 shows its schematic cross section. It has a 700 mm space for maintenance work and other utilities can be installed at the bottom dead space, if required. Micro tunneling method can be applied for its construction.

Specification, quantity and the proposed construction method of the interceptors, including No. 1 sector, are shown in the Table S 5 and the profile of the Interceptors is shown in Figure S 2.

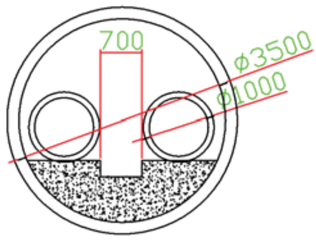

Figure S 2 Cross Section of No.1 Interceptor

Table S 5 Specification, Quantity and Proposed Construction Method of the Interceptors

Interceptor	Specifications	Length (m)	Method	Remarks
No.1	ϕ 3500 (Reinforced concrete)	425	Shield/TBM	
	ϕ 1000 mm x 2 Line (HDPE)	480 x 2 =960	Installation inside pipe gallery	
	ϕ 1000 mm x 2 Line (DIP)	90 x 2 =180	Open cut/trench	From Ušće PS to Interceptor No. 1
No.2	ϕ 1400 mm (HDPE)	900	Open cut/trench	
	ϕ 1400 mm (DIP)	45+65 =110	Jacking/injection	Including drainage pipe
No.3	ϕ 2000 mm (HDPE)	1826	Open cut/trench	
No.4	Horse shoe 380 cm (Reinforced concrete)	943	Open cut/trench	
No.6	ϕ 4000 mm (Reinforced concrete)	852	Shield/TBM	
No.10	ϕ 2800 mm (Reinforced concrete)	3000	Shield/TBM	
	Box culvert 3000x3000 mm (Reinforced concrete)	80	Open cut/trench	
Collector from Mostar PS to Interceptor No.10	ϕ 1600 mm (HDPE)	155	Open cut/trench	
	ϕ 1600 mm (Reinforced concrete)	166	Jacking/semi-shield	

(2) Pumping Stations

For Ušće pumping station, it has been planned to construct newly because of shortage of the capacity against the increased sewage generation and degradation of the facilities by aging and for Mostar pumping station, it has been planned to replace all the mechanical and electrical facilities deteriorated by aging.

The Survey followed these plans and reviewed the reconstruction plan for Ušće pumping station and replacement plan for Mostar pumping station.

Specifications and number of pump determined as a result of the Survey are shown in Table S 6.

In the rehabilitation work of Mostar pumping station, it was confirmed that its civil structures can be made durable by minor repair work. Mechanical screening process was added to the original reconstruction plan of the Mostar pumping station.

Table S 6 Specification and Quantity of Pumps

Name	Status	Main Facilities			
		Pump	Sand removal	Screen	SCADA Generator
New Ušće PS	Planned	Newly (50.2 m^3/min x 5 nos)	Newly	Newly	Newly
Mostar PS	Rehabilitation	Replace (42.0 m^3/min x 6 nos)	–	Newly	Replace

(3) Veliko Selo WWTP

Design influent water quality and effluent water quality for the facilities planning of Veliko Selo WWTP are summarized in Table S 7.

Table S 7 Design Water Quality

Item	Influent	Effluent
BOD_5	192 mg/l	25 mg/l
COD_{Cr}	385 mg/l	125 mg/l
SS	224 mg/l	35 mg/l
T-nitrogen	35 mg/l	10 mg/l
T-phosphorus	8 mg/l	1 mg/l

Note: Influent design water quality is calculated by dividing projected pollutant load in 2031 shown in Table S 4 by daily average flow in 2031 shown in Table S 3.
Effluent design water quality refers to ELV for Communal Wastewater Discharge to the receiving bodies

Projected influent flows from 2015 until 2031 to Veliko Selo WWTP are as shown in Table S 3.

For the wastewater and sludge treatment processes, the Survey basically adopted the concept of the Preliminary designs after technical verifications. Although there are minor modifications in the specifications of each unit process, there is no significant change in the process itself except the biological treatment process of the sewage treatment.

The Preliminary design selected the activated sludge method after comparison with the sequencing batch reactor and the membrane bioreactor and applied the anaerobic-anoxic-oxic process (A2O) method as one of the activated sludge methods. The Survey conducted the comparison study for the verification of the biological treatment process. The study compared the A2O, SFDNP (Step feed type denitrification nitrification process) and CAASP (Carrier added activated sludge process) as presently popular variation of the activated sludge method for the nitrogen and phosphorus removal.

Table S 8 shows outlines of the comparison results. As a conclusion, SFDNP is recommended due to the following advantages.

- Operation of SFDNP is easier since all stages of tanks can be operated with the same conditions due to equalization of pollutant loading against solids content.
- High removal efficiency of nitrogen is achieved without internal circulation comparing to A2O.
- Stable removal efficiency of phosphorous is achieved comparing to the other processes owing to physical-chemical process.
- Operation of A2O has difficulty to maintain the balance of microbes for removing nitrogen and phosphorous at the same time.
- Phosphorous removed by biological process will be easily discharged again in anaerobic digestion.
- A2O has difficulty to satisfy effluent standard in terms of nitrogen considering contribution of nitrogen from digestion process due to limitation of circulation ratio.
- Initial investment of SFDNP is the least owing to less hydraulic retention time comparing to A2O.
- SFDNP is the most economical in terms of Net Present Value

Table S 8 Comparison of Sewage Treatment Processes

	Anaerobic Anoxic Oxic process (A2O)	Step feed type denitrification nitrification process (SFDNP)	Carrier added activated sludge process (CAASP)
Outline of process	Anaerobic anoxic oxic process (A2O) is the combined process of biological nitrogen removal and enhanced biological phosphorus removal.	Step feed type denitrification nitrification process with coagulant (SFDNP) is the combined process of biological nitrogen removal and physical-chemical phosphorus removal.	Carrier added activated sludge process (CAASP) increases concentration of microbe in bioreactors tanks. Stable nitrification is achieved owing to nitrifying bacteria contained in carriers. Phosphorous is removed by applying enhanced biological removal process.
Advantage	● Less excess sludge generation. ● Less chemical expense of coagulant comparing to SFDNP.	● Energy saving by less circulation of nitrified mixed liquor. ● Stable removal efficiency of phosphorous is achieved.	● Stable performance of purification of organic substances and nitrification. ● Least HRT of bioreactors. ● Less chemical expense comparing to SFDNP.

	Anaerobic Anoxic Oxic process (A2O)	Step feed type denitrification nitrification process (SFDNP)	Carrier added activated sludge process (CAASP)
Disadvantage	● Additional tanks and dosing equipment for phosphorus removal. ● Instability of phosphorus removal ● Larger HRT of bioreactor	● More excess sludge generation than A2O. ● More chemical expense of coagulant.	● Larger excess sludge generation comparing to A2O. ● Careful management of carriers. Instable phosphorous removal.
Environmental and social consideration	● Least excess sludge generation ● High energy consumption.	● More excess sludge generation than A2O. ● Least energy consumption.	● More excess sludge generation than A2O. ● High energy consumption.
Initial investment	(122 %)	(100 %)	(201 %)
O&M cost	(91 %)	(100 %)	(104 %)
Net present value	(112 %)	(100 %)	(169 %)
Evaluation	B	A	C

Net present value: Discount rate = 10% / period = 30year

As for the sludge treatment process, as a result of alternatives comparison, the process comprised of thickening, anaerobic digestion with biogas utilization and mechanical dewatering is adopted for sludge treatment process. Sludge cake is planned to be transported to the appropriate disposal sites such as sanitary landfill site. Utilization of digestion gas is planned introducing cogeneration system which generates electricity and utilizes recovered heat for warming the digesters.

Although energy utilization of sludge is considered in the sludge treatment process, from the survey result of the potential users and present legal condition, introduction of sludge fuelization process is recommended to implement in the future stage.

In addition to the treatment process planning, following newly developed technologies are recommended considering energy saving:

Newly developed technology	Advantage
1. Disc filter for tertiary treatment	Less power consumption, least initial investment, easy stage development of tertiary treatment, most economical in terms of life cycle cost
2. ultrafine bubble diffuser in bioreactor	Most effective in terms of energy saving, non-clogging feature, most economical in terms of life cycle cost
3. screw press dewatering machine for sludge treatment	Least operation and maintenance cost due to lowest energy consumption, easy operation and maintenance, most economical in terms of Net Present Value

The schematic flow of the optimized treatment process recommended for Veliko Selo WWTP is shown in Figure S 3.

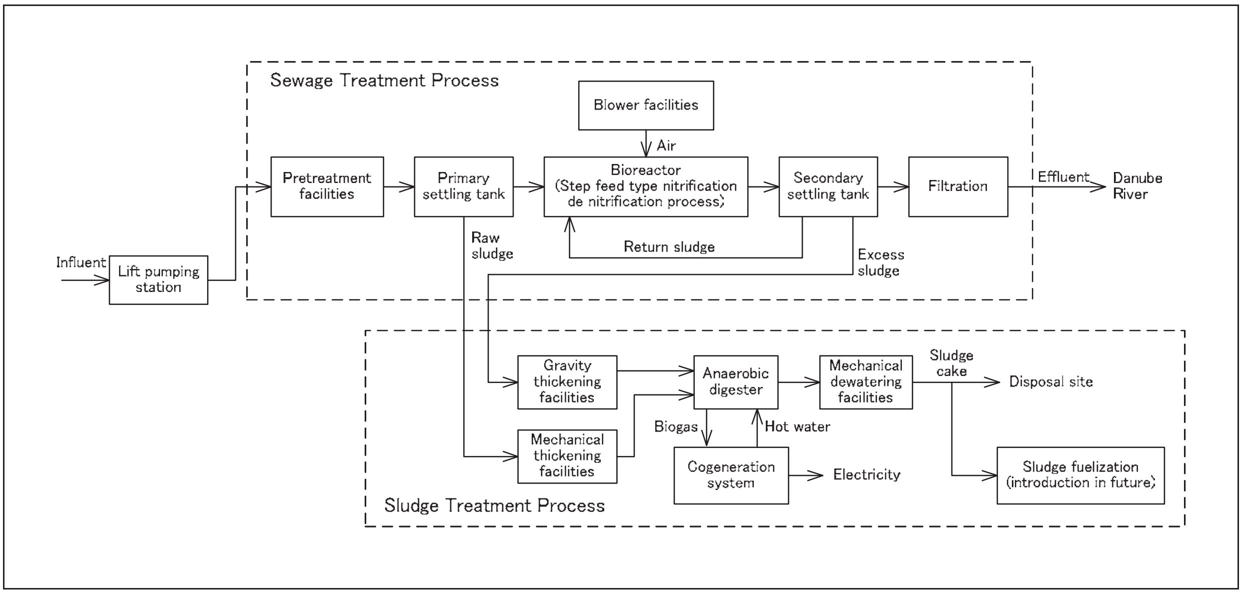

Figure S 3 Schematic Flow of Treatment Process

General layout of the facilities in the site has been prepared as in the Figure S 4.

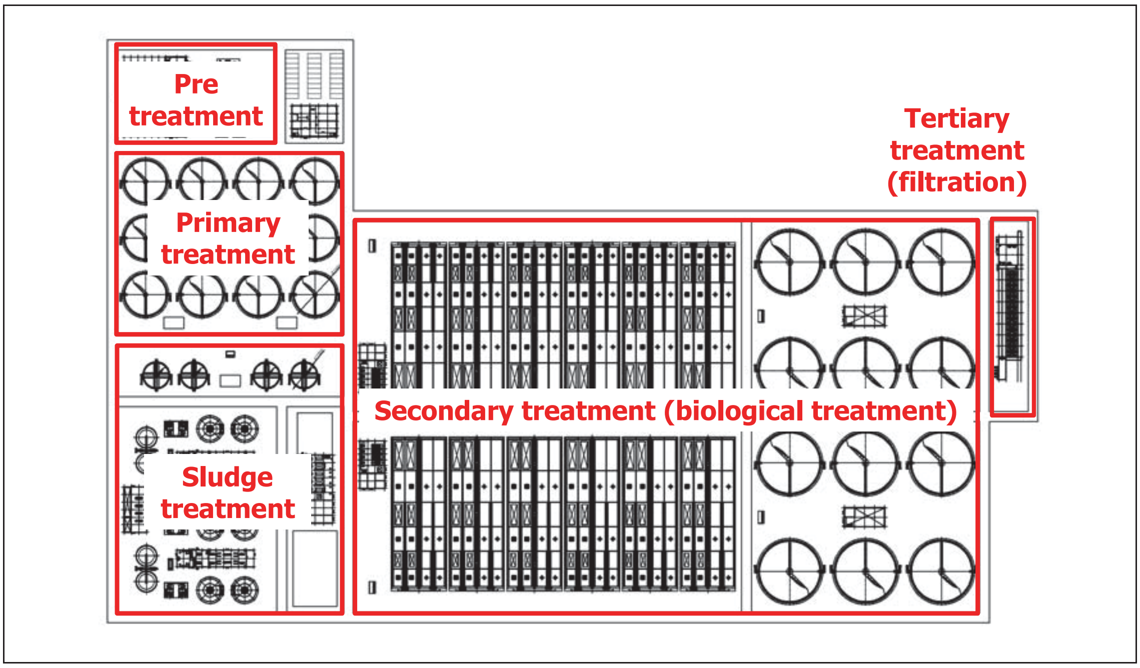

Figure S 4 Zoning of the Facilities

Hydraulic profile has been prepared and presented in the Figure S 5.

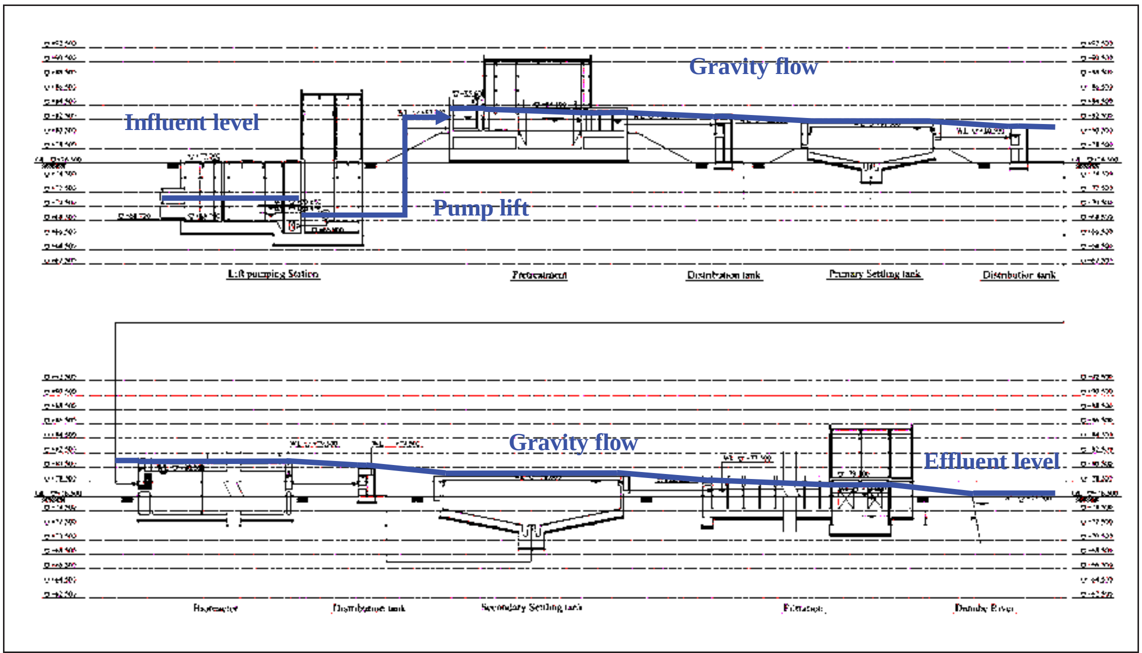

Figure S 5 Hydraulic Profile Planning

Special Notes on Facilities Planning:

It was presupposed that the facilities planning is carried out based on the consent of the Serbian side represented by LDA. Most of facilities planning was carried out in accordance with this presupposition, it was made known, however, that the consent regarding the sewage treatment process can be only given by the Revision Committee which includes the ministerial level members based on documents prepared by consultants hired by Serbian authorities. Consequently it became difficult to obtain the consent to the facilities planning of the sewage treatment process within time frame of the Survey. Therefore, LDA and the JICA Study Team agreed to proceed to the further works, such as the cost estimates, economic and financial analysis and project evaluation, with Study Team's conclusion (SFDNP), leaving the final consent to the Revision Committee to be organized in future as early as possible.

S4. Project Cost estimation and Implementation Schedule

(1) Project Cost and O&M Cost

The estimated project cost for the Project is EUR 437 million (JPY 45.9 billion) including taxes and EUR 370 million (JPY 38.9 billion) excluding taxes, as shown in Table S 9.

Table S 9 Estimated Project Cost

No	Items	L.C. (1,000 EUR)	F.C. (1,000 EUR)	Total (1,000 EUR)
1.	Construction cost			
A	Veliko Selo WWTP			
A-1	Site preparation work	15,386	0	15,386
A-2	Lift pump facilities	2,524	6,100	8,624
A-3	Pretreatment facilities	2,254	1,402	3,656
A-4	Primary settling tank	5,847	1,612	7,459
A-5	Bioreactor	27,725	10,786	38,511
A-6	Blower facilities	1,844	4,194	6,038
A-7	Secondary settling tank	9,081	3,414	12,495
A-8	Filtration	2,351	6,913	9,264
A-9	Gravity thickener	842	427	1,269
A-10	Anaerobic digester	26,422	11,408	37,830
A-11	Sludge treatment facilities	2,277	4,925	7,202
A-12	Pipe works	6,418	14,386	20,804
A-13	Administration building	1,886	3,937	5,823
A-14	Substation and generator building	1,625	5,275	6,900
A-15	Cogeneration building	673	1,853	2,526
A-16	Landscaping work	2,015	0	2,015
	Sub-total of A	109,170	76,632	185,802
B	Interceptor			
B-1	Interceptor No.1	6,416	4,623	11,039
B-2	Interceptor No.2	3,981	351	4,332
B-3	Interceptor No.3	7,752	0	7,752
B-4	Interceptor No.4	9,752	0	9,752
B-5	Interceptor No.6	3,874	10,587	14,461
B-6	Interceptor No.10 including collector	5,957	18,906	24,863
	Sub-total of B	37,732	34,467	72,199
C	Pumping station			
C-1	Ušće pumping station	3,208	2,806	6,014
C-2	Mostar pumping station	1,152	2,300	3,452
	Sub-total of C	4,360	5,106	9,466
	Sub-total of 1	**151,262**	**116,205**	**267,467**
2.	Administration cost	16,799	0	16,799
3.	Consulting cost*1	7,282	8,800	16,082
4.	Physical contingency for construction cost	8,456	6,562	15,018
5.	Price escalation for construction cost	16,726	13,522	30,248
6.	Land acquisition and compensation*1	7,300	0	7,300
7.	Interest during construction	0	14,116	14,116
8.	Commitment charge	0	2,742	2,742
9.	Tax and duty	67,198	0	67,198
	Sub-total of (2-9)	**123,761**	**45,742**	**169,503**
	Total including Tax and Duty	**275,023**	**161,947**	**436,970**
	Total excluding Tax and Duty	**207,825**	**161,947**	**369,772**

Note*1: Physical contingency and price escalation of this item are included in the cost.

The estimated annual operation and maintenance cost for the Project is 9.4 million EUR/year (988 million Yen/year), as shown in Table S 10.

Table S 10 Estimated Operation and Maintenance Cost

No	Items	Total (1,000 EUR/year)
1.	Salary	510
2.	Electricity	2,111
3.	Maintenance	1,238
4.	Disposal of sludge cake	1,656
5.	Consumable	2,878
6.	Cleaning of interceptors	213
7.	Others	807
	Total	**9,414**

(2) Phased Implementation of the Project

The Project requires a large amount of investment to complete. Phased implementation was studied to make the project sizable.

Several options were compared from the viewpoints of project effect, priority and investment effect and finally Mostar catchment area and lower Danube catchment area were selected as the first phase implementation area. The projected hydraulic load in 2031 is almost half of the total load.

The components which will be constructed in the Phase-I project are Veliko Selo WWTP (half of capacity), Interceptor No. 4, No. 6 and No. 10 and Mostar pumping station as shown in Figure S 6.

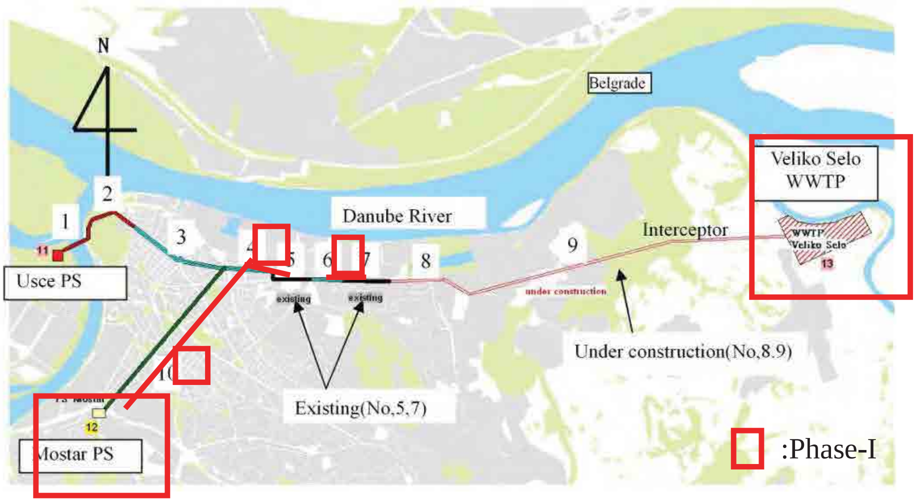

Figure S 6 Components of Phase-I Project

(3) Estimated Cost of Phase-I Project

The estimated project cost for the Phase-I Project is EUR 275 million (JPY 28.9 billion) including taxes and EUR 233 million (JPY 24.5 billion) excluding taxes, as shown in Table S 11.

Table S 11 Estimated Project Cost of Phase-I Project

No	Items	L.C. (1,000 EUR)	F.C. (1,000 EUR)	Total (1,000 EUR)
1.	Construction cost			
A	Veliko Selo WWTP			
A-1	Site preparation work	12,163	0	12,163
A-2	Lift pump facilities	1,983	3,246	5,229
A-3	Pretreatment facilities	2,212	1,025	3,237
A-4	Primary settling tank	3,027	806	3,833
A-5	Bioreactor	14,498	5,393	19,891
A-6	Blower facilities	937	2,096	3,033
A-7	Secondary settling tank	4,803	1,708	6,511
A-8	Filtration	1,783	3,699	5,482
A-9	Gravity thickener	437	224	661
A-10	Anaerobic digester	13,323	5,704	19,027
A-11	Sludge treatment facilities	2,033	3,432	5,465
A-12	Pipe works	4,601	7,119	11,720
A-13	Administration building	1,831	2,745	4,576
A-14	Substation and generator building	1,271	3,438	4,709
A-15	Cogeneration building	495	927	1,422
A-16	Landscaping work	2,015	0	2,015
	Sub-total of A	67,412	41,562	108,974
B	Interceptor			
B-1	Interceptor No.4	9,752	0	9,752
B-2	Interceptor No.6	3,874	10,587	14,461
B-3	Interceptor No.10 including Collector	5,957	18,906	24,863
	Sub-total of B	19,583	29,493	49,076
C	Pumping station			
C-1	Mostar pumping station	1,152	2,300	3,452
	Sub-total of C	1,152	2,300	3,452
	Sub-total of 1	**88,147**	**73,355**	**161,502**
2.	Administration cost	10,608	0	10,608
3.	Consulting cost*1	7,282	8,800	16,082
4.	Physical contingency for construction cost	4,895	4,095	8,990
5.	Price escalation for construction cost	9,747	8,536	18,283
6.	Land acquisition and compensation *1	7,300	0	7,300
7.	Interest during construction	0	8,523	8,523
8.	Commitment charge	0	1,707	1,707
9.	Tax and duty	42,430	0	42,430
	Sub-total of (2-9)	**82,262**	**31,661**	**113,923**
	Total including Tax and Duty	**170,409**	**105,016**	**275,425**
	Total excluding Tax and Duty	**127,979**	**105,016**	**232,995**

Note *1; Physical contingency and price escalation of this item are included in the cost.

The estimated annual operation and maintenance cost for the Phase-I Project is 4.9 million EUR/year (515 million Yen/year), as shown in Table S 12.

Table S 12 Estimated Operation and Maintenance Cost for Phase-I Project

No	Items	Total (1,000 EUR/year)
1.	Salary	332
2.	Electricity	1,081
3.	Maintenance	676
4.	Disposal of sludge cake	828
5.	Consumable	1,439
6.	Cleaning of interceptors	129
7.	Others	420
	Total	**4,905**

(4) Implementation Schedule of Phase-I project

In case that Phase-I Project is financed through Japanese ODA Loan, implementation schedule starting from signing of Loan Agreement has been developed as shown in Table S 13 taking into account necessary steps. Implementation of the project is estimated to extend over 90 months (7.5 years) in total.

Table S 13 Implementation Schedule

	Period	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Signing of L/A	-								
Selection of Consultant	9 months								
Detailed Design	12 months								
Preparation of Specifications & Bidding Documents	(6) +3 months			Land Acquisition					
Selection of Contractor	12 months							Operation Start	
Construction Works	42 months								
Trial Operation Period	12 months								

S5. Financial and Economic Analysis and Institution

(1) Tariff setting

The results of the Willingness-To-Pay (WTP) Survey will be used as a benchmark for the acceptable tariff increase for sewerage treatment capacity developed by the Project. From the Survey results the overall result of willingness to pay was 46% more than the current payment on the average. And if we set the cutoff point at 80% of the population, the maximum tariff that the BVK can charge is 25% of the current payment.

Table S 14 shows the tariff equivalent unit benefit for financial and economic evaluations. The financial tariff increase is RSD 23 in total for the Project. The implementability is deemed high.

The unit benefit for economic evaluation can be equal to the average WTP. Thus for the entire population, the average WTP multiplied by the population is the total economic benefit.

Table S 14 Financial Tariff Increase and Economic Willingness-To-Pay

Unit: RSD/m^3

	Average Effective Tariff	Financial Tariff Increase	Economic WTP
Water	34.8	8.7	13.0
Sewerage	57.1	14.0	26.0
Total	91.9	23.0	42.0

Note: the average effective tariff is tabulated on the billed tariff and supplied water, treated sewage volumes during the first quarter of 2012 by BVK. The financial tariff increment is 25%, the economic WTP is 46% of the average effective tariff.

(2) Financial Evaluation

In the financial cash flow analysis of the phase I project, the project life is set at 40 years after the commissioning of the facilities in 2021. The financial internal rate of return on investment (FIRR) is derived to be 2.3% with which financing of the project with market rate borrowing is deemed difficult. Given the opportunity of low interest rate financing, the entire project financing without government subsidy is theoretically possible.

The FIRR for the entire project (Phase I + II) has come to be 4.3% indicating somewhat improved financial returns. The financing of the project with market rate borrowing is deemed difficult. Given the opportunity of low interest rate financing, the entire project financing without government subsidy is theoretically possible.

(3) Economic Evaluation

In the financial cash flow analysis of the phase I project, the economic internal rate of return on investment (EIRR) is derived to be 9.5%. The EIRR for the entire project (Phase I + II) turns out to be 12%. Both subprojects indicate sound economic viability of the project from national economic viewpoint.

(4) Financial Sustainability for BVK

The above analysis indicates that the project will not impose excessive burden for BVK. However, in implementation of any project there will be unforeseen contingencies that deteriorate the financial conditions of the operation of the project.

Therefore there may be three recommendations in this regard:

1) Capital Subsidy
2) Tariff Increase
3) Transfer of current employees and training

(5) Implementation Organization

It is recommended to set up a special task force with authority to issue notices for procurement, evaluate and select contractors, approve documents and physical deliverables and endorse payments to ensure timely implementation of the project. The taskforce appointed by the implementing agency, namely LDA, is normally termed as Project Implementation Unit (PIU).

PIU is headed by Project Manager appointed by the implementation agency. It is envisaged that there will be three distinct areas of implementation.

1) Legal Contractual
2) WWTP
3) Interceptor

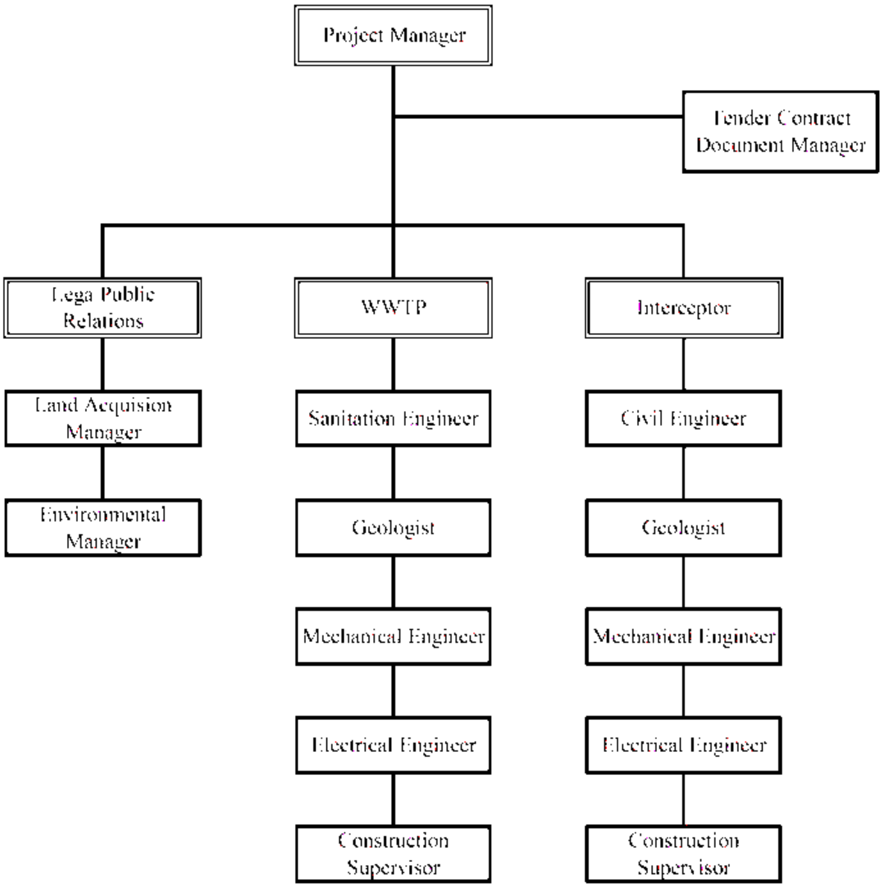

Figure S 7 Implementation Organization

S6. Environmental and Social Consideration

The environmental and social considerations have been carried out according to the Serbian legislation and Japan Bank for International Cooperation Guidelines for Confirmation of Environmental and Social Considerations, April 2002 (JBIC Guidelines). While the Serbian legislation requires EIA report in the detail design stage after the F/S and preliminary design is approved by Revision Committee and preparation of LARAP (land acquisition and resettlement action plan) is not required, the Survey prepared preliminary EIA reports and LARAP in accordance with the requirements of JBIC Guidelines. The monitoring plan was also prepared for proper implementation of EIA and LARAP.

Major impacts and mitigation measures are shown in Table S 15. Most impacts are considered to be controllable by proper implementation of the countermeasures, including LARAP.

Table S 15 Major Impacts and Mitigation Measures

Item	Impact	Mitigation Measures
Involuntary resettlement and land acquisition	There is no involuntary resettlement. 75 ha of land are required for WWTP site only. 251 landowners with 1,250 project affected persons will be influenced by land acquisition	LARAP (land acquisition and resettlement action plan) is prepared, the policy for compensation and entitlement are set and the cost, implementation arrangement is described.
Land use and utilization of local resources	The construction of WWTP may change the land use and cause loss of properties such as crops and forest.	It will be properly compensated by LARAP implementation.
Existing social infrastructures and services	Some parts of the interceptors will be constructed by open cut method and the traffic disturbance will be expected.	In cooperation with traffic authorities, advance notice, alternative routes, posting warning signs and directions should be planned and prepared.
Cultural heritage	The interceptor No. 2 will be installed near around the Belgrade Fortress which is the important cultural heritage.	The request should be made to obtain the conditions for construction by the Belgrade City Institute for Protection of Cultural Monuments. The architect should be present during construction.
Accidents	The construction may cause the accidents. Especially the construction of interceptor No. 2, 3 and 4 are open-cut method and traffic disturbance may raise the risk of accidents.	The plan to reduce the accidents during construction should be prepared based on the Law on Occupational Safety and regulation on Occupational Safety for Construction Works.
Soil erosion	The proposed WWTP area has been flooded frequently in past. The bank stabilization is required to protect WWTP from the bank erosion due to the flood.	The bank stabilization is already considered in the F/S. The contractor should follow the design which will be finalized in the detail design stage.
Protected area	Usce PS is in the inner protection zone of the Belgrade wellhead and also in the urban green area.	The conditions of construction shall be given by Ministry of Agriculture, Forestry and Water Management during review period of F/S and preliminary design.
Air pollution	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	It can be minimized with the application of best practice construction methods (modern technologies) and site management, as should be defined in the detail design. Construction vehicles, machinery and equipment should be in good working condition and well maintained.
Water pollution	Usce PS is in the inner protection zone of the Belgrade wellhead. The upper level of the aquifer is 25 m below the ground and the deepest point of Usce PS is 10 m so that the facility will not cause any pollution on the groundwater quality, if it is operated property. If the source of pollution is spilt over in the area, there is a real risk that the contamination would reach the wells.	An appropriate monitoring plan has to be established that includes monitoring of groundwater quality at monitoring piezometers. The effluent will be discharged into the Danube River and the effluent quality will be met by the effluent standards set by the Serbian legislation so that the impact on the receiving water body is not expected.
Waste	The spoil will be generated during installation of pipelines and construction of WWTP. The sludge will be generated from WWTP during operation.	The sludge can be utilized in agriculture if the quality meets the standards stipulated by the law. Waste Management Plan is obligation as per Waste Management Law in Serbia. The plan should be prepared by the contractor during the construction and by BVK during operation of the WWTP. The disposal of waste should follow the waste management plan.
Noise and vibrations	Construction machines will cause noise and vibration during construction. Additionally, the operation of sewerage system such as pump stations with generators will cause noise and vibration during operation.	Noise pollution should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. For the operation, low-noise mechanical equipment should be adopted and installed in acoustically lined buildings or enclosures.
Offensive odors	Odors emitted at wastewater treatment works may be potential nuisance to the general public.	The process equipment for these operations is usually housed in buildings that are ventilated and sometimes have exhaust air odor treatment. Odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures.

S7. Conclusion and Recommendations

The survey prepared the facilities planning of the sewerage facilities for the Sewerage System Improvement Project for the City of Belgrade. The facilities planning covers interceptors, pumping stations and Veliko Selo WWTP, which conveys all the wastewater from the Central system, currently discharged to the rivers without treatment, to the WWTP and treat it to the level complying with Standards of EU directive.

As a result of the project cost estimation, it was revealed that the estimated project cost is higher than the fund availability currently considered to be possible. Then the Survey introduced the phased implementation of the project to make the project sizable compared to the fund availability. Phase-I Project, which conveys all the wastewater from Central system on the right bank of the Sava River except the Mokrolung catchment area, corresponding 52% of the total wastewater from the entire Central system, and treat it in Veliko Selo WWTP, was concluded to be sizable compared to the expected fund availability, financially and economically viable and feasible from the viewpoints of project effect, priority and investment effect.

The Sewerage Improvement Project for the City of Belgrade started in 1990 when the construction of interceptors No.5 and No.7 started, and currently construction of No.8 and No.9 interceptors is ongoing. Without Phase-I project, facilities constructed more than 20 years ago and to be constructed will be further left in nonperforming state. Therefore, early realization of the Phase-I project is desperately required.

Towards the realization of the projects, concerned organizations, such as the State Government, the Belgrade City, LDA and BVK are required to take necessary actions in accordance with each organization's competence.

The project belongs to the Belgrade City. Therefore, the City Hall should take full responsibility for the implementation of the project and operation of the project facilities. However, considering the objectives of the project, that is to contribute to the improvement of the environment and to fulfill the prerequisite of the accession to the EU, which is the highly prioritized national credo, the State Government should take the initiative to promote the project by expeditious approval and license proceedings related to the project preparation and implementation and arrangement with foreign and international funding agencies. Also the State Government should take an appropriate responsibility for the project financing through subsidy because the project would contribute to the national policies, such as the environmental protection and the accession to the EU.

Even in the case of the Belgrade City or the State Government, a borrower of a loan is possible to be responsible for financing of the non-eligible portion of the project cost. In the case that the Belgrade City would be a borrower of the loan, as the foreign loan requires a sovereign guarantee, close coordination with the State Government is required in the application of and negotiation for the loan. In the project implementation and operation stages, it would carry out its responsibility through its subordinate organizations, namely LDA for the project implementation and BVK for the operation of the sewerage system. It is not only expected to take the lead to those organizations but also take initiatives in coordination with the State Government, related governmental organizations and other related Belgrade City organizations. Furthermore, the City is responsible for decision on water supply/sewerage tariff which ensures BVK's sound operation after the project.

LDA would be the main player in the project preparation and implementation. In the preparation stage, many required actions are beyond the competence of LDA. Many actions, such as some approval and license procedures, financing arrangements, negotiation with financing organizations, etc., would proceed out of LDA's control. Nevertheless, LDA must be an initiator of these actions. In the implementation stage, LDA literally plays the main role. All the activities in the project implementation will come under LDA's responsibilities and these responsibilities are presently scattered among various sections of LDA. Therefore it is highly recommended to organize a unit to implement the project (PIU) by gathering functions and responsibilities required for the project implementation.

BVK is responsible for the operation and maintenance of the facilities constructed under the project. Presently BVK is operating and maintaining the sewerage facilities except WWTP. WWTP is a new facility and is required to be equipped with technology and human resources for the operation and maintenance. BVK should create a new section responsible for the WWTP operation by allocating/appointing proper human resource and providing proper technical training. Probably, it is required to expand the present sections for the operation and maintenance of the interceptors and pumping stations. BVK is responsible for its sound financial operation as a self-supporting organization. The Survey concluded that the project is financially viable by increasing sewerage tariff by 23% of the present. Therefore, BVK should be prepared to initiate the tariff increase procedures. The adoption of the progressive tariff structure may be one of the options to ease the impact of the tariff increase on lower income users.

Preparatory Survey Report
on the Sewerage System Improvement Project for the City of Belgrade
in Republic of Serbia

Volume I Summary & Main Report

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List of Abbreviations

ATP	Affordability to Pay
A2O	Anaerobic Anoxic Oxic Process
B/C	Benefit Cost Ratio
BOD	Biochemical Oxygen Demand
BOCM	Bilateral Offset Credit Mechanism
BVK	Belgrade Waterworks and Sewerage
CASP	Conventional Activated Sludge Process
CAASP	Carrier Added Activated Sludge Process
CDM	Clean Development Mechanism
COD	Chemical Oxygen Demand
CP	Counterpart
CF	Conversion Factor
CVM	Contingent Valuation Method
DO	Dissolved Oxygen
EBRD	European Bank for Reconstruction and Development
EIA	Environmental Impact Assessment
EIRR	Economic Internal Ratio of Return
ELV	Emission Limit Values
EU	European Union
F.C.	Foreign Currency
F/S	Feasibility Study
FIRR	Financial Internal Ratio of Return
GDP	Gross Domestic Product
GOJ	Government of Japan
GHG	Green House Gas
HRT	Hydraulic Retention Time
ICPDR	International Commission for the Protection of the Danube River
IPPC	Integrated Pollution and Prevention Control
ISO	International Organization for Standardization
ISRBC	International Sava River Basin Commission
JBIC	Japan Bank for International Cooperation
JICA	Japan International Cooperation Agency
JST	JICA Study Team
L/A	Loan Agreement
LARAP	Land Acquisition and Resettlement Action Plan
L.C.	Local Currency

LCC	Life Cycle Cost
LDA	Belgrade Land Development Agency
MBR	Membrane Bioreactor
M/D	Minutes of Discussion
MLSS	Mixed Liquor Suspended Solids
MP	Master Plan
NPV	Net Present Value
ODA	Official Development Aid
O&M	Operation and Maintenance
PDD	Project Design Document
PAPs	Project Affected Peoples
PE	Population Equivalent
PEIA	Preliminary Environmental Impact Assessment
PFI	Private Finance Initiative
PI	Performance Indicator
PIU	Project Implementation Unit
PS	Pumping station
RDNP	Recycled Denitrification Nitrification Process
SBR	Sequencing Batch Reactor
SCADA	Supervisory Control and Data Acquisition System
SEA	Strategic Environmental Assessment
SEPA	Serbian Environmental Protection Agency
SFDNP	Step Feed type Denitrification Nitrification Process
SRT	Solids Retention Time
SS	Suspended Solids
T-N	Total Nitrogen
T-P	Total Phosphorus
WFD	Water Framework Directive
WTP	Willingness To Pay
WWTP	Wastewater Treatment Plant

1. Introduction

1.1 Background of the Survey

The Republic of Serbia acceded to the International Commission for the Protection of the Danube River (hereinafter referred to as "ICPDR") in August 2003 and promoted the sewerage system development. Consequently the development of the sewerage collection system has progressed substantially but the wastewater treatment plants remain not developed due to the constraint of financial sources, resulting in the increase of discharge of untreated sewage to the water bodies.

In the City of Belgrade, the capital city of the Republic of Serbia, the sewage is collected by sewer but discharged to the rivers without treatment. As the Danube River, which runs through the city center and receives the untreated sewage from the city, is an international river, if the untreated sewage causes deterioration of the river water quality, it may develop into an international issue. In addition, since the drinking water supply services in the City of Belgrade depend on surface water and groundwater sources, discharge of untreated sewage may cause not only an increase in operation cost of water treatment plant but also raise concern with respect to safe quality of the drinking water in future.

The Republic of Serbia sets the first priority on joining the EU, hence securing the river water quality which meets the EU standards is absolutely imperative for this realization. The Government of Serbia formulated "National Physical Plan of the Republic of Serbia" as a state development plan and in accordance with the plan the City of Belgrade prepared a city master plan with target year of 2021, "Master Plan of Belgrade to 2021" which was approved in September 2003 by the city council. Following the city master plan, Belgrade Waterworks and Sewerage (hereinafter referred to as "BVK") prepared "Master Plan of the Belgrade Sewerage System to 2021" for its sewerage development.

The Government of Serbia requested the Japanese Government to extend Official Development Assistance Loans (hereinafter called "Japanese ODA Loan") for a sewerage project, Sewerage System Improvement Project for the City of Belgrade (hereinafter referred to as "the Project"), which is to implement a part of the said sewerage master plan.

In response to the request of the Government of Serbia, the Government of Japan (hereinafter referred to as "GOJ") has decided to conduct the Preparatory Survey on the Sewerage System Improvement Project for the City of Belgrade (hereinafter referred to as "the Survey") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation programs of GOJ, was assigned to undertake the Survey. M/D (Minutes of Discussion) for the Survey was agreed on February 3, 2012 between the City of Belgrade and JICA.

1.2 Objective of the Survey

The objective of the Survey is to provide information in order to prepare an appropriate project implementation plan. Such information includes project objectives, facilities planning, projects costs, implementation schedule, procurement and implementation methods, implementation structure (construction and O&M), economic and financial evaluation, and environmental and social considerations.

1.3 Survey Area and Facilities Covered by the Survey

The Project is to construct the sewerage facilities for the Central System in the Belgrade Sewerage Master Plan. Figure 1.1 shows the Central System and the location of its major facilities. The major facilities to be covered by the Survey are as follow:

- Veliko Selo Wastewater Treatment Plant (WWTP)
- Interceptors (No.1 to 7 and 10 indicated in the figure below)
- Ušće and Mostar pumping stations
- Sludge treatment facilities

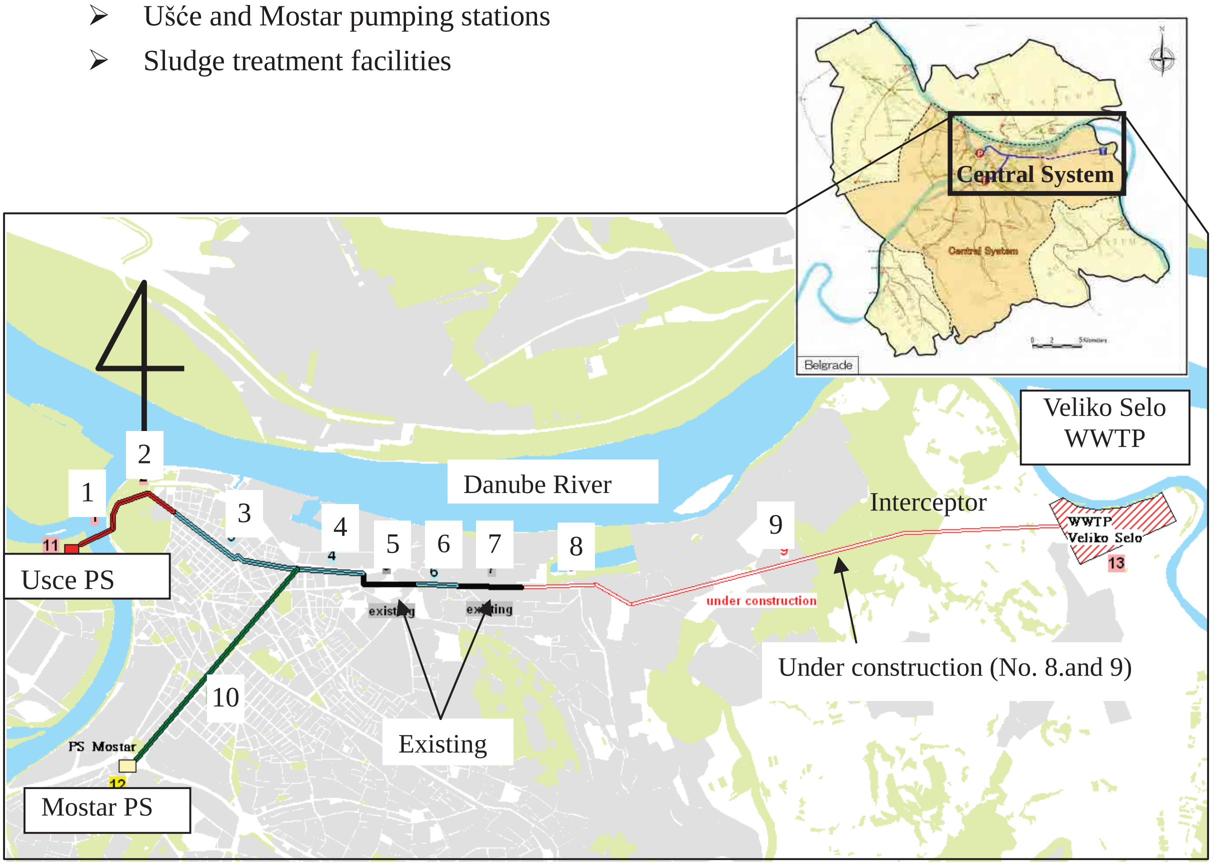


Figure 1.1 Facilities Covered by the Survey

1.4 Survey Organizations

The implementing organizations of the Serbian side for this Survey are the City of Belgrade, Belgrade Land Development Public Agency (LDA), and Belgrade Waterworks and Sewerage (BVK). Of these organizations, LDA that takes responsibility for construction of above major facilities and BVK that takes responsibility for operation of these facilities transferred after completion, work as counterpart organizations to the JICA Study Team (JST).

LDA is a public company founded by the City of Belgrade and is in charge of management, development and improvement of town building, land and important infrastructures for the City of Belgrade. BVK is a public utility company also founded by the City of Belgrade and is in charge of operation of water supply and sewerage works of Belgrade.

LDA established a Steering Committee chaired by Mr. Željko Ožegović, member of City Council, to monitor the progress and to give advice for the implementation of the Survey.
Members of concerned organizations are as follows:

(Member of the Steering Committee)

Mr. Željko Ožegović	Member of the City Council
Mr. Borisav Milutinović	Assistant to General Manager for Technical Departments, Belgrade Land Development Public Agency
Ms. Aleksandra Nikolić	Deputy Director of Program and Land Development Preparation Department, Belgrade Land Development Public Agency
Mr. Predrag Bogdanović	Assistant to Managing Director for Development, Design and Investments, Belgrade Waterworks and Sewerage
Mr. Vladimir Janković	Assistant to Managing Director for Sewerage System, Belgrade Waterworks and Sewerage
Ms. Marina Živanović Byrne	Head of Sewerage Development and Design Department, Belgrade Waterworks and Sewerage

(C/P Team Member: LDA)

Ms. Mirjana I. Đorđević	Civil Engineering
Ms. Svetlana Kolarž	Mechanical Engineering
Ms. Zorica Sarić	Environmental Study
Ms. Danijela Miščević	Civil Engineering for Construction

(C/P Team Member: BVK)

Ms. Marina Živanović Byrne	Civil Engineer (Sewerage System Development)
Ms. Ana Popović Milijić	Civil Engineer (Water Supply System Development)
Mr. Uroš Urošević	Hydrogeology Engineer (Groundwater Sources Protection and Development)
Ms. Marija Mihajlović	Technology Engineer (Environment and Water Quality)
Mr. Mirko Maksimović	Mechanical Engineer (Wastewater Pump Stations and SCADA)

(JST Member)

Name	Position	Organization
Mr. TAKECHI Akira	Team Leader/Sewerage Planning (1)	TECI
Mr. TAKAHASHI Haruki	Deputy Team Leader/Sewerage Planning (2)	TECI
Mr. TANAKA Norio	Mechanical Facility Design	TECI
Mr. KAWASAKI Shigeru	Electrical Facility Design	TECI
Mr. AZUI Koichiro	Civil Structure Design	TECI
Mr. IWAMOTO Koichi	Cost Estimation/Construction Planning	TECI
Dr. NISHIMAKI Hiroshi	Sewerage Business Management/Economics and Finance	TECI
Ms. YAMADA Shoko	Environmental and Social Considerations	TECI
Mr. SAKAMOTO Yoshihisa	CDM/JI Planning	TECI

TECI: TEC INTERNATIONAL Co., Ltd.

1.5 Work Schedule

The Survey period (approx. 10 months) was divided into two phases as given below. The survey flow chart is shown in Figure 1.2.

Phase I: Confirmation of existing situation and brief design of the Project
1) Basic investigation and review of current sewerage plan
2) Study Tour on Sewerage Technology in Japan by C/P
3) Consideration and comparison of alternatives and selection of the optimum project

Phase II: Preparation of preliminary design and estimation of project effects
1) Preparation of preliminary design and estimation of project effects for the optimum project
2) Preparation of Final Report

1.6 Contents of the Report

This report contains all the results of the Survey and comprises of the main report together with supporting documents/data.

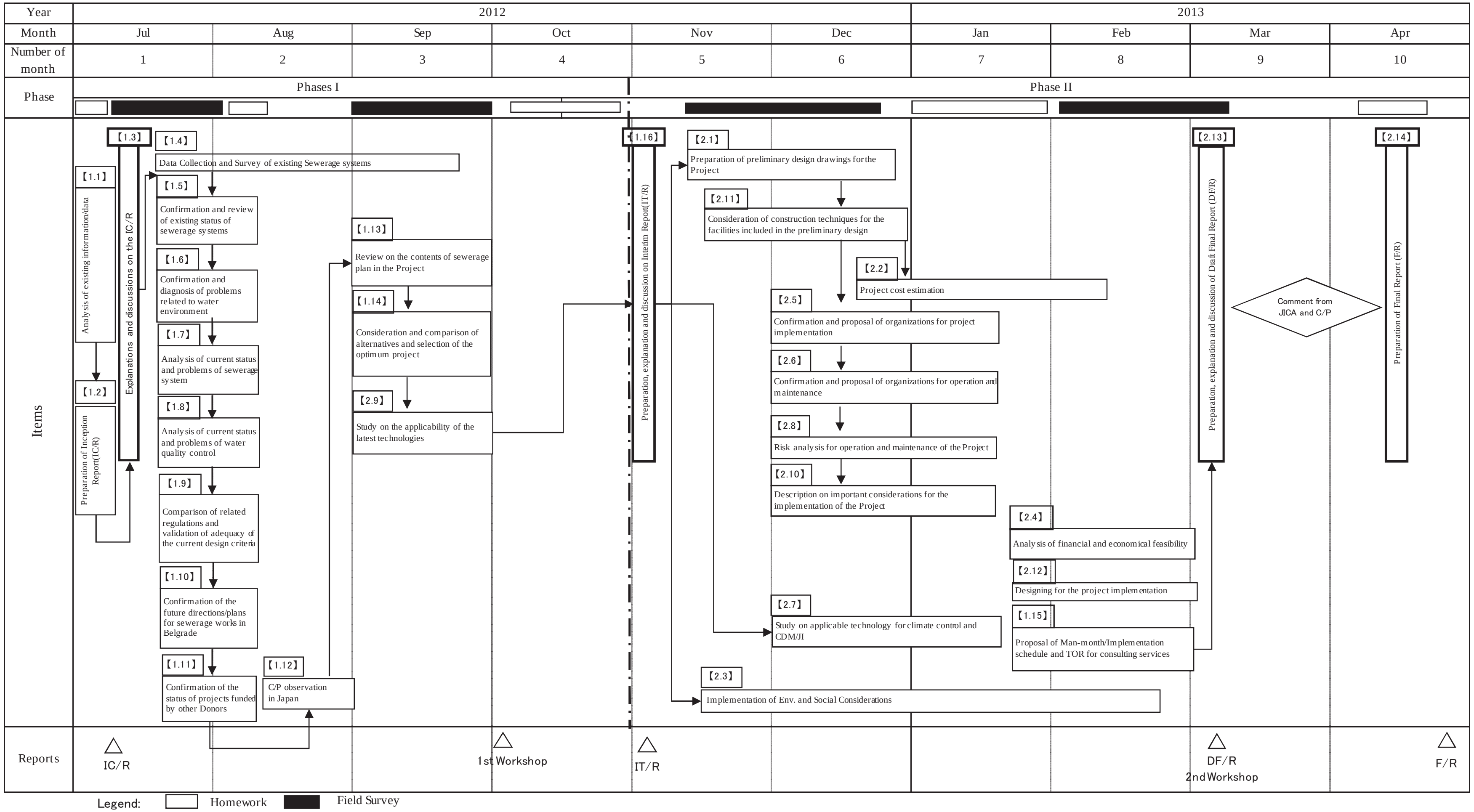


Figure 1.2 Flow Chart of the Survey

2. Project Background and Basic Information

2.1 Water Environmental Management in Serbia

2.1.1 Water Environment Management

Republic of Serbia is situated in southeast Europe in the heart of the Balkan Peninsula. The Danube, the second longest river in Europe (total length 2850 km) flowing from west to east, flows through Serbia for 588 km. Passing over Vojvodina in the Pannonia Plain, the city of Belgrade, leaving the country through the Balkan Mountains - Iron Gate, and finally flows into the Black Sea. The River Sava (206 km length through Serbia), Drina (length 220 km through Serbia) and Morava (length 308 km, only through Serbia), with the Danube, are the main sources of water supply in the country. The Danube river basin covers 87% of national territory.

(1) International Commission for the Danube River and the Sava River

On international level the International Commission for the Protection of the Danube River (ICPDR) and the International Sava River Basin Commission (ISRBC) are relevant institutions established as transnational body under the monitoring and coordination of several institutions in charge for monitoring of the water quality in the Danube and Sava River.

The ICPDR has been established to implement the Danube River Protection Convention, which forms the overall legal instrument for co-operation on transboundary water management in the Danube River Basin. The Convention was signed on June 29, 1994 in Sofia (Bulgaria) and came into force in 1998. It aims to ensure that surface waters and groundwater within the Danube River Basin are managed and used sustainably and equitably. The ISRBC has been established for purpose of the implementation of the Framework Agreement on the Sava River Basin.

(2) Harmonization of Its Legislation with EU Directives

Serbia is in the process of harmonization of its legislation with EU directives. In regard to environmental legislation, environmental investment planning is based on the National Program for Environmental Protection adopted in 2010 and the Sustainable Development Strategy adopted in 2008. Serbia has achieved a high level of alignment.

As regards waste management, Serbia has aligned its legislation with the key EU policies on waste and hazardous waste management, introducing the principles of waste prevention, reuse, recycling and recovery. Serbia has substantially aligned its legislation with the EU acquis on packaging and packing waste and on specific waste streams. Implementation has started. Legislation providing for waste separation is likewise in place. The National Waste

Management Strategy adopted in May 2010 provides for increasing the number of EU-compliant landfills and the collection rates for municipal waste.

As regards water quality, only 10% of wastewater discharged is treated. Sewage collection ranges from over 70% in urban areas to less than 10% in rural Serbia. The country's three largest cities (Belgrade, Nis and Novi Sad) have no wastewater treatment plants. Surface water quality is problematic, notably in the tributaries of the big Rivers Danube and Sava. There are quality issues related to both the microbiology and physical-chemical properties of drinking water in some parts of the country.

Whilst Serbian drinking water legislation has been largely aligned with EU law, large parts of the Water Framework Directive (WFD) still remain to be aligned with the EU Acquis. This includes the principle of cost recovery for water services, the delineation of water basins to replace the current delineation of water districts following administrative/political boundaries and the definition and mandate of the competent authority. EU legislation on the protection of groundwater against pollution and deterioration, groundwater monitoring, the Nitrates Directive and Urban Wastewater Treatment Directive still need to be fully introduced into Serbian law. Implementing legislation on emission limit values of pollutants in water and deadlines for its accomplishment has been adopted. Complying with the overall legislative framework, organizing governance of this sector in line with the principles of the WFD and catching up with the unusually vast backlog, notably in development of wastewater infrastructure, will be major challenges for Serbia.

Concerning climate change, good progress can be reported although a number of important implementation steps remain incomplete. The National Strategy for Incorporation of Serbia into the Clean Development Mechanism under the Kyoto Protocol was adopted by the Government in February 2010 for agriculture.

(3) New Government and Ministries in Charge of Water

With the recent reshuffle of government ministries according to the new Law on Ministries adopted on 26th July 2012, new Serbian Government have in total 17 ministries. Ministries relevant to water management are:

Ministry of Agriculture, Forestry and Water Management, Republic Water Directorate perform duties related to the water management policy, water supply except water distribution, protection against water, implementation of measures for protection against water, water regime and water borders of Republic of Serbia, inspection monitoring in water management according to the law and other duties determined by the legislation.

Ministry of Health among others controls health and sanitary conditions of the potable water, controls sanitary and hygienic conditions of the plants, facilities and equipment and regular inspections of such installations.

Ministry of Energy, Development and Environmental Protection among other duties is responsible for environmental protection and environmental inspection, excessive water pollution, water protection against pollution with an aim to prevent deterioration of surface water and groundwater quality. Environmental Protection Agency is in charge for development, harmonization and management of national information system; monitoring of the air and water quality, management of National Laboratory, collecting and processing environmental data, data processing procedures development, coordination and cooperation with European Environmental Protection Agency and European Information and Observation Network as well as other duties determined by the Serbian legislation.

Ministry of Natural Resources, Mining and Spatial Planning is among other duties responsible to manage and perform duties in relation to the sustainable development on natural resources (water, air, soil, minerals, forestry, fishes, wild plants and animals).

Apart from the stated, **Ministry of Regional Development and Local Government** has, among others, duty to manage and perform activities related to realization of infrastructure projects of regional and local importance that are financed or co- financed by financial means of Republic of Serbia and international donations and loans.

Ministry of Construction and Urbanism among others perform duties in relation to the communal infrastructure projects.

2.1.2 Law/Regulation on Water Environment Management

There are four main laws related to Sewerage Project: Water Law (Official Gazette of the Republic of Serbia, nr 30/2010 of 07.05.2010), Integrated Environmental Pollution Prevention and Control Law (Official Gazette of the Republic of Serbia, nr 135/2004) adopted in 2004, Waste Management Law (Official Gazette of the Republic of Serbia, nr 36/2009 and 88/2010), and Energy Law (Official Gazette of the Republic of Serbia, nr 57/2011).

(1) Water Law (Official Gazette of the Republic of Serbia, nr 30/2010)

Content of the law includes among others, the following key points:

- Gives definition on organic bio degradable load as “BOD_5 of 60 g per day” per PE (population equivalent)

- Water infrastructure in Article 19 related to the wastewater system (main collector, WWTP, sludge treatment facilities, effluent outlet pipe discharge into the receiving bodies, and other facilities)
- Part IV of the Law defines Integrated Water Management, under section 4.3 is water protection from pollution, ELV (emission limit values) definition; 4.3.2 Plan for water pollution protection; 4.3.3 protection measures, under article 98 obligation for the wastewater treatment; under article 99 obligation for the legal entity representative to measure quantity and quality of wastewater discharged; under 4.3.4 authorities for inspection of the wastewater quality.

(2) Integrated Environmental Pollution Prevention and Control Law (Official Gazette of the Republic of Serbia, nr 135/2004)

The Law on Integrated Pollution and Prevention Control (IPPC) adopted in 2004 in Serbia to control industrial wastewater and hazardous substance discharged to public water body and/or to sewer, which prescribes obligation of big industry polluters to prepare and submit IPPC documentation in order to get IPPC license. IPPC license integrates all environmental aspects and give obligation to the industry operator to report on quarterly and annual basis on all environmental parameters required by the permit. However implementation of this Law is postponed and deadline of 2015 shifted to 2020 by amendments to the IPPC Law.

(3) Waste Management Law (Official Gazette of the Republic of Serbia, nr 36/2009 and 88/2010)

Article 4 defines exclusion of type of waste treated by the Waste Management Law for among others; under article 4, not applicable waste is “sludge from sewerage system and septic tanks, except the sludge from the sludge treatment facilities”, where is clear the sewage sludge in general is not deemed as waste but treated sludge can be considered as a waste.

Waste Management Strategy of Republic of Serbia 2010-2019 classified sewage sludge, usage in agriculture, treatment in incinerators, in cement industry and disposal to the landfill. This is in accordance with EU Directive 86/278/EEC on land protection in agriculture. Under the Water Law, secondary legislation on ELV for wastewater determines conditions for sewage sludge usage in agriculture.

(4) Energy Law (Official Gazette of the Republic of Serbia, nr 57/2011)

This defines under article 2, biomass as biodegradable part of the product, waste and biological waste from agriculture (including biological and animal materials), forestry and the related industry, and biodegradable part of industrial and communal waste.

Under the Energy Law Republic of Serbia, under article 4 it is said “biomass is not considered, for the purpose of this act, fossil fuel ..., waste from the wastewater treatment facilities...”. The Ministry of Energy and Environment is asked to confirm if the sewage sludge treated to the level of dried sludge or carbonized sludge could be considered as alternative fuels. Official reply from the Ministry is that sewage sludge, according to the current legislation, **once treated** is considered as waste and not as biomass or fuel.

(5) Bylaws related to Emission Limit Values (ELV)

Regulation on Emission Limit Values of pollutants in water and deadlines to reach the ELV (Official Gazette of the Republic of Serbia, nr 67/2011 and 48/2012)

By this regulation, emission limit values (ELV) for the certain groups or categories of pollutants are defined and specific for (1) process water before discharge to the public sewerage, (2) process and other water that are discharged directly to the recipient, (3) treated water discharge from the public sewerage system to the recipient and (4) wastewater from septic and collection tanks discharge to the recipient and the deadlines to comply with the values.

In Article 3 of the said Regulation under point 9 definition of the residues from the wastewater treatment (“ostatak iz procesa preciscavanja) is defined as sludge treated or untreated from the wastewater treatment facilities.

ELV of pollutants for process wastewater before discharge to the public sewer is given under Article 8 of the ELV Regulation. Detailed ELV are under Annex 2 of the ELV Regulation (Table 1, Section III).

ELV of pollutants for process wastewater and other wastewater before discharge directly to the recipient is given under Article 9 of the ELV Regulation. Detailed ELV are under Annex 2 of the ELV Regulation (Section I and II). ELV of pollutants for wastewater after treatment and before discharge from the public sewer system to the recipient are given under Annex 2 (Table 2, 3, 4, 5 and 6, Section III).

Article 15 says: ELV for the residues of the wastewater treatment are given under Annex 2 (Table 7, Section III). Residues from wastewater treatment may be used in the agriculture or other purposes (for example for covering landfill or landscaping) if the values are in the limits given in the Table 7. Before use, the residues have to be treated in order to reduce number of pathogens and adjust for certain purpose. However the treatment of residues from the process wastewater treatment is according to the waste legislation.

Article 19 defines the deadline to achieve the compliance with ELV regulation. However by the recently adopted regulation "Regulation on amendments and changes of ELV Regulation" (May 2012) article 19 is changed to the extended deadlines:

Legal entities, entrepreneurs and persons that have wastewater treatment facilities and/or discharge wastewater to the recipient or public sewer are obliged to comply with ELV according to ELV Regulation the latest by **31 December 2030**.

Excluded from the deadline are wastewater treatment plants with load higher than 2000 PE discharging directly to the recipient will have to comply with ELV the latest by **31 December 2045**, and for communal wastewater discharging from the settlements less that 2000 PE, compliance will be according to the water management plan.

Nevertheless, for new wastewater treatment plants, the deadline to reach ELV is immediately.

Under **annex 1**, general criteria for determining pollutants in wastewater are given.

Under **annex 2**,
Section I defines ELV for the process water of 45 industries/
Section II defines ELV for 5 businesses
Section III defines ELV for Communal wastewater

Above indicated Table 1 to 7 in "Official Gazette nr.67/2011" which show detailed Emission Limit Values (ELV) is attached in the Appendix.

(6) Bylaws related to Limit Values of Surface Water

Regulation on limit values of priority hazardous materials that pollute surface water and the deadlines for compliance with them (Official Gazette of the Republic of Serbia, nr 50/2012)

This regulation sets environmental standards for surface water protection for prioritized materials. Deadline for achievement is set in article 6 saying that date will be set after Government prepare Current Status Analysis of Prioritized Materials in Surface water that are not affected by cross border pollution. Until that date, maximal values are to be determined by the Regulation on hazardous materials in water (Official Gazette of the Republic of Serbia, nr 31/1982).

Regulation on Limit Values of pollutants in surface and groundwater and sediment

By this Regulation limit values of pollutants in surface water and groundwater and sediment are determined as well as deadline to comply with it.
Article 4: Limit values of pollutant in surface water are given in Annex 1 –Surface water
Article 5: Limit values of pollutant that are indicators of general parameters, oxygen regime, nutrient substance, salinity, metals, organic substances and microbiological parameters in surface water, for certain class of surface water are determined by regulation of environmental and chemical status parameters, given in Table 1, Table 2 and Table 3, Annex 1. In Chapter V Deadlines to achieve limit values is set as 31 December 2032.

Above indicated Table 1 to 3 in "Official Gazette nr 50/2012" which show detailed Limit Values of Pollutant for surface water is attached in the Appendix.

2.1.3 Plan and Present Sewage Treatment in Serbia

Serbian National Environmental Protection Program NEPP (Official Gazette nr 12/2010 dated 12.03.2010) set up goals in relation to the environmental protection. Among them only goals related to the water/wastewater are listed below:

<u>Short term goals 2010-2014</u>

- To introduce effluent standards according to the Directive Urban Wastewater Treatment–91/271/EEC by the end of 2011
- To harmonize national legislation with other EU directives related to the water
- Harmonization and implementation of Nitrates Directive 91/676/EEC

<u>On-going objectives 2010-2019</u>

- To improve water quality in water courses by reducing discharges of untreated industrial and municipal wastewater
- To upgrade or renew operation of the existing municipal wastewater treatment plants
- To provide collection and treatment of municipal wastewaters in settlements exceeding 100,000 inhabitants
- To provide treatment of municipal wastewaters in settlements without organized water supply and which significantly impact direct recipient and water quality in sensitive zones
- To increase coverage with public sewer systems to 65%

Mid-term objectives 2015-2019

- To adjust the bathing water quality standards to the Bathing Water Directive 76/160/EEC
- To ensure environmentally and technically sound reuse or disposal of sewage sludge from WWTPs

Current Status of Wastewater Treatment Plant in Serbia is shown in the following table. Total number of WWTP in Serbia is 26 in the local municipalities excluding Belgrade.

Table 2.1 Present Situation of 26 WWTPs

nr	Location WWTP	Water catchment	Designed capacity (PE)	Constructed capacity (PE)	Connected citizens (persons)	Achieved effect of treatment (PE)	Achieved effect of system (PE)	Remarks
1	Arandjelovac banja	Morava	25,000	25,000	12,155	8,750	4,254	Works with limited capacity
2	Bac	Banat & Backa	13,000	13,000	3,652	5,460	1,534	Not regular maintenance, technical problems during operation
3	Bela Palanka	Morava	20,000	20,000	8,195	11,200	4,589	Constructed 2007.
4	Becej	Banat & Backa	50,000	50,000	10,310	28,000	5,774	Works with reduced capacity, although effect are satisfactory
5	Valjevo	Sava	100,000	100,000	51,880	63,000	32,684	In general satisfactory
6	Velika Plana	Morava	40,000	40,000	11,347	22,400	6,354	Relatively good work with reduced capacity
7	Vlasotince	Morava	20,000	10,000	11,349	4,200	4,767	Problem with operation because of lack of pre-treatment of industrial water
8	Vrsac	Banat & Backa	140,000	90,000	21,974	44,100	10,767	Problem with operation because of lack of pre-treatment of industrial water
9	Gornji Milanovac	Morava	100,000	50,000	23,982	31,500	15,109	Gas line not finished, but operation satisfactory
10	Despotovac	Morava	5,000	5,000	2,836	1,750	993	Works with decreased capacity
11	Dimitrovgrad	Morava	9,500	9,500	6,759	5,320	3,785	Relatively good work
12	Jagodina	Morava	89,000	45,000	32,030	28,350	20,179	Relatively good work
13	Kanjiza	Banat & Backa	8,000	8,000	6,630	4,480	3,713	Overload occasionally. Technical problems with mechanical equipment
14	Kikinda	Banat & Backa	120,000	40,000	24,322	19,600	11,918	Not stabile operation, technical problems
15	Kladovo	Morava	20,000	10,000	7,137	1,000	714	Partially constructed, non satisfactory work
16	Kragujevac	Morava	250,000	125,000	102,461	70,000	57,378	Works with decreased capacity
17	Medvedja	Morava	3,000	3,000	2,529	1,680	1,416	Relatively good operation
18	Paracin	Morava	62,700	29,000	15,175	18,270	9,560	Generally good operation
19	Svilajnac	Morava	10,000	10,000	8,925	4,200	3,749	Works with limited effects
20	Sokobanja	Morava	10,000	5,000	7,735	2,100	3,249	Works with limited effects
21	Sombor	Banat & Backa	180,000	180,000	31,397	100,800	17,582	Problem with operation because of lack of pretreatment of industrial water
22	Stara Moravica	Banat & Backa	5,000	5,000	1,140	1,750	399	Problem with operation because of lack of pretreatment of industrial water
23	Subotica	Banat & Backa	230,000	230,000	59,989	196,650	51,291	Reconstruction finished in 2010, commissioned
24	Surdulica	Morava	22,000	15,000	11,241	5,250	3,934	Reconstructed
25	Topola	Morava	8,000	8,000	3,795	4,480	2,125	Relatively good work
26	Horgos	Banat & Backa	2,000	2,000	2,846	1,120	1,594	Lack of capacity, low standard of treatment
Total			1,542,200	1,127,500	481,791	685,410	279,410	

2.1.4 Subotica Wastewater Treatment Plant

Subotica WWTP is located in the southern part of the city of Subotica. The receiving water body for treated water is Lake Palic, one of the most popular tourist destinations in the province of Vojvodina. The WWTP was built in the middle of 1970s because of the occurrence of ecological disaster in Lake Palic in 1971 with massive pestilence of fishes.

The sewerage network in Subotica has been built as combined system which collects wastewater and storm water alike. The city is divided into eight major collection areas and whole network is gravitation-based. Total length of the sewerage network is approximately 240 km as shown in Table 2.2 and 60 % of the planned area is covered by the sewerage network so far. Total number of connections is 17,750.

Table 2.2 Length of Sewerage Network

No.	Type of material	Length
1	Reinforced concrete	5,459 m
2	PE – polyethylene	1,509 m
3	Asbestos cement	98,234 m
4	Concrete	41,941 m
5	Ceramic	169 m
6	PVC	79,834 m
7	Masonry wall	12,388 m
	Total	239,534 m

The original capacity of the WWTP was 27,000 m^3/day and the WWTP was planned to purify organic substances by conventional activated sludge process. The original facilities were comprised of lift pumps, pretreatment facilities, i.e. mechanical screenings and sand removals, sewage treatment facilities, i.e. one primary settling tank, two aeration tanks and three secondary settling tanks, and the lagoon system. There are three serially connected lagoons attached to the WWTP. However, aeration equipment for the aeration lagoon has stopped operating.

The Subotica municipality assembly adopted a decision to upgrade and extension of the existing WWTP aiming the increase of its capacity and removal of nutrient, i.e. nitrogen and phosphorus. The project named as “Subotica Wastewater Treatment Plant Upgrade and Extension” has been conducted. The objectives of the project are the followings.

- Increase of treatment capacity from 27,000 m^3/day to 36,000 m^3/day
- Removal of nitrogen and phosphorus in line with the EU Directives
- Energy efficiency increase of the wastewater treatment system
- Safe and modern bioactive sludge surplus treatment
- Quality protection and improvement of Lake Palic

Approximately eighteen million euro has been allocated for the implementation of the project. Half of the funds were provided by the loan from the European Bank for Reconstruction and Development (EBRD). Five million euro was granted by the European Union through the Delegation of the EU. The city of Subotica secured another three million euro from its own founds. The government of Italy and Netherland and the public water company supported this capital project with smaller amount of funds.

Sewage treatment facilities comprising two primary settling tanks, two aeration tanks and two secondary settling tanks was implemented for increase of treatment capacity and nutrient removal. Sludge treatment facilities comprising mechanical thickening, anaerobic digester with biogas utilization and mechanical dewatering was implemented for proper sludge treatment and energy utilization of biogas. The construction works were commenced in September 2007 and completed in March 2009. The layout of Subotica WWTP after completion of upgrade and extension project is shown in Figure 2.1.

Figure 2.1 Layout of Subotica WWTP

2.2 Water Environmental Management in the City of Belgrade

2.2.1 Natural Features in the City of Belgrade

(1) Geography

Belgrade lies 116.75 meters above sea level and is located at the confluence of the Danube and Sava rivers. The city has an urban area of 360 km^2, while together with its metropolitan area it covers 3,223 km^2. On the right bank of the Sava, central Belgrade has a hilly terrain, while the highest point of Belgrade proper is Torlak hill at 303 m. The mountains of Avala (511 m) and Kosmaj (628 m) lie south of the city. Across the Sava and Danube, the land is mostly flat, consisting of alluvial plains and loessial plateaus.

(2) Geology

The figure below shows the geological situation of whole Belgrade City. The proposed WWTP site is red marked location in the map and geological condition is quaternary alluvial deposit of the Danube bed.

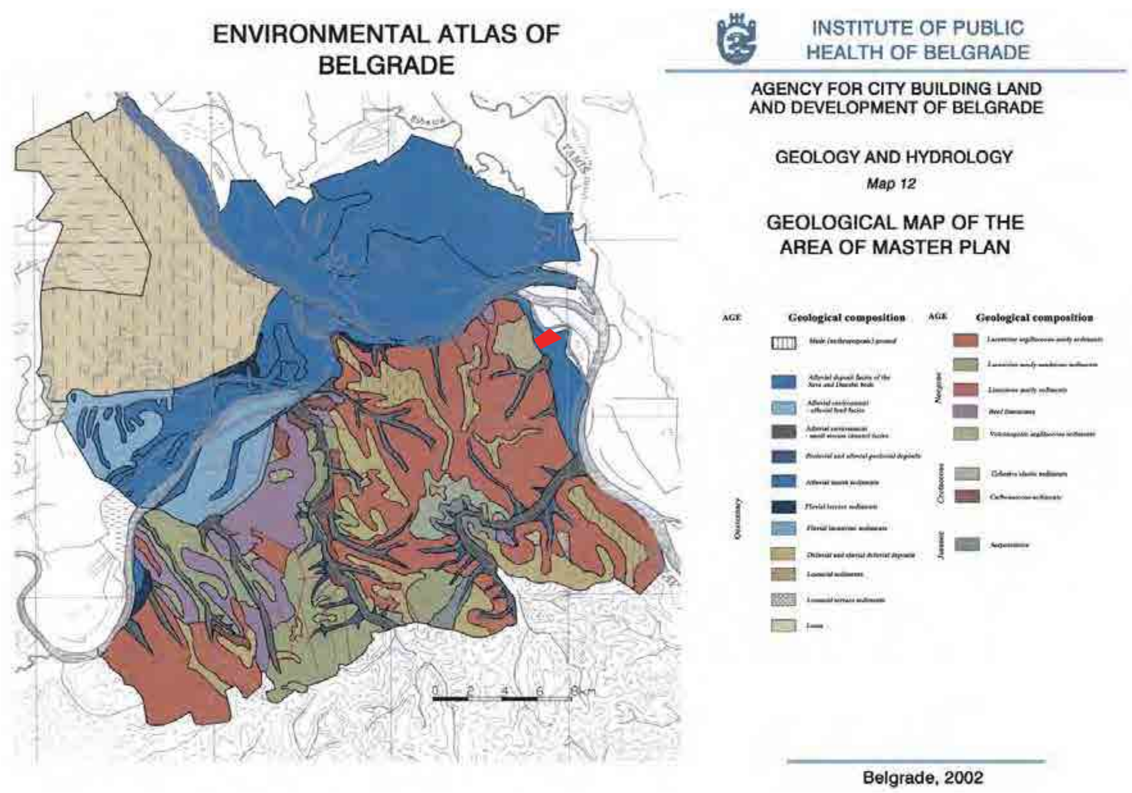


Figure 2.2 Geological Map

(3) Climate Conditions

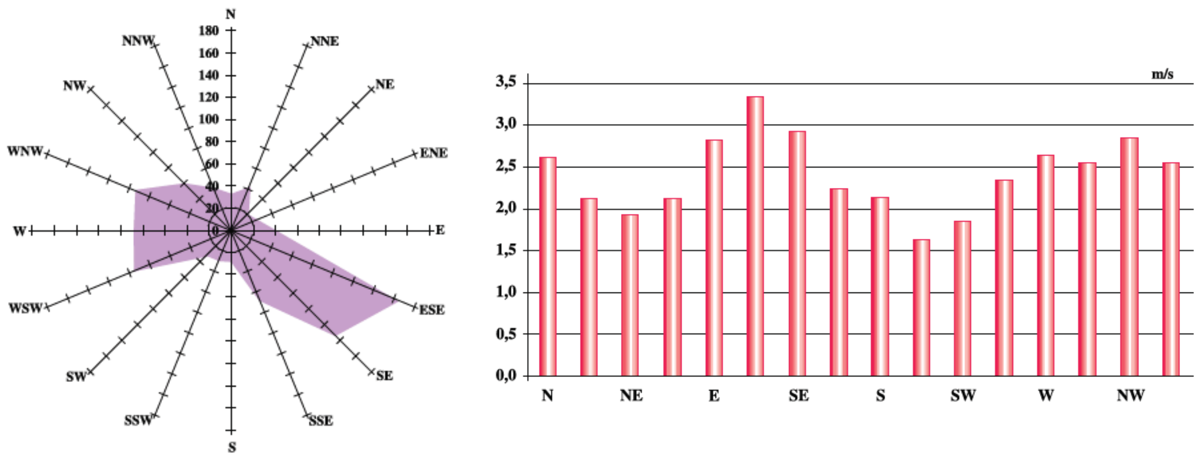
Belgrade and its surroundings have moderate continental climate with annual average temperature of 12°C. January is the coldest month, with -3.0 °C and July is warmest, with 28.1 °C. The average annual precipitation is about 670 mm.

Table 2.3 Main Meteorological Data, 1887-2002

	Annual data	January	February	March	April	May	June	July	August	September	October	November	December
Mean air temperature, °C	11.7	0.1	1.9	6.8	12.0	17.0	20.1	22.1	21.7	17.7	12.5	6.7	2.1
Mean maximum air temperature, °C	16.8	3.3	6.0	11.8	17.4	22.7	25.8	28.1	28.0	24.0	18.0	10.7	5.2
Mean minimum air temperature, °C	7.3	-3.0	-1.6	2.6	7.2	11.7	14.7	16.4	16.0	12.6	8.2	3.5	-0.6
Mean quantity of precipitations, l/m2	669.5	42.8	38.2	44.2	57.8	71.0	86.3	65.3	53.3	49.7	54.8	53.8	53.2
Maximum quantity of precipitations, mm	1051.2	112.0	127.7	144.7	157.9	191.7	218.2	262.5	198.8	183.7	217.6	129.8	178.7
Minimum quantity of precipitations, mm	322.6	4.2	1.1	1.6	10.6	8.7	7.9	2.1	1.6	1.0	-	2.2	0.6
Sun duration*, h	2105.1	71.9	97.8	149.6	186.1	233.5	261.3	295.3	276.4	214.1	166.6	88.3	63.4
Mean humidity of air*, %	69.5	79.7	74.3	66.0	62.1	64.1	65.0	62.7	62.8	66.7	71.7	77.7	81.0

*Period 1925–2002

Source: Statistical Yearbook of Belgrade 2010



Source: Statistical Yearbook of Belgrade 2010

Figure 2.3 Annual Rose of Winds and Mean Speed of Wind, 1952-2002

(4) Population

The change of the population from 1961 to 2002 is shown in Table 2.4. The population was increased till 1991 but in 2002 the population was decreased. According to the preliminary results of Census 2011, the population is 1,639,121.

Table 2.4 Population Change, 1961-2002

	Population			Population per km^2	Households	Persons per 1 household
	Total	Male	Female			
1961	942,190	464,414	477,776	…	310,587	3.0
1971	1,209,361	590,352	619,009	375.4	401,443	3.0
1981	1,470,073	717,699	752,374	456.3	489,438	3.0
1991	1,602,226	775,362	826,864	497.2	515,040	3.1
2002	1,576,124	747,854	828,270	489.1	567,325	2.8

Source: Statistical Yearbook of Belgrade 2010

2.2.2 Present Water Quality of Public Water Body

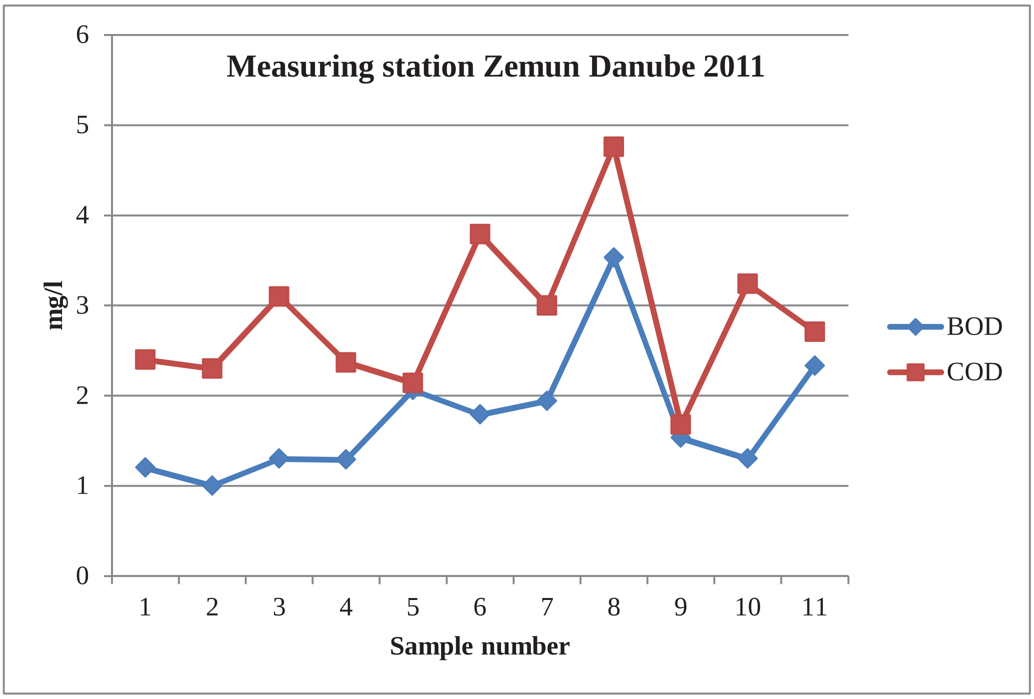
Water quality of the river in Serbia is under responsibility of Serbian Environmental Protection Agency (SEPA), which is a governmental institution under the supervision of the Ministry of Energy, Development and Environmental Protection. Its main task is development, management and coordination of the national environmental information system, collection and integration of the environmental data, production of yearly state of the environment reports also giving recommendations for future steps aiming a general improvement in this field.

Water quality data at monitoring points of Danube and Sava River

Data on river water quality are provided by SEPA for 2006 up to 2011 for Danube River at Zemun station (upstream of Belgrade), Sava River at Ostruznica station (upstream of Belgrade) and Danube River at Vinca station (downstream of Belgrade).

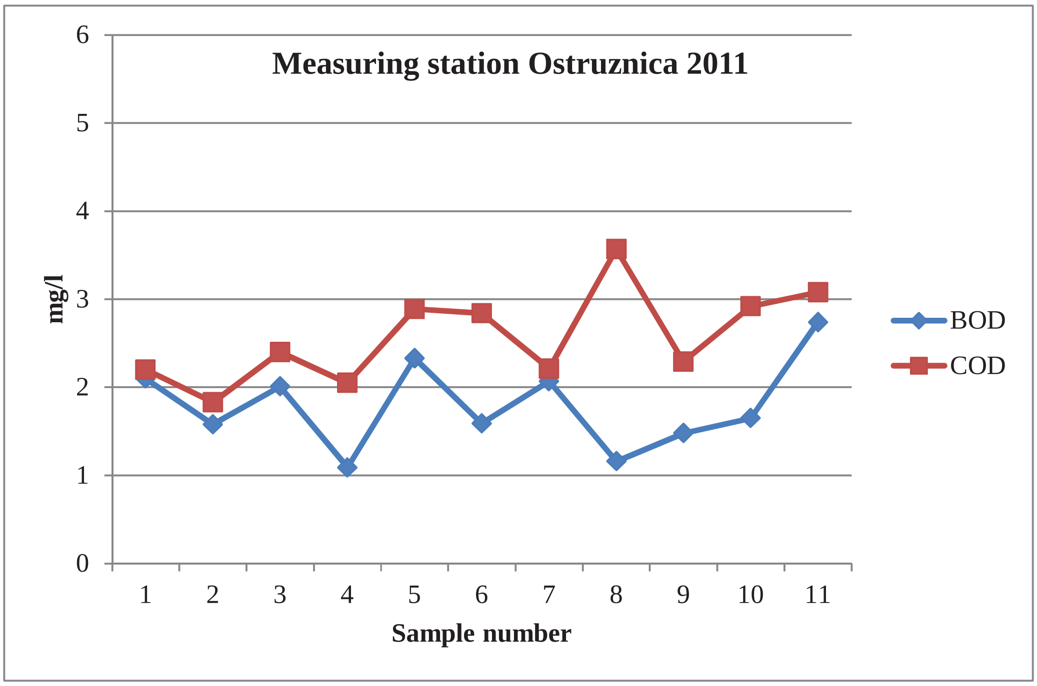
The measurement of river water quality of Danube and Sava is performed according to the “Program of systematical quality monitoring of surface and groundwater Republic of Serbia”. The samples are taken monthly at the depth of 0.5 m under the surface level. SEPA is accredited lab by National Accreditation Body of Republic of Serbia.

The water qualities of river at the closest measuring station are shown below as per data received from SEPA:



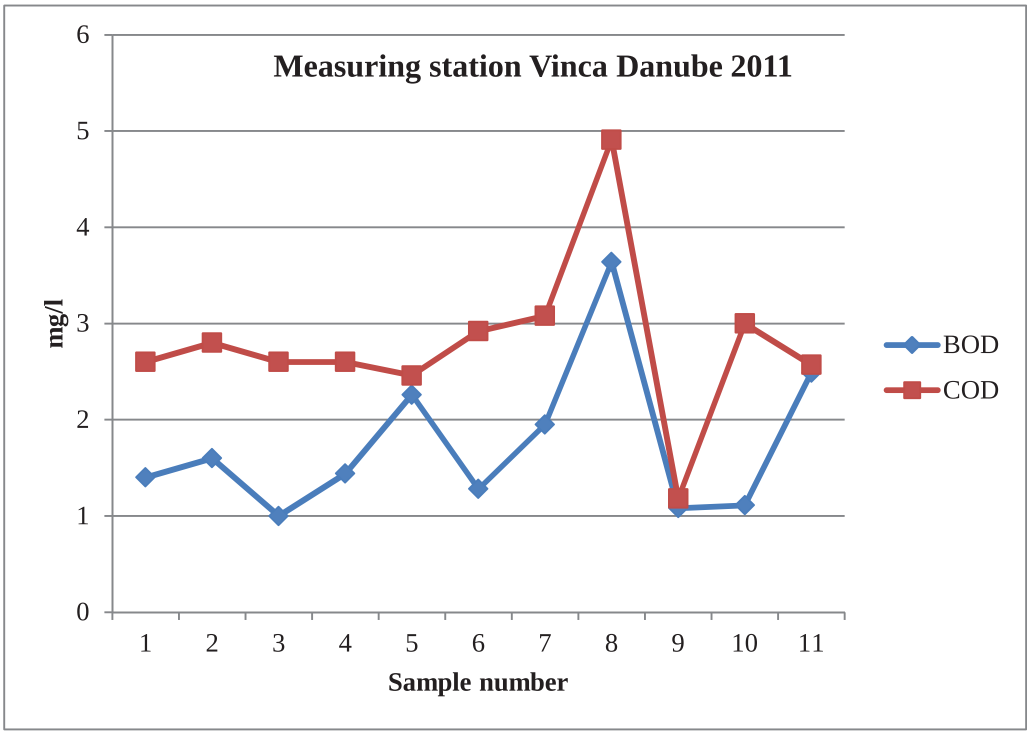
Source: SEPA

Figure 2.4 Danube Water Quality at Zemun Station in 2011 (Upstream of Belgrade)



Source: SEPA

Figure 2.5 Sava Water Quality at Ostruznica Station in 2011 (Upstream of Belgrade)



Source: SEPA

Figure 2.6 Danube Water Quality at Vinca Station in 2011 (Downstream of Belgrade)

According to the recent data shown in the diagrams above, it seems that assimilative capacity of Danube River is good enough, so there are no differences in BOD_5 or COD levels upstream and downstream of Belgrade.

But achieved class of water quality of Danube River and Sava River in Belgrade area corresponds to Class III due to the most probable number (MPN) of coliform and SS as shown in Table 2.5, even though required level is Class II.

Table 2.5 Classification of the River Water for Relevant Stations

Monitoring Station	DO	BOD5	COD	MPN of Coliform	SS	PH	Colour	Smell	Achieved Class	Required Class
Danube Zemun	II	II	I	III	III	I	I	I	III	II
Danube Vinca	II	II	I	IV	III	I	I	I	III	II
Sava Ostruznica	II	II	I	III	II	I	I	I	II/III	II

Source: Monitoring data of SEPA

2.2.3 Water Quality Management in Belgrade

(1) Administrative Responsibility

On the city level, the City of Belgrade administration has role of water quality control and monitoring. City administration consists of 14 secretariats as shown in Figure 2.7, among them the responsibility of water quality control and monitoring is specifically on the Secretariat for Environmental Protection.

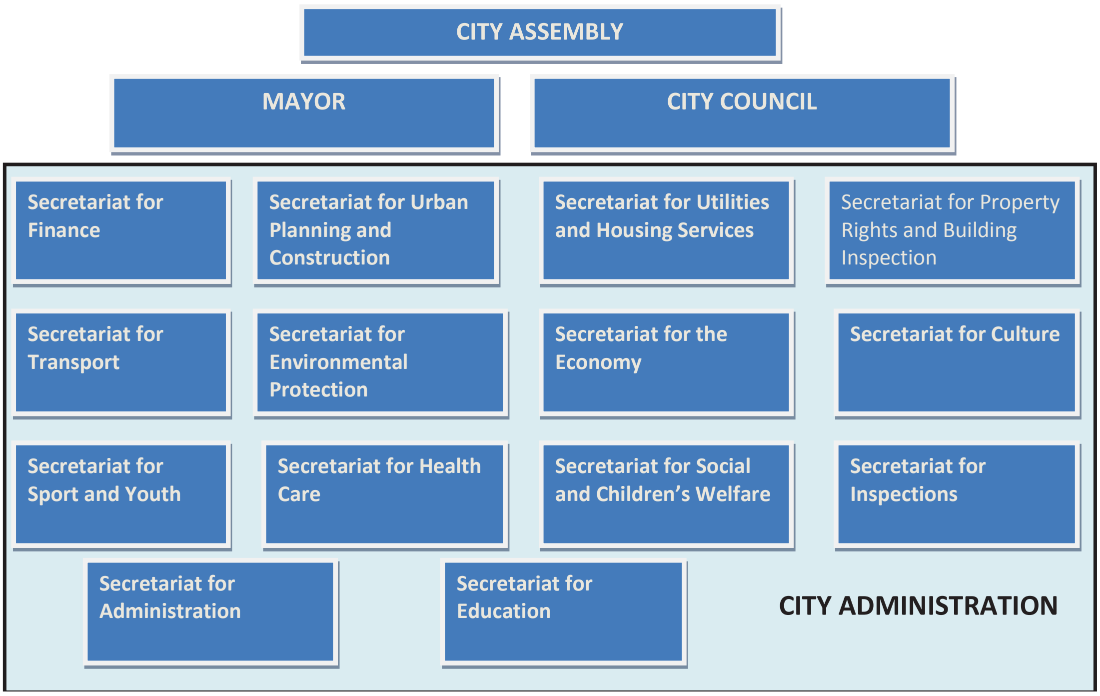


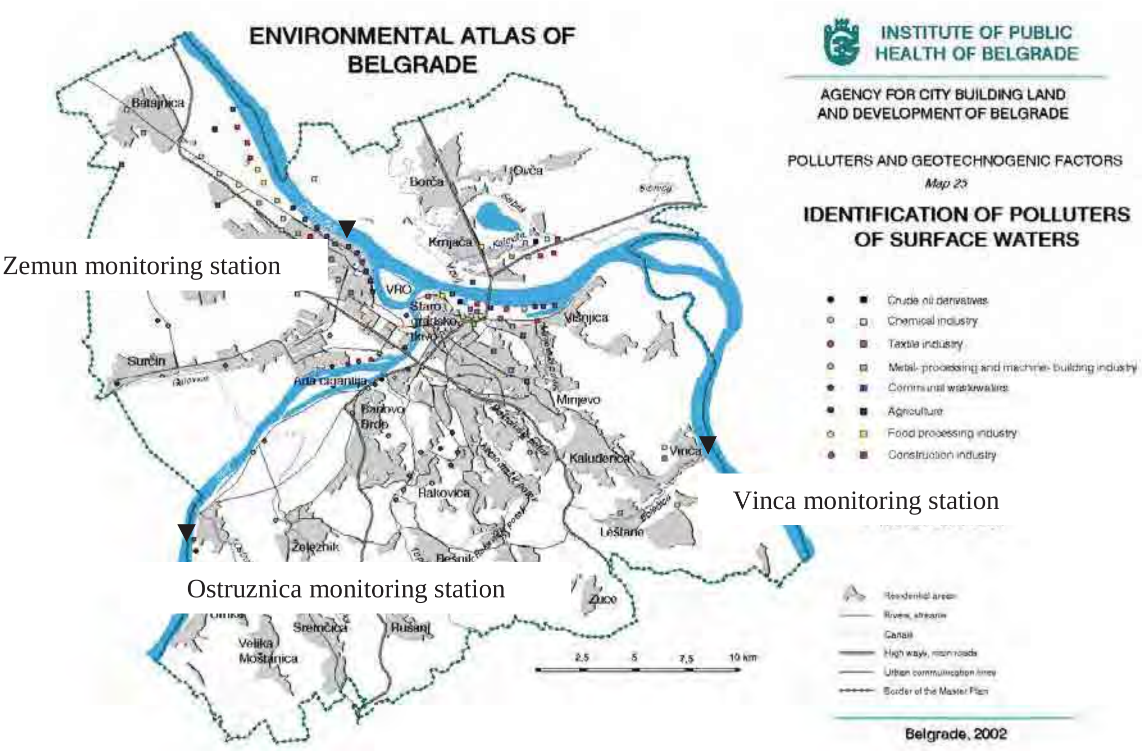
Figure 2.7 Organization Chart of the City of Belgrade

Organization of the Secretariat for Environmental Protection consists of the following 4 sectors;

- Sector of Environmental Monitoring
- Sector of Project Planning and Management
- Sector of Environmental Management
- Sector of Inspection

(2) Industrial Wastewater Control in Belgrade

In the picture below are indicated biggest industry polluters and discharges to the river or public sewer.



Source: Institute of Public Health of Belgrade

Figure 2.8 Map of Industry Discharge

According to the available data from Belgrade Chamber of Commerce, industry of Belgrade is represented by 115000 workers employed in 7948 enterprises, representing 29% of GDP in economy of Belgrade. Main industry branches are energy production (electricity, heating, etc.), metal industry, chemical and pharmaceutical industry, textile and leather, paper industry, food processing and wood processing and production. Among them, 25 are listed as big industry polluters and are listed under IPPC permits obligation. The 25 industries are listed below;

<u>The 25 big industry polluters with IPPC in Belgrade County</u>

1. Power plant TE Nikola Tesla A Obrenovac
2. Power plant TE Nikola Tesla B, Obrenovac
3. Power plant TE Kolubara, Kolubara
4. District heating plant Kolubara
5. District heating company to Novi Beograd
6. District heating company to Zemun
7. District heating company to Dunav
8. District heating company to Vozdovac
9. District heating company to Konjarnik
10. District heating company to Mirijevo
11. District heating company to Cerak
12. District heating company to Banovo Brdo
13. District heating company to Miljakovac
14. District heating company to Medakovic
15. Oil refinery “Rafinerija nafte Beograd”

16. IGM Trudbenik
17. Organika, polyurethane foam production
18. AD Vrenje, yeast production
19. Poultry production Vizelj
20. AD Imlek, milk production
21. Umka, paper production
22. Poultry production Pupc Univerzal Mladenovac
23. Poultry production Piljan Surcin,
24. Poultry production Jugokoka Ripanj
25. Poultry production AD Dragan Markovic, Obrenovac

Among various responsibilities shared between national and local authorities monitoring of the industry is conducted either by BVK or SEPA or both and in some cases none. Needless to say, most of IPPC industries are still not issued with the water permits therefore they cannot submit IPPC application and get IPPC license. Due to the fact that data on the mentioned industries are not available by the city administration, there is no clear understanding on their discharge activities.

In conclusion, in the following table, the available data for industries are shown in this relation on the water permit status, IPPC status and control of discharge.

Comparing the data given on Figure 2.8, it is clearly shown that many industries in City of Belgrade are still not listed neither as water permit obligation not as monitoring obligation.

Table 2.6 Overview on the Situation of Polluting Industries (Different Sources)

Name of the industry	Water permit	IPPC	Discharge monitoring
AD Beogradska pekarska industrija “Klas”	yes	-	discharge quality monitored by BVK
JKP “Gradsko saobracajno preduzece”	yes	-	discharge quality monitored by BVK
JKP “Beogradske elektrane (in the listed IPPC above number 5-14)	yes	obligation yes, but still not in procedure	discharge quality monitored by BVK and SEPA
Metro Cash Carry	yes	-	no monitoring by BVK and SEPA in 2010 and 2011
OMV Srbija	yes	-	no monitoring by BVK and SEPA in 2010 and 2011
NIS Petrol Novi Beograd	yes	-	no monitoring by BVK and SEPA in 2010 and 2011
NIS Petrol Cukarica	yes	-	monitored by BVK
Klinicki centar Srbije	yes	-	no monitoring by BVK and SEPA in 2010 and 2011
AD Beogradska industrija piva	yes	-	monitored by BVK
Oil refinery “Rafinerija nafte Beograd” (in the listed IPPC above number 15)	no	obligation yes, but still not in procedure	SEPA and BVK
Power plant TE Nikola Tesla A Obrenovac and Power plant TE Nikola Tesla B, Obrenovac (in the listed IPPC above number 1-2)	no	obligation yes, but still not in procedure	SEPA
Power plant TE Kolubara, Kolubara (in the listed IPPC above number 3)	no	obligation yes, but still not in procedure	SEPA

Name of the industry	Water permit	IPPC	Discharge monitoring
IGM Trudbenik (in the listed IPPC above number 16)	no	obligation yes, but still not in procedure	no monitoring
Organika, polyurethane foam production (in the listed IPPC above number 17)	no	obligation yes, but still not in procedure	no monitoring
AD Vrenje, yeast production (in the listed IPPC above number 18)	no	obligation yes, but still not in procedure	no monitoring
Poultry production Vizelj (in the listed IPPC above number 19)	no	obligation yes, but still not in procedure	no monitoring
AD Imlek, milk production (in the listed IPPC above number 20)	no	obligation yes, but still not in procedure	SEPA
Umka, paper production (in the listed IPPC above number 21)	no	obligation yes, but still not in procedure	SEPA
Several poultry production facilities (Pupc Univerzal Mladenovac, Piljan Surcin, Jugokoka Ripanj, AD Dragan) (in the listed IPPC above number 22-25)	no	obligation yes, but still not in procedure	no monitoring
Fabrika hartije Beograd	no	-	SEPA and BVK
BVK water treatments facilities	no	-	SEPA and BVK
District heating plant Kolubara (in the listed IPPC above number 4)	not available data	obligation yes, but still not in procedure	not available data

On the other hand 47 industries with 66 sampling locations and with the discharge directly to the public sewer are monitored and analyzed by BVK. These are shown in Figure 2.9. Some of the BVK listed industries are also monitored by Serbian Environmental Protection Agency, although SEPA monitors industry discharging directly to the recipient as well.

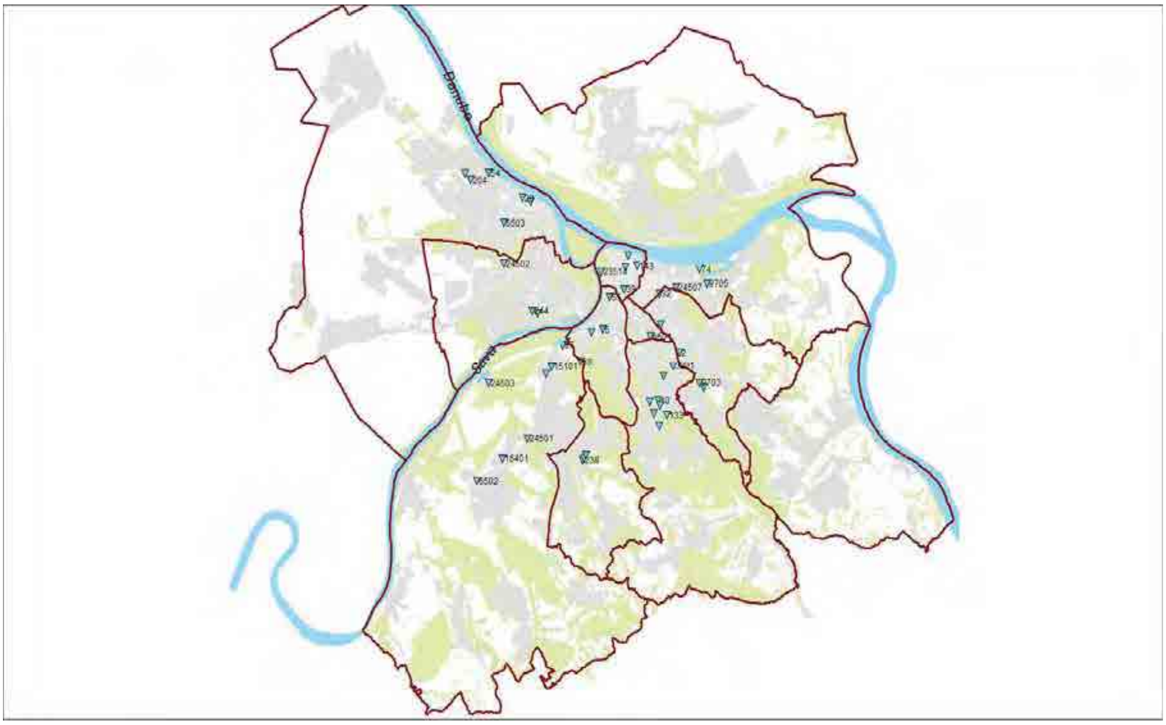


Figure 2.9 Industry Discharge Monitored by BVK (Discharge to the Public Sewer)

(3) Monitoring Points of Wastewater Discharge from Sewerage System to Rivers

There are 8 monitoring points for direct discharge of sewage from sewer to Sava River and Danube River, shown in the Figure 2.10. In this respect, BVK monitors, samples and analyzes the sewage at 8 points, Sajam, Lasta, Ušće, Dorcol, Istovariste, Ada Huja I, Ada Huja II and Visnjica.

Figure 2.10 Location Map of 8 Discharge Points

2.2.4 Problem of Water Quality Management

From environmental aspects, the Belgrade sewerage system is far behind EU standards, as wastewater is discharged to the Sava and Danube rivers without any treatment. According to the current deadlines defined by legislation, operator of the wastewater treatment plants will have to be fully compliant with emission limit values for discharge to the recipient by the end of 2045. Therefore, it is required to prepare city action plan on the activities to achieve full compliance till the requested deadline.

Such action plan has to be fully harmonized with other environmental aspects, especially in regards to the sludge disposal. Current legislation regarding the sludge disposal is not fully harmonized with EU, thus concept “waste to energy” may not be implemented for sewage sludge. In general, Waste Management Plan for the city of Belgrade needs to be analyzed and harmonized with water management plan on the city level, including local energy strategy and economic development plan.

On the institutional level, many different vertical and horizontal institutions are responsible for water management. Several ministries are in charge on the national level to apply and harmonize legislation with the EU directives in the water and environmental protection. In the previous period, new laws related to water and environmental protection were adopted, but in many cases secondary legislations are still missing. Due to the recent government change in 2012, many ministries are now in reorganizational stage. These reorganizational activities will delay actions foreseen in The National Environmental Protection Program.

All regularly collected data on river quality and industrial and business discharges are not systematically exchanged and coordinated between stakeholders. National Hydro meteorological Institute is collecting flow and level data, but Serbian Environmental Protection Agency is collecting river quality data for certain industries in Belgrade. BVK also monitors industries discharging to the public sewer. Most of big polluters listed as IPPC do not have any kind of discharge control and do not possess water permits, even obligatory by legislation. All these requirements on discharge control with quantity and quality are obligations given in the new Law on Water adopted in 2010. However implementation and enforcement of the requirements given by this Law are delayed.

2.3 Present Sewerage System in Belgrade

2.3.1 Master Plan of the City of Belgrade

Assembly of the City of Belgrade has adopted "Mater Plan of the City of Belgrade to 2021 (MP2021) prepared by the Urban Planning Institute of Belgrade in 2003". According to MP2021, the City of Belgrade has 17 urban municipalities as shown in Table 2.7 and Figure 2.11. Summary of planned land use in City of Belgrade is shown in Figure 2.12 and Table 2.8. The land under agricultural use currently is expected to be used as residential, economic, commercial, or traffic land and so on by 2021.

(1) City of Belgrade Municipalities

Boundary of Master Plan of the city of Belgrade are defined comprising following municipalities or parts of municipalities: Čukarica, Part of Grocka, New Belgrade, part of Palilula, Rakovica, Savski venac, Part of Surčin, Stari grad, Part of Voždovac, Vračar, Part of Zemun, and Zvezdara.

Table 2.7 Belgrade City Municipalities

No	Municipalities	No	Municipalities
1	Stari grad	11	Barajevo
2	Vračar	12	Sopot
3	Savski Venac	13	Mladenovac
4	Zvezdara	14	Lazarevac

No	Municipalities	No	Municipalities
5	Rakovica	15	Obrenovac
6	Čukarica	16	Grocka
7	New Belgrade	17	Surčin
8	Palilula		
9	Voždovac		
10	Zemun		

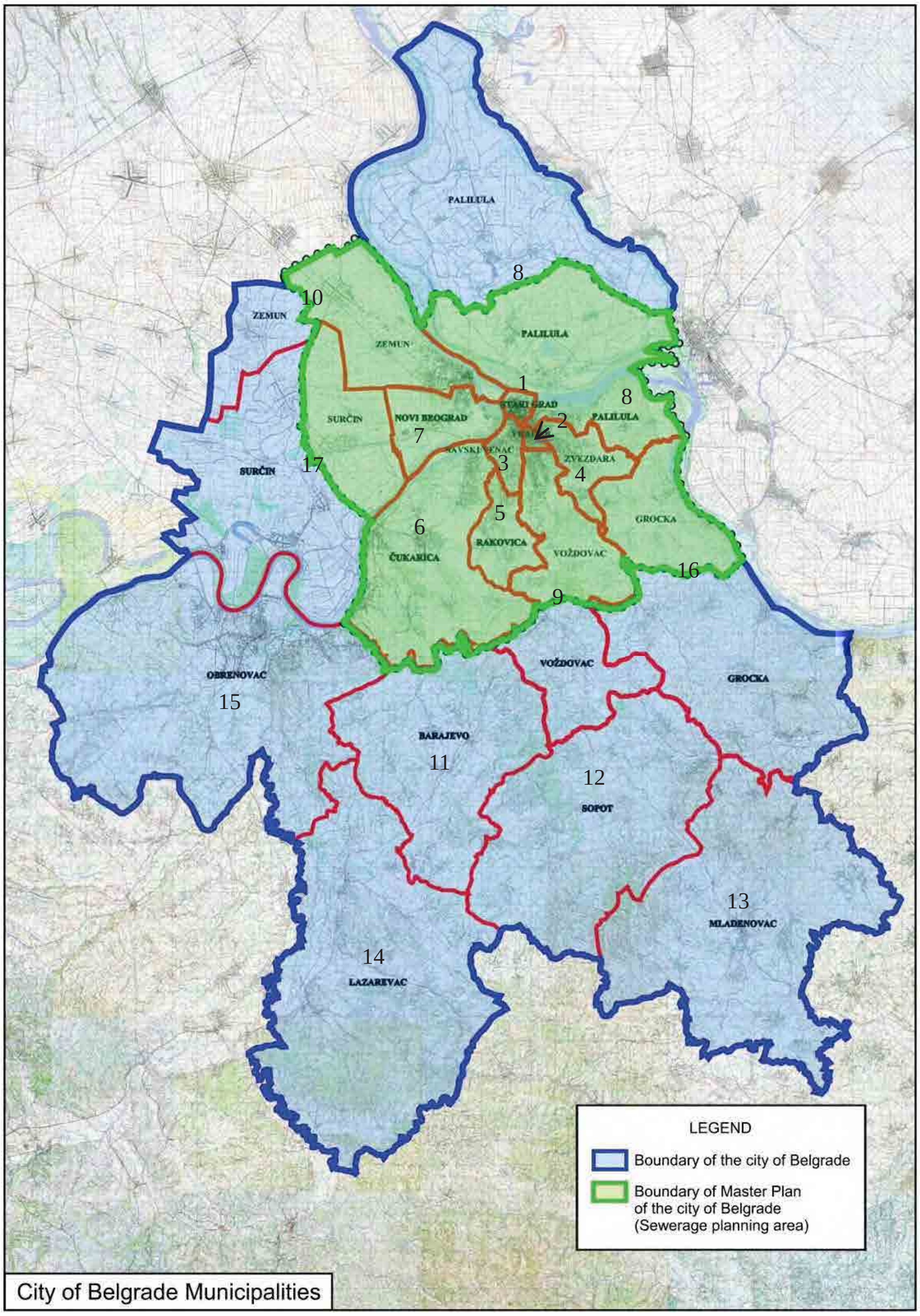


Figure 2.11 City of Belgrade Municipalities

(2) Land Use

The land use is shown in the figure below.

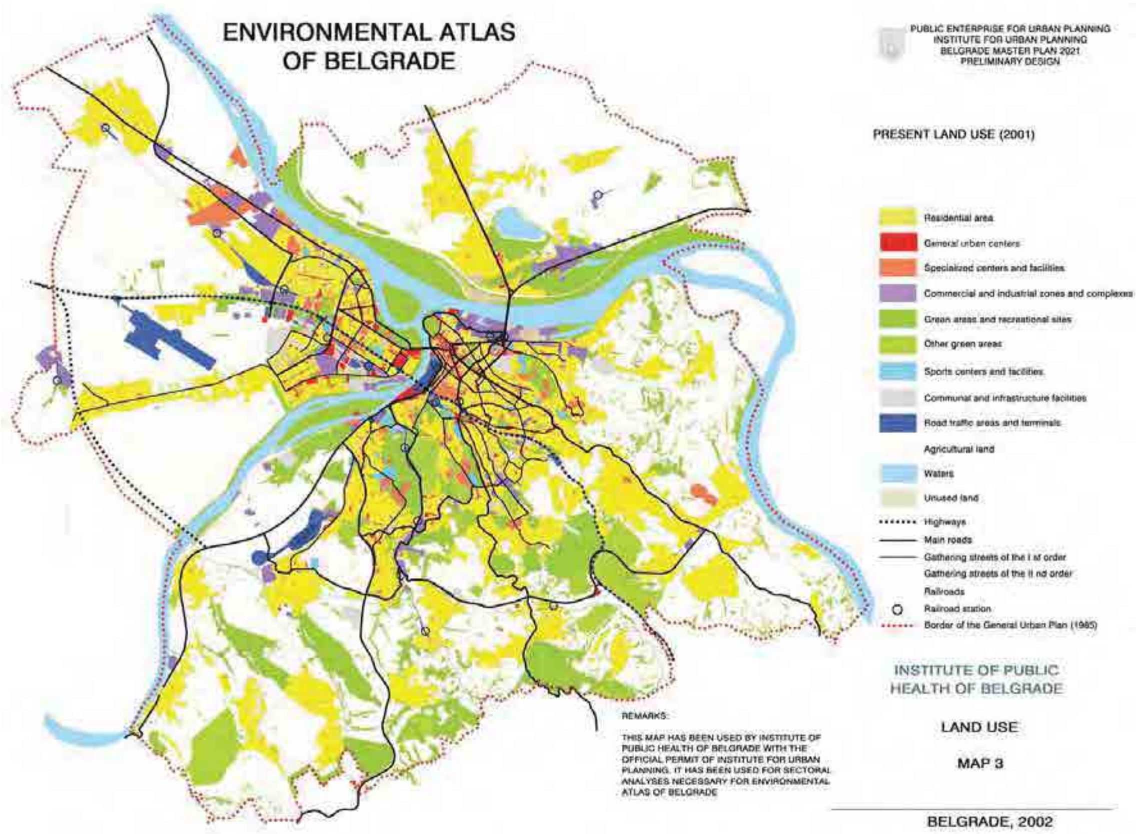


Figure 2.12 Land Use

Under the Belgrade MP2021, the detail land use of the current and 2021 is analyzed. The total area of the land within the Belgrade Master Plan boundaries is 77,602 ha. The Master Plan envisages that in 2021, most of this area, a total of about 23,200 ha, will be used for agriculture. Water surfaces, dominated by the Sava and Danube watercourses, will amount to about 4,200 ha. The planned surface area for graveyards is about 500 ha. The land contemplated for housing will be about 14,200 ha, and the land for industrial activity about 3,500 ha. City centers will cover about 1,800 ha, public facilities about 1,400 ha, sports facilities and complexes about 1,200 ha. The transport system and areas designated for traffic will take up about 6,000 ha.

Table 2.8 Planned Land Uses in 2001 and 2021

	Current 2001 (ha)	Planned increase 2021-2001 (ha)	Total planned (ha)
Housing	12,571.65	1,570.25	14,141.90
Econoic activities and economic zones	1,595.22	1,929.35	3,524.57
Commercial zones and city centers	667.98	1,147.60	1,815.58
Public services, public facilities and compexes	1,123.10	275.04	1,398.14
Sports, sports facilities and complexes	685.87	502.01	1,187.88
Green areas	11,365.27	9,044.64	20,409.91
Agricultural areas and facilities	39,657.32	-16,463.32	23,194.00
Water surfaces	4,071.05	101.16	4,172.21
Graveyards	344.69	144.51	489.20
Transport and areas designated for traffic	4,424.15	1,503.56	5,927.71
Utility services and infrastructural areas	345.30	436.40	781.70
Undeveloped land	750.39	-750.39	
TOTAL	**77,602.00**		**77,602.00**

Source: MP2021

2.3.2 Sewerage System in Belgrade

As for the Figure 2.13 prepared by Pre-FS with MP, the City of Belgrade has 5 sewerage systems, Central, Batajnica, Banat, Ostružnica System and Boleč sub-system. However, sewerage system has collection network only, and collected sewage is discharged into the Sava or Danube River without any treatment. Boundary of the General Master Plan of Belgrade is almost same as the borders of the sewerage master plan, but Sewerage network will cover some additional area which is located out of the boundary due to the topological reason (natural inflow) such as Bolec subsystem. Surface area under sewerage system is given in Table 2.9. Central system has 18 subbasins that are shown catchment area wise in Figure 2.13. Name of subbasins is listed in Table 2.10.

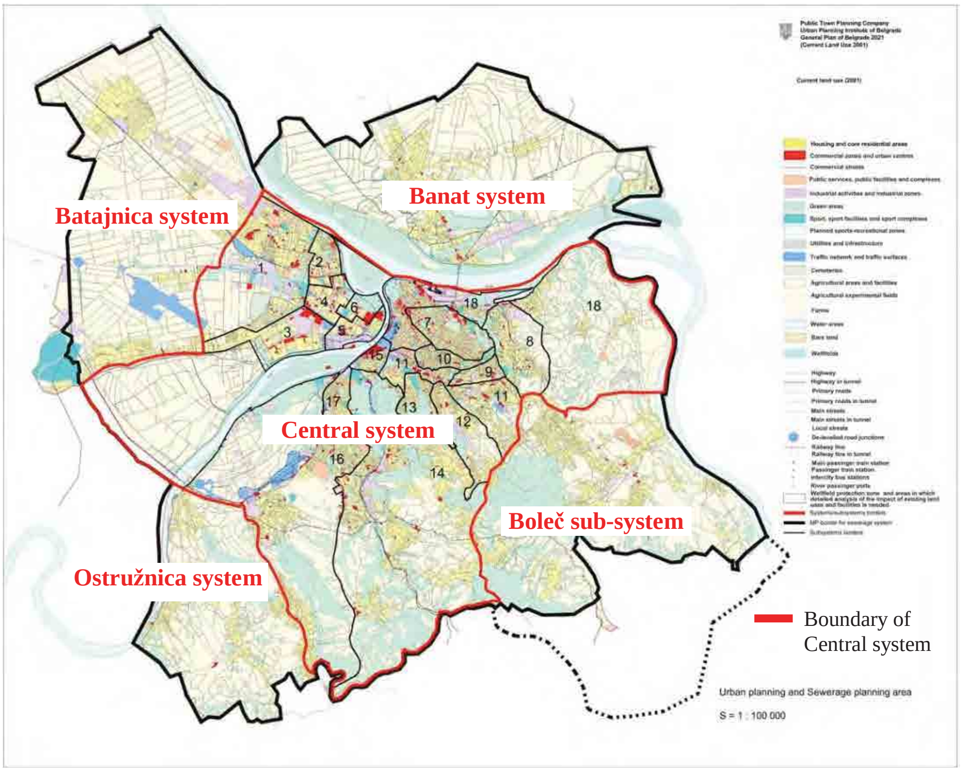


Figure 2.13 Urban Planning and Sewerage Planning Area

Table 2.9 Surface under Sewerage

Name	Surface in 2007 (ha)	Surface in 2021 (ha)
Central system	10,370	13,594
Batajnica system	2,727	3,677
Banat system	1,806	3,115
Ostružnica system	1,307	1,374
Boleč sub-system	2,294	3,045
Total	18,504	24,767

Source: Pre-FS with MP

Table 2.10 Name of Subbasins in Central System

No	Subbasin	No	Subbasin	No	Subbasin
1	Gornji Zemun	7	Bulbuder collector	13	Banjica collector
2	Karađorđev trg	8	Mirijevo collector	14	Topčider collector
4	Nova Nova	9	Duboki creek	15	Senjak
3	Galovica	10	Čubura collector	16	Železnik
5	Gazela	11	Mokrolug collector	17	Banovo Brdo
6	Ušće immediate basin	12	Kumodraž collector	18	Danube immediate basin

(1) Overview of Sewerage System

(A) Central System

Central system has the largest catchment areas in Belgrade. This system covers territory of the municipalities of New Belgrade, Stari Grad, Vračar, Savski Venac, Zvezdara and Rakovica, and portions of Zemun, Čukarica, Voždovac and Palilula municipalities. Veliko Selo WWTP, Ušće Pumping Station, Mostar Pumping Station and Interceptor which are in the scope of this project are located in Central system. Present central sewerage system is explained in the next section.

(B) Batajnica System

According to the Master Plan with Pre-FS, Batajnica system belongs to part of Zemun and Surčin municipalities.

(C) Banat System

Banat system covers the municipality of Palilula, on the left bank of the Danube River.

(D) Ostružnica System

Ostružnica system covers part of the Čukarica Municipality, on the right bank of the Sava River.

(E) Boleč Subsystem

Boleč subsystem is mostly located within the boundaries of the MP of Belgrade 2021 and the remaining part approximately 4,000 ha (30% of the subsystem) is located outside of the boundaries of the MP of Belgrade 2021. The remaining part of the subsystem is located in Vrčina municipality. Sewage from Boleč subsystem will be conveyed into Central system.

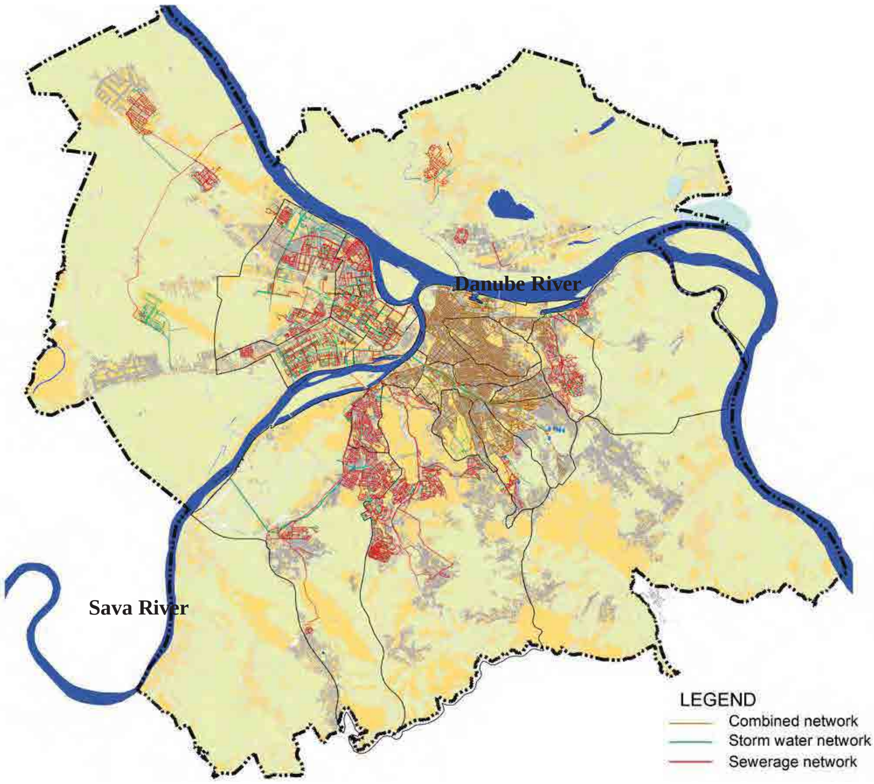
(2) Summary of Sewerage Network

According to the Pre-FS with MP, the lengths and dimensions of collectors in the present sewerage system is calculated as given in Table 2.11. Total length of the sewerage network is approximately 1,880 km. Sewerage networks data has been collected and input by GIS department in BVK. Since data collection is still under progress, all network data is still not covered. Network data is shown in Figure 2.14.

Table 2.11 Existing Pipe Length Calculated by Pre-FS with MP

Dimensions of the collector	The length of the sewerage network (km)			
	Combined system	Separate system		Total
		Sewage waters	Storm waters	
< Ø 500	373	565	493	1,431
Ø 500 - 1000	10	18	135	163
Ø 1000 - 2000	2	3	24	29
Ø 2000 - 2600	1	-	1.6	2.6
Special up to 1m	65	53	17	135
Special > 1m	35	27	57	119
Total	486	666	728	1,880

Source: Pre-FS with MP



Source: Pre-FS with MP

Figure 2.14 Existing Sewerage Network

2.3.3 Present Sewerage System in Central System

Taking into consideration facilities which are in the scope of works in this Project, sewerage system can be divided into 4 catchment areas such as “Ušće PS”, “Mostar PS”, “Mokrolug collector”, and “Danube”. Locations of these catchment areas are shown in Figure 2.15.

Ušće PS catchment area corresponds to the inflow catchment area of Ušće PS (Interceptor No.

1), Mostar PS catchment area corresponds to the inflow catchment area of Mostar PS (Part of Interceptor No. 10), Mokrolug collector catchment area corresponds to the inflow catchment area of part of Interceptor No. 10, and Danube Catchment Area corresponds to the inflow catchment area of Interceptor No. 3-9.

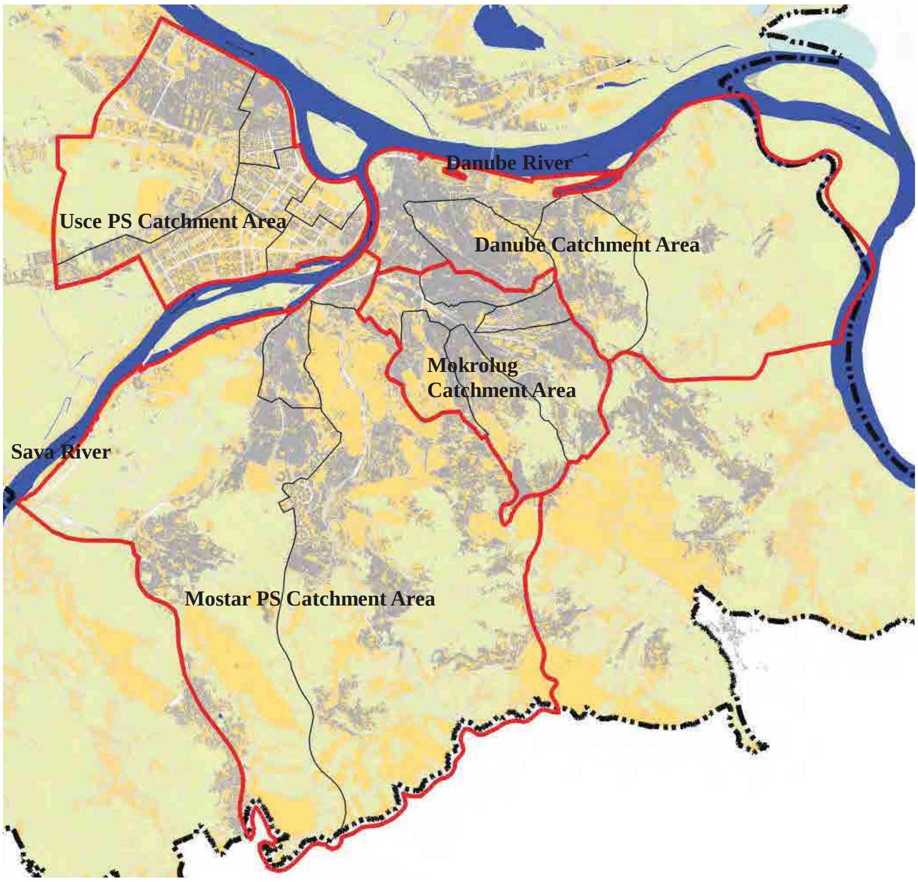


Figure 2.15 Location of the Catchment Areas in Central System

(1) Present Collection System of Ušće PS Catchment Area (Catchment Area of Interceptor No. 1)

Ušće PS catchment area is located in the left bank of the Sava River. There are two sewage discharge points into the Sava River and the Danube River. This catchment area has adopted separate sewerage system. Ušće PS catchment area is divided into 6 subbasins, "Gornji Zemun", "Karađorđev trg", "Nova Nova", "Galovica", "Gazela", and "Ušće immediate basin". Main facilities in this catchment area are shown in Figure 2.16.

This catchment area has five sewerage pumping stations named as Galovica PS, Gazela PS, Karađorđev PS, Nova-Nova PS and Ušće PS.

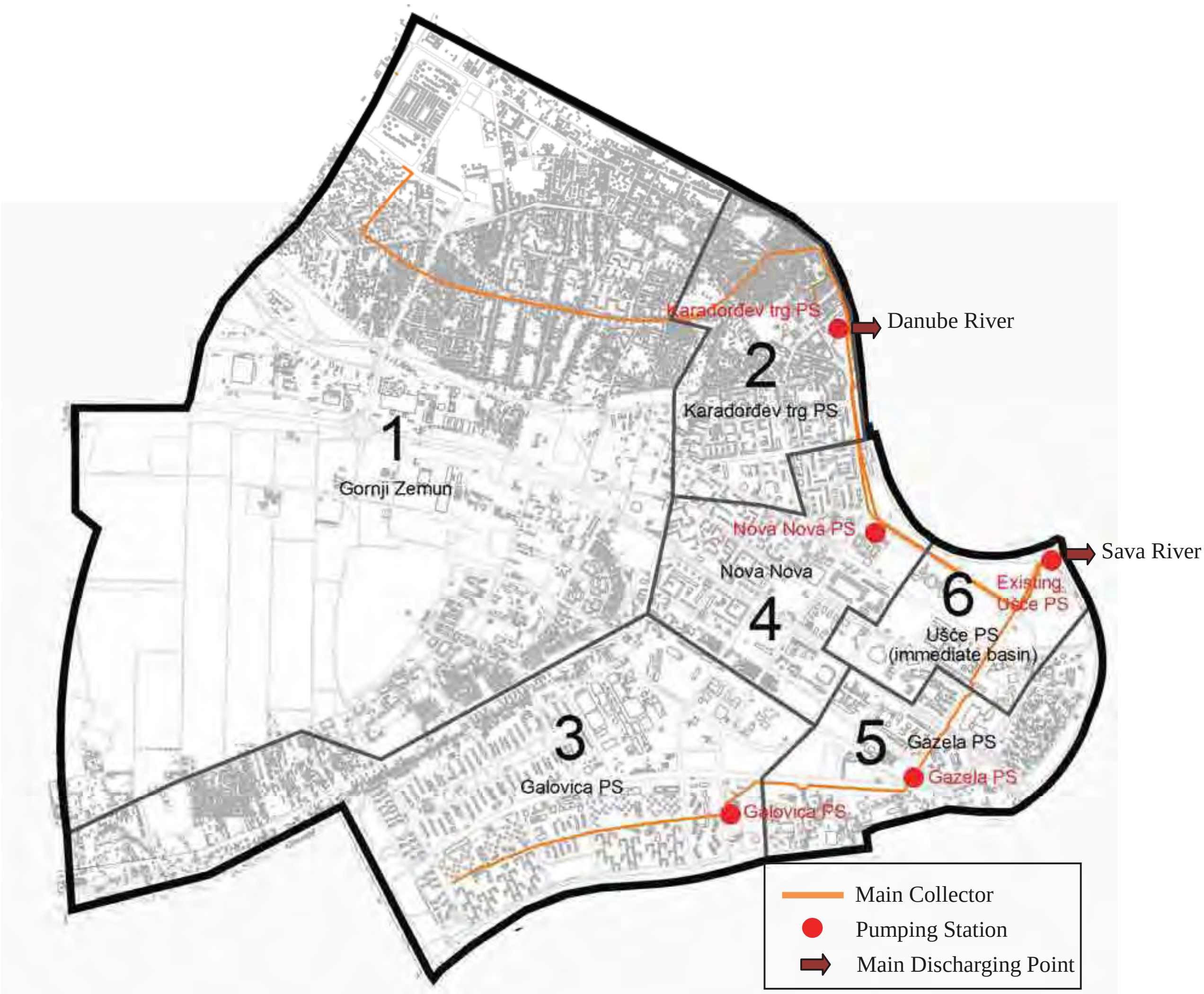


Figure 2.16 Main Facilities in Ušće PS Catchment Area

As for Pre-FS with MP, Percentage of sewered population was estimated based on the data from the invoices of water supply and sewerage in 2007. Percentage in each subbasin is shown in Table 2.12. Approximately, 97% of inhabitants can use sewerage services in this subbasin. Sewerage connections to existing sewerage network will be done by 2021.

Table 2.12 Percentage of Sewered Population in Ušće PS Catchment Area

No	Subbasin	Surface (ha)	The number of inhabitants covered by the water supply services	The number of inhabitants covered by sewerage services	Ratio of connection to the sewerage (%)
1	Gornji Zemun	2,580	110,499	97,784	91.25
2	Karađorđev trg	340	62,892	62,857	99.95
4	Nova Nova	360	56,179	56,179	100.00
3	Galovica	930	105,351	104,663	99.35
5	Gazela	330	16,693	16,363	98.02
6	Ušće immediate basin	210	6,182	6,169	99.79
Total		4,750	357,796	344,016	97.05

Source: Pre-FS with MP

Detail of pumping stations is explained below.

(A) Galovica PS

Galovica PS has two functions such as sanitary and storm water system in one pumping station. Three pumps are for sewerage. Sewage is pumped and diverted to the Gazela PS. Pump capacity for sewerage are: 250 l/s x 2nos, 200 l/s x 1nos and 100 l/s x 1nos, with a total capacity of 800 l/s.

(B) Gazela PS

Gazela PS has two functions of sanitary and storm water system in one pumping station. Four pumps are for sanitary. Sewage is pumped and diverted to the Ušće PS. Pump capacity for sanitary is: 250 l/s x 4nos, with a total capacity of 1,000 l/s.

(C) Karađorđev trg PS

Karađordjev trg PS has two functions of sanitary and storm water system in one pumping station. Karadjordjev trg collection system covers central part of Zemun and northern-west part of New Belgrade. Sanitary water is discharged directly into the Danube River. The capacity of pumps for sewerage is: 360 l/s x 4nos, with a total capacity of 1,440 l/s.

(D) Nova Nova PS

Nova Nova PS is newly constructed and took over the function of the Stara PS in 2008. Nova Nova collecting system is located in the central area of New Belgrade. Wastewater is pumped and diverted to the Ušće PS. Pump capacity for sewerage is: 175 l/s x 3nos, with a total capacity of 525 l/s.

(E) Ušće PS

Ušće PS is the main pumping station on the left bank of the Sava River in Central system. All of the sewerage networks are concentrated in the Ušće PS. Wastewater is discharged directly into the river at the meeting point of the Sava and Danube River. The pumps are working only when the water level of the Sava River become higher than the level of outlet channel. Pump capacity for sanitary is: 350 l/s x 3nos and 800l/s x 1nos, with a total capacity of 1,850 l/s.

(2) Present Collection System of Mostar PS Catchment Area (Part of the Catchment Area of Interceptor No.10)

This collection system is located in southern part of Central system. This catchment area has separate sewerage system. The Mostar PS catchment area is divided into 4 subbasins, “Topčider collector”, “Senjak”, “Železnik”, and “Banovo Brdo”. Main facilities in this catchment area are shown in Figure 2.17.

All sanitary water from Železnik, Žarkovo, Banovo Brdo, and Topčider subbasins are received at Čukarica PS. Then sewage is diverted into the Sava River directly. Wastewater from Senjak subbasin is also discharged into the Sava River directly. After construction of the Interceptor from Mostar PS to Veliko Selo WWTP, these subbasins will be connected to Mostar PS. The sewerage networks for the catchment area of Čukarica have a total length of about 263.4 km and collectors are in wide range of dimensions and shapes.

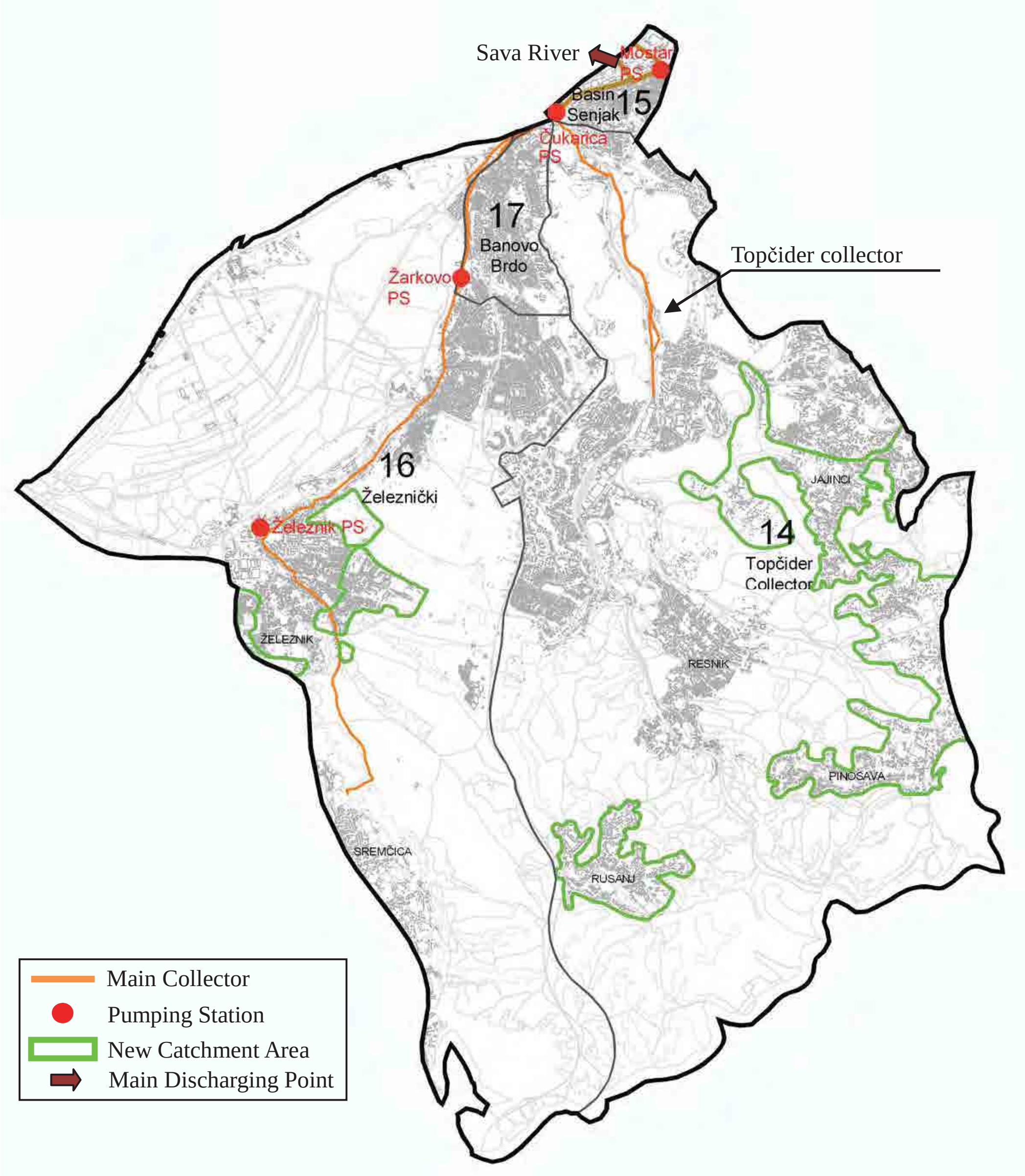


Figure 2.17 Main Facilities in Mostar PS Catchment Area

As for Pre-FS with MP, Percentage of sewered population for household and legal entities is shown in Table 2.13. About 85% of inhabitants can use sewerage service in this subbasin. Upstream part of Topčider collector and part of Železnik are newly developed. Sewerage connections to existing sewerage network are under construction.

Table 2.13 Percentage of Sewered Population in Moster PS Catchment Area

No	Subbasin	Surface (ha)	The number of inhabitants covered by the water supply services	The number of inhabitants covered by sewerage services	Ratio of connection to the sewerage (%)
14	Topčider collector	7,800	133,093	100,822	75.75
15	Senjak	190	5,950	5,940	99.83
16	Železnik	6,580	104,804	93,885	89.58
17	Banovo Brdo	380	53,847	52,186	96.92
Total		14,950	297,694	252,833	84.93

Source: Pre-FS with MP

Detail of pumping stations is explained below.

(A) Železnik PS

Železnik PS covers the lower areas of Železnik. This PS has function of pumping only sanitary water. Pump capacity is: 100 l/s x 3nos, with a total capacity of 300 l/s.

(B) Žarkovo PS

Žarkovo PS covers approximately 1,334 ha. The collection system covers the areas of Sremčica, Železnik and the local collection system Žarkovo. Sewage is pumped towards Čukarica PS. Pump capacity is: 350 l/s x 2nos and 115l/s x 1nos, with a total capacity of 815 l/s.

(C) Čukarica PS

Čukarica PS is located near new Sava Bridge on the left bank of the river and it has two pump chambers for Čukarica collector and Topčider collector. Catchment area of Čukarica PS is covered with upstream areas from the pump station, Železnik PS and Žarkovo PS. Therefore, Čukarica PS is one of the most important facilities in this collecting system to pump out sewage to the downstream. Sewage is discharged into the Sava River directly so far. Pump capacity (for Čukarica collector) is: 250 l/s x 2nos, with total of 500 l/s. Pump capacity (for Topčider collector) is: 700 l/s x 1nos and 900l/s x 1nos, 200-300l/s x 3nos, with a total capacity of approx. 2,400 l/s.

(D) Mostar PS

Mostar PS is a sewage pumping station, construction of which was started in the middle of 1970's and fully completed in the middle of 1980's after suspension. The pumping station was aimed originally to convey sewage generated from collection areas of Senjak, Banovo Brdo, Zelenicki and Topčider to recipient interceptor. However, the pumping station has never been operated for the intended purpose since the pressured discharge pipes from the pumping station has never been connected to the interceptor. Pump capacity is: 700 l/s x 6 nos, with a total capacity of 4,200 l/s.

(3) Present Collection System of Mokrolug Collector Catchment Area (Part of the Catchment Area of Interceptor No. 10)

Mokrolug collector catchment area is covered with “Banjicki collector”, “Kumodraski collector”, “Duboki creek”, “Čubura collector” and “Mokrolug collector”. Main facilities in this catchment area are shown in Figure 2.18.

These catchment areas adopt combined system. Due to increased sewage in this area, new Mokrolug collector as storm water pipe was constructed parallel from Mokrolug subbasin to the Sava River. Collectors from each subbasin are connected to Old Mokrolug collector through overflow structures, and overflows are connected to new Mokrolug collector as storm water. Combined water from old Mokrolug collector is discharged into the Sava River directly.

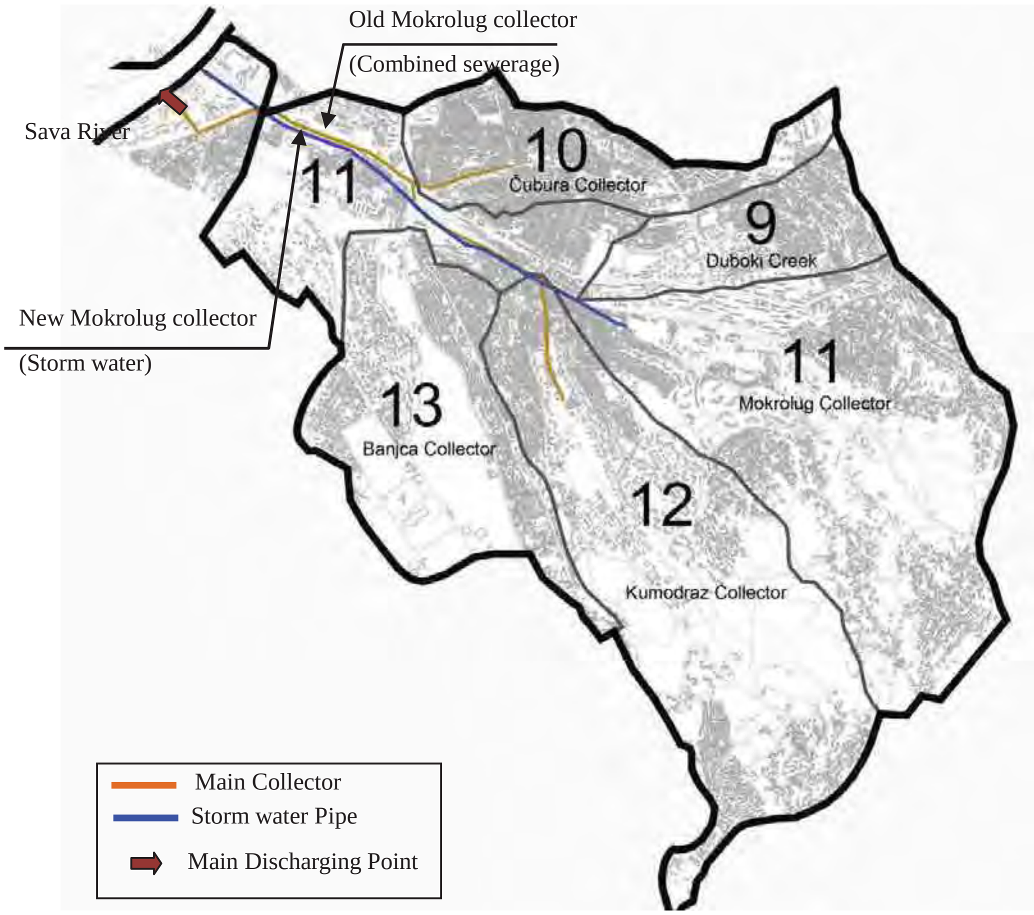


Figure 2.18 Main Facilities in Mokrolug Collector Catchment Area

As for Pre-FS with MP, Percentage of sewered population for inhabitants and legal entities is shown in Table 2.14. About 92% of inhabitants can use sewerage service in this sub-basin.

Table 2.14 Percentage of Sewered Population in Mokrolug Collector Catchment Area

No	Subbasin	Surface (ha)	The number of inhabitants covered by the water supply services	The number of inhabitants covered by sewerage services	Ratio of connection to the sewerage (%)
9	Duboki creek	210	48,225	44,883	93.07
10	Čubura collector	270	37,289	37,095	99.48
11	Mokrolug collector	1,270	48,443	40,752	84.12
12	Kumodraž collector	810	51,492	46,488	90.28
13	Banjica collector	490	45,430	43,564	95.89
Total		3,050	230,879	212,782	92.16

Source: Pre-FS with MP

There is no pumping station in this catchment area.

(4) Present Collection System of Danube Catchment Area (Part of the Catchment Area of Interceptor Ušće - Veliko Selo WWTP)

The Danube catchment area is located in the northern part of central system. This catchment area is divided into 3 subbasins, “Mirijevo collector”, “Bulbuder collector”, and “Danube immediate basin”. Sanitary and part of storm water from the Danube catchment area are discharged into the Sava River or the Danube River directly through several collectors. In the future these collectors will be connected to Interceptor.

These catchment areas in old city adopt the combined sewerage system. There are two existing pumping stations named “Železnička PS” and “Dorćol PS”, which are connected to existing sewerage network, and collected sewage is discharged into the Danube River directly.

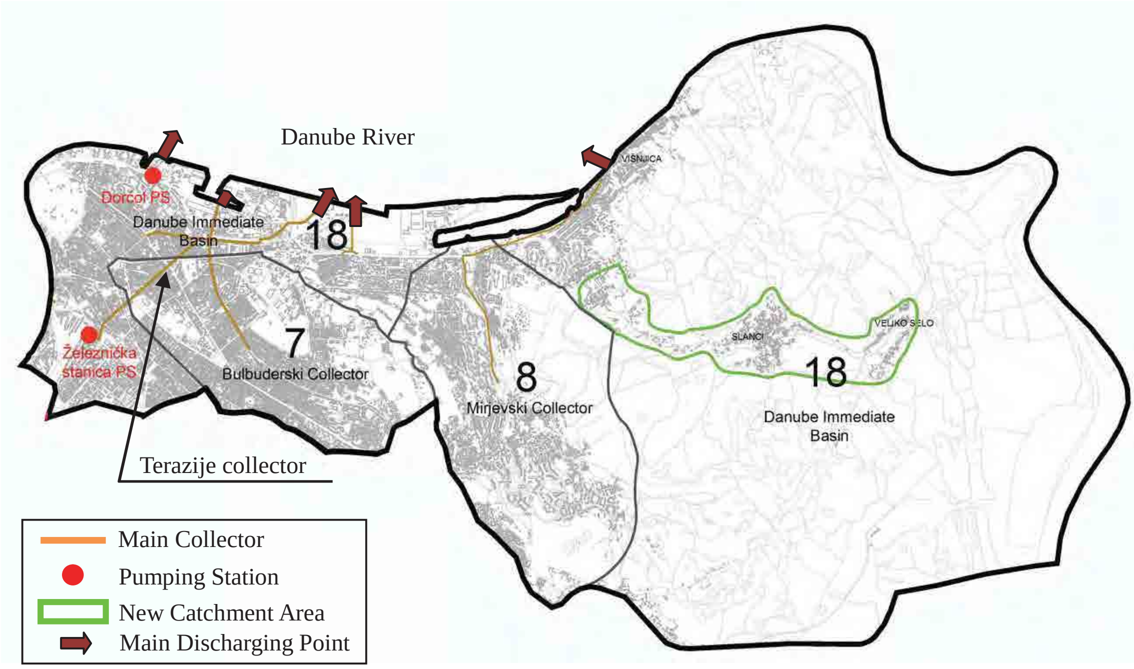


Figure 2.19 Main Facilities in Danube Catchment Area

As for Pre-FS with MP, Percentage of sewered population for household and legal entities is shown in Table 2.15. About 97% of inhabitants can use sewerage service in this subbasin. Sewerage connections to existing sewerage network will be done by 2021.

Since inhabitants live in Slanci and Veliko Selo areas located in new catchment area, they pay the water and sewage tariff, and percentage of sewered population is counted as sewered population. But sewage from these area discharges into stream directly with storm water. Therefore sanitary collectors have been planned to connect to Veliko selo WWTP directly by 2031.

Table 2.15 Percentage of Sewered Population in Danube Catchment Area

No	Subbasin	Surface (ha)	The number of inhabitants covered by the water supply services	The number of inhabitants covered by sewerage services	Ratio of connection onto the sewerage (%)
7	Bulbuder collector	690	4,197	4,117	98.09
8	Mirijevo collector	1,010	360	344	95.47
18	Danube immediate basin	5,450	6,074	5,890	96.97
Total		7,150	10,631	10,351	97.36

Detail of pumping stations is explained below.

(A) Železnička PS

Pumping station distributes sanitary and storm water from the lowest part of the Central system near the Sava River. The force main pipe from Železnička PS is conveyed up to Balkanska street and connects the existing collector towards the Terazije tunnel. Pump capacity for sewerage is: 300 l/s x 3nos and 450l/s x 1nos, with total capacity of 1,350 l/s.

(B) Dorćol PS

Pumping station distributes sanitary and storm water from the lowest part of the Danube catchment area into the Danube River. Catchment area of Dorćol PS covers about 90 ha in the residential zone of Dorćol. Pump capacity for sewerage is: 300 l/s x 3nos, with a total capacity of 900 l/s.

(5) Present SCADA (Supervisory Control And Data Acquisition) System

SCADA system is a useful tool for handling routine task, 24 hours online automated control, power saving and data provision for performance indicators. At present, the SCADA system is introduced in the Mostar pumping station for sewerage system and in the Makis water treatment station for water supply system. As for SCADA of sewerage system, it is connected with other small pumping stations by GMS line and sewerage network is centrally controlled. Hence, SCADA of water supply system which was donated by Japanese ODA (Grant Aid) is connected with other WTPs, pumping stations and reservoirs. System diagram is shown in Figure 2.20.

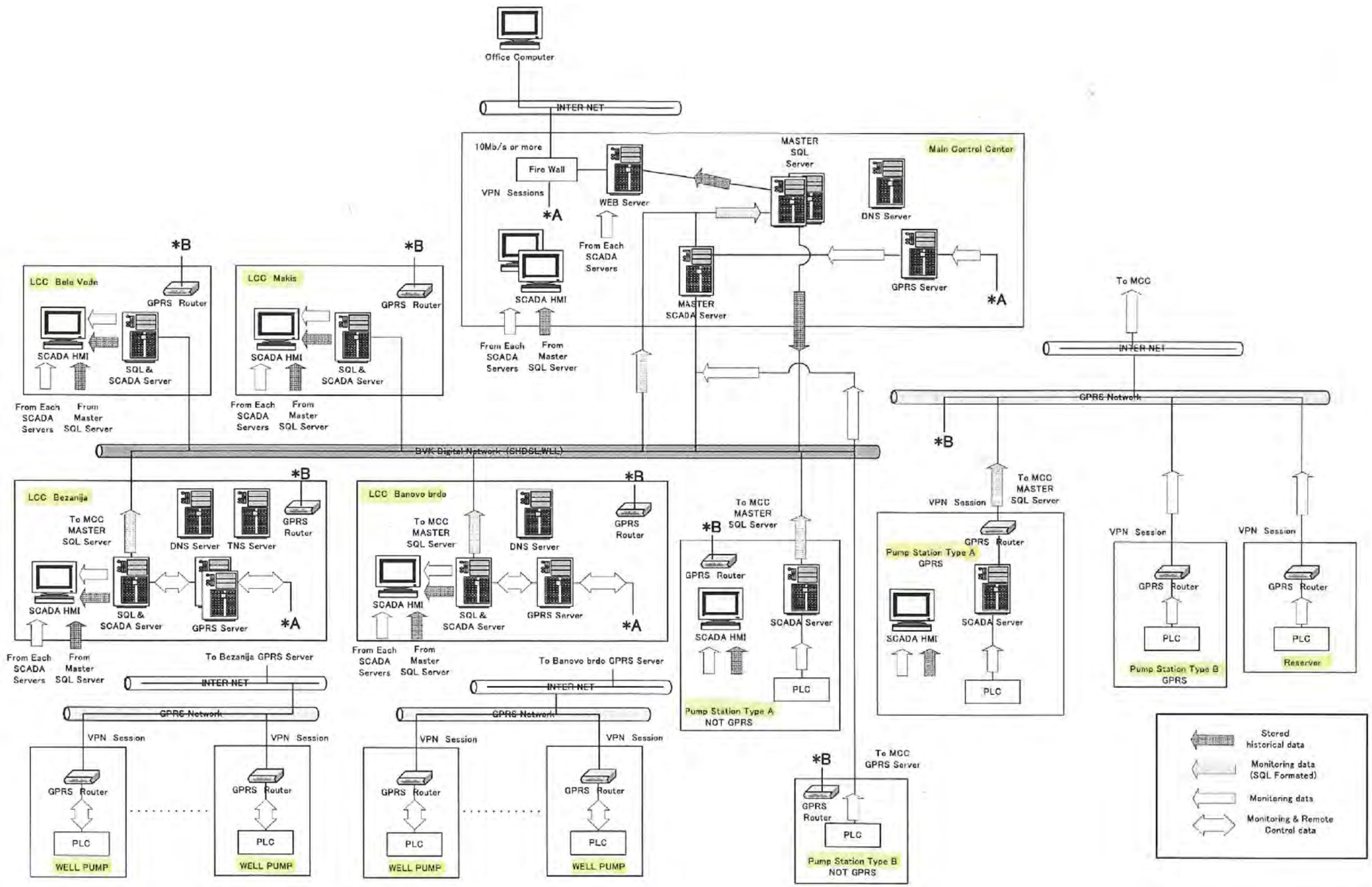


Figure 2.20 Schematic Diagram of SCADA System for Water Supply

2.4 Review of Existing Plan / Design

2.4.1 Review and Confirmation of Existing Plan

(1) Inhabitants

MP2021 is one of the upper level plans for Sewerage planning. Total number of inhabitants in the area covered by the MP2021 is given in Figure 2.21. According to the projection, the number of inhabitants in the area covered by the MP will reach 1,400,000 in 2021. The estimated number of inhabitants in 2031 will be 1,440,000 given by using linear regression trends.

Pre-FS with MP adopted 1,450,000 inhabitants in 2031 for the design value of the projection. This number is slightly higher than the estimated inhabitants by using liner trend based on MP2021.

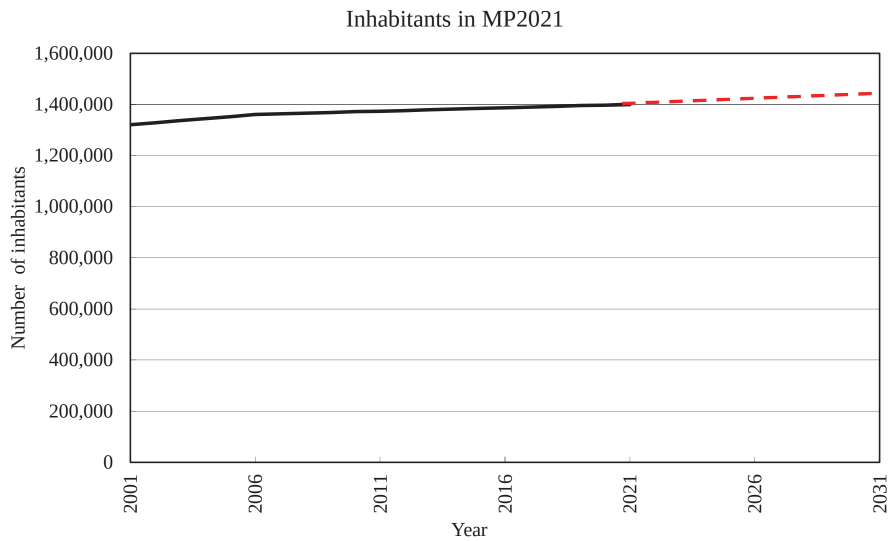


Figure 2.21 Number of Inhabitants (MP2021)

Latest Census has been done in 2011, and first results of Census 2011 could be available in 2012. According to the Census 2011, Inhabitants of the City of Belgrade is 1,639,121. Approximately, there is an increase of 4% from last Census results (1,576,124). MP2021 has estimated 3.4% increase in inhabitants from 2002 to 2011, thus inhabitant growth rate is slightly higher than estimated rate, but actual trend of inhabitant increase is going to follow the estimated one by MP2021 so far (See Figure 2.22).

Therefore, Planed inhabitants estimated by Pre-FS are reasonable to use in the planning frame works in this project.

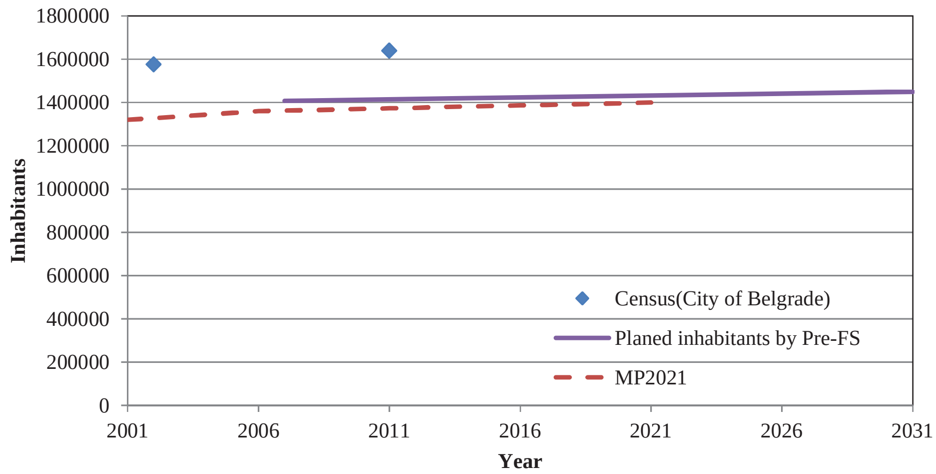


Figure 2.22 Actual and Planned Number of Inhabitants

As for Pre-FS with MP, detailed population data was analyzed based on the Census 2002. Pre-FS with MP provided more detailed number of inhabitants by using Geographic Information System (GIS), which encompasses entire area where water is billed in 2007. The summary of numbers of inhabitants is shown in Table 2.16.

Table 2.16 Summary of Estimated Inhabitants in 2007

		No	Subbasin	Surface (ha)	Number of inhabitants
Central System	Ušće PS Catchment Area	1	Gornji Zemun	2,580	110,499
		2	Karađorđev trg	340	62,892
		4	Nova Nova	360	56,179
		3	Galovica	930	105,351
		5	Gazela	330	16,693
		6	Ušće immediate basin	210	6,182
		Sub-total		4,750	357,796
	Mostar PS Catchment Area	14	Topčider collector	7,800	133,093
		15	Senjak	190	5,950
		16	Železnik	6,580	104,804
		17	Banovo Brdo	380	53,847
		Sub-total		14,950	297,694
	Mokrolug Collector Catchment Area	9	Duboki creek	210	48,225
		10	Čubura collector	270	37,289
		11	Mokrolug collector	1,270	48,443
		12	Kumodraž collector	810	51,492
		13	Banjica collector	490	45,430
		Sub-total		3,050	230,879
	Danube Catchment Area	7	Bulbulder collector	690	124,566
		8	Mirijevo collector	1,010	60,699
		18	Danube immediate basin	5,450	131.348
		Sub-total		7,150	316.613
Sub-total of the central system				29,900	1.202.982
Batajnica subsystem				13,650	64.724
Banat subsystem				12,210	63,063
Bolec subsystem				14,470	56,816
Ostruznica subsystem				6,540	19,833
Total				76,770	1,407,418

Source: Pre-FS with MP

Under this estimation, Inhabitants in each subbasin are estimated as shown in Table 2.17. JICA study also adopts the sewerage inhabitants by subbasin prepared by Pre-FS with MP.

Table 2.17 Planned Inhabitants by Subbasin

		Subbasin	2007		2010	2012	2015	2021	2031
			Number of inhabitants	%	Number of inhabitants				
Central System	Ušće PS Catchment Area	1. Gornji Zemun	110,499	7.85	110,900	111,200	111,600	112,450	113,800
		2. Karađorđev trg	62,892	4.47	63,200	63,300	63,550	64,000	64,800
		3. Nova Nova	56,179	3.99	56,400	56,500	56,750	57,150	57,900
		4. Galovica	105,351	7.49	105,700	106,000	106,400	107,200	108,550
		5. Gazela	16,693	1.19	16,800	16,800	16,850	17,000	17,200
		6. Ušće immediate basin	6,182	0.44	6,200	6,200	6,250	6,300	6,350
		Sub-total	357,796	25.42	359,200	360,000	361,400	364,100	368,600
	Mostar PS Catchment Area	14. Topčider collector	133,093	9.46	133,600	134,000	134,450	135,400	137,100
		15. Senjak	5,950	0.42	5,950	6,000	6,050	6,100	6,150
		16. Železnik	104,804	7.45	105,250	105,450	105,850	106,650	108,000
		17. Banovo Brdo	53,847	3.83	54,050	54,200	54,400	54,800	55,500
		Sub-total	297,694	21.16	298,850	299,650	300,750	302950	306,750
	Mokrolug Catchment Area	9. Duboki creek	48,225	3.43	48,400	48,500	48,700	49,100	49,700
		10. Čubura collector	37,289	2.65	37,450	37,500	37,650	37,950	38,400
		11. Mokrolug collector	48,443	3.44	48,600	48,750	48,900	49,300	49,900
		12. Kumodraž collector	51,492	3.66	51,700	51,800	52,000	52,400	53,050
		13. Banjica collector	45,430	3.23	45,600	45,700	45,900	46,200	46,800
		Sub-total	230,879	16.41	231,750	232,250	233,150	234,950	237,850
	Danube Catchment Area	7. Bulbuder collector	124,566	8.85	126,250	125,350	125,800	126,750	128,350
		8. Mirijevo	60,699	4.31	61,400	61,100	61,300	61,800	62,550
		18. Danube immediate basin	131,348	9.33	130,150	132,150	132,700	133,650	135,300
		Sub-total	316,613	22.49	317,800	318,600	319,800	322,200	326,200
	Sub-total of Central system		1,202,982	85.47	1,207,600	1,210,500	1,215,100	1,224,200	1,239,400
Batajnica system			64,724	4.6	65,000	65,100	65,350	65,900	66,700
Banat system			63,063	4.48	63,300	63,500	63,700	64,200	65,000
Bolec system			56,816	4.04	57,000	57,200	57,400	57,800	58,500
Ostruznica system			19,833	1.41	19,900	20,000	20,050	20,200	20,400
TOTAL			1,407,418	100	1,412,800	1,416,300	1,421,600	1,432,300	1,450,000

Source: Pre-FS with MP

(2) Hydraulic Load in the Central System

(A) Water Production and Consumption in the City of Belgrade

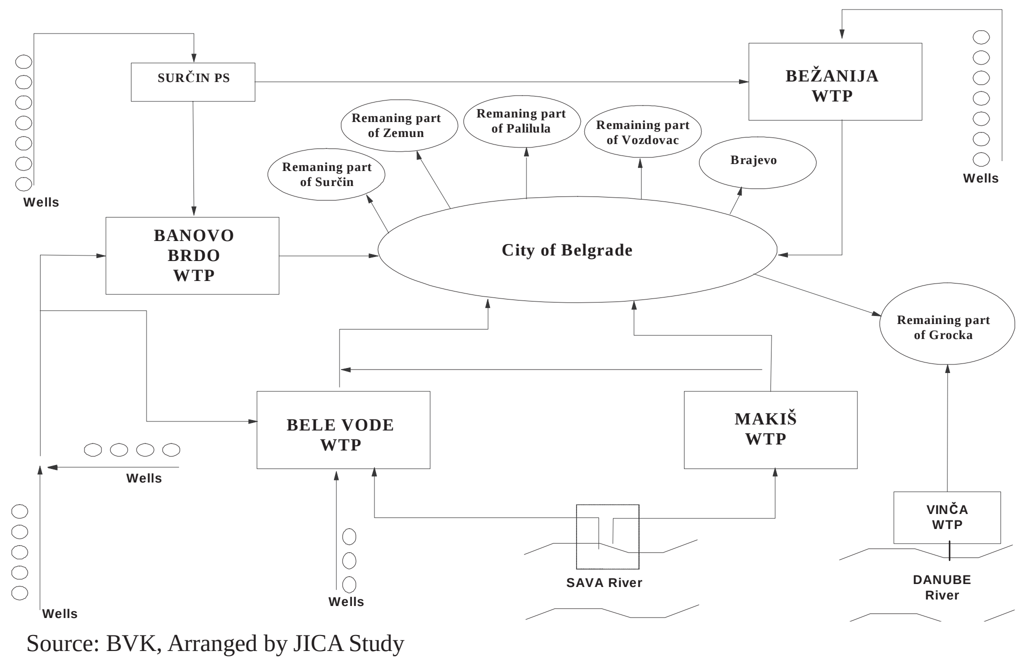
BVK produced the water to the amount of around 202 million m^3 in 2011. Raw water is from underground aquifers in the coastal areas of the Sava River and direct intake from the Sava or Danube River. There are 99 wells along the Sava River to withdraw raw water. There are 5 water treatment plants (WTPs) in the city of Belgrade. Makis WTP and Vinca WTP treat raw water taken from the Sava River or Danube River. Banovo Brdo WTP and Bezanua WTP treat raw water withdrawn from ground through wells. Bele Vode WTP treats raw water from both sources. The ratio of groundwater abstraction and river water was 55% versus 45% as shown in Table 2.18.

Table 2.18 Amount of Water Production in 2011

	Produced water (m^3)	%
Groundwater	110,736,668	55
River water	91,289,822	45
Total	202,026,490	100

Source: BVK

Water supply area is covered within the MP boundary of the city of Belgrade plus the suburbs. Suburbs areas are “part of Surčin”, “part of Palilula”, “part of Zemun”, “part of Voždovac”, “part of Grocka”, and “Barajevo”. Schematic diagram of water supply network is shown in Figure 2.23 and amount of water production is shown in Table 2.19. Amount of water consumption by inhabitants and legal entities are decreasing every year from 2003. Billed water in 2011 has decreased by more than 20% compared to 2000.



Source: BVK, Arranged by JICA Study

Figure 2.23 Schematic Diagram for Water Supply Network

Table 2.19 Amount of Water Production in 2011

Year	Water Production					
	Produced water (m^3)	Operational consumption (m^3)	Supplied water (m^3)	Billed water (m^3)	Billed for inhabitants (m^3)	Billed for legal entities (m^3)
2000	245,386,599	9,681,757	235,704,842	163,345,726	116,914,983	46,430,743
2001	241,144,118	9,803,531	231,340,587	153,626,951	108,562,832	45,064,119
2002	231,198,353	9,369,704	221,828,649	158,302,057	115,618,460	42,683,597
2003	245,013,929	8,613,933	236,399,996	158,132,114	115,834,903	42,297,211
2004	236,899,986	9,136,706	227,763,280	154,338,543	113,850,554	40,487,989
2005	226,856,348	9,532,310	217,324,038	158,283,095	118,656,861	39,616,234
2006	223,148,194	9,230,914	213,917,280	151,896,227	116,067,411	36,513,013
2007	220,762,893	9,826,869	210,936,024	150,166,537	113,913,716	36,252,821
2008	217,638,685	-	-	138,749,740	105,664,594	33,085,146
2009	213,543,319	-	-	138,388,583	107,127,640	31,260,943
2010	202,537,587	-	-	131,983,524	103,059,627	28,923,897
2011	202,026,490	9,721,543	192,304,947	127,834,825	99,931,664	27,903,161

Source: BVK, Data of operational consumption and supplied water from 2008 to 2010 are missing

Water consumption by inhabitants is decreasing as shown in Table 2.20. Specific consumption of inhabitant has decreased to 183 lpcd in 2011.

Table 2.20 Specific Consumption of Inhabitants

	(A) Amount of billed water for domestic (m^3/year)	(B) **Inhabitants (Number)	Specific consumption (lpcd) (A)/365/(B)x1000
2005	118,656,861	1,432,922	227
2006	116,067,411	1,458,716	218
2007	113,913,716	1,482,743	210
2011	99,931,664	1,492,522	183

Water consumption of legal entities such as hospitals, institutions, industries and so on, are also decreasing as shown in Table 2.21. Specific consumption of legal entities in Pre-FS with MP are based on the employees who belong to these entities. However, the number of employees is not found as statistical data, and specific consumption are calculated as the billed water divided by inhabitants, and presented in the table. Specific consumption based on inhabitants has decreased to 51 lpcd in 2011. This indicates a drop of 25 lpcd compared to figure in 2005.

Table 2.21 Specific Consumption of Legal Entities

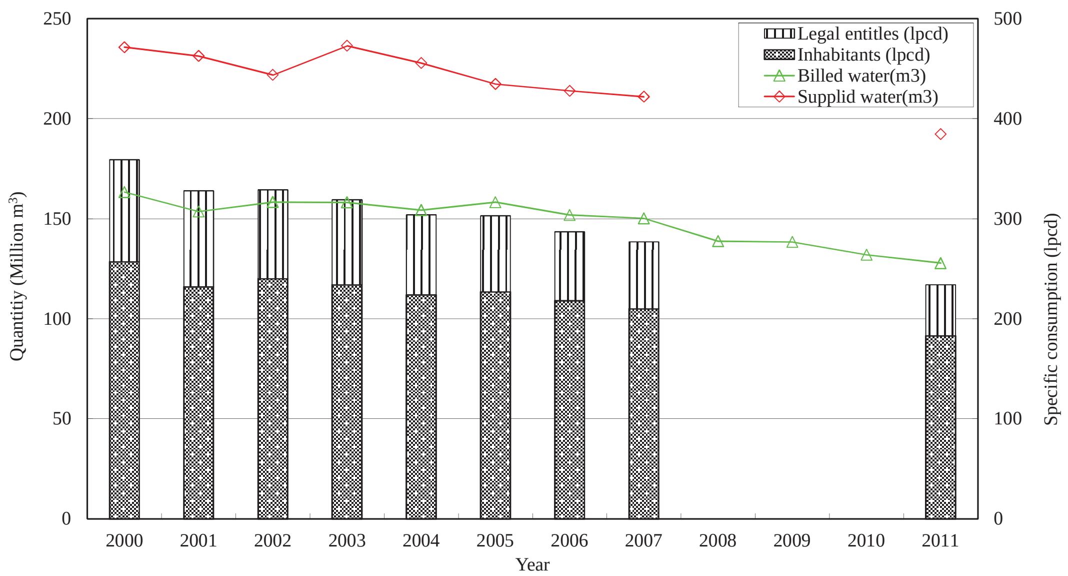
	(A) Amount of billed water for legal entities (m^3/year)	(B) *Employees (Number)	(C) Inhabitants (Number)	Specific consumption (lpcd)	
				(A)/365/(B) x1000	(A)/365/(C) x1000
2005	39,616,234	448,000	1,432,922	242	76
2006	36,513,013	457,000	1,458,716	219	72
2007	36,252,821	465,000	1,482,743	214	66
2011	27,903,161	499,000	1,492,522	153	51

Source: BVK, *MP2021

The trends of the water supply and consumption from 2000 to 2011 are shown in Figure 2.24. Presently, 235 lpcd (184 lpcd for inhabitants, 51 lpcd for legal entities such as commercial/industrial) is used from water billing data.

According to the brochure “Belgrade waterworks and sewerage development and reforms from 2000 until 2008; BVK”, Water tariff has increased since 2000. For example, Price for Domestic use was around 0.03 euro/m^3 in 2000 and 0.38 euro/m^3 in year 2007, it means more than 10 times increase in these 7years. Due to this price increase, customer seems to have saved using potable water, and consequently billed amount of water is decreasing.

The difference in amount of supplied water and billed water is indicated by Non-revenue water (NRW). It is approx. 30%. According to the brochure, BVK invests for replacement of water pipe, about 20km to 40km annually in these 10 years to reduce Non-revenue water, but it could maintain only the current level of NRW. Therefore NRW seems to keep this level in future also because of the less budget for maintenance works.



Source: BVK

Figure 2.24 Amounts of Water Supply and Consumption

Under these circumstances, Pre-FS with MP proposed two scenarios which are: "consumption water in 2031 will be same as current value" or "consumption water will decrease by 30% from current value". Finally, water consumption shown in
Table 2.22 adopted same amount as current value after deep deliberation.

JICA Study adopted this solution because this decision was made in 2011 just one year ago. However, JICA study recommends that next Sewerage Master Plan be prepared based on the next Census results so as to be able to evaluate the water consumption data. Subsequently, evaluated planning can be prepared to adjust sewerage facilities such as WWTP until next phase.

Table 2.22 Project Water Consumption in Central Area

Year	Water Consumptions	
	Domestic	Legal entities
Up to 2031	220 lpcd	Per Employee 200 lpcd *(Per Inhabitants)* *2015 60 lpcd* *2021 64 lpcd* *2031 67 lpcd*

Source: Pre-FS with MP

(B) Ratio of Water Uses resulting into Sewage

Ratio of water uses that is finally generated as sewage is adopted as 0.8 based on the literature in Serbian. Since this ratio was studied in Serbia, no objection is made by this study.

(C) Projected Sewage Quantity (Inhabitants and Legal Entities)

Projected sewage quantity from inhabitants and legal entities are shown in Table 2.23.

Table 2.23 Projected Sewage Quantity from Inhabitants and Legal Entities

	Subbasin	Inhabitants (m^3/day)			Legal entities (m^3/day)			Total (m^3/day)		
		2015	2021	2031	2015	2021	2031	2015	2021	2031
Ušće PS Catchment Area	1. Gornji Zemun	17,400	18,000	18,200	4,200	4,400	4,700	21,600	22,400	22,900
	2. Karađorđev trg	9,900	10,200	10,400	3,900	4,100	4,400	13,800	14,300	14,800
	3. Nova Nova	8,800	9,100	9,300	3,500	3,800	4,000	12,300	12,900	13,300
	4. Glavica	16,600	17,200	17,400	3,100	3,300	3,500	19,700	20,500	20,900
	5. Gazela	2,600	2,700	2,800	2,200	2,300	2,500	4,800	5,000	5,300
	6. Ušće immediate basin	1,000	1,000	1,000	1,000	1,100	1,200	2,000	2,100	2,200
	Sub total	56,300	58,200	59,100	17,900	19,000	20,300	74,200	77,200	79,400
Mostar PS Catchment Area	14. Topčider collector	23,000	23,800	24,100	5,800	6,100	6,600	28,800	29,900	30,700
	15. Senjak	1,000	1,100	1,100	300	300	400	1,300	1,400	1,500
	16. Železnički	18,100	18,800	19,000	2,800	3,000	3,200	20,900	21,800	22,200
	17. Banovo Brdo	9,300	9,600	9,800	3,700	3,900	4,200	13,000	13,500	14,000
	Sub total	51,400	53,300	54,000	12,600	13,300	14,400	64,000	66,600	68,400
Mokrolug Collector Catchment Area	9. Duboki creek	8,300	8,600	8,700	2,300	2,400	2,600	10,600	11,000	11,300
	10. Čubura collector	6,400	6,700	6,800	2,200	2,400	2,500	8,600	9,100	9,300
	11. Mokrolug collector	8,400	8,700	8,800	2,500	2,700	2,900	10,900	11,400	11,700
	12. Kumodraz collector	8,900	9,200	9,300	1,700	1,800	1,900	10,600	11,000	11,200
	13. Banjica collector	7,900	8,100	8,200	8,200	8,700	9,300	16,100	16,800	17,500
	Sub total	39,900	41,300	41,800	16,900	18,000	19,200	56,800	59,300	61,000
Danube Catchment Area	7. Bulbuderski collector	21,500	22,300	22,600	10,200	10,800	11,600	31,700	33,100	34,200
	8. Mirijevski collector	10,500	10,900	11,000	900	900	1,000	11,400	11,800	12,000
	18. Danube immediate basin	22,700	23,500	23,800	14,800	15,700	16,800	37,500	39,200	40,600
	Sub total	54,700	56,700	57,400	25,900	27,400	29,400	80,600	84,100	86,800
Total		202,300	209,500	212,300	73,300	77,700	83,300	275,600	287,200	295,600

Source: Pre-FS with MP

(D) Infiltrated Water

Infiltrated water is estimated based on the sampling data in 2007. In case of Central system the values adopted are 0.12 l/s/ha in 2015, 0.10l/s/ha in 2021, and 0.05 l/s/ha in 2031 by Pre-FS. Since these results are based on the most reasonable data at this moment, the results can be followed by JICA study. Projected infiltrated water is shown in Table 2.24.

Table 2.24 Projected Infiltrated Water

	Subbasin	Infiltration (m^3/day)		
		2015	2021	2031
Ušće PS Catchment Area	1. Gornji Zemun	9,500	7,300	8,100
	2. Karađorđev trg	12,100	11,700	11,700
	3. Nova Nova	2,300	2,500	2,700
	4. Glavica	4,600	6,100	6,700
	5. Gazela	800	1,100	1,100
	6. Ušće immediate basin	500	600	700
	Sub total	29,800	29,300	31,000
Mostar PS Catchment Area	14. Topčider collector	21,300	25,200	27,700
	15. Senjak	500	700	700
	16. Železnički	19,000	15,800	17,100
	17. Banovo Brdo	10,500	12,100	12,300
	Sub total	51,300	53,800	57,800
Mokrolug Collector Catchment Area	9. Duboki creek	3,300	2,900	3,000
	10. Čubura collector	3,100	3,600	3,700
	11. Mokrolug collector	3,800	4,000	4,200
	12. Kumodraz collector	3,700	4,900	5,200
	13. Banjica collector	5,700	5,200	5,300
	Sub total	19,600	20,600	21,400
Danube Catchment Area	7. Bulbuderski collector	5,500	6,000	6,100
	8. Mirijevski collector	2,900	3,800	3,900
	18. Danube immediate basin	9,300	8,300	9,200
	Sub total	17,700	18,100	19,200
Total		118,400	121,800	129,400

Source: Pre-FS with MP

(E) Target Year

Project target year is set as 2031. Since at least 7 years is needed for financing, detail design, and construction, collector which are connected into Interceptor can be improved by 2021. Therefore the difference of hydraulic load between 2021 and 2031 is very small as shown in Table 2.23 and Table 2.24. Diameter of Interceptor should be designed based on hydraulic load in 2031 so as not to construct additional pipes in future. Also, Wastewater treatment plants and mechanical/ electrical equipments can be designed to be implemented in phases. Accordingly, inflow quantity estimation in Veliko Selo WWTP is explained in next section.

(F) Summary of Planning Parameters

Planning parameters are shown in Table 2.25.

Table 2.25 Summary of Planning Framework for Hydraulic Load in Central system

Item		Description	Remarks
1. Inhabitants			
	Central System	2015: 1,215,100 2021: 1,224,200 2031: 1,239,400	
	Bolec System	2015: 12,000 2021: 16,000 2031: 23,700	According to LDA, Bolec subsystem will be connected into Veliko Selo WWTP after 2021 untill 2031.
2. Water consumption			
	Domestic	220 lpcd	
	Leagal entitles	200 lpcd (per Emproyee)	
3. Ratio of water uses resulting into sewage		0.80	
4. Water infiltration		0.05～0.12 l/s/ha	

(G) Ratio of Flow

1) Sanitary Water

Based on the flow survey in 2007, “1.10” was adopted as the coefficient of seasonal sewage flow.

Table 2.26 Ratio of flow on sanitary water

Ratio of flow	Remarks
1.1	Daily maximum/Daily average

According to Table 2.27, Ratio of seasonal flow of water production between average flow and maximum flow is about 1.05. Therefore the coefficient of seasonal sewage flow is reasonable.

Table 2.27 Amount of Water Production

Month	Amount of water production (m^3)		
	2009	2010	2011
Jan	18,244,246	17,059,558	16,474,704
Feb	16,221,915	15,716,754	15,121,795
Mar	17,966,316	17,423,212	16,704,345
Apr	17,597,243	16,476,724	16,023,585
May	18,631,004	17,086,836	16,762,663
Jun	17,657,108	17,082,883	17,045,368
Jul	18,443,934	17,686,679	17,530,116
Aug	18,366,296	17,486,468	17,914,649
Sep	17,794,628	16,581,758	17,560,832
Oct	18,029,957	17,231,971	17,382,961

Month	Amount of water production (m^3)		
	2009	2010	2011
Nov	17,148,380	16,104,071	16,661,365
Dec	17,442,292	16,600,673	16,844,107
Total	213,543,319	202,537,587	202,026,490
Ave.	17,795,277	16,878,132	16,835,541
Min.	16,221,915	15,716,754	15,121,795
Max.	18,631,004	17,686,679	17,914,649
Max/Ave	1.05	1.05	1.06

Source: BVK

2) Infiltrated Water

Based on the flow survey in 2007, “1.30” was adopted as the coefficient of seasonal infiltrated water flow.

Table 2.28 Ratio of Flow on Infiltrated Water

Ratio of flow	Remarks
1.3	Daily maximum/Daily average

(H) Hydraulic Load in Each Catchment Area

Hydraulic load in the catchment area of Ušće PS is shown in Table 2.29.

Table 2.29 Hydraulic Load from the Ušće PS Catchment Area

	Subbasin	Hydraulic load Daily Average (m^3/day)		
		2015	2021	2031
Ušće PS Catchment area	Gornji Zemun	31,100	29,700	31,000
	Karađorđev trg	25,900	26,000	26,500
	Nova Nova	14,600	15,400	16,000
	Galovica	24,300	26,600	27,600
	Gazela	5,600	6,100	6,400
	Ušće immediate basin	2,500	2,700	2,900
	Total	104,000	106,500	110,400

Hydraulic load in the Mostar PS catchment area is shown in Table 2.30.

Table 2.30 Hydraulic Load from the Mostar PS Catchment Area

	Subbasin	Hydraulic load Daily Average (m^3/day)		
		2015	2021	2031
Catchment area of the Mostar PS	Železnik	39,900	37,600	39,300
	Banovo Brdo	23,500	25,600	26,300
	Topčider collector	50,300	55,100	58,400
	Senjak	1,800	2,100	2,200
	Total	115,500	120,400	126,200

Hydraulic load in the Mokrolug Collector catchment area is shown in Table 2.31.

Table 2.31 Hydraulic Load from the Mokrolug Collector Catchment Area

	Subbasin	Hydraulic load Daily Average (m^3/day)		
		2015	2021	2031
Mokrolug collector Catchment area	Duboki creek	13,900	13,900	14,300
	Čubura collector	11,700	12,700	13,000
	Mokrolug collector	14,700	15,400	15,900
	Kumodraž collector	14,300	15,900	16,400
	Banjica collector	21,800	22,000	22,800
	Total	76,400	79,900	82,400

Hydraulic load in the Danube catchment area is shown in Table 2.32.

Table 2.32 Hydraulic Load from the Danube Catchment Area

	Subbasin	Hydraulic load Daily Average (m^3/day)		
		2015	2021	2031
Catchment area of the Danube immediate basin	Bulbuder collector	37,200	39,100	40,300
	Mirijevo collector	14,300	15,600	15,900
	Danube immediate basin	46,800	47,500	49,800
	Total	98,300	102,200	106,000

(3) Mass Load

The assessment of pollutant emissions were made in 2007 considering samples from 10 measuring points which included the following collectors: Banjicki, Stari Cukaricki, Novi cukaricki, Topciderski, Novi collector Zemun-Ušce, Gazela-Ušce, Gornji Zemun-Ušce, Dure Dakovica (pre Terazijskog tunnel), Dure Dakovica (posle Terazijskog tunnel), and Vojvode

Dobrnjca collector. Collectors where measurements and sampling were completed belong to the central system.

- 8270.5 ha area covered by 10 sampling points
- 1,113,510 persons (number of inhabitants and legal entities) are connected to collectors covered by sampling points.

The results of measurement are shown in
Table 2.33. Pre-FS with MP explained that mass load per person is very similar to German standard. Therefore German standard was adopted for the unit pollution loads from inhabitants. JICA study adopts this result.

Table 2.33 Measurement Results Prepared by Pre-FS with MP

Item		Total Mass Load (Mass load per person)	Remarks (Standards)
Mass Loads	BOD_5	53,942 kg/day (48 g/person)	58 g/person(Japan) 60 g/person(German)
	COD_{cr}	130,280 kg/day (117 g/person)	27 g/person(Japan) * 120 g/person(German)
	SS	68,623 kg/day (62 g/person)	45 g/person(Japan) 70 g/person(German)
	T-kN**	12,646 kg/day (11 g/person)	11 g/person(Japan) *** 11 g/person(German)
	T-P	2,277 kg/day (2 g/person)	1.3 g/person(Japan) 2.5 g/person(German)

Note: *COD_{Mn}, **Total-Kjeldahl Nitrogen, ***Total-Nitrogen

(4) Projected design value for sizing Veliko Selo WWTP

(A) Hydraulic Load

Projected hydraulic load (influent flow) to Veliko Selo WWTP from 2015 until 2031 is shown in Table 2.34.

Table 2.34 Projected Influent Flow

Year	2015	2021	2031
Daily average flow	394,000 m^3/day	409,000 m^3/day	448,700 m^3/day
Daily maximum flow	464,000 m^3/day	474,000 m^3/day	521,200 m^3/day
Hourly maximum flow	696,000 m^3/day	717,100 m^3/day	788,800 m^3/day
Wet weather flow	1,209,600 m^3/day	1,252,800 m^3/day	1,341,100 m^3/day

Note: Kmax hour (Hourly max/Daily max) is adopted at 1.5 for the Central system, Kmax rain (Wet weather flow/Hourly max) is adopted at 1.75.
Hydraulic load in 2031 is included from Bolec subsystem

(B) Mass Load

Projected mass load to Veliko Selo WWTP from 2015 until 2031 is shown in Table 2.35.

Table 2.35 Projected Mass Load

Item		2015	2021	2031
Population Equivalent(PE)		1,301,000	1,347,000	1,439,000
BOD_5	60g/PE/day	78,060 kg/day	80,820 kg/day	86,340 kg/day
CODcr	120g/PE/day	156,120 kg/day	161,640 kg/day	172,680 kg/day
TSS	70g/PE/day	91,070 kg/day	94,290 kg/day	100,730 kg/day
T-kN	11g/PE/day	14,311 kg/day	14,817 kg/day	15,829 kg/day
T-P	2.5g/PE/day	3,253 kg/day	3,368 kg/day	3,598 kg/day

Note: Population Equivalent is the population when mass load of BOD_5 is 60g/person/day
Mass loads in 2031 are included from Bolec subsystem

2.4.2 Sewerage Development Plan in Central System

As for current planning documents, Existing or new collectors will be connected to planned Interceptor directly or via overflow structures, and then Interceptor will convey sewage into Veliko Selo WWTP as shown in Figure 2.25. Since some part of Interceptor has already been constructed, JICA study evaluates based on the present developing planning to select an optimum solution. Sewerage development policy and plan for sewerage network, Interceptor, and Veliko Selo WWTP is explained below.

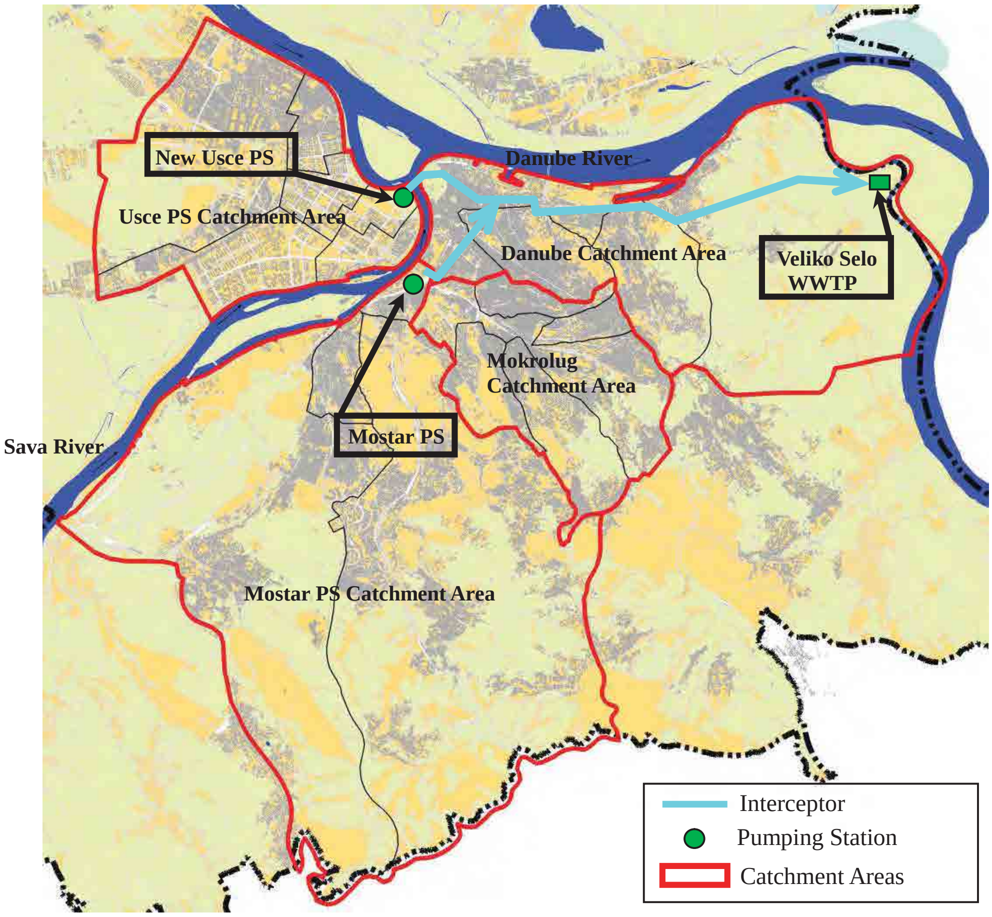


Figure 2.25 Sewerage Development Plan in Central System

(1) Sewerage Development Policy and Plan in Ušće PS Catchment Area

This catchment area has almost improved sewerage facilities except construction of New Ušće PS. Since existing Ušće PS does not have sufficient capacity (1,850 l/s) to pump out total amount of sewage from this catchment area. Moreover, this old pumping station is not available to extend. Therefore, part of sewage collected from Gornji Zemun and Karađorđev trg subbasin are discharged directly into the Sava River from Karađorđev trg PS. Collector pipe from Karađorđev trg PS to Ušće PS has already been laid, hence, operator just needs to change the connection by valve operation after construction of New Ušće PS, Interceptor, and Veliko Selo WWTP.

Main problems of this catchment area are related to the location of New Ušće PS, shape of force main to cross the Sava River, and the function of pumping station. Regarding the location, getting permission to use the location for new pump station based on the preliminary report is under the progress. JICA Study adopts this location because of the reasons mentioned below.

- Permission to use the location will be provided by the end of this year.

- Proposed location adjacent to existing Ušće PS has enough space to construct new one.

Shape of force main (Sava river crossing section) is very important factor to send sewage to WWTP properly. If river crossing pipe will be damaged, sewage will not reach the WWTP. As a result, the sewage treatment will become unstable due to less inflow mass load. Since present planning to cross the Sava River is by single line, JICA study proposes two lines to cross the Sava River as alternative. This alternative study is explained in Chapter 5 “Facilities Planning of Interceptor”.

(2) Sewerage Development Policy and Plan in Mostar PS Catchment Area

This catchment area needs to be improved at upstream part of Topčider collector because of new development. According to Pre-FS with MP, this part of sewerage connections to existing sewerage network will be done by 2021. Other collector has already been laid and these have enough capacity to collect and transport sewage to the Čukarica Pumping Station. Čukarica PS discharges the sewage into the Sava River directly because Mostar PS is nonfunctional. Projected Hydraulic load is shown in Table 2.36.

Table 2.36 Hydraulic Load at Mostar Pumping Station

Item	2031
Daily ave.(m^3/d)	128,000
Daily max in Dry (m^3/d)	150,000
Hourly max in Wet (m^3/d)	253,500 2,930 (l/s)

Main problem of this catchment area is non-availability of existing Mostar PS because of the aging. The pumping station has six pump units, electric panels, two diesel generators, two transformers, building services, etc. The pumping station is expected to be utilized once the pressured discharge pipes are connected to the recipient interceptor and the transmission system to the Veliko Selo WWTP is completed. However, equipment and concrete structures of Mostar PS are left for long time and have not been functional even though the facilities are maintained properly. Hence, the evaluation of the existing facilities has been conducted to decide on to what extend the facilities can be utilized in the current conditions and to understand about required rehabilitation and renovation works for recovering the proper function.

In addition, at Mostar PS mechanical screen is not installed. Since these screens have to be considered in order to prevent attrition of pumps and pipes by dusts, JICA study investigated the possibility of installation in Mostar PS. This study is explained in Chapter 5 “Facilities Planning of Pumping Station”.

(3) Sewerage Development Policy and Plan in Mokrolug Collector Catchment Area

Combined sewerage system is adopted in this catchment area. Therefore sewage and storm water are collected in existing old Mokrolug collector and conveyed to the traffic junction near Mostar PS. Before the connection of Interceptor No. 10 (Hitna pomoć – Venizelosova), an overflow structure will be constructed to separate the sanitary water. Then separated sanitary water will be directed towards the planned Interceptor No. 10 and sewage from Mostar PS will be connected to Interceptor No. 10. The overflow water (more than 3 times of sewage hourly peak flow in dry condition) will be discharged into the Sava River via Mokrolug collector. Projected Hydraulic load is given in Table 2.37, and Development plan for this catchment area is explained in Figure 2.26.

Table 2.37 Hydraulic Load at Overflow Structure (Beginning of Interceptor No. 10)

Item	Hydraulic load in 2031 (m^3/day)
Daily average	82,500
Daily maximum	95,000
Hourly maximum in Wet	425,000 4,920 (l/s)

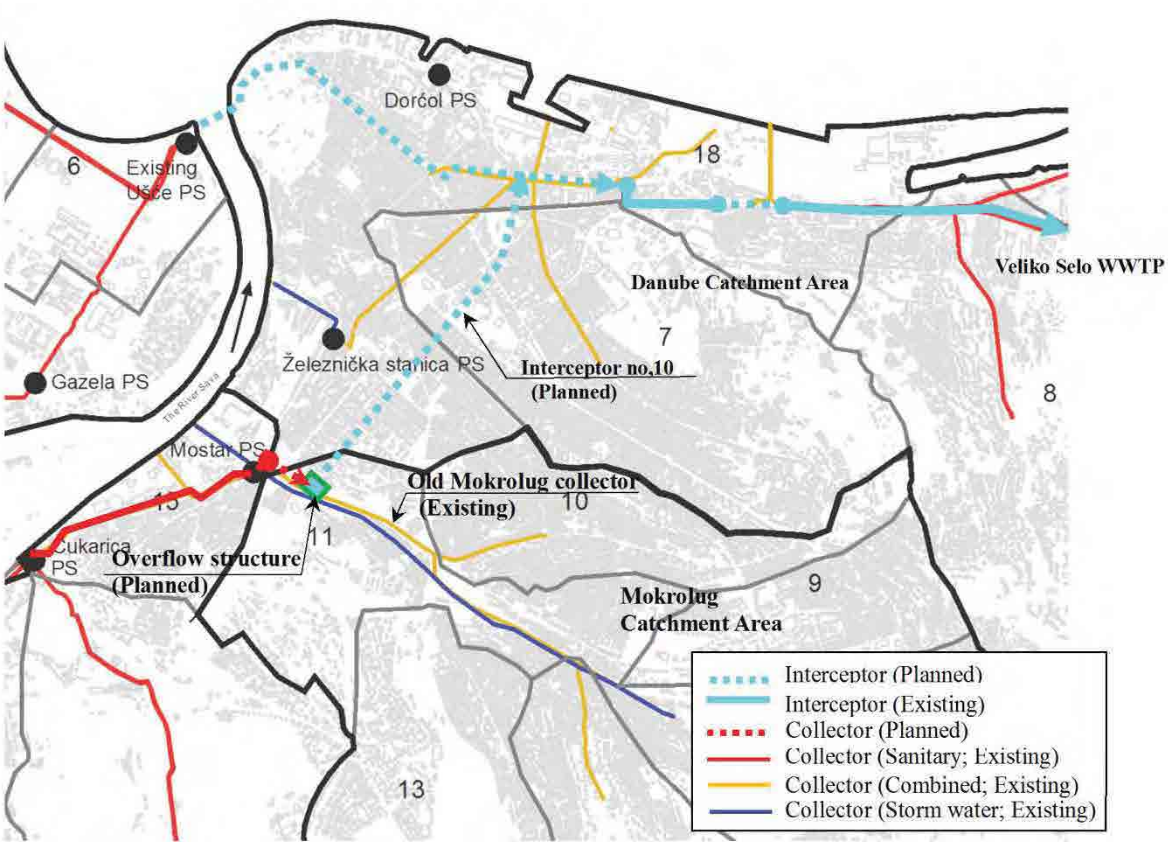


Figure 2.26 Development Plan for Mokrolug Collector Catchment Area

Main problem of this catchment area is the construction location and structure of the overflow structure, because the construction site is located on the main road and the overflow structure will receive flow from two collectors and separate combined sewage into sanitary and overflow water. Since the location of this overflow structure has been decided by Detailed design, JICA Study follows this location plan.

(4) Sewerage Development Policy and Plan in Danube Catchment Area

Danube catchment area can be divided into 3 subbasins, Bulbuder collector, Mirijevo collector, and Danube immediate basin. Danube immediate subbasin also can be divided into 4 areas, Železnička pumping Station, Dorćol Pumping Station, Pristaniste Pumping Station, Slanci and Veliko Selo, and small collectors along with Interceptor. Development plan for this catchment area is explained in Figure 2.27. Regarding hydraulic load of each subbasin, Pre-FS with MP explains that in case of Danube catchment area, hourly maximum in dry condition is adopted as 1.5 times of daily maximum condition. Similarly, hourly maximum flow in wet condition is calculated as twice the hourly maximum in dry condition. Excessive storm water will be discharged into the Danube River through overflow structures.

Bulbuder collector will be connected into Interceptor via an overflow structure. Projected Hydraulic load is shown in Table 2.38

Table 2.38 Hydraulic Load from Bulbuder Collector Catchment Area

Item	Hydraulic load in 2031 (m^3/day)
Daily average	40,300
Daily maximum	45,500
Hourly maximum in Wet	136,500 1,580(l/s)

Mirijevo collector will be connected to Interceptor directly. This area used to adopt combined sewerage system, but storm water pipes are constructed recently. Therefore existing pipe can be connected as sewage pipe into Interceptor. Projected Hydraulic load is shown in Table 2.39.

Table 2.39 Hydraulic Load from Mirijevo Collector Catchment Area

Item	Hydraulic load in 2031 (m^3/day)
Daily average	15,900
Daily maximum	18,300
Hourly maximum in Dry	27,500 320(l/s)

Danube immediate subbasin (Železnička PS area) is sanitary and storm water pumping station from the lowest part of the Sava catchment area. Sewage is distributed into Terazije collector. Terazije collector will be connected into Interceptor near the meeting point of Interceptor No. 4 and No. 10 via an overflow structure. Projected Hydraulic load is shown in Table 2.40. Hourly maximum in wet condition at pumping stations are calculated based on pump capacity proposed by Pre-FS with MP.

Table 2.40 Hydraulic Load from Železnička Pumping Station Catchment Area

Item	Hydraulic load in 2031 (m^3/day)
Daily average	18,900
Daily maximum	21,600
Hourly maximum in Wet	64,800 750(l/s)

Note: Pump capacity is 300l/s x 3nos + 450l/s x 1nos (2 duty, 2 stand-by)

Danube immediate subbasin (Dorćol PS area) is sanitary pumping station in the lowest part of the Danube catchment area. A force main pipe from pumping station up to Interceptor No. 3 will be needed. Projected Hydraulic load is shown in Table 2.41.

Table 2.41 Hydraulic Load from Dorćol Pumping Station Catchment Area)

Item	Hydraulic load in 2031 (m^3/day)
Daily average	15,100
Daily maximum	17,300
Hourly maximum in Wet	51,800 600(l/s)

Note: Pump capacity is 300l/s x 3nos (2 duty, 1 stand-by)

Danube immediate subbasin (Pristaniste PS area) will be constructed to convey sewage from factories and households to Interceptor. Projected Hydraulic load is shown in Table 2.42.

Table 2.42 Hydraulic Load from Pristaniste Pumping Station Catchment Area

Item	Hydraulic load in 2031 (m^3/day)
Daily average	6,300
Daily maximum	7,200
Hourly maximum in Wet	21,600 250(l/s)

Note: Pump capacity is 90l/s x 3nos (2 duty, 1 stand-by) +70l/s x 2nos (1 duty, 1 stand-by)

Danube immediate subbasin (Slanci and Veliko Selo area) are new catchment area where people are engaged in agriculture mainly. This new catchment area is planned adopting separate sewerage system. Since this catchment area did not divide from Danube immediate basin, JICA study estimates sewage from this catchment area as below. Inhabitant of new catchment area is estimated by the ratio between Danube immediate basin and new catchment area as shown in Table 2.43.

Table 2.43 Number of Inhabitants

Item	2011	Ratio
Danube immediate basin (Pre-FS)	131,150	97.5%
Slanci and Veliko Selo (Census2011)	3,309	2.5%

Hydraulic load of new catchment area is estimated by the above ratio as shown in Table 2.44 and Table 2.45.

Table 2.44 Estimated Hydraulic Load from New Catchment Area

Item		2021	2031
Danube immediate basin	Daily average (m^3/day)	47,000	50,000
	Daily maximum (m^3/day)	54,000	57,000
Slanci and Veliko Selo	Daily average (m^3/day)	1,200	1,300
	Daily maximum (m^3/day)	1,350	1,450

Table 2.45 Hydraulic Load from the New Catchment Area of Slanci and Veliko Selo

Item	Hydraulic load in 2031 (m^3/day)
Daily average	1,300
Daily maximum	1,450
Hourly maximum in Dry	2,200 26(l/s)

Danube immediate subbasin (Other small area) is small area located between Dorćol PS and Terazije collector. Sanitary water and storm water from this area are collected by existing collector and connected Terazije collector and then discharged to Interceptor via an overflow structure. Projected Hydraulic load is shown in Table 2.46.

Table 2.46 Hydraulic Load from the Catchment Area of Small Collectors

Item	Hydraulic load in 2031 (m^3/day)
Daily average	8,200
Daily maximum	9,650
Hourly maximum in Wet	29,000 340(l/s)

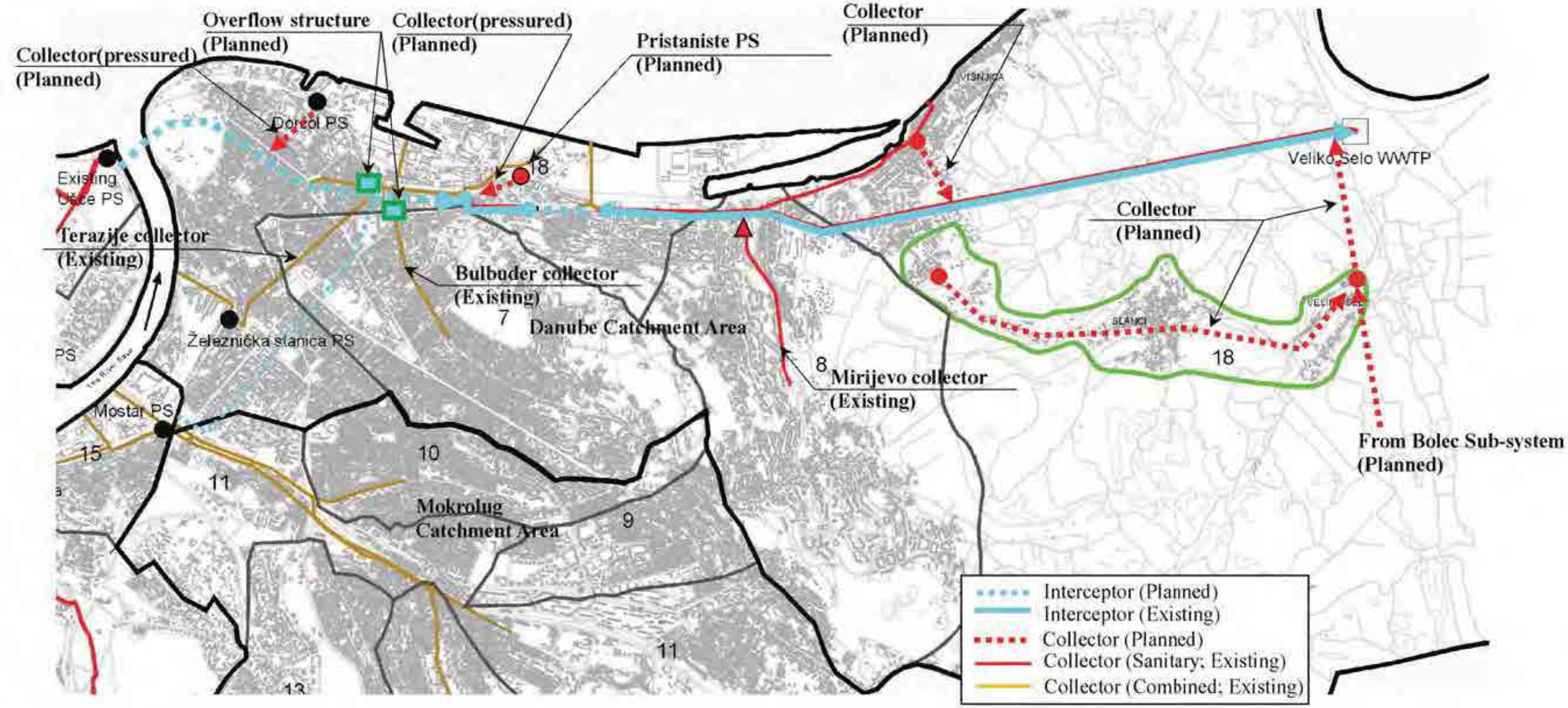


Figure 2.27 Development plan for Danube Catchment Area

Main problem of this catchment area is how to convey sewage from new catchment area to Veliko Selo WWTP. As for Pre-FS with MP, Sewage from this area will be connected directly into Veliko Selo WWTP by 2031. Since collector from Bolec subsystem will be laid in same location as collector from new catchment area, JICA study plan considers that both collectors will meet before the connection to WWTP, and convey sewage into WWTP by a collector.

(5) Sewerage Development Policy and Plan in Interceptor

Sewage development policy of interceptor in current plan is shown in Table 2.47 and location of Interceptor is shown in Figure 2.28.

To feed sewage to Veliko Selo WWTP, Interceptor shown in table below will be needed. In addition, to receive sewage from Mostar catchment area into Interceptor No. 10, collector from the receiving manhole of Mostar PS to Interceptor No. 10 need to be constructed. Therefore, Collector is also listed in the development plan of Interceptor.

Table 2.47 Current development Plan of Interceptor

No	Policy	Remarks
1	ϕ 150 cm Force main from New Ušće PS	Approx. 430m from Sava river crossing part. Approx. 90m from New Ušće PS to Interceptor No.1
2	ϕ 140 cm Force main from New Ušće PS	Km 0+000 – km 0+946 Approx. 946m
3	ϕ 200 cm by gravity flow up to the connection of Terazijski tunnel and Interceptor from Mostar pumping station. Trench work is adopted so as not to be cut down utilities underground.	km 0+946 – km 2+772 Approx. 1,830m
4	ϕ 380 cm from the Terazijski tunnel connection up to existing Interceptor No.5 Trench work is adopted so as not to be cut down utilities underground.	km 2+772 – km 3+715 Approx. 940m
5	Existing pipe 380/380 cm It was constructed in 1980's.	km 3+715 – km 4+238 Approx. 520m
6	ϕ 380 cm after Interceptor No.5 until Interceptor No.7 Micro-tunnelling work is adopted because of the deep depth laying.	km 4+238 – km 5+090 Approx. 850m
7	Existing pipe 380/380 cm It was constructed in 1980's.	km 5+090 – km 5+867 Approx. 780m
8	Existing pipe ϕ 400 cm It was constructed in 2012 by Shield (TBM) method.	km 5+867 – km 6+800 Approx. 930m
9	Existing pipe ϕ 400 cm It was constructed in 2012 by Shield (TBM) method.	km 6+800 – km 12+639 (Veliko Selo WWTP) Approx. 5,840m
10	ϕ 280 cm from Hitna Pomoć to Venizelosova. Basically, Micro-tunnelling work is adopted because of the deep depth laying. But, at the downstream of interceptor, trench work is adopted due to shallow depth.	Approx. 3000 m
Collector	ϕ 160 cm from Mostar PS to Interceptor No.10. Trench work is adopted because of the shallow depth at the upstream of pipe line. Pipe jacking method is adopted due to deep depth at the downstream of pipe line.	Approx. 320 m

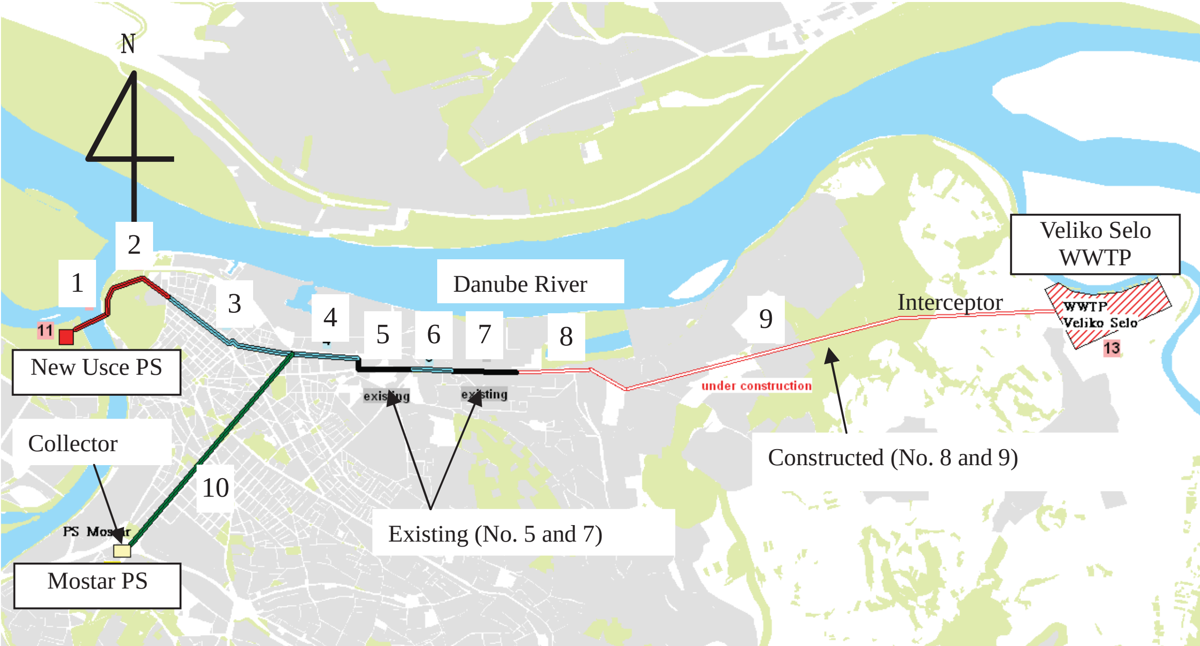


Figure 2.28 Location of Interceptor

(6) Sewerage Development Policy and Plan in Veliko Selo WWTP

Planning parameters of Veliko Selo WWTP are explained in the Section 6.1 and the alternatives of selection of sewage and sludge treatment method are explained in the Chapter 6. Basically, the construction of WWTP will be more efficient in undertaken in one phase. However, it will require a lot of construction cost, and it is uncertain to receive inflow of sewage into WWTP as planned. These are the harmful risk to maintain the WWTP. Therefore, it is better to construct WWTP in two phases so as not to have idle facilities. In addition, if sewage is not increasing as planned, the capacity of WWTP can be adjusted in second phase. Since priority development areas will be selected with their costs, construction phase works will be proposed in Section 7.

Schematic diagram of existing pipe networks are shown in Figure 2.29 and projected hydraulic load by subbasin is shown in Table 2.48. According to these data, in case Veliko Selo WWTP will not be constructed, sewage discharges into the River directly. Sewage (daily average in 2021) from the Mostar PS catchment area is maximum in amount being 11.8 million m^3/day (29%), followed by sewage in Ušće PS catchment area of 10.7 million m^3/day (26%), followed by Danube catchment area contributing sewage amount of 10.2 million m^3/day (25%), and then Mokrolug collector catchment area with sewage amounting 8.2 million m^3/day (20%).

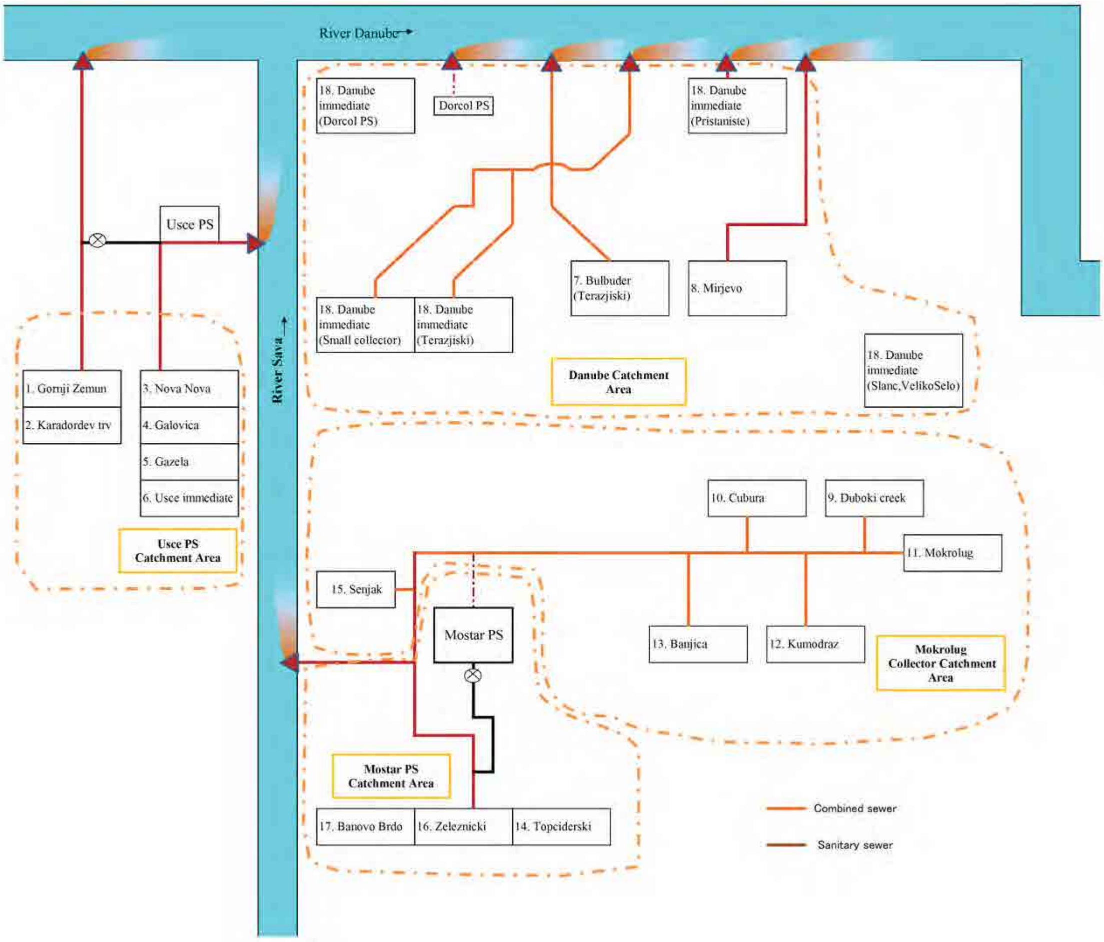


Figure 2.29 Schematic Diagram of Existing Pipe Network

Table 2.48 Projected Hydraulic Load

Subbasin	Daily ave. (m^3/day)	
	2021	**2031**
1. Gornji Zemun	29,700	31,000
2. Karađorđev trg	26,000	26,500
3. Nova Nova	15,400	16,000
4. Glavica	26,600	27,600
5. Gazela	6,100	6,400
6. Ušće immediate basin	2,700	2,900
Total of Ušće PS catchment area	**106,500**	**110,400**
14. Topčider collector	55,100	58,400
16. Železnički	37,600	39,300
17. Banovo Brdo	25,600	26,300
Total of Mostar PS catchment area	**118,300**	**124,000**
9. Duboki creek	13,900	14,300
10. Čubura collector	12,700	13,000

Subbasin	Daily ave. (m^3/day)	
	2021	**2031**
11. Mokrolug collector	15,400	15,900
12. Kumodraz collector	15,900	16,400
13. Banjica collector	22,000	22,800
15. Senjak	2,100	2,200
Total of Mokrolug collector catchment area	**82,000**	**84,600**
7. Bulbuderski collector	39,100	40,300
8. Mirijevski collector	15,600	15,900
18. Danube immediate basin	47,500	49,800
Total of Danube catchment area	**102,200**	**106,000**
Total	**409,000**	**425,000**

To improve the current sewerage system in Central system, the sewerage improvement works listed below will be required. Work lists are shown in Table 2.49, and locations of these works are shown in Figure 2.30.

Table 2.49 Lists of Improvement Works

No.	Catchment area	Item	Description	Remarks
1	Ušće	New Ušće Pumping Station	Newly construction	Scope of the project
2		Interceptor No.1 and 2	Force main pipe from Ušće PS	Scope of the project
3	Mostar	Mostar PS	Rehabilitation	Scope of the project
4		Connection pipe from Mostar PS into Interceptor No.10	Sanitary pipe	Scope of the project
5		Extension of Topčider collector	Sanitary pipe	–
6		Collector in Senjak subbasin	Sanitary pipe	–
7	Mokrolug	Overflow structure on old Mokrolug collector	Newly construction	Scope of the project
8	Danube	Interceptor No.3	Sanitary pipe	Scope of the project
9		Interceptor No.4	Sanitary pipe	Scope of the project
10		Interceptor No.6	Sanitary pipe	Scope of the project
11		Interceptor No.10	Sanitary pipe	Scope of the project
12		Dorcol PS	Pump replacement Sanitary pipe (Pressured)	–
13		Pristaniste PS	Newly construction Sanitary pipe (Pressured)	–
14		Connection pipe from Mirjevski collector to Interceptor	Sanitary pipe	–
15		Overflow structure from collector into Interceptor	Bulbuderski collector	–
16		Overflow structure from collector into Interceptor	Small collector	–
17		Collector at Slanci, Veliko Selo	Sanitary pipe	–
18		Collector at Visnijica	Sanitary pipe	–
19	–	Bolec Sub-system	Newly construction	–
20	–	Veliko Selo WWTP	Newly construction	Scope of the project

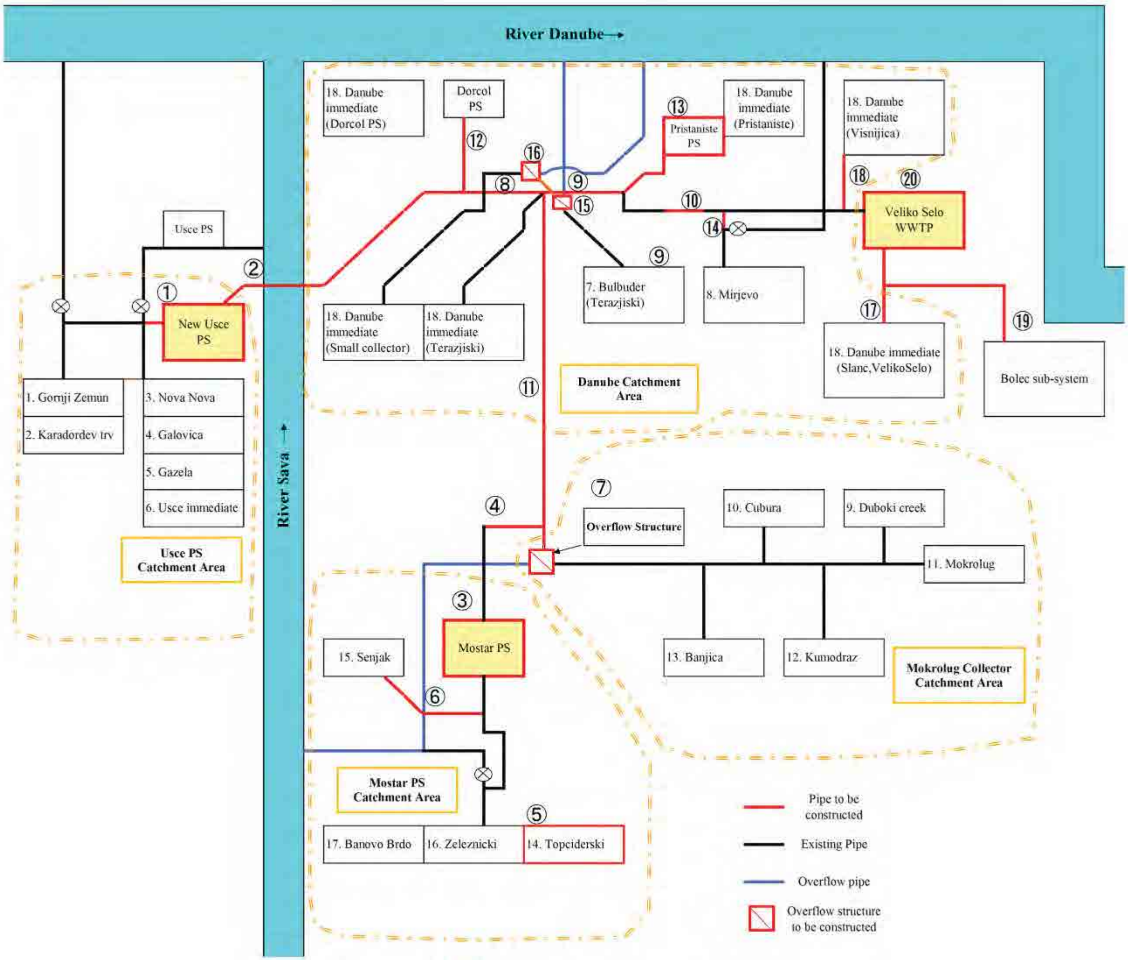


Figure 2.30 Location of improvement Works

The schematic diagram of pipe networks in case all sewerage facilities are constructed in 2031 is shown in Figure 2.31. And Inflow quantity into Veliko Selo WWTP from each subbasin is shown in Figure 2.32.

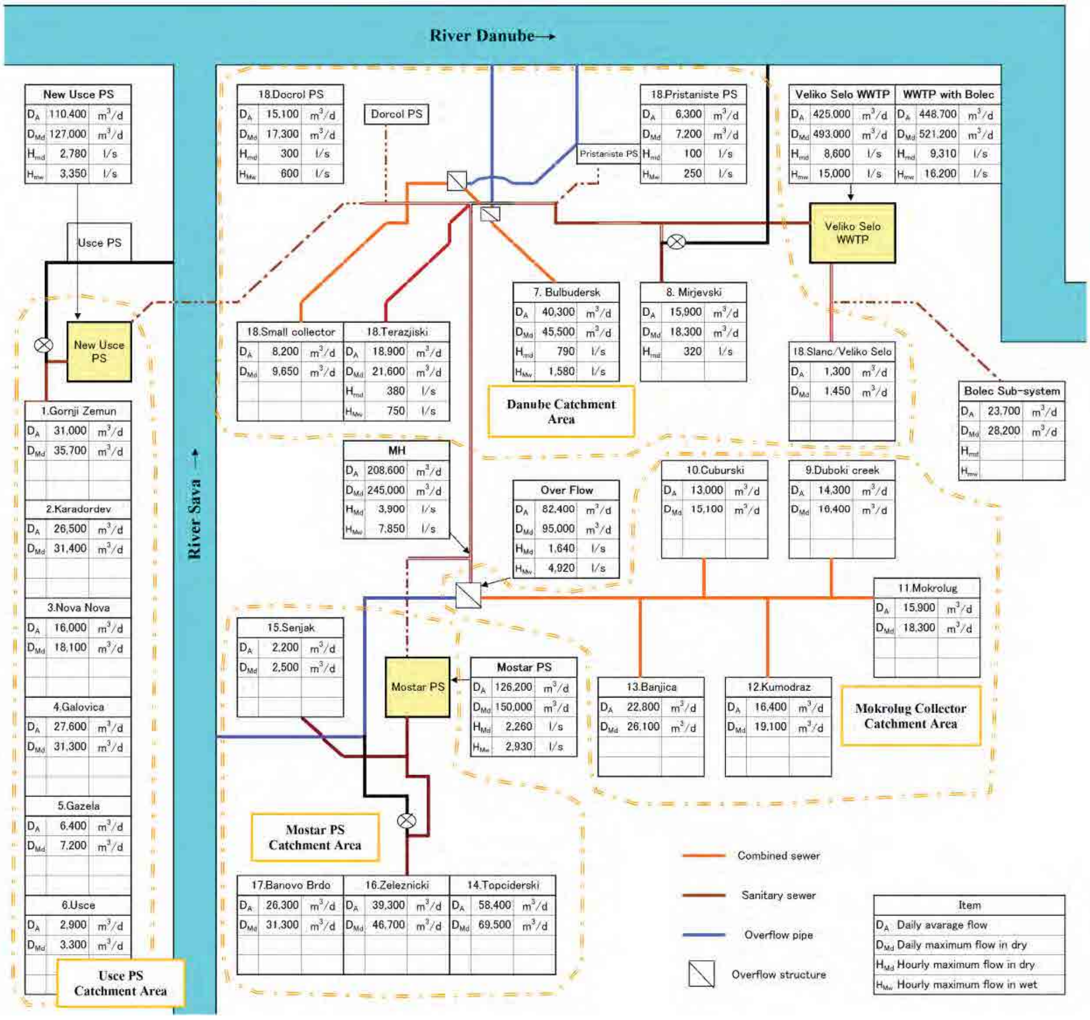


Figure 2.31 Schematic Diagram in 2031 (After Construction of All Pipe Network)

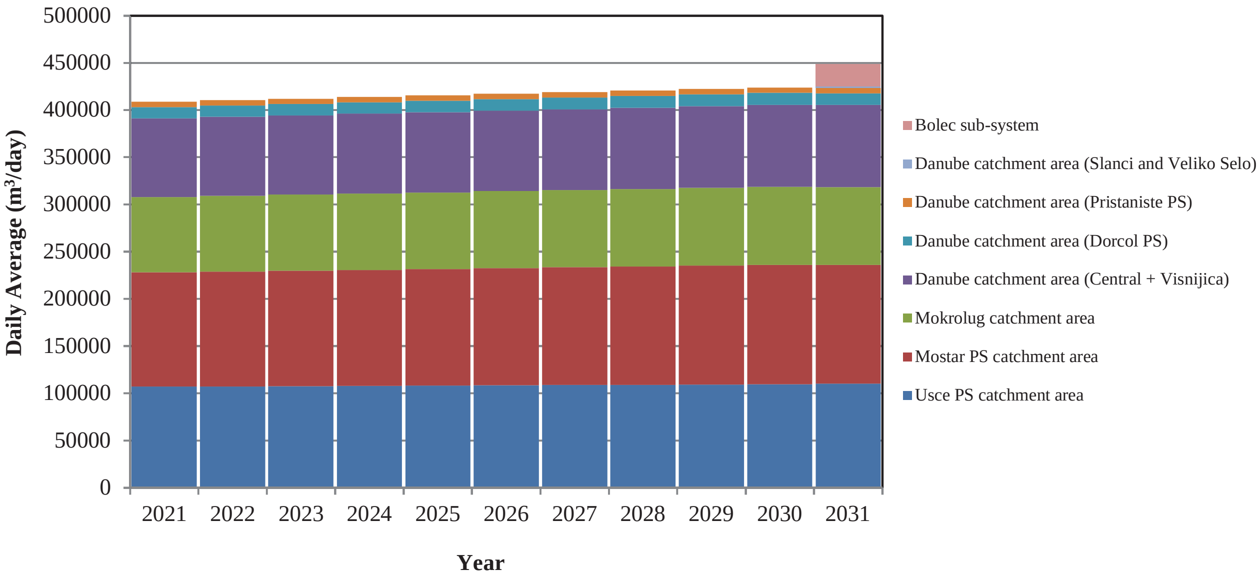


Figure 2.32 Inflow into Veloko Selo WWTP from Each Subbasin

3. Study Tour in Japan

3.1 Background and Objectives

In order to provide bases for the further discussion, "**Study Tour on Sewerage Technology in Japan"** was planned. The purpose of the Study Tour was to acquire useful knowledge on state of the art technology in sewerage field in Japan for Belgrade Sewerage Project.

3.2 Participants and Schedule

Study Tour on Sewerage Technology in Japan was implemented during 10 days from 20th to 29th August 2012, inviting 5 participants.

(List of Participants)

Mr. Željko Ožegović	Member of the City Council
Mr. Goran Trivan	Secretary of Secretariat for Environmental Protection
Mr. Borisav Milutinović	Assistant to General Manager for Technical Departments, LDA
Ms. Aleksandra Nikolić	Deputy Director of Program and Land Development Preparation Department, LDA
Mr. Vladimir Janković	Assistant to Managing Director for Sewerage System, BVK

(Program of Study Tour on Sewerage Technology in Japan)

Day			Program (AM)	Program (PM)	Place
1	20	Mon	Arriving at Tokyo, Japan	Orientation	Tokyo
2	21	Tue	Tokyo Tobu Recycle Center (Fuelization of Sludge)	Tokyo Kitatama No.2 WWTP (A2O process)	Tokyo
3	22	Wed	Yokohama Sludge Recycle Center (Biomass)	Yokohama Fukuura Industrial WWTP (Industrial wastewater treatment)	Tokyo
4	23	Thu	Kasumigaura Water Reclamation Center, Lake Kasumigaura (Advanced technology for PN removal)		Tokyo
5	24	Fri	Lectures on sewage & sludge treatment (Japan Sewage Works Agency)	Presentation by Belgrade side Sewerage technology introduction	Tokyo
6	25	Sat	Move to Osaka		Osaka
7	26	Sun	Holiday in Kyoto		Osaka
8	27	Mon	Osaka Nakahara WWTP (Validation project)	Kobe Higashinada WWTP (Validation project)	Osaka
9	28	Tue	Kona Cuubu Reclamation Center (Advanced technology for PN removal)	Move to Tokyo Review meeting	Tokyo
10	29	Wed	Leaving Japan		

3.3 Outline of Observed Sewerage Facilities

<Study Tour on 21st August>

(1) Tokyo Tobu Sludge Recycle Center (10:30 – 12:00)

(A) Sludge Fuelization (Carbonize Process)

Organic substances constitute 80 % of sewage sludge. Hence, sewage sludge can be utilized as energy resources. There are three advantageous motives to introduce the sludge fuelization.

- Sustainable utilization of sewage sludge as biomass
- Financial benefit owing to utilizing sewage sludge as valuable resources
- Reduction of greenhouse gas

This process carbonizes sewage sludge and produces the product which can be utilized in the power generation plant as substitutes of coal.

(2) Tokyo Kitatama No.2 Wastewater Treatment Plant (14:00 – 16:00)

(A) Improvement of Combined Sewer System

In combined sewer system, rainwater is carried together with sanitary sewage. This mixed wastewater is sometimes released to the receiving water body when rainfall exceeds a certain level without any treatment. The Rapid Fiber Filter treats the excess wastewater to prevent release of non-treated wastewater and maintain water quality of the receiving water body.

(B) Advanced Treatment Process (Anaerobic Anoxic Oxic Process)

Anaerobic Anoxic Oxic Process is advanced treatment process to remove nutrient. This process is the combined process of biological nitrogen removal and biological phosphorus removal. Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. Microbes discharge phosphorus in anaerobic tanks and uptakes more phosphorus than discharged amount in the following aerobic tanks. Ammonia nitrogen is oxidized to nitrate nitrogen and nitrite nitrogen by nitrifying bacteria such as Nitrosomonas and Nitrobacter in aerobic tanks. Nitrate nitrogen and nitrite nitrogen is deoxidized to nitrogen gas by denitrifying bacteria such as Pseudomonas, Micrococcus, Achromobacter and Bacillus in anoxic tanks.

<Study Tour on 22nd August>

(1) Yokohama Sludge Recycle Center (10:00 – 12:00)

(A) Utilization of Sewage Sludge

Utilization of biogas	Biogas generated from anaerobic digestion process is utilized to generate electricity which affords the majority of power consumption. Heat energy recovered from engines is utilized to warm sludge in the digesters.
Utilization of sludge	All amount of ash from the incinerators is utilized as either raw material of cement or backfilling material. Ash is mixed to produce cement in the cement factories. Ash is also mixed to excavated soil to improve quality as backfilling material.

(B) Mechanical Dewatering

In this sludge recycle center, there are three types of mechanical dewatering machines. Dewatering process and performances of three types can be compared.

- Centrifugal Dewatering
- Screw Press Dewatering
- Belt Press Dewatering

Screw presses dewatering machines are comprised of screws, outer screens, pressers, driving devices, flocculation devices and control panels. The dewatering machines dewater sludge by squeezing flocculated sludge with screws and perforated metal screens. The dewatering machines require less energy compared to conventional dewatering machines such as centrifugal owing to low-speed rotation.	

(2) Yokohama Fukuura Industrial Wastewater Pretreatment Plant (14:00 – 16:00)

(A) Outline of the Plant

Fukuura industrial wastewater pretreatment plant was constructed aiming to establish urban industrial development free from environmental pollution. This plant treats wastewater from three kinds of enterprises i.e. plating, prickling and printing/dyeing industries. Wastewaters from industries are divided into the following categories of wastewater and treated separately.

- High Concentration Cyanic Wastewater (Capacity: 3 m^3/day)
- Low Concentration Cyanic Wastewater (Capacity: 130 m^3/day)

- Chromic Wastewater (Capacity: 75 m^3/day)
- Acid / Alkali Wastewater (Capacity: 1,245 m^3/day)
- Printing / Dyeing Wastewater (Capacity: 4,000 m^3/day)

(B) Treatment Processes

Wastewater	Treatment Processes
Cyanide	The electrolysis process is adopted for the pretreatment of high concentration cyanic wastewater. Effluent from this process is mixed with low cyanic concentration wastewater after reduction of the cyanic concentration to approximately 1,000 mg/l by electrolysis and treated together. Alkaline chlorination process is adopted for the treatment of low concentration cyanic wastewater.
Chromic	Chemical reduction process employing sodium bisulfite is adopted for the treatment of hexavalent chromium. The pH control process is divided into two stages due to the instability of the formed chromium hydroxide.
Acid / Alkali	Coagulation precipitation process is adopted for the treatment of acid / alkali wastewater due to the formation of hydroxide. The pH control process is divided into two stages as the same as treatment process of the chromic wastewater. Further, the oxidation of bivalent iron to trivalent iron is carried out in oxidation tank.
Printing / Dyeing	Floatation process is adopted for physicochemical process which can remove organic matter such as COD, oil, fat and colors.

<Study Tour on 23rd August>

(1) Kasumigaura Water Reclamation Center (10:00 – 12:00)

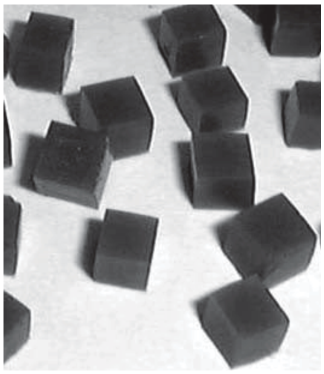
(A) Advanced Treatment Processes

In this WWTP, there are four types of advanced treatment processes to remove nutrient. Treatment process and performances of four processes can be compared.

- Conventional Activated Sludge Process with Coagulant (CASP)
- Anaerobic Anoxic Oxic Process (A2O)
- Carrier Added Activated Sludge Process (CAASP)
- Recycled Denitrification and Nitrification Process with Coagulant (RDNP)

Treatment process	Nitrogen removal	Phosphorous removal
CASP	-	Physical-chemical removal
A2O	Biological removal	Biological removal
CAASP	Biological removal	Biological removal
RDNP	Biological removal	Physical-chemical removal

(B) Explanation of Advanced Treatment Processes

Treatment process	Explanation
Conventional Activated Sludge Process with Coagulant (CASP)	Conventional activated sludge process with coagulant (CASP) is the combined process of organic substance removal and physical-chemical phosphorus removal. Phosphorus is removed by adding coagulant such as aluminum sulfate and poly aluminum chloride. Denitrification cannot be carried out in this process. Hence, removal efficiency of nitrogen is very limited.
Anaerobic Anoxic Oxic Process (A2O)	Anaerobic anoxic oxic process (A2O) is the combined process of biological nitrogen removal and enhanced biological phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. Physical-chemical phosphorus removal process is also installed for backup of biological process since biological process becomes frequently unstable due to difficulties to maintain anaerobic condition on wet weather condition.
Carrier Added Activated Sludge Process (CAASP)	CAASP enables to increase concentration of microbe in aeration tanks by adding carriers which contains microbe inside. Hydraulic retention time can be reduced owing to increase of microbe. CAASP is usually adopted for biological nitrogen removal process since it requires longer hydraulic retention time and sludge retention time. Stable nitrification is achieved owing to nitrifying bacteria contained in carriers since carriers are retained in aeration tanks. 
Recycled Denitrification and Nitrification Process with Coagulant (RDNP)	Recycled denitrification nitrification process with coagulant (RDNP) is the combined process of biological nitrogen removal and physical-chemical phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by adding coagulant such as aluminum sulfate and poly aluminum chloride. RNDP with coagulant is the conventional process of nitrogen and phosphorous removal.

<Study Tour on 24th August>

(1) Morning Session

Time: from 09:00 to 12:00
Place: Conference Room, Head Office, Tokyo Engineering Consultant Co., Ltd.

Time	Schedule
From 09:00 to 10:00	Lecture-1 : Sewage Works in japan & Management of Sewerage Works Lecturer: Mr. Yoshiharu IMAJIMA, Japan Sewage Works Agency
From 10:00 to 11:00	Lecture-2 : World's Leading Wastewater Treatment Technology in JAPAN Lecturer: Dr. Toshikazu HASHIMOTO, Japan Sewage Works Agency
From 11:00 to 12:00	Lecture-3 : Biofuel Project -Converting Biomass into Solid Fuels- Lecturer: Mr. Hakuei YAMAMOTO, Japan Sewage Works Agency

(2) Afternoon Session

Time: from 13:00 to 17:30
Place: Conference Room, Head Office, Tokyo Engineering Consultant Co., Ltd.

Time	Schedule
From 13:00 to 13:15	Opening Address: Mr. Hiroshi KAMEDA, President of TEC Guest Address: Mr. Željko Ožegović, Member of the City Council, the City of Belgrade Introduction of Guests: 5 from City of Belgrade and 2 form JICA
From 13:15 to 14:00	Presentation : Sewerage Development in Belgrade Presenter: Mr. Borisav Milutinović, Public Agency for Land Development and Construction of Belgrade
From 14:00 to 14:15	Break time
From 14:15 to 15:00	Technology Introduction-1: Technologies on Sewer Rehabilitation Presenter: Sekisui Chemical Co., Ltd.
From 15:00 to 15:45	Technology Introduction-2: Technologies on Sewage Treatment Presenter: Hitachi Plant Technologies, Ltd.
From 15:45 to 16:00	Break time
From 16:00 to 16:45	Technology Introduction-3: Technologies on Sludge Dewatering and Filtration Process Presenter: Ishigaki Company, Ltd.
From 16:45 to 17:30	Technology Introduction-4: Technologies on sewage Sludge Fuelization Presenter: Tsukishima Kikai Co., Ltd.

<Study Tour on 27th August>

(1) Osaka Nakahama Wastewater Treatment Plant (10:00 – 12:00)

(A) Concept of the Project

The project enhances energy saving and energy utilization by introducing the following technologies and aims to achieve self-energy sufficient wastewater treatment plant.

- High-efficiency Solid-liquid Separation
- High-efficiency High-temperature Digestion
- Smart Generation System

These technologies also contributes the reduction of emission of greenhouse gas and operation costs owing to energy saving and energy utilization.

(B) Advanced Technologies

Technology	Explanation
High-efficiency Solid-liquid Separation	Raw sewage is treated by filtration instead of primary settling tanks. Filtration can remove pollution loading more effectively than primary settling tanks and influent to aeration tanks contains less pollution loading. Hence, energy required for aeration is reduced. At the same time, increase of primary sludge contributes increase of energy production.
High-efficiency High-temperature Digestion	High-temperature digestion and addition of carrier enables to reduce the retention time to approximately five days. High-temperature and carrier enhances and stabilizes anaerobic digestion process and contributes increase of biogas production.
Smart Generation System	Fuel cell power generation, hybrid fuel system, has quite high power generation efficiency. This system can reduce power consumption by combination with the optimum control of plant operation. This system manages energy consumption of whole plant and contributes to achieve high self-energy sufficiency of plant.

(2) Kobe Higashinada Wastewater Treatment Plant (14:00 – 16:00)

(A) Concept of the Project

The project enhances energy utilization so that the WWTP plays a key role of renewable energy utilization. The project has been implemented taking the following steps.

- Step-1: Purifying digestion gas equivalent to natural gas in order to utilize purified gas as fuel for natural gas automobiles
- Step-2: Utilization of 100% of digestion gas by purifying equivalent to utility gas and supplying excess purified gas to utility gas pipeline
- Step-3: Increase of biogas production by receiving unutilized biomass resources which originated from plant and food generated in the area

This project introduces the technologies to purify digestion gas, to supply purified gas to automobiles and utility gas pipeline and to receive and treat unutilized biomass efficiently with sewage sludge. This project contributes the reduction of emission of greenhouse gas and operation costs owing to supply of purified gas to users.

(B) Introduced Technologies

Anaerobic Digestion

Production of Utility Gas

Production of Automotive Fuel

Automotive Fuel Supply Station

<Study Tour on 28th August>

(1) Konan Chubu Water Reclamation Center (10:00 – 12:00)

(A) Advanced Treatment Process (Step Feed Denitrification Nitrification Process)

Step Feed Denitrification Nitrification Process is the combined process of biological nitrogen removal and physical-chemical phosphorus removal. This process has been developed to improve the removal efficiency of nitrogen. Step feeding of sewage to each stage equalizes the solid contents of the tanks of each stage. Equalization of organic loading and nitrogen loading results in high removal efficiency of nitrogen.

(B) Advanced Treatment Process (Ozone and Biological Activated Carbon Process)

Treatment process	Explanation
Ozone Process	This process contributes removal of organic contents and chemical substances, decolorization, deodorization and disinfection owing to the strong oxidation effect of ozone. Ozone is produced by silent electric discharge and injected into treated effluent of sewage treatment process.
Biological Activated Carbon Process	This process contributes removal of organic contents, decolorization and deodorization owing to the absorbability of activated carbon and the decomposition by microbe in activated carbon layer. Activated carbon is produced from wood, coal, etc. by carbonization process.

4. Facilities Planning of Interceptor

4.1 Review of Existing Plan / Design / Specifications

The basic design of Interceptor (Ušće – Veliko Selo) is done by "Institute Jaroslav Černi" in 1979. After that Main Project (Detailed design) considering facility planning were conducted around 1982 – 1986. Interceptor No. 5 and No. 7 were constructed based on this design at the same time of railway construction. However, other interceptor has not been constructed for a long time because of the change in social condition.

The construction of Interceptor restarted from Interceptor No. 8 and No. 9 in 2009, and the construction of these interceptors has just completed in the end of 2012. Also facility plan of interceptor No. 10 was revised to be constructed in near future, but it has not been constructed yet due to the high construction cost. The latest status of Interceptors is given in the Table 4.1. Pre-FS with MP conducted by Institute Jaroslav Černi in 2011 follows these facilities as development plan basically.

Table 4.1 Current Plan for Interceptor

Interceptor	Location	Status
No.1	Sava river crossing	Preliminary Design (2009)
No.2	Ušće – T.Koscka	
No.3	T.Koscka – Vojvode Dobrnjca	Detailed Design (1982)
No.4	Vojvode Dobrnjca – Pancvo bridge	
No.5	Tunnel Karaburma	Constructed
No.6	Tunnel Karaburma	Detailed Design (1982)
No.7	Vojvode Micka – Minel	Constructed
No.8	Minel – Rospi Cuprija (tunnel)	Constructed
No.9	Tunnel Visnjica	Constructed
No.10	Hitna pomoc – Venizelosova	Detailed Design (2009)

Urban planning documents were prepared/will be prepared based on the above designs. These documents covered the routes of the interceptor and the facilities of the sewer system.

FOR THE INTERCEPTOR (from "Ušće" pumping station to "Veliko Selo" WWTP)

1) Section within General Regulation Plan for construction area of local government unit – City of Belgrade – areas VII, IX and X – off-print I-9 (under preparation)
2) Detailed Urban Plan of Kalemegdan, (Official Gazette of the City of Belgrade, No. 6/69)
3) Section within Detail Regulation Plan for construction area of local government unit – City of Belgrade – areas I and II– off-print I-2 (under preparation)

4) Detail Regulation Plan of a part of the central zone – spatial areas of 11 blocks between streets: Francuska, Djure Djakovica, Knezopoljska and the boundary of a part of the port economic area –Municipality of Stari Grad, Official Gazette of the City of Belgrade No. 12/04
5) Detail Regulation Plan of a part of the central zone of the blocks between streets Venizelosova (Djure Djakovica), Knez Miletina i Djordja Jovanovica – Municipality of Stari Grad, Official Gazette of the City of Belgrade No. 18/06
6) Detail Regulation Plan for construction of “Pristaniste” sewerage pumping station, Official Gazette of the City of Belgrade No. 23/04
7) Detail Regulation Plan for the area between streets: Bulevar Despota Stefana (29. Novembra), Mitropolita Petra, Dragoslava Srejovića (Partizanski put) and Mije Kovacevica, with "Pančevački most" interchange, Official Gazette of the City of Belgrade No. 34/09
8) General Regulation Plan for the area between streets: Dzordza Vasingtona, Bulevar Despota Stefana, Vojvode Dobrnjca, Venizelosova i Knez Miletine, in the Municipality of Stari Grad, Official Gazette of the City of Belgrade No. 58/09
9) Detailed Urban Plan for construction of the main heating pipeline from “DUNAV” heating plant to “Terazije” plateau, Official Gazette of the City of Belgrade No. 10/87 (planning document is amended by the defined corridor of interceptor)
10) Section within General Regulation Plan for construction area of local government unit – City of Belgrade – areas III and IV– off-print I-2
11) Detail Regulation Plan for the area between streets: Bulevar Despota Stefana (29. Novembra), Mitropolita Petra, Dragoslava Srejovića (Partizanski put) i Mije Kovacevica, with "Pančevački most" interchange, Official Gazette of the City of Belgrade No. 34/09.
12) Detailed Urban Plan for Visnjicka Street from Mije Kovačevic Street to Slanački put, Official Gazette of the City of Belgrade No. 25/83 (Planning document is amended by the defined corridor of interceptor)
13) Detailed Urban Plan of Visnjica settlement, Official Gazette of the City of Belgrade No. 11/78 (planning document is amended by the defined corridor of interceptor)
14) Amendment to Detailed Urban Plan of Visnjica settlement, Official Gazette of the City of Belgrade No. 10/86.

FOR Collector from “Mostar” pumping station to Hitna Pomoć-Djure Djakovića

1) General Regulation Plan for construction area of local government unit – City of Belgrade – areas I and II – off-print I-8 (under preparation)
2) Detailed Urban Plan for reconstruction and construction of the complex between the Highway, Kneza Milosa Street, Durmitorska Street, and Clinical Center of the Medical Faculty, Official Gazette of the City of Belgrade No. 18/78.
3) Detailed Urban Plan of the Clinical Institutional Centre of the Medical Faculty, Official Gazette of the City of Belgrade No. 2/75

4) Detailed Urban Plan for reconstruction of four blocks between streets: Dzordza Vasingtona, Drinciceva, 29. Novembra, Vojvode Dobrnjca i Takovska, Official Gazette of the City of Belgrade No. 9/91
5) Detailed Urban Plan for reconstruction of blocks between streets: Francuska, Djure Djakovica, Knezooljska and the boundary line of the complex of a part of port economic area, Official Gazette of the City of Belgrade No.18/88.

Review of existing development plan is explained in the Table 4.2 and Figure 4.1. Under this review or existing plan and design, Interceptor No. 1 (Length=425m) is needed for alternative plans in Interceptor. Other Interceptors are adopted in existing development plan, but some specifications such as pipe diameter or construction method are considered in the following section as brief preliminary design.

Table 4.2 Policy of Development Plan for Interceptor

Interceptor	Current planning	This project
No. 1	Force main pipe (Dia 1500 mm) from New Ušće PS. To be constructed by Horizontal Direction Drilling (HDD).	Alternatives are considered
No. 2	Force main pipe (Dia 1400 mm) from New Ušće PS. Trench work is adopted so as not to cut down utilities underground.	Current development plan is adopted
No. 3	Gravity flow pipe (Oval 2000-1700 mm) from the end of Interceptor No. 2 to meeting point of Terazijski tunnel and Interceptor No. 10. Trench work is adopted so as not to cut down utilities underground.	Current development plan is adopted
No. 4	Gravity flow pipe (Horse shoe 3800 mm) from the end of Interceptor No. 3 to interceptor No. 5 (existing). Trench work is adopted so as not to cut down utilities underground.	Current development plan is adopted
No. 6	Gravity flow pipe (Dia 4000 mm) from the end of Interceptor No.5 to Interceptor No. 7 (existing). Micro-tunnelling work is adopted because of the deep depth laying.	Current development plan is adopted
No. 10	Gravity flow pipe (Dia 2800 mm) form the meeting point of Mokrolug Collector and collector form Mostar PS. Basically, Micro-tunnelling work is adopted because of the deep depth laying. But, in the downstream stretch of interceptor, trench work is adopted due to shallow depth.	Current development plan is adopted
Collector from Mostar PS	Gravity flow pipe (Dia 1600 mm) from receiving manhole from Mostar PS to the starting point of Interceptor No. 10.	Current development plan is adopted

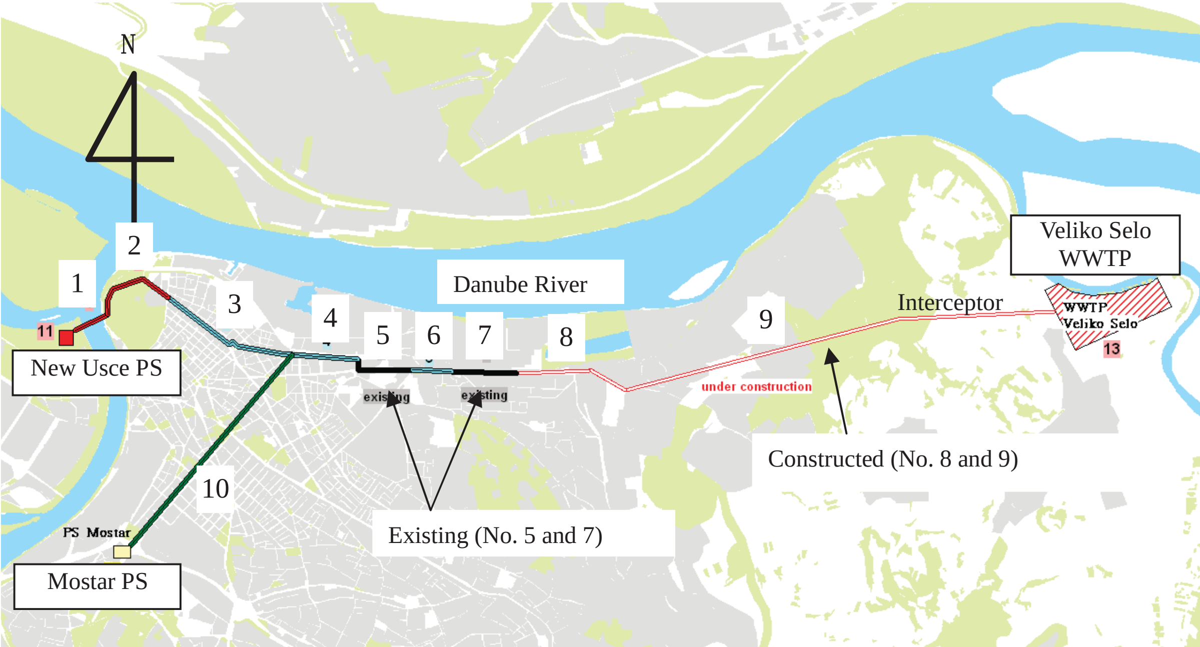


Figure 4.1 Location of Interceptor

Flow calculation of Interceptor is shown in Table 4.3 based on the current development plan. Since velocity is between 1.5 m/s to 1.9 m/s, Pipe diameter of interceptor is suitable against hydraulic flow.

Table 4.3 Flow Calculation of Interceptor

Interceptor	Shape of pipe and Slope	Planed capacity of flow	Hourly maximum in wet condition	Flow velocity	Remarks
No. 1	ϕ 1500 mm (pressure)	-	3.35 m^3/s	-	Pipe gallery(ϕ 3500 mm) New Ušće PS (3.35 m^3/s)
No. 2	ϕ 1400 mm (pressure)	-	3.35 m^3/s	-	
No. 3	Oval 2000-1700 mm 1‰	4.81 m^3/s	3.35 m^3/s	1.52 m/s	Dorcol PS (0.6 m^3/s)
No. 4	ϕ 3800 mm 0.5‰	18.9 m^3/s	14.10 m^3/s	1.82 m/s	Terazie (0.38 m^3/s), Interceptor No. 10 (7.85 m^3/s), Small collector (0.34 m^3/s) Bulbuderski (1.58 m^3/s).
No. 5 Existing	ϕ 3800 mm 0.5‰	21.6 m^3/s	14.35 m^3/s	1.84 m/s	Pristance PS (0.25 m^3/s)
No. 6	Horse shoe 4000 mm 0.5‰	21.6 m^3/s	14.35 m^3/s	1.84 m/s	
No. 7 Existing	Existing ϕ 4000 mm 0.5‰	21.6 m^3/s	14.35 m^3/s	1.84 m/s	

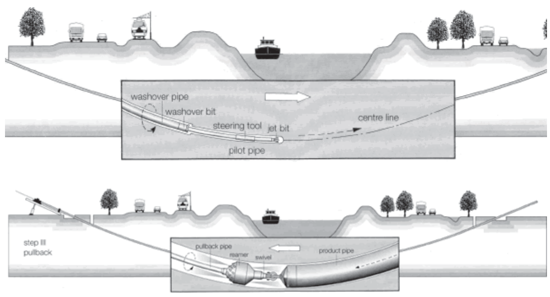
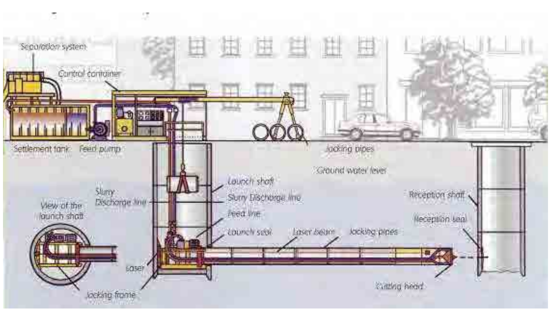
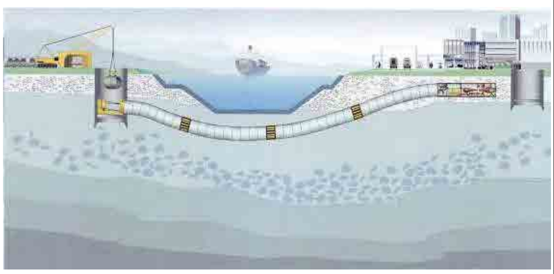
Interceptor	Shape of pipe and Slope	Planed capacity of flow	Hourly maximum in wet condition	Flow velocity	Remarks
No. 8 Existing	ϕ 4000 mm 0.5‰	21.6 m^3/s	14.67 m^3/s	1.85 m/s	Mirjevski (0.32 m^3/s)
No. 9 Existing	Existing ϕ 4000 mm 0.5‰	21.6 m^3/s	14.67 m^3/s	1.85 m/s	Into Veliko Selo WWTP
No. 10	ϕ 2800 mm 0.8‰	10.6 m^3/s	7.85 m^3/s	1.88 m/s	Mostar PS (2.93 m^3/s) Mokrolug (4.92 m^3/s)

Alternative study for Interceptor No. 1 is made in the next section.

4.2 Alternative Plans for Interceptor No.1 (Sava River Crossing)

Interceptor No.1 was studied in Preliminary Design of New Ušće Pumping station 2008. According to this report, Dia 1000 mm x 2 line and Dia 1500 mm x 1 line are considered. The construction method was also studied in this report as shown in Table 4.4. Finally, Dia 1500 mm x1 line by shield method with arc-shape line was recommended.

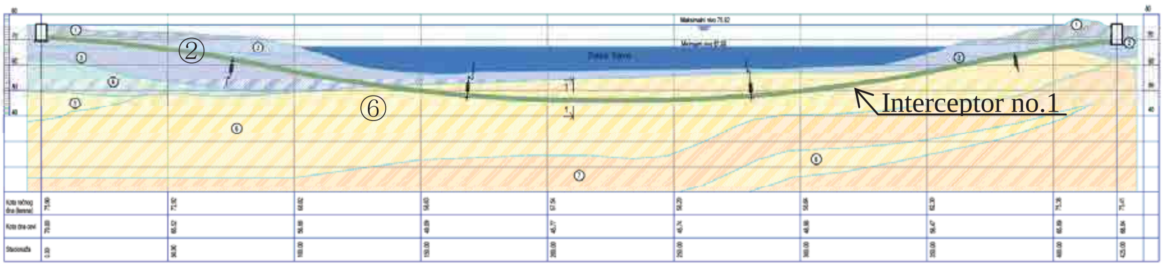
Table 4.4 Construction Method Proposed by Preliminary Design

Trench method	Horizontal Direction Drilling method
	
Shield method (Straight shape)	Shield method (Arc shape)
	

Source：Preliminary design 2008

However, Shield method with arc-line shape is very difficult to control the construction because of such a short pipe length and uniformity in type of soil as shown in Figure 4.2. That's why cost is not very difference compared to other cases even if shaft can be made smaller. In addition, when one line pipe will be laid, there are no countermeasures in case of pipe choking or pipe damage. There may occur some problems about maintenance works. Therefore, JICA study evaluates for this force main section based on the preliminary design to prevent troubles.

Regarding Interceptor No. 2, Installation of two lines was studied. However, this alternative was discarded from the view of protection of cultural heritage. The interceptor No. 2 will be installed under Bulevar Vojvode Bojovića, which passes along Belgrade Fortress Area, cultural heritage. Based on the opinions from Belgrade City Institute for the Protection of Cultural Monuments, the location within the road and the width of open cut were carefully selected not to affect the cultural heritage by construction and operation of interceptor. Therefore, Dia 1400 mm in one line is adopted.



② Sands	γ = 16.0 kN/m^3	c = 5 kN/m^2	φ = 14^o
⑥ limestone	γ = 21.0-22.0 kN/m^3	c = 150-200 kN/m^2	φ = 25-30^o

Figure 4.2 Cross Section

4.2.1 Conditions

(1) Hydraulic Load

Generally, Design value for pumping station uses "Hourly maximum flow in Dry condition" because of the separate network system in the catchment area of Ušće pumping station (PS). However, as for the sampling data collected in 2007 to 2008, Ušće PS experienced some infiltrated water because the catchment area of Ušće PS is located in flat ground and influenced by the river water level.

Under these circumstances, Design value of Ušće PS is adopted "Hourly max in wet condition" to enable pumping of inflow sewage in wet condition. Design value in this project is shown in Table 4.5.

Table 4.5 Hydraulic Load

	2021	2031
Daily average	107,000 m^3/d	110,000 m^3/d
Daily maximum in wet condition	160,000 m^3/d	165,000 m^3/d
Hourly max in wet condition	280,000 m^3/d 3,240 l/s	289,000 m^3/d 3,350 l/s

(2) Selection of Pipe Diameter to Keep the Minimum Flow Velocity

Design standards are shown in Table 4.6. As for German standards, the minimum velocity needs to keep more than 0.5 m/s. On the other hand, Japanese standard explains that the minimum velocity is more than 0.6 m/s, and it recommends choosing much faster velocity in case of the large diameter pipes.

As for Serbian standards, “A minimum velocity is 0.7 m/s. This shall be achieved at least once in every 24 h. Velocities below 0.7 m/s may be acceptable during certain operating conditions provided that the criterion above is satisfied. When pumps are incapable of achieving the conditions given above consideration shall be given to the incorporation of a compressed air system for periodic flushing of the system”. It means if flow velocity is more than 0.5 m/s in night, flow velocity will be maintained more than 0.7 m/s in Hourly maximum flow.

Table 4.6 Design Standards

	Minimum flow velocity		
	Japan	German (ATV-134)	Serbian
Velocity (m/s)	0.6	0.5	0.7

The literature “Minimum Velocity to Prevent Deposition of Soil Particles in Force Mains; 1997” has been studied in Japan. According to this, the minimum flow rate is required to prevent deposition theoretically have been reported. The minimum flow rate for each individual pipe diameter is shown in Table 4.7.

Table 4.7 Minimum Velocity (Soil Diameter1 mm; sp.gr.2.65)

Dia. \ slope	-45	-20	0	20	45
400	0.00	0.29	0.39	0.44	0.47
800	0.00	0.31	0.41	0.47	0.50
1000	0.00	0.32	0.42	0.48	0.51
1500	0.00	0.33	0.43	0.49	0.52

Note: when diameter is 2 mm, it gets 1.6 times of flow velocity

It indicates if the particle size of the sediments is less than 1 mm transportation competency is obtained at most critical section (in case of 45 degree's slope with more than 0.5 m/s). From the results above, the minimum flow rate of the force main is required more than 0.5 m/s to ensure the ability to remove the sediment (to prevent deposition).

(3) Selection of Pipe Diameter

As discussed above, Minimum flow velocity has to be more than 0.5 m/s. The flow velocities are calculated for different shapes of the force main.

Table 4.8 Flow Velocities by Different Shape of Pipes

Shape	Hourly max in wet (4w+1s)	Daily ave ～Daily max (3w+2s)	Night flow (1w+4s)
	3,350 l/s	2,490l/s	830 l/s
DN900 x 2	2.63 m/s	1.96 m/s	0.65 m/s
DN1000 x 2	**2.13 m/s**	**1.59 m/s**	**0.53 m/s**
DN1200	2.95 m/s	2.12 m/s	0.71 m/s
DN1400	**2.17 m/s**	**1.56 m/s**	**0.54 m/s**
DN1500	1.89 m/s	1.41 m/s	0.47 m/s

Note: Pump capacities are 830 l/s each (4 working + 1 stand-by). One stand-by pump is required in hourly max in wet condition by BVK's regulation.

<In case of two lines>
From the point of view of minimum flow velocity, JICA study proposed DN1000 mm x 2 lines.
＜In case of one line＞
DN1400 is proposed to keep the minimum flow velocity because of the difficulty of pipe maintenance. Sufficient velocity will help the pipes not to cause the sedimentation.

4.2.2 Alternative Plans

General layout plan of the force main is shown in Figure 4.3.

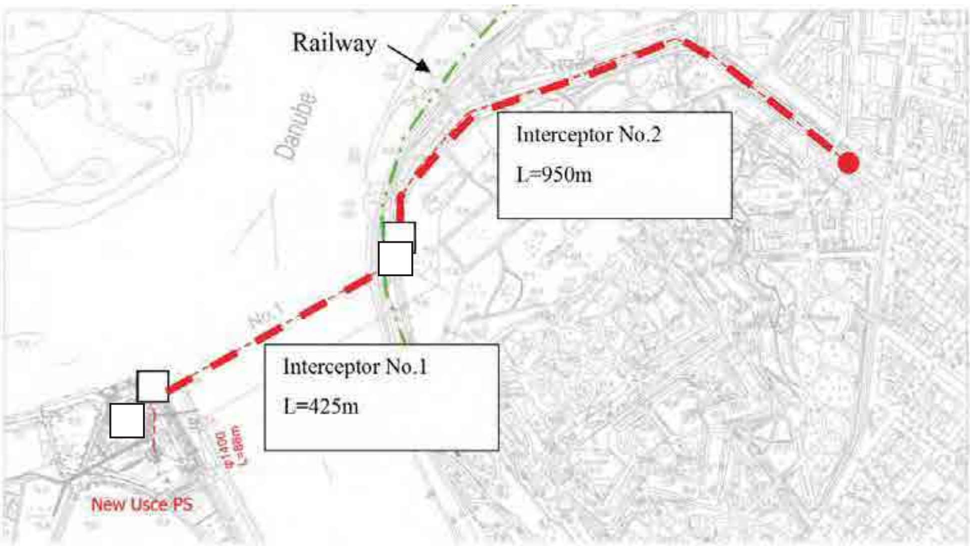


Figure 4.3 Location of Force Main

(1) Options to Be Compared

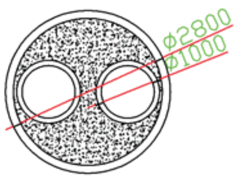
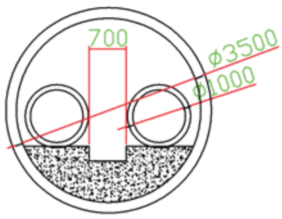
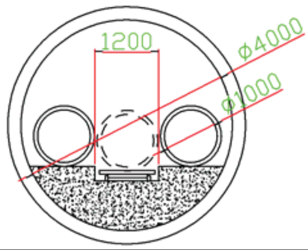
In this section the following cases as shown in Table 4.9 are considered and selection is made from feasible technical and economical point of view. Since existing plan has recommended "Dia1500mm x 1 line", alternative study is adopted same shape of pipe to compare with existing plan. And in case of Interceptor No. 2 "Dia1400mm x1 line" is adopted.

Table 4.9 Alternatives

Item	Case-1 (Diameter 1500 (1400 mm) x 1 Line)		Case-1 (Diameter 1000 mm x 2 Line (both for operation))			
	Case-1-1	Case-1-2 (existing plan)	Case-2-1	Case-2-2	Case-2-3	Case-2-4
Description	One force main pipe will be installed with Straight line-shape	One force main pipe will be installed with Arc line-shape	Two force main pipe will be installed with Arc line shape	One Casing pipe will be constructed, then two force main pipes will be installed inside casing pipe, then inside of casing pipe will be filled in mortar.	One large diameter pipe (Dia 3500 mm) will be constructed as pipe gallery, then two force main pipes will be installed inside pipe gallery.	One large diameter pipe (Dia 4000 mm) will be constructed as pipe gallery to have enough workability inside pipe gallery, then two force main pipes will be installed inside pipe gallery.
Construction method	Micro tunneling	Micro tunneling	Horizontal Direction Drilling	Micro tunneling	Micro tunneling	Micro tunneling

These pipe shapes in case 2-2, 2- 3 and 2-4 are shown in Table 4.10.

Table 4.10 Shape of the Pipes in the Section of Sava River Crossing

Item	Case-2-2 Dia 2800 mm Micro tunneling	Case-2-3 Dia 3500 mm Micro tunneling	Case-2-4 Dia 4000 mm Micro tunneling
Description	Smallest diameter, but pipes can’t be inspected and repaired. Inside of casing pipe will be filled by Mortar	Space inside of pipe gallery is only for walking. Other utilities can be installed at dead space	Enough workability for inspection and pipe replacement Other utilities can be installed at dead space
Shape			

(2) Possibility of Maintenance for Above Options

Possibility of the maintenance for each case at Interceptor No. 1 is considered as given in Table 4.11.

<Inspection by Human or TV camera>
Case-1 scenarios are not possible to inspect pipes at all because pumping station has no storage to retain the sewage during these maintenance works, so operation cannot be stopped even at night time. Hence, Inflow pipes into pumping station are not sufficient to retain some sewage, and there is no space to construct a retention tank. Case-2 scenarios are possible to inspect pipes except Case-2-1. Sewage cannot be discharged from pipes because of arc-line shape in Case-2-1.

<Cleaning by Human, or Flashing or Poly-pig>
Case-1 scenarios are not possible to maintain at all because the operation of pumping station cannot be interrupted even at night time. In addition, pumping station has no storage to retain during these maintenance works. Case-2 scenarios are possible by using one pipe or stand-by pipe. But in case of Case-2-1, cleaning only can be considered by Poly-pig because of arc shape lines.

<Repairing by Pipe lining or replacing>
Case-1 scenarios will not be able to repair the pipe without discharging sewage into river

directly. Case-2-1 will also not repair the pipe, because sewage cannot be discharged from pipes because of arc-line shape. Only case-2-4 is possible to repair or replace the damaged pipes. If small damages such as small cracking, case-2-3 is also possible to be treated by coating or covering the material but it will not be repaired properly.

Table 4.11 Possibility of Maintenance at Interceptor No.1 (Sava River Crossing)

	Case-1-1 D1500 (Straight)	Case-1-2 D1500 (Arc)	Case-2-1 D1000 x 2 (HDD)	Case-2-2 D1000 x 2 (D2800)	Case-2-3 D1000 x 2 (D3500)	Case-2-4 D1000 x 2 (D4000)
Inspection	no	no	no	yes	yes	yes
Cleaning	no	no	yes	yes	yes	yes
Repairing	no	no	no	no	no	yes

Since Interceptor No. 2 will be laid in one line, pipe cannot be maintained. Schematic diagrams during normal operation and maintenance work for force main pipe (Interceptor No. 1 and No. 2) in case of Case-2-2, Case-2-3, and Case-2-4 are shown in Figure 4.4.

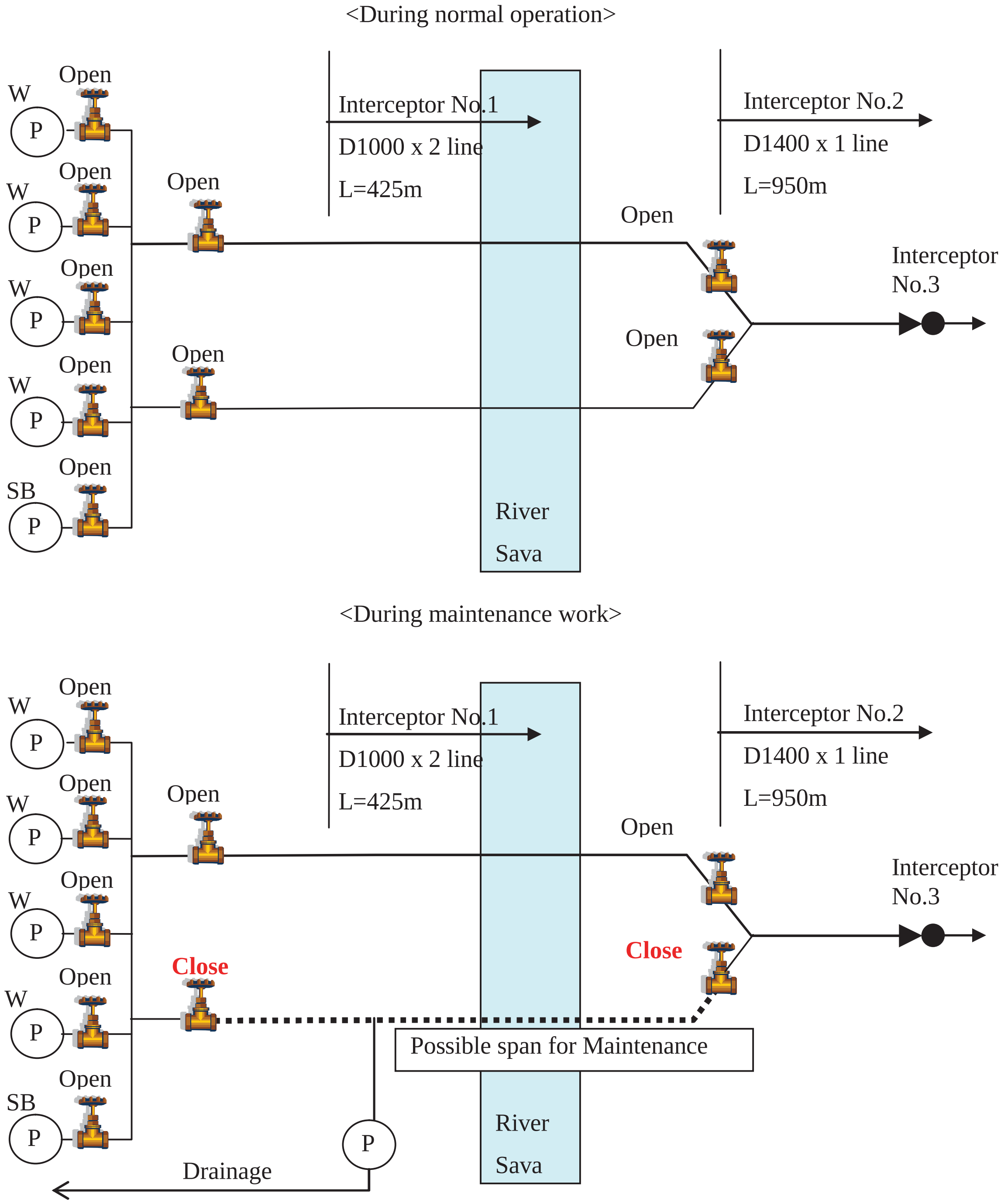
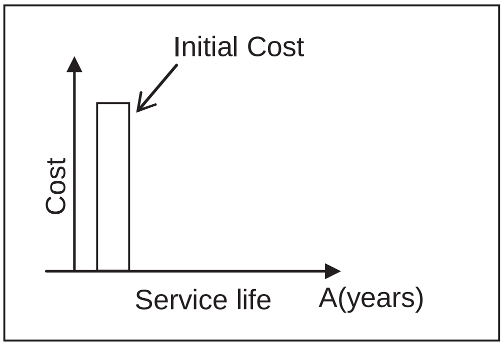


Figure 4.4 Schematic Diagrams During Normal Operation and Maintenance Work

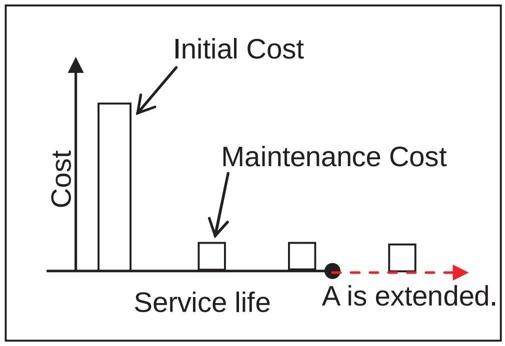
(3) Consideration of Service Life

Service life is influenced by the maintenance of the structure. If pipes are maintained appropriately, their life would be extended. On the other hand, if pipes are not maintained, their life will be shorter. Life Cycle Cost (LCC) consideration in this study is based on this point.

(Without Maintenance)



(With Maintenance)



Nominal service life from the experience of sewerage works and studies about pipe life in German or European countries is shown in Table 4.12.

Table 4.12 Structure / Pipe Service Life

Item	Service life
Concrete structure	80 -100 years
Concrete pipe	50 - 80 years
Steel pipe	35 - 50 years
HDPE pipe	80 - 100 years
Ductile pipe	40 - 50 years

To compare the annual cost between the difference pipe materials, JICA study considers the service life given below.

Table 4.13 Service Life in This Case Study

<table>
<tr><th colspan="2">Item</th><th>Service life</th><th>Remarks</th></tr>
<tr><td colspan="2">Concrete structure</td><td>100 years</td><td>for shaft/Manhole/Pipe gallery etc.</td></tr>
<tr><td rowspan="2">Concrete pipe</td><td>—</td><td>80 years</td><td></td></tr>
<tr><td>Case-1</td><td>50 years</td><td></td></tr>
<tr><td colspan="2">Steel pipe</td><td>40 years</td><td>In case of pipe protection</td></tr>
<tr><td rowspan="2">HDPE pipe</td><td>Case -2-4</td><td>100 years</td><td></td></tr>
<tr><td>Case-1 and Case2-1～2-3
Interceptor No.2</td><td>80 years</td><td></td></tr>
</table>

4.2.3 Evaluation Policy

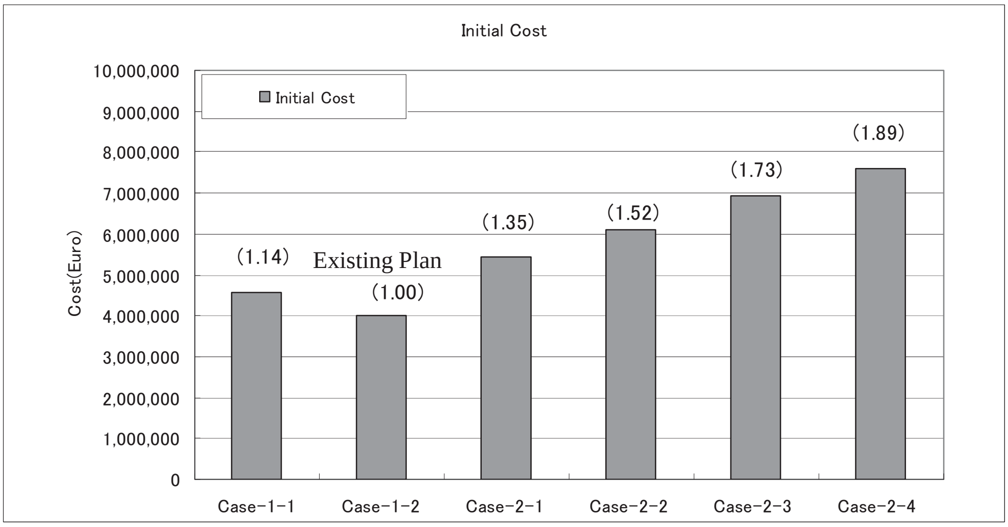
The evaluation method of this case study considers the following 4 items to perform a comprehensive evaluation.

Construction Cost (Initial Cost):	Costs included force main from Interceptor No. 1 and No. 2 and Shaft and the relevant structures.
Life Cycle Cost:	Construction costs are divided into their service life (year) and added their maintenance costs (annually).
Risk Management:	Solution would be obtained for expected problems such as the natural accident or future changes or construction method.
Environmental Consideration:	Impacts on environment by construction and operation and in case of accident

4.2.4 Results

(1) Initial Cost

The lowest initial cost is for Case-1-2 and highest one should be for Case-2-4 because of the construction of two large diameter pipes. The difference in initial cost of Case-1-2 and Case-2-4 is about 1.9 times. Unit costs of construction for force main (L=1375 m) from Case-1-1 to Case-2-4 are estimated as about 3,300 euro/m, 2,900 euro/m, 4,000 euro/m, 4,400 euro/m, 5,000 euro/m, and 5,500 euro/m.



Note: These costs are used for the purpose of comparison of case study. Cost for budget would be difference based on the accurate estimations.

Figure 4.5 Initial Cost

(2) Annual Cost (LCC Cost)

Since Annual Cos is considered in their service life, Case-2 scenarios will have efficient cost more than Case-1 scenarios. Therefore the gap between Case-1 and Case-2 scenarios is considerably narrowed.

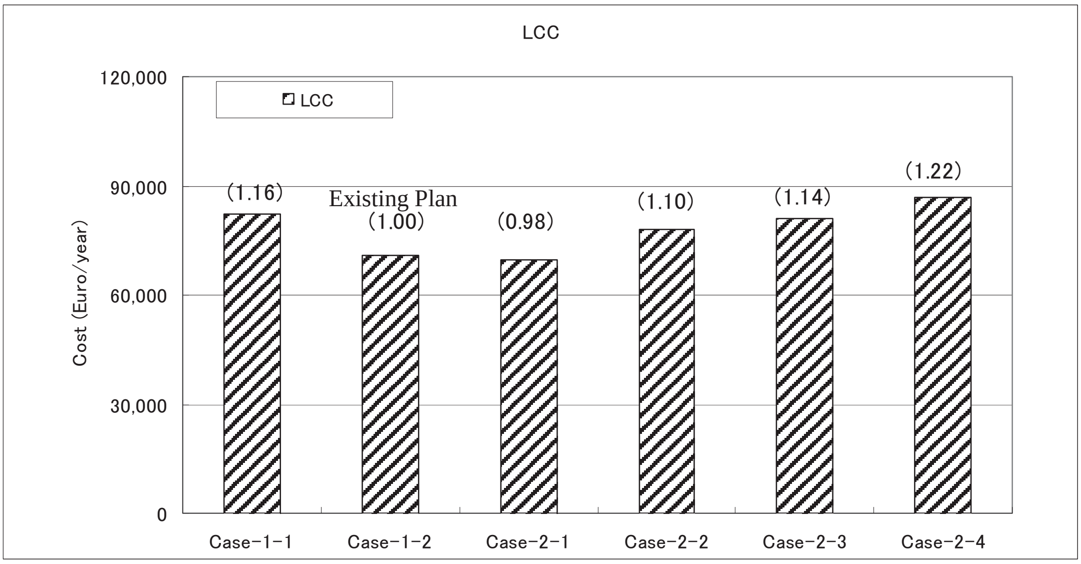


Figure 4.6 Annual Cost

(3) Risk Management

Risks of each case can explain the following key points.

Harmful accident for pipe line:	Since pipe lines under river will be affected directly from unexpected accident or scouring of river flow etc., it is better to have a protection to avoid these harmful accidents.
Flexibility against future change:	Since pipe line has long life, it is better to have some flexibility against changing such as increasing or decreasing of flow quantity in future.
Construction technologies:	Sava River crossing is one of the difficult construction sections of this project because of high ground water level and variety of soil condition. Therefore adapted technologies are required to have enough experience of similar situation.

The results of risks are shown in Table 4.14.

Table 4.14 Results of Risk Management

	Case-1-1	Case-1-2	Case-2-1	Case-2-2	Case-2-3	Case-2-4
a) Accident	C	C	C	A	A	A
b) Flexibility	C	C	B	B	B	A
c) Construction method	A	C	C	A	A	A

Note: A (positive) to C (negative)

As for the accident, Case-2-2, Case-2-3 and Case-2-4 are positive because pipes are protected by outer pipes. As for the flexibility, Case-2-4 is positive because of the availability of replacement. And Case-2-1, Case-2-2 and Case2-3 are also much better than Case-1 scenarios. Because planned sewage quantity will be decreasing, operator can adjust the flow velocity by using one pipe instead of two pipes. As for the construction method, Case-1-2 is negative because of the difficulty of arc-shape construction in short span. Case-2-1 is also negative because of the less experience for large diameter's construction.

(4) Environmental Consideration

The force main is located in the place specified in the environmental protection area, but sewage is discharged into the river so far because there are no WWTPs in Belgrade. According to the "Water Law", the operator (BVK) will have obligation not to discharge raw sewage directly into the public water bodies after 2030. When sewage treatment plant starts and Water Law is fully applied, Operator is required to manage this matter in any situation. Under these circumstances, environmental impacts are evaluated how to manage the sewage in case of pipe damages and maintenance to prevent the direct discharge of sewage into the river and soil contamination by each case. The results of these considerations are shown in Table 4.15.

Table 4.15 Results of Environmental Consideration

Items	Case-1-1	Case-1-2	Case-2-1	Case-2-2	Case-2-3	Case-2-4
In case of pipe damage	C	C	C	A	A	A
In case of maintenance	C	C	A	A	A	A

As for Case-1-1 and Case-1-2, Sewage will discharge into the river and contaminate the river water and soil, when pipes are choked or damaged by accident, or during maintenance. Case-2-1 and Case-3 can convey sewage to WWTP by using one pipe, if only one pipe is damaged. However some sewage may leak into the river and soil from the other damaged pipe because of no protection of pipes and cause the contamination of river water and soil. As for the other cases, pipes are protected by an outer pipe, therefore sewage does not leak into the river or soil in any situation. There may be no significant differences on environmental impacts by construction method and size.

4.3 Proposed Optimum Plan

Table 4.16 shows the results as discussed above. Case-2-2 is the best alternative because of low cost and high advantage of risk and environmental consideration. However, Case-2-3 is adopted because maintenance is much easier for operator than Case-2-2 from the C/P determination.

Table 4.16 Summary of the Results

		Case-1-1 D1500 (Straight)	Case-1-2 D1500 (Arc)	Case-2-1 D1000x2 (HDD)	Case-2-2 D1000x2 (D2800)	Case-2-3 D1000x2 (D3500)	Case-2-4 D1000x2 (D4000)
Construction Method		Micro-tunneling	Micro-tunneling	Horizontal Direction Drilling	Micro-tunneling	Micro-tunneling	Micro-tunneling
Initial Cost		1.14	1.00	1.35	1.52	1.73	1.89
Annually Cost (LCC cost)		1.16	1.00	0.98	1.10	1.14	1.25
Risk Management	a) Accident	C	C	C	A	A	A
	b) Flexibility	C	C	B	B	B	A
	c) Construction method	A	C	C	A	A	A
Environmental Consideration	a) In case of pipe damage	C	C	C	A	A	A
	b) In case of maintenance	C	C	A	A	A	A
Total		Indicial costs of Case-1 scenarios are cheaper than other cases, but the differences of LCC costs are similar from Case-1-2 to Case-2-3. As for risk management and environmental consideration, Case-2-2 to Case-2-4 is more positive than other cases. Case2-2 is the best solution from a comprehensive viewpoint. And when the benefit of installation of other utilities such as optical cable inside pipe gallery can be considered; Case-2-3 also becomes the best solution.					

4.4 Facility Planning

4.4.1 Construction Method for Pipe Laying

Generally, pipe laying can be divided into three methods, Open cut/Trench method, Jacking/Injection method, and Shield/TBM method. To construct it safely and efficiently, a suitable method have to be selected in each field situation. Brief explanations of each method are explained below.

< Open cut/Trench Method >

At first, the pipe laid position is excavated by open cut with/without soil retaining wall such as sheet pile, then pipe can be laid by hand work, and then soil is filled to restore the place as in the original state. This method can be selected when pipe laying position is shallow from ground level or if unknown utilities are installed in same position. Construction cost is basically cheaper than other methods, but traffic obstacle are made due to the excavation works on roads.

< Jacking/Injection Method >

This method is categorized in un-open cut technologies. Generally, this method can be adopted when pipe diameter is up to 2000 mm because of the limitation of pipe material for jacking/injection. At first, the departure/arrival shaft is constructed at right position, then jacking/injection machinery is installed in the departure shaft, and then appropriate pipes are injected toward the arrival shaft by machine, and then these shafts are removed to restore the place as the original states. This method can be selected when pipe laying position is deep from ground level or if the roads along which pipes are to be laid are located in high traffic area. Construction cost is higher than open cut/trench method, but the impacts on road traffic are relatively small.

< Shield/TBM Method >

This method is also categorized in un-open cut technologies. Generally, this method can be used for large diameter structures such as tunnels, subway/underground train, public utility conduit, and so on. At first, the departure/arrival shaft is constructed at right position, then shield/TBM machine is installed in the departure shaft, and then shield/TBM machine excavates the soil toward the arrival shaft, then pipes are constructed by segments made from reinforced concrete in the tunnel, and then these shafts are removed to restore the place as the original states. This method is adopted if jacking/injection method cannot be selected due to the pipe diameter or soil condition such as hard rock soil. Construction cost is most expensive compared to other methods.

(1) Interceptor No. 1

(A) General

For the construction of this pipe line, Shield method is adopted as discussed in the previous section. First of all, pipe gallery (Dia 3500 mm) will be constructed under crossing Sava River, and then force main pipe (Dia 1000 mm x 2 line) will be laid inside pipe gallery. Closed shield machine is suitable for cohesive soils under water table. Generally, Jacking/injection method is much cheaper than this method because of the low production cost of the machine, but the length (approx. 425 m) of the Sava River crossing is too long and pipe diameter is too large to use this technology. Suitable pipe material of this section is ductile iron pipe from New Ušće PS to departure shaft because of the connectivity of valves, and High density Polyethylene Pipe (HDPE) inside pipe gallery. Layout plan of utilities in the pipe gallery is shown in Figure 4.7. The installation of electric light and ventilation equipment are required for the purpose of maintenance of the force main. Plain concrete is needed to be casted to lay the force main pipe and to avoid floating by the ground water. Force main pipe (HDPE pipe) can be welded inside pipe gallery, or pipes can be brought in the pipe gallery after pipes are welded in the shaft.

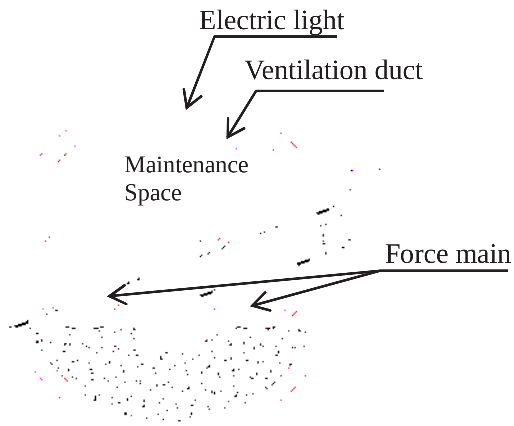


Figure 4.7 Layout of the Pipe Gallery

Drawings of interceptor No. 1 is shown in the Drawings "SEW-01, 02, 15 and 20".

(B) Required Shaft Size and Construction Space

Reference size of departure/arrival shaft is shown in the Table 4.17.

Table 4.17 Reference size of Departure/Arrival Shaft (Interceptor No. 1)

Inner Diameter	Outer diameter (reference)	Machine length (reference)	Required space for departure shaft (reference)	Shaft size (reference)
3500 mm	4,300 mm	8,000 mm	900 m^2	L12.0 m x B7.0 m

Required space for departure shaft is estimated considering the space for segment stock, rail way, grout plant, office, operating house, and so on. Candidate site for the construction of departure/arriving shaft is shown in Figure 4.8 and Figure 4.9. Departure shaft will be located in the site for new Ušće PS, since there is no space for construction on the opposite shore.

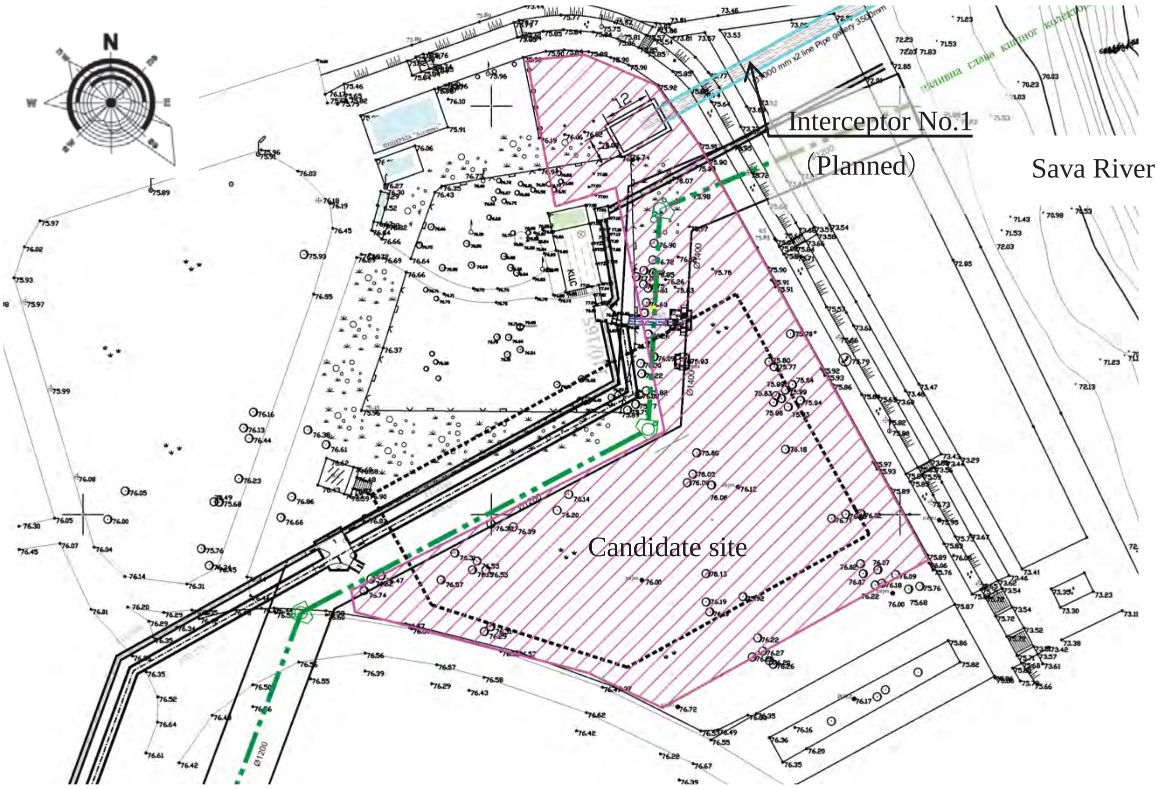


Figure 4.8 Candidate Site for Departure Shaft of Interceptor No. 1

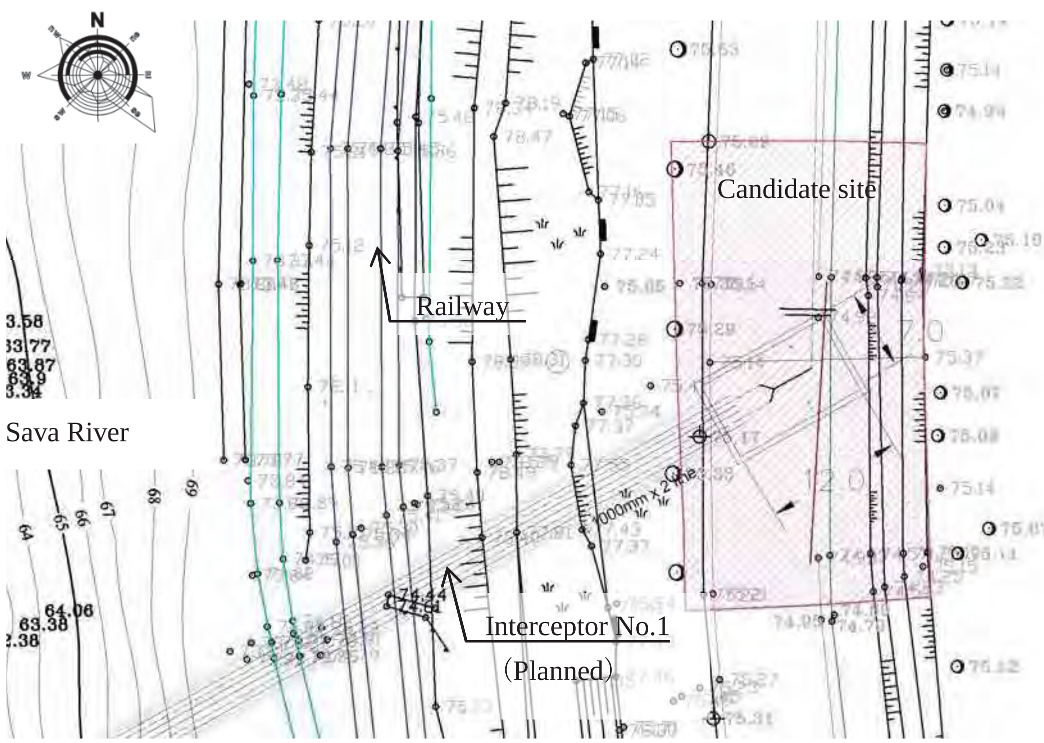
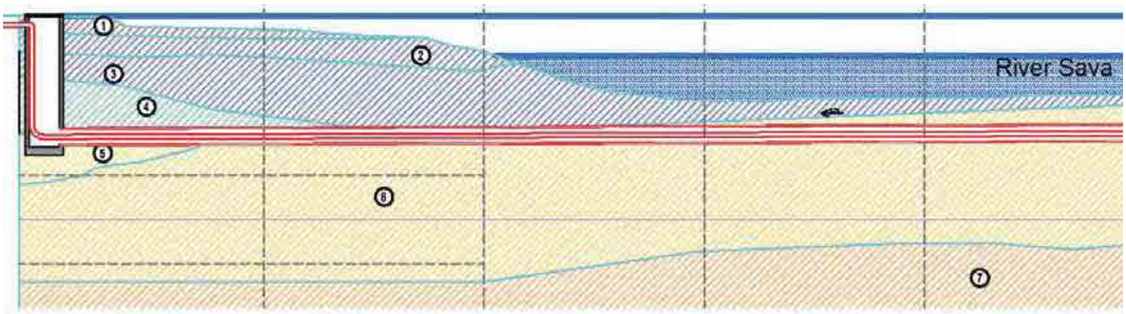


Figure 4.9 Candidate Site for Arrival Shaft of Interceptor No. 1

(C) Soil Condition

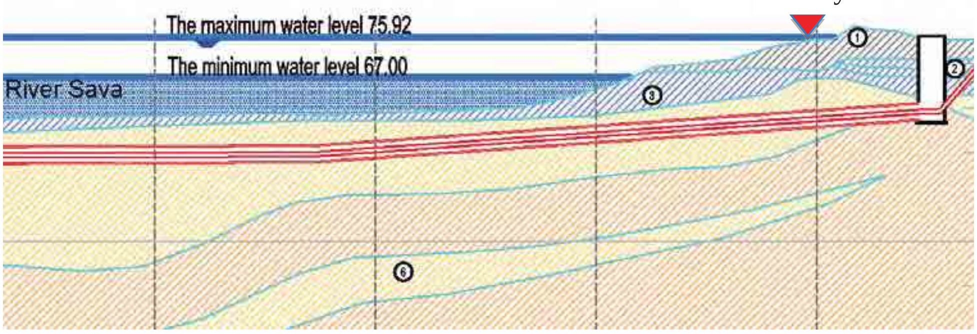
Soil condition below the Sava River is explained in “Preliminary Design for New Ušće Pumping Station (2007)”.

＜Left bank of the Sava River>



＜Right bank of the Sava River＞

Railway



① Organic sandy soil ②③ : Sandy silt ④⑤ : Sandy soil（④ Lacustrine sediments）⑥ : Limestone

Since most part of soil distribution in shield work is limestone, no major problem is assumed for workability. But, Shaft works have to take consideration for ground water.

(D) Consideration in Main Project/Detailed Design

Railway Crossing

Regarding the condition of construction, pipe gallery takes 15 m offset distance from railway vertically, and force man pipes laid in pipe gallery are protected by pipe gallery itself. Before the main project/detail design, these conditions of construction are required to confirm by Railway Company.

(2) Interceptor No.2

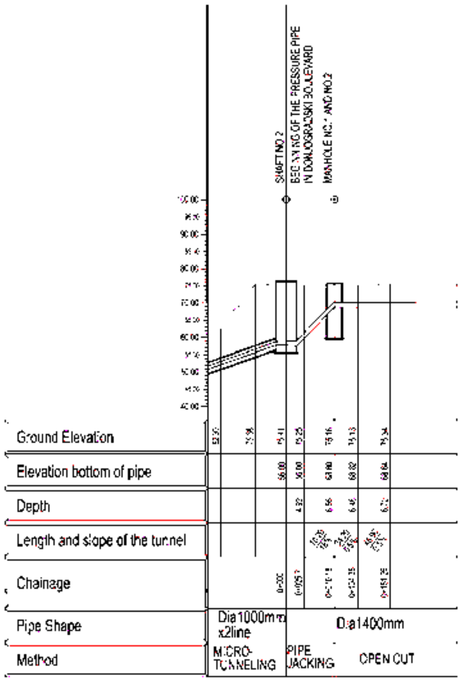
(A) General

The construction of this pipe line shall basically adopt open cut/trench method because of the protection of monuments underground. However, two spans explained in the Figure 4.10 are required to be constructed by jacking/injection method. Regarding the selection of pipe materials, HDPE pipe for pressure pipe line is suited to be used for open cut/trench work section. Although concrete pipe or iron pipe will be able to be selected in Jacking/injection work sections, ductile iron pipe is recommended for these sections because of the durability against sewage and the compatibility with HDPE pipe.

Figure 4.10 Planned section for adopting jacking/injection work

a) After River crossing (L=65 m)

Since upflow section of interceptor No.1 after river crossing is tend to settle sands, force main pipe are not recommended to have 90° degrees upflow in the shaft. Therefore construction of force main pipe at this section is planned to adopt jacking/injection method to have a lower slope so as to send the sands with ease into downstream.



b) Drainage pipe (L=45 m)

This drainage pipe was planned for the purpose of maintenance to discharge sewage from Interceptor No. 2 in current Preliminary design. Drainage pit was also planned near the Sava River to remove sewage with suction by vacuum car, because there is no suitable place to construct drainage pit along the road. Therefore, drainage pipe need to be protected by casing pipe, and casing pipe takes 15 m offset distance from railway vertically.

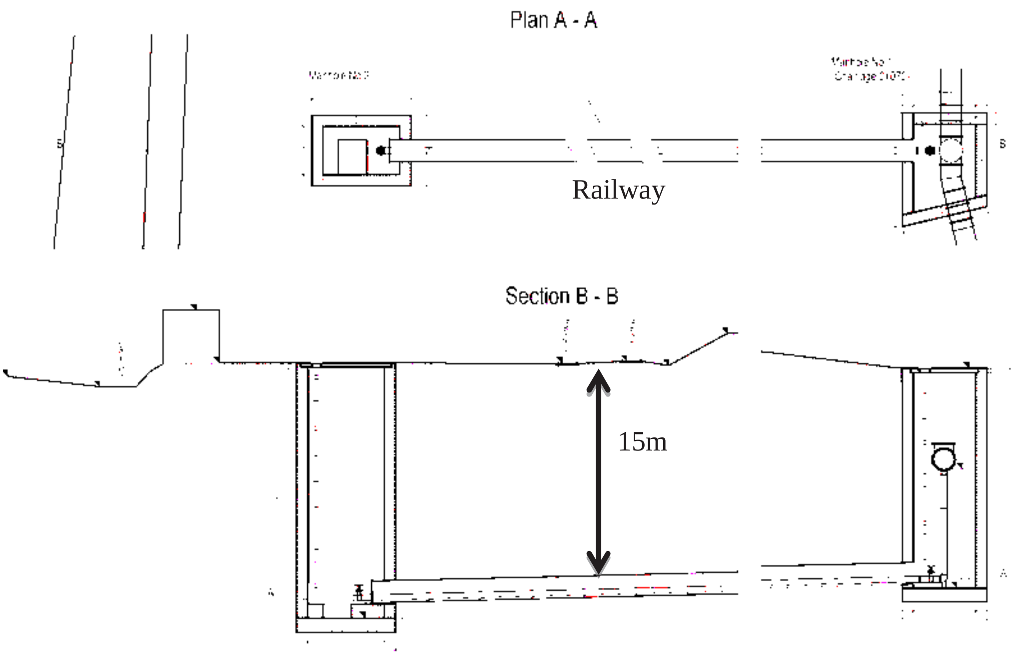


Table 4.18 Summary of Interceptor No.2

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No.2 (From km0+000 to 0+946)	946m	ϕ 1400mm	-0.5‰ (Pressured)	4m ～ 6m	+ 56.00 (Upstream) +76.68 (Downstream)

Note; masl stands for meter above sea level

Drawings of interceptor No. 2 is shown in the Drawings “SEW-02～04, and 15”.

(B) Required Shaft Size and Construction Space

Reference size of departure/arrival shaft is shown in Table 4.19.

Table 4.19 Reference Size of Departure/Arrival Shaft (Interceptor No.2)

Inner Diameter	Machine length (reference)	Required space for departure shaft (reference)	Shaft size (reference)
1400mm	2,500mm	300m^2	L5.0m x B8.0m

Required space for departure shaft is estimated considering the space for pipe stock, grout plant, office, operating house, and so on.

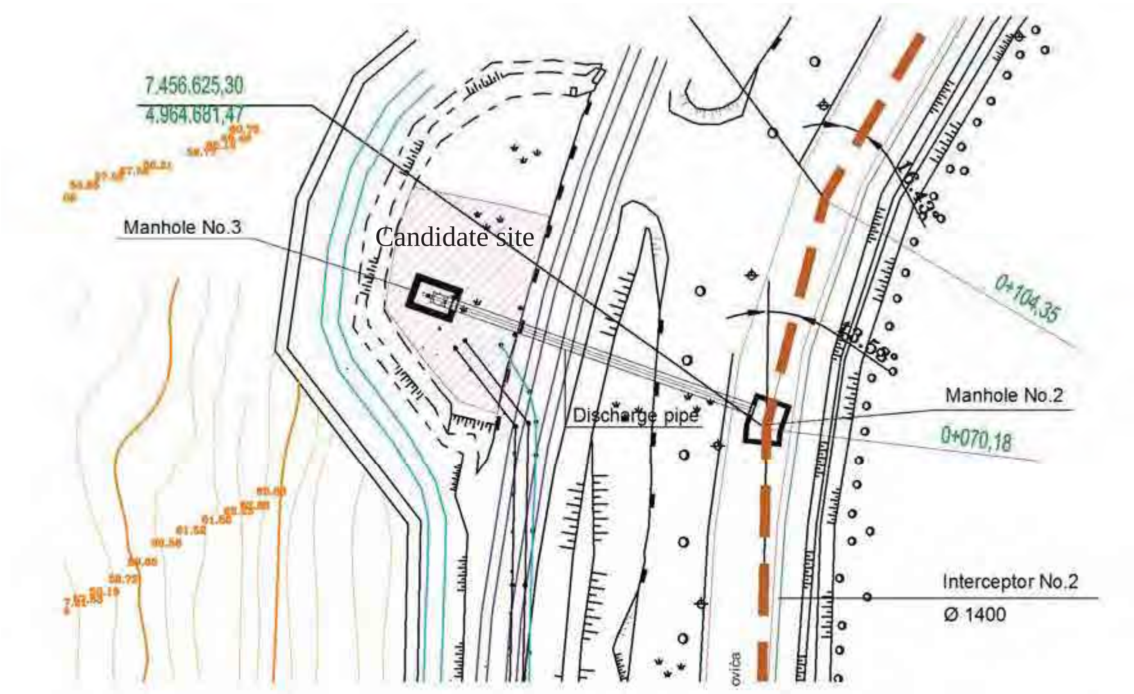


Figure 4.11 Candidate Site for Departure Shaft of Drainage pipe

(C) Soil Condition

Characteristic of soil at jacking/injection work section is assumed to be sandy soil or sandy silt based on the soil survey (see in the soil condition of interceptor No. 1). Therefore, there is no problem to adopt jacking/injection works at these section.

(D) Consideration at Main Project/Detailed Design

Railway Crossing

Regarding the condition of construction, casing pipe of drainage pipe takes 15 m offset distance from railway vertically. Before the main project/detail design, these conditions of construction are required to be confirmed by Railway Company.

(3) Interceptor No. 3

(A) General

The construction of this pipe line basically adopts open cut/trench method because of the protection of unknown utilities underground. If all information of utilities is available in future, Jacking/injection method can be adopted.

Regarding the selection of pipe materials, In-situ Oval shape pipe (200/170cm) was adopted because of the availability of precast pipe in large diameter size. However, precast pipe made from concrete, or polyethylene pipe is available nowadays. These precast pipe or plastic pipes can be laid easier than in-situ concrete pipes. And flow velocity is faster than oval pipe during low flow rate. Therefore, round shape HDPE pipe (Dia 2000 mm) is adopted in this study.

Since existing Dorcol PS (out of scope in this project) will transmit sewage to Interceptor No. 3, connecting manhole is planned at the meeting point (See in the Drawings “SEW-07 and 24”).

Table 4.20 Summary of Interceptor No. 3

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No.3 (From km0+946 to 2+772)	1,826 m	ϕ 2000 mm	1.0‰ (Gravity flow)	4 m ～ 8 m	+ 76.68 (Upstream) +75.00 (Downstream)

Note; masl stands for meter above sea level

Drawings of interceptor No. 3 is shown in the Drawings “SEW-04～09 and 15”.

(B) Consideration in Main Project/Detailed Design

Anti-sulfate Corrosion for Concrete Structures

The receiving manhole from New Ušće PS and Dorcol PS will require the anti-sulfate protection such as anti-sulfate concrete or coating, because the long distance of pressured pipe line from Pumping station is expected to create anaerobic condition inside pipe.

Examine the Application of Adopting Pipe Jacking/Injection Method

Since Interceptor No. 3 is located in the center of city, many utilities are laid below the road. But the exact locations of some of these utilities are not certain. Therefore, open cut/trench works need to be selected not to cut down the utilities by using jacking/injection works. However, in some special section of pipe line such as the road or tram (railway) crossing, it is better to use jacking/injection methods so as not to interrupt the road traffic, the application of these method need to be considered in the further stage.

(4) Interceptor No. 4

(A) General

The construction of this pipe line adopts open cut/trench method because of the shallow covering.

Regarding the selection of pipe materials, In-situ house shoe shape pipe (380/380cm) made from reinforced concrete is adopted because of the unavailability of such large diameter precast pipe. The beginning point of Interceptor No .4 will meet 3 large diameter pipes, Interceptor No. 3, Interceptor No. 10, and existing Terazijski Collector. Therefore, at this point very big connecting structure was planned in the current detailed design of Interceptor No. 10 “GLAVNI PROJEKAT KOLEKTORA TUNELA HITNA POMOĆ – VENIZELOSOVA (ĐURE ĐAKOVIĆA)” done by institute Jaroslav Cerni. Layout plan of connecting structure is shown in Figure 4.12.

Before the construction of this connecting structure, existing combined sewer needs to be removed. Then existing combined sewer will be connected to storm water collector via overflow weir. And then sanitary sewage divided from combined sewer by overflow weir can be connected to the connecting structure. Storm water collector will be through under Interceptor No. 3 by inverted siphon at the crossing point.

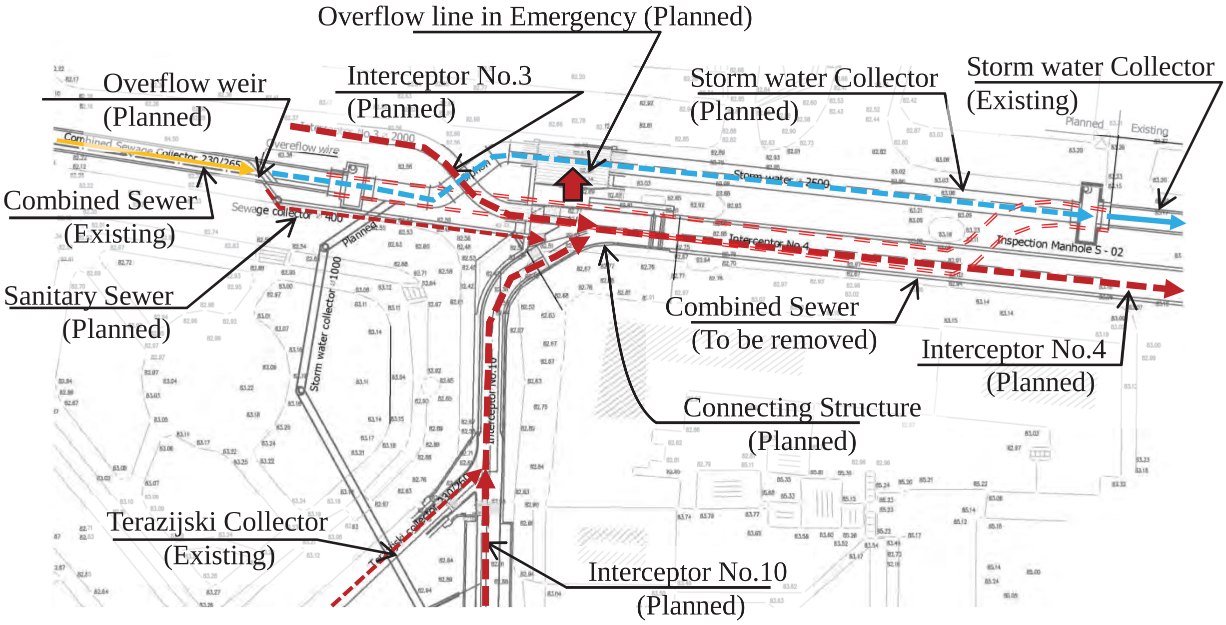


Figure 4.12 Layout Plan of the Connecting Structure at the Begging of Interceptor No. 4

Bulbulderski Collector will be connected to Interceptor No. 4 at km 2+954. Manhole and overflow weir is planned at this meeting point based on the current plan. (See in the Drawings "SEW-09, 42 and 43")

Since planned Pristaniste PS (out of scope in this project) will convey sewage to Interceptor No. 4 at km 3+670, connecting structure is planned at the meeting point (See in the Drawings "SEW-11 and 45").

Table 4.21 Summary of Interceptor No. 4

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No.4 (From km2+772 to 3+715)	943 m	Horseshoe 380/380 cm	0.5‰ (Gravity flow)	9 m ～ 12 m	+ 73.70 (Upstream) +73.23 (Downstream)

Note; masl stands for meter above sea level

Drawings of interceptor No. 4 is shown in the Drawings "SEW-09～11 and 15 ".

(B) Consideration in Main Project/Detailed Design

Relocation of Utilities

Before the construction of Interceptor No. 4, many buried utilities will need to be relocated to be constructed by open cut/trench method. Therefore, a detailed relocation plan has to be considered.

(5) Interceptor No. 6

(A) General

The construction of this pipe line adopts Shield/TBM technology because of the very large diameter (Dia 4000 mm) and deep covering.

Interceptor No. 6 was located between Interceptor No. 5 and 7 constructed in 1980's. Since shafts of these interceptors are not retained, new shaft will be constructed in the appropriate position.

Table 4.22 Summary of Interceptor No. 6

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No.6 (From km4+238 to 5+090)	852 m	ϕ 4000 mm	0.5‰ (Gravity flow)	8 m ～ 32 m	+ 72.96 (Upstream) +72.54 (Downstream)

Note; masl stands for meter above sea level

Drawings of interceptor No. 6 is shown in the Drawings "SEW-12～14 and 16"

(B) Required Shaft Size and Construction Space

Reference size of departure/arrival shaft is shown in the Table 4.23.

Table 4.23 Reference Size of Departure/Arrival Shaft (Interceptor No.6)

Inner Diameter	Outer diameter (reference)	Machine length (reference)	Required space for departure shaft (reference)	Shaft size (reference)
4,000 mm	4,800 mm	8,600 mm	900 m^2	L12.0 m x B7.0 m

Required space for departure shaft is estimated considering the space for segment stock, rail way, grout plant, office, operating house, and so on.

Candidate site for the construction of departure/arriving shaft is shown in Figure 4.13 and Figure 4.14.

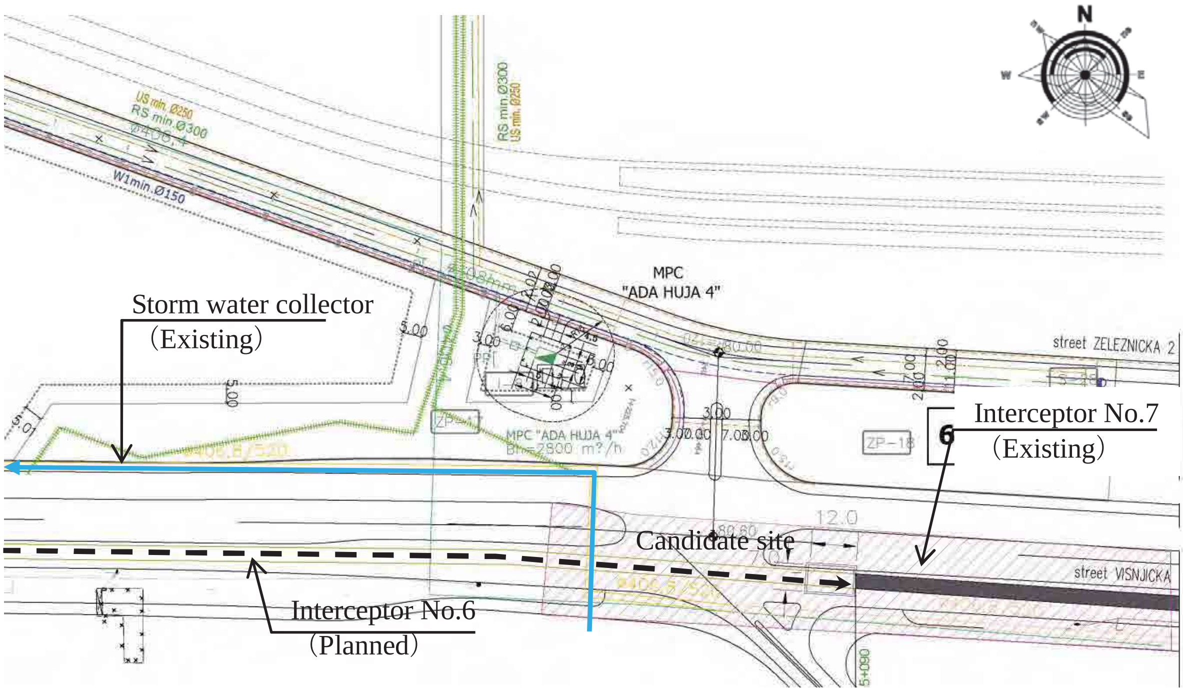


Figure 4.13　Candidate Site for Departure Shaft of Interceptor No. 6

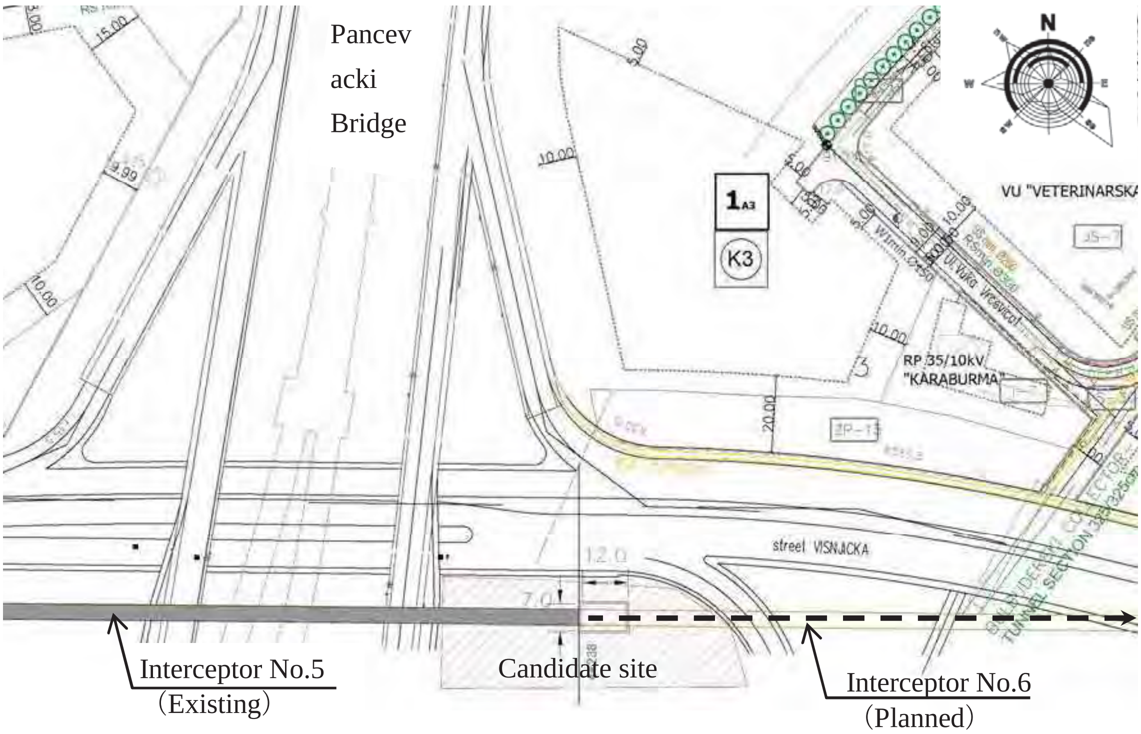


Figure 4.14　Candidate Site for Arrival Shaft of Interceptor No. 6

(C) Soil Condition

Soil survey was conducted in the detailed design in 1982. Characteristic of soil at shield/TBM work section is assumed to be limestone, sandstone or marls. Lithological profile is shown in Appendix.

(D) Consideration in Main Project/Detailed Design

Relocation of Storm Water Collector

Storm water collector has to be relocated before the construction of Interceptor No. 6. Since the level of both pipes is almost same, storm water collector has to be through under Interceptor by inverted siphon or diversion into other pipe line. However, the accurate level of storm water collector is not known. Therefore, the detail survey of the invert level and catchment area of storm water collector need to be conducted in detail design.

(6) Interceptor No. 10

(A) General

Detailed design of Interceptor No. 10 has been done by institute Jaroslav Cerni. According to the report, Dia 2800 mm pipe constructed by Shield/TBM method is adopted from the beginning of Interceptor No. 10 to the short of the meeting point with Terazijski Collector, and Box 3000 x 3000 mm constructed by trench method is adopted from this point to the meeting point of Interceptor No. 4.

In the beginning of Interceptor No. 10, old Mokrolug collector and collector from Mostar PS meet. Therefore, the connecting structure is planned. Since Old Mokrolug Collector is combined sewer pipe, overflow structure is needed to divide combined sewage into sanitary sewage and storm water in wet period. Overflow rate is planned 3 times of hourly peak flow in dry. Layout plan of the connecting structure is shown in Figure 4.15.

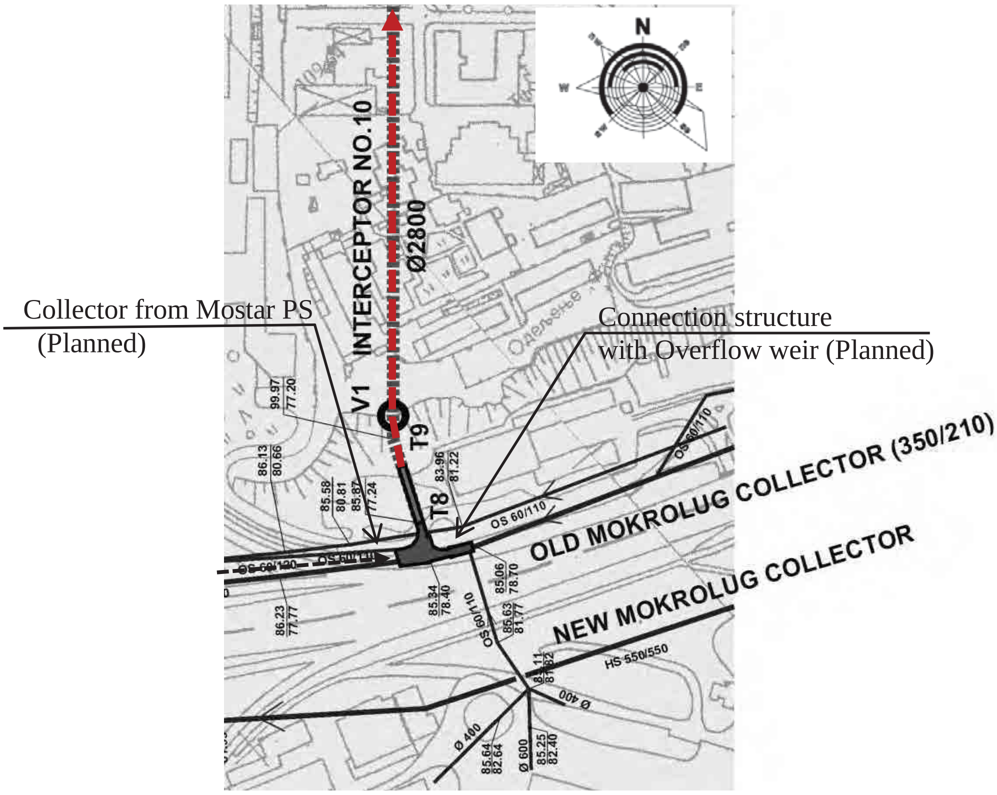


Figure 4.15 Layout Plan of the Connecting Structure at the Beginning of Interceptor No. 10

Table 4.24 Summary of Interceptor No. 10

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No. 10	3000 m	ϕ 2800 mm	0.5‰ (Gravity flow)	8 m ～ 32 m	+ 77.24 (Upstream) +76.95 (Downstream)

Note; masl stands for meter above sea level

Drawings of interceptor No. 10 is shown in the Drawings "SEW-47～49".

(B) Required Shaft Size and Construction Space

Reference size of departure/arrival shaft is shown in the Table 4.25.

Table 4.25 Reference Size of Departure/Arrival Shaft (Interceptor No. 10)

Inner Diameter	Outer diameter (reference)	Machine length (reference)	Required space for departure shaft (reference)	Shaft size (reference)
2,800mm	3,600mm	7,600mm	800m^2	L11.0m x B6.0m

Required space for departure shaft is estimated considering the space for segment stock, rail way, grout plant, office, operating house, and so on.

Candidate site for the construction of departure/arriving shaft is shown in Figure 4.16 and Figure 4.17.

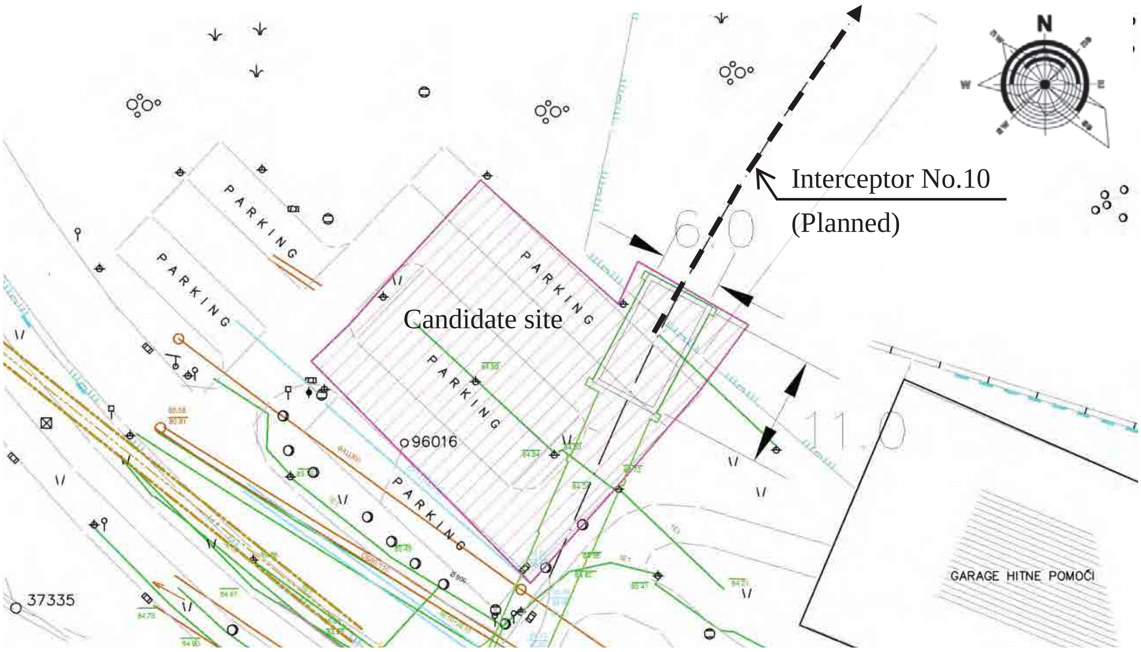


Figure 4.16 Candidate Site for Departure Shaft of Interceptor No. 10

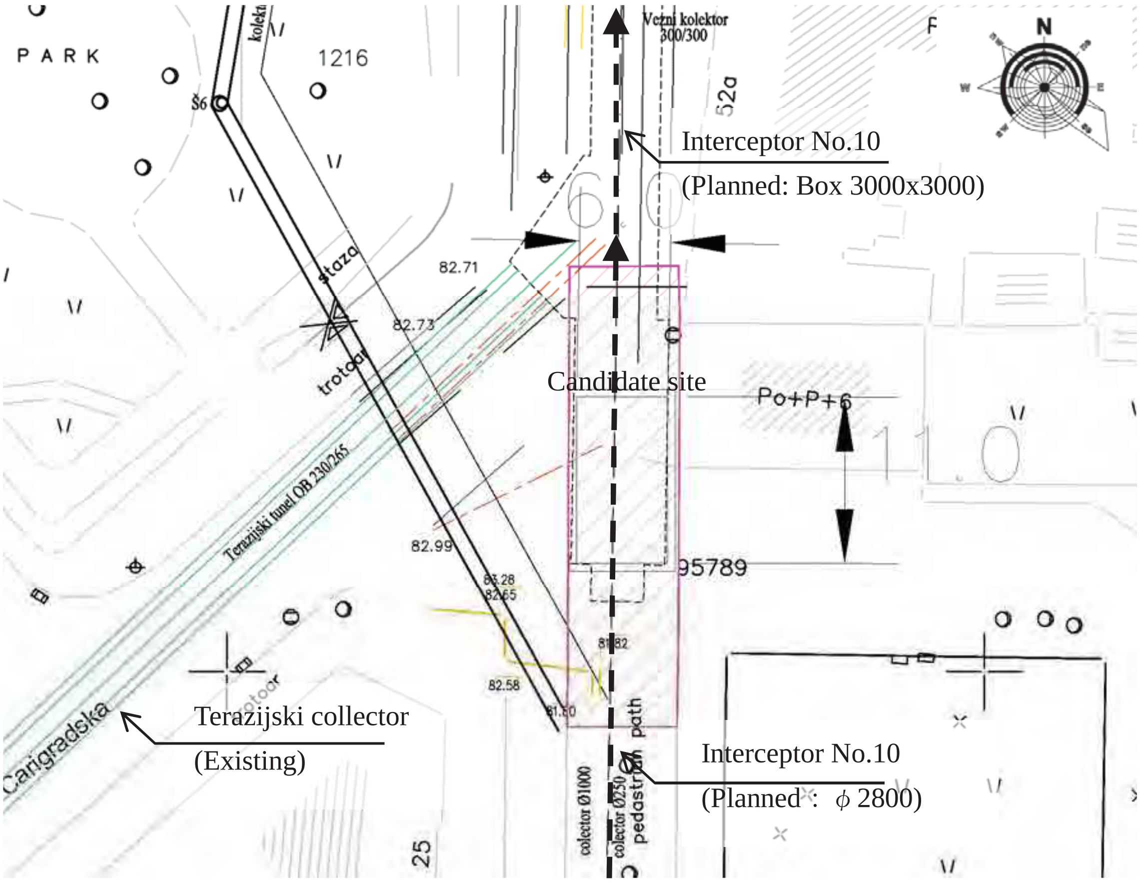


Figure 4.17　Candidate Site for Arrival Shaft of Interceptor No. 10

(C)　Soil Condition

Survey has been done in the detail design of Interceptor No. 10. According to the report, most part of excavation soil layer by the Shield/TBM works is marls or limestone. Lithological profile is shown in Appendix.

(7)　Collector from Mostar PS to Interceptor No. 10

(A)　General

The function of this pipe line (Dia.1600 mm) is to deliver sewage from the receiving manhole of Mostar PS to Interceptor No. 10. Receiving manhole is planned to be installed on the pressured pipe line (Dia 700 x 2 line). Layout plan of collector is shown in Figure 4.18. The construction of this pipe line adopts open cut/trench works at the shallow covering section (L=155 m) and for jacking/semi-shield works at the deep covering section (L=166 m).

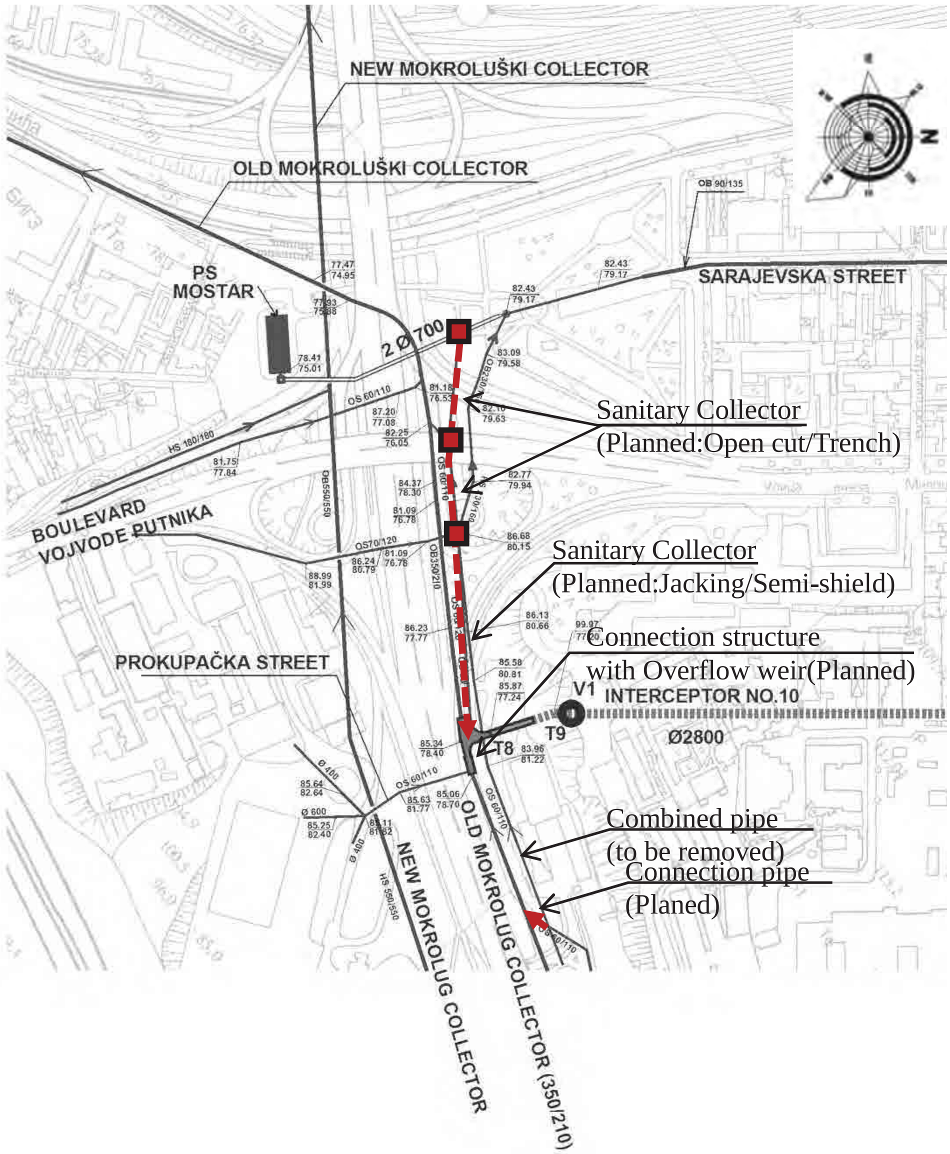


Figure 4.18 Layout Plan of the Collector from Mostar PS to Interceptor No. 10

Table 4.26 Summary of the Collector from Mostar PS to Interceptor No. 10

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Collector	321 m	ϕ 1600 mm	1.5‰ (Gravity flow)	4 m ～ 9 m	+ 78.50 (Upstream) +78.01 (Downstream)

Note; masl stands for meter above sea level

Drawings of collector are shown in the Drawings “SEW-50～51”.

(B) Required Shaft Size and Construction Space

Reference size of departure/arrival shaft is shown in Table 4.27

Table 4.27 Reference size of Departure/Arrival Shaft (Collector)

Inner Diameter	Machine length (reference)	Required space for departure shaft (reference)	Shaft size (reference)
1600 mm	2,500 mm	300 m^2	L5.0m x B8.0m

Required space for departure shaft is estimated considering the space for pipe stock, grout plant, office, operating house, and so on. Candidate site for the construction of departure/arrival shaft is shown in Figure 4.19 and Figure 4.20.

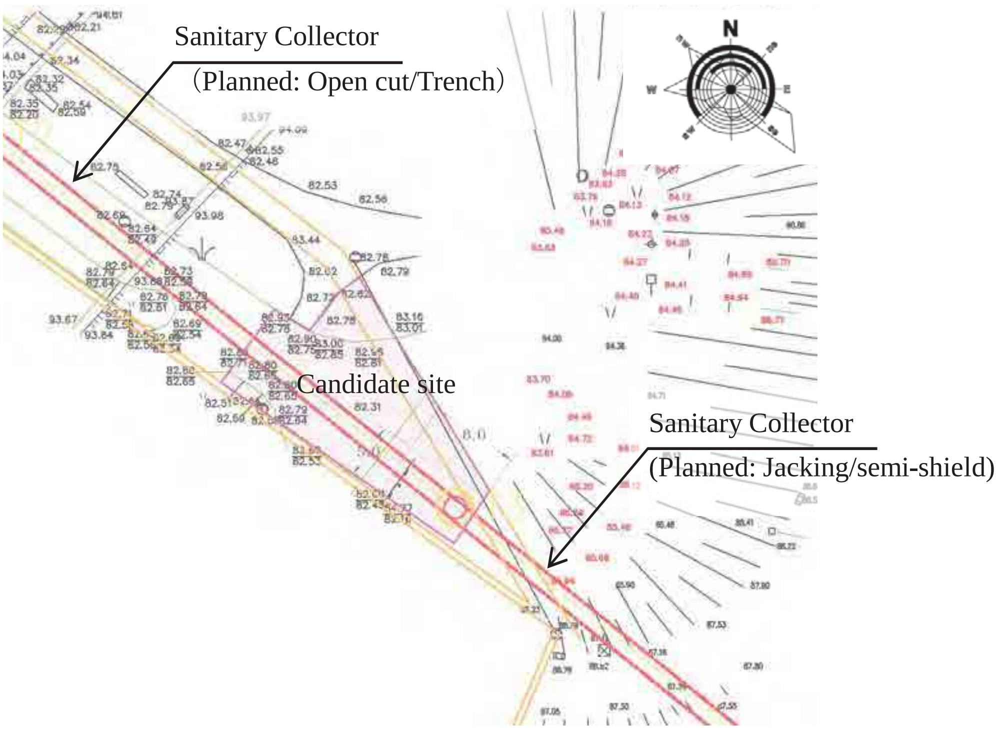


Figure 4.19 Candidate Site for Departure Shaft of Collector

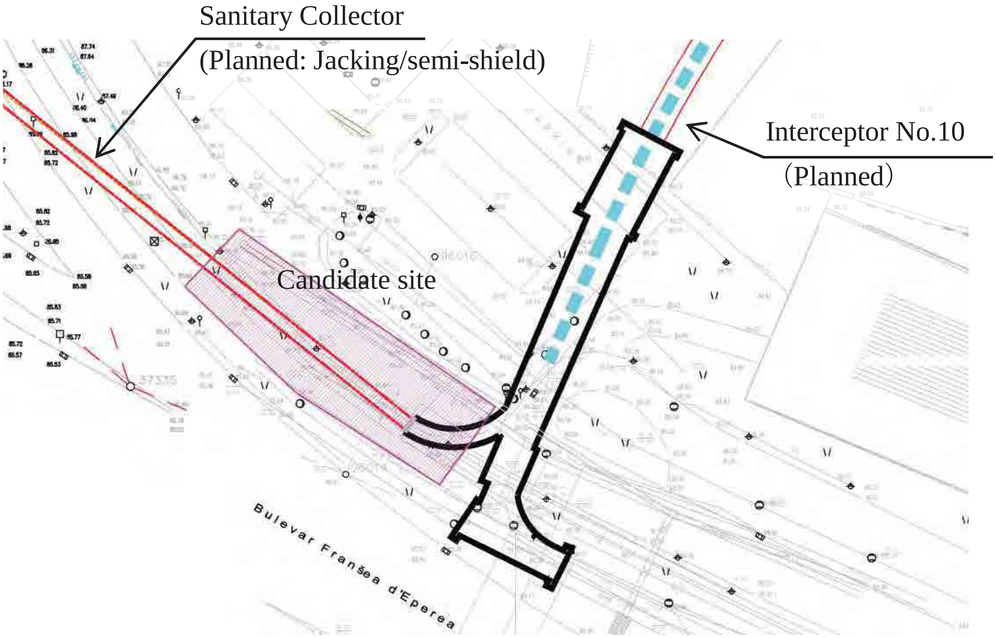


Figure 4.20 Candidate Site for Arrival Shaft of Collector

(C) Soil Condition

The soil property of surface layer of this area is back filling sands observed during the construction of highway. Since large diameter gravels are assumed not to be found, Jacking/semi-shield method will be able to be adopted.

(D) Consideration in Main Project/Detailed Design

Confirmation of Soil Condition

The soil survey of jacking/semi-shield section has not been conducted so far. Jacking/semi-shield method seems to be adopted, however it is better to carry out the soil survey in order confirm the selection of jacking/semi-shield method.

(8) Interceptor No. 5, No. 7, No. 8 and No. 9 (Constructed)

(A) General

Interceptor No. 5 and No. 7 were constructed in 1990. Also, Interceptor No. 8 and No. 9 were constructed during 2009 to 2012.
Detailed information of Interceptor No. 5 and No. 7 such as as-build drawing does not exist. As for the detailed design, the pipe specification is explained as shown in Table 4.28. Before Interceptor No. 8 was connected to Interceptor No. 7, the exact location and level were

determined by underwater survey because Interceptor No. 7 was filled in groundwater. Therefore, this way also can be adopted in case of the construction of Interceptor No. 6. Detailed information of Interceptor No. 8 and No. 9 is shown in Table 4.28.
These pipe lines are selected of suitable diameter for the flow volumes. The actual flow velocity is about 1.8 to 1.9 m/s. See detail in Table 4.3.

Table 4.28 Summary of constructed Interceptor No. 5, No. 7, No. 8 and No. 9

	Length	Pipe size	Average slope	Pipe depth from G.L.	Bottom of Pipe (masl)
Interceptor No.5 (From km3+715 to 4+238)	523 m	Horseshoe 380/380 cm	0.5‰ (Gravity flow)	12m～28m	+ 73.23 (Upstream) +72.96 (Downstream)
Interceptor No.7 (From km5+090 to 5+867)	777 m	Horseshoe 380/380 cm	0.5‰ (Gravity flow)	7m ～ 8m	+ 72.54 (Upstream) +72.10 (Downstream)
Interceptor No.8 (From km5+867 to 6+800)	933 m	ϕ 4000 mm	0.5‰ (Gravity flow)	8m ～12m	+ 72.10 (Upstream) +71.63 (Downstream)
Interceptor No.9 (From km6+800 To12+638)	5,838 m	ϕ 4000 mm	0.5‰ (Gravity flow)	4m ～200m	+ 71.63 (Upstream) +68.72 (Downstream)

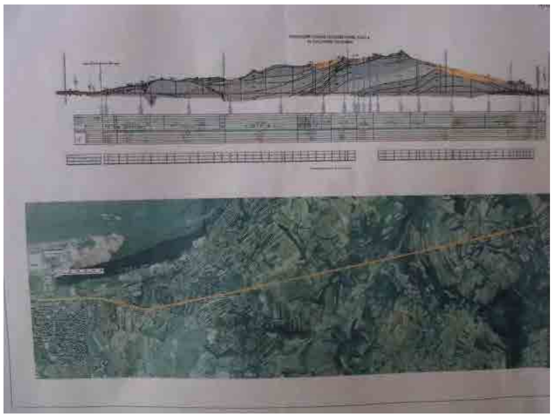
Note; masl stands for meter above sea level

Drawings of interceptor No. 5, No. 7, No. 8 and No. 9 are shown in the Drawings "SEW-11～14 and 16～18".

The tender of Interceptor No. 9 was conducted by the international bid, and then the local construction company named "Hidrotehnika - Hidroenergetika" received an order from LDA. LDA bought TBM machine made by German company named "WIRTH". The construction company has operated pipe works by using this TMB machine. Supervision of this works is engaged by LDA.

The quality of their works is quite good because the construction site is well organized and their products are also high quality. Therefore, they have enough experiences about pipe works by using micro-tunneling technologies so as to complete the remaining part of Interceptors from a technical viewpoint.

In addition, TBM machine has already removed from the arrival shaft of Interceptor No. 8 and it was moved to the site of Veliko Selo WWTP. This machine seems to be reused to construct Interceptor No. 6. This is the cheapest way and rational approach to construct it. However, JICA study doesn't assume to do so because of the uncertainly about the condition of TBM machine at the time of this construction period in future.

TBM machine	Layout and Section
	
Construction site	Constructed pipe by TBM
	

4.4.2 Specification and Quantity of Pipe Works as the Optimum Project in JICA Study

Specification and quantity of the optimum project in this study are shown in the Table 4.29. Since Shafts, inspection manholes, and connecting structures are regarded as parts of pipe lines, these are included among the quantities.

Table 4.29 Specification and Quantity of the Pipe Works as Optimum Project

Interceptor	Specification	Length (m)	Method	Remarks
No. 1	ϕ 3500 (Reinforced concrete)	425	Shield/TBM	
	ϕ 1000 mm x 2 Line (HDPE)	480 x 2 =960	Installation inside pipe gallery	
	ϕ 1000 mm x 2 Line (DIP)	90 x 2 =180	Open cut/trench	From Ušće PS to Interceptor No.1
No. 2	ϕ 1400 mm (HDPE)	900	Open cut/trench	
	ϕ 1400 mm (DIP)	45+65 =110	Jacking/injection	Including drainage pipe
No. 3	ϕ 2000 mm (HDPE)	1826	Open cut/trench	
No. 4	Horseshoe 380 cm (Reinforced concrete)	943	Open cut/trench	
No. 6	ϕ 4000 mm (Reinforced concrete)	852	Shield/TBM	
No. 10	ϕ 2800 mm (Reinforced concrete)	3000	Shield/TBM	
	Box culvert 300x300 cm (Reinforced concrete)	80	Open cut/trench	
Collector from Mostar PS to Interceptor No. 10	ϕ 1600 mm (HDPE)	155	Open cut/trench	
	ϕ 1600 mm (Reinforced concrete)	166	Jacking/semi-shield	

5. Facilities Planning of Pumping Station

5.1 Review of Existing Plan / Design / Specifications

Existing pumping station located in Central system is explained in “3.3 Present Sewerage System in Belgrade”. This chapter is studied for two pumping stations (New Ušće PS and Moster PS) which is the scope of this study. Location of both pumping station and main facilities of pumping station is shown in Figure 5.1 and Table 5.1.

New Ušće PS in planned for the replacement of existing Ušće PS because existing Ušće PS has insufficient capacity against the increase of inflow recently and civil structure is also getting older.

Mostar PS has sufficient capacity for inflow, but it has not been operated so far because Interceptor where sewage will be delivered from Mostar PS has not been constructed yet.

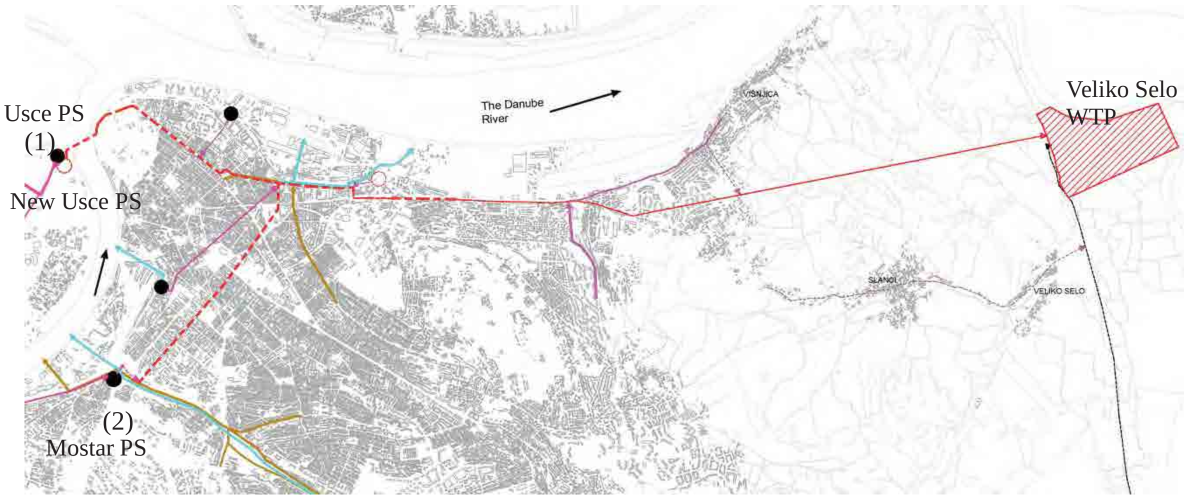


Figure 5.1 Location of Pumping Station

Table 5.1 Main Facilities of Pumping Station

Name		Construction year	Main facilities			
			Pump	Sand removal	Screen	Generator
(1)	Ušće PS	1969	350 l/s x 3nos + 800l/s x 1nos (4duty)	No	No	Yes
	New Ušće PS	Planned	800 l/s x 5nos (4duty + 1stand-by)	Planned	Planned	Planned
(2)	Mostar PS	1980’s	700 l/s x 6nos (5duty + 1stand-by)	No	No	Yes

5.2 Facility Planning

5.2.1 Policy of the Consideration of Facility Planning

(1) Ušće PS

About 40 years have passed after the construction of Ušće PS. Their service life as civil structure is assumed to be over by visual inspection. In addition, one pump was replaced to increase the pump capacity, however the capacity is still insufficient. And no more space is remaining at this pumping station to replace other pumps. So, it is reasonable to construct new pumping station instead of the old one.

Therefore, in case of Ušće PS, JICA study conducts the verification of validity of Preliminary design, and then proposes the improvement plan if required. Finally, the adopted plan will be selected as the optimum plan.

(2) Mostar PS

Mostar PS has been constructed since 1980's, but civil structure has not become depleted so much. Mechanical equipments are also aged. Although, operator runs these pumps for maintenance purpose, brief visual survey is required to confirm these pumps will be able to work properly during operation. Electrical equipments are also required to confirm if these can be reutilized. In addition, a hearing survey of operators is needed to improve the facility plan.

Therefore, in case of Moster PS, JICA study conducts a brief visual survey and a hearing survey, and then improvement facility planning is proposed. Finally, the adopted plan is selected as the optimum plan.

5.2.2 Facility Planning for New Ušće Pumping Station

(1) Hydraulic Load in New Ušće PS

According to the Pre-FS with M/P, Hydraulic loading was planned as shown in Table 5.2. Design value for pumping station uses “Hourly maximum flow in Wet”. It is calculated around 1.75 times as much as the daily maximum flow in wet in Pre-FS. Daily maximum flow includes not only infiltrated water from groundwater, but also infiltration from river water.

Table 5.2 Hydraulic Load in New Ušće PS

Item	2031
Daily ave. (m^3/d)	110,000
Daily max in Wet (m^3/d)	165,000
Hourly max in Wet (m^3/d)	289,000 3,350 (l/s)

(2) Inflow Chamber and Channel

Two collectors convey sewage into existing Ušće PS. Inlet chamber for New Ušće PS is planned to be constructed on the existing sewer to receive sewage from both collectors. Inlet channel of box culvert 2000 x 2000 mm is planned. Existing collectors will be used as emergency pipe line.

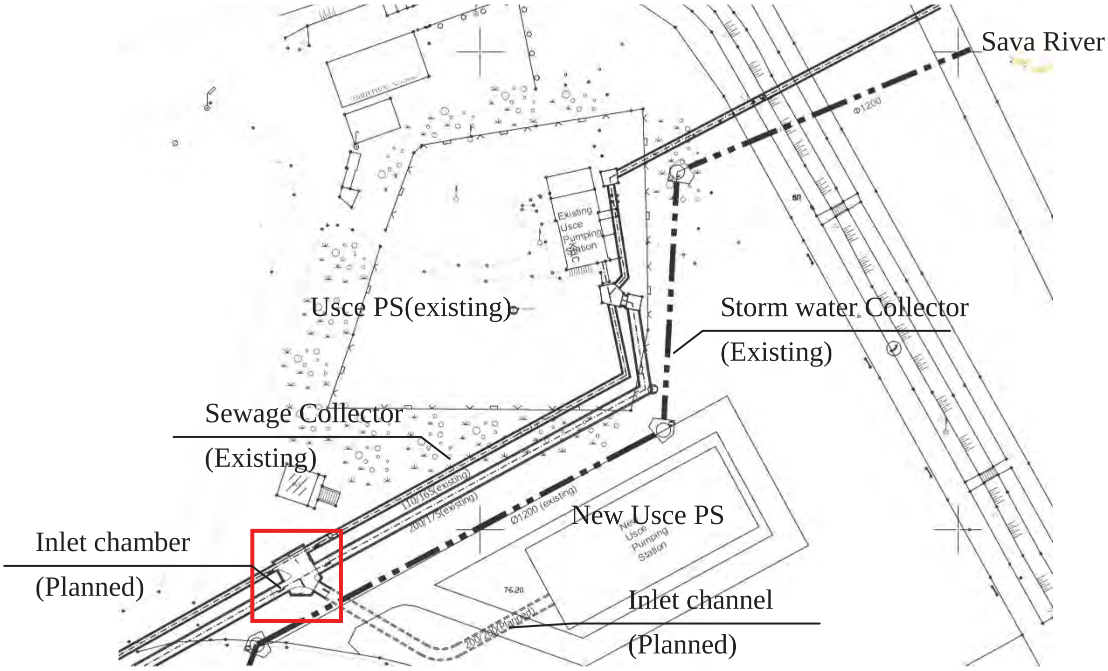


Figure 5.2 Layout Plan for New Ušće PS

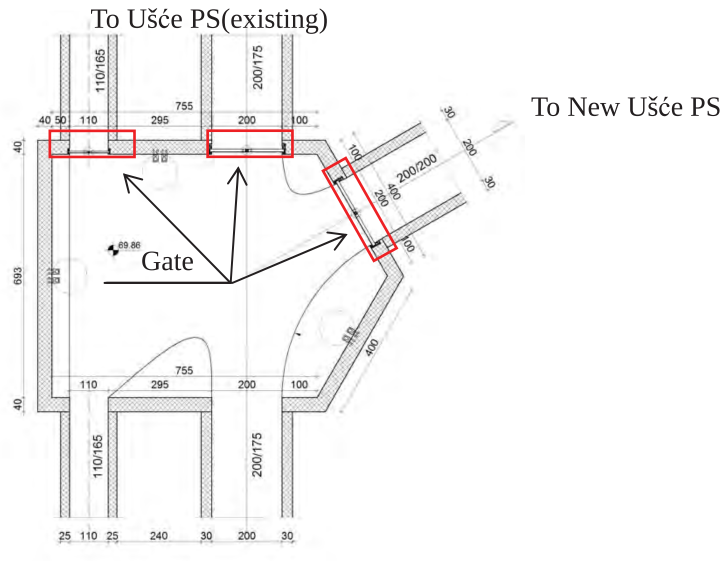


Figure 5.3 Layout Plan for Inlet Chamber

(3) Force Main Pipe from New Ušće PS

Force main pipe of Dia 1000 mm x 2 lines are planned. See detail in chapter 5.

(4) Evaluation of Main Function of New Ušće PS

According to the Pre-FS with MP and Preliminary design report of New Ušće PS, New Ušće PS is planned as Figure 5.4. Main function of pumping station has a sand trap with grab bucket and mechanical screen. Pump capacity is planned as 800 l/s x 5 number in Pre-FS.

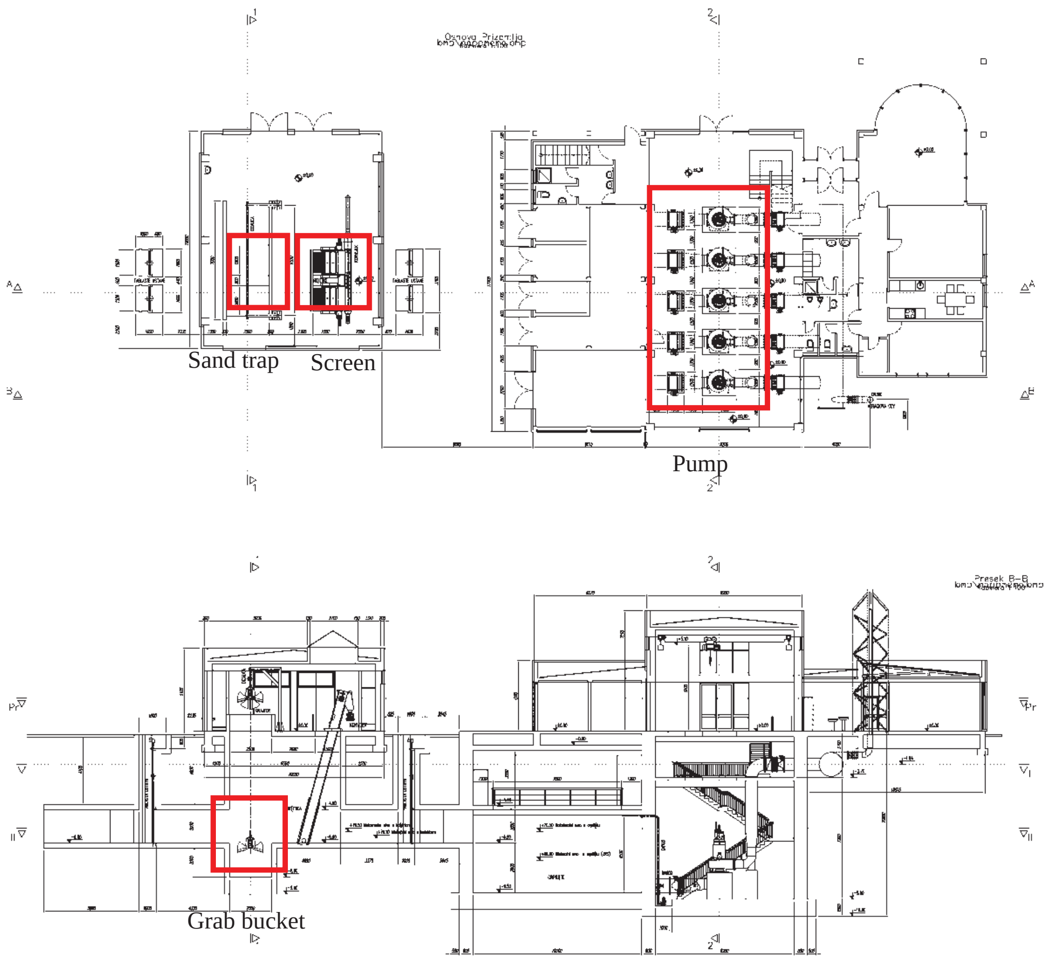


Figure 5.4 Existing Plan of New Ušće PS

The expected problems in this pumping station are mentioned in the Table 5.3.

Table 5.3 Expected Problem and Countermeasure

No	Problem	Verification	Countermeasure
a	Sand is not removed properly because of the small sand trap	Ability of sand removal	-Improvement in sand removal
b	Sulfate gas (Bad smell) is emitted.	-	-Relevant regulation will be adopted

Verification of Ability of Sand Removal at Pumping Station

According to the Preliminary design, the selected method of sand removal is to install sand trap with grab bucket finally to remove the sands. Result of verification is shown in Table 5.4. Flow velocity in hourly max is about 1.3 m/s at channel. This velocity is not suitable for sand (Dia.1.0 mm) sedimentation and for mechanical screens also.

Table 5.4 Verification of Ability of Sand Removal

item	Channel※	Design flow (velocity)	Maximum speed to be deposited sands into sand trap (Dia.1mm)	Verification
Preliminary Design	Width 1.5 m x Length 6 m x Depth 0.7 m x 2 channel	2.8 m^3/s (1.3 m/s)	Chanel Depth + Sand Trap = 0.7+0.5=approx. 1.2 m 1.2 m÷0.1 m/s(deposition)=12s 6m÷12s=<u>0.5 m/s (required)</u>	1.3 m/s ＞0.50 m/s
Recommendation	Width 4.0 m x Length 9 m x Depth 0.7 m x 2 channel	2.8 m^3/s (0.5 m/s)	1.2 m÷0.1 m/s=12 s 9 m÷12 s=<u>0.75 m/s (required)</u>	0.5 m/s ＜0.75 m/s

Length of channel indicate the effective length for sand removal
Deposition speed；100 mm/s (Dia 1 mm), 63 mm/s (Dia 0.6 mm)
Critical tractive force (Shields curve)；0.5 m/s (Dia 1 mm)

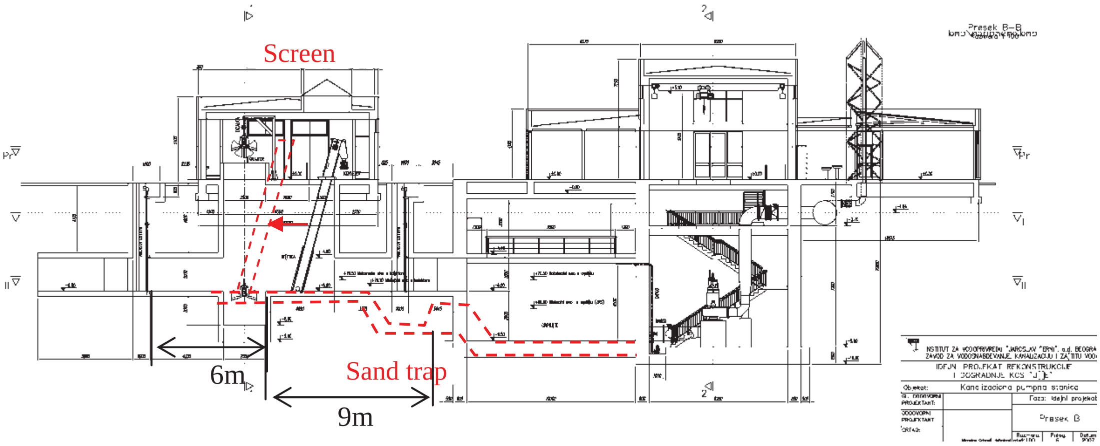


Figure 5.5 Alternative of facility design for New Ušće PS

JICA study proposed that Ušće PS needs sand trap or grit chamber after screen and sand pumps should be installed in the chamber instead of the grab bucket so as not to pump up sands into the force main. As for sands less than Dia.1.0 mm, flow velocity in force main pipe will be considered so as not to deposit sands. Since changing from current design is to wider the channel, move screens and sand traps back and forth, required land of this pumping station is same as the current design. Therefore, no effect will be expected for location permission.

Drawings of New Ušće PS are shown in the “Volume IV Drawings” of Final Report.

(5) Capacity Calculation of New Ušće PS

Capacity calculation of New Ušće PS is conducted based on the above considerations. See detail in Appendix.

(6) Planning for Operation and Maintenance

(A) Removal of Sand and Solid Wastes

Settled sands in sand trap will be removed by sand pumps. And, wastes and debris will be removed by mechanical screens.

(B) Maintenance inside Pipe Gallery

Drainage pumps, electric lights, and ventilation pipes will be installed in pipe gallery of force main (Sava River crossing) for the purpose of the maintenance. Ventilation inside pipe gallery is needed before maintenance person enters the pipe gallery. Ventilation and electrical equipment can be installed in the shaft or pipe gallery, but there will be high humidity condition. Therefore the selection of equipment should be made taking care of the material.

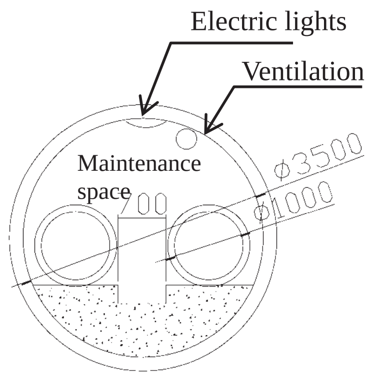


Figure 5.6 Section of Pipe gallery

Air release valves will be installed before downflow sections. And Sluice valves before pipe connection part, drainage pipes and drainage pits will be installed to discharge sewage inside force main pipes.

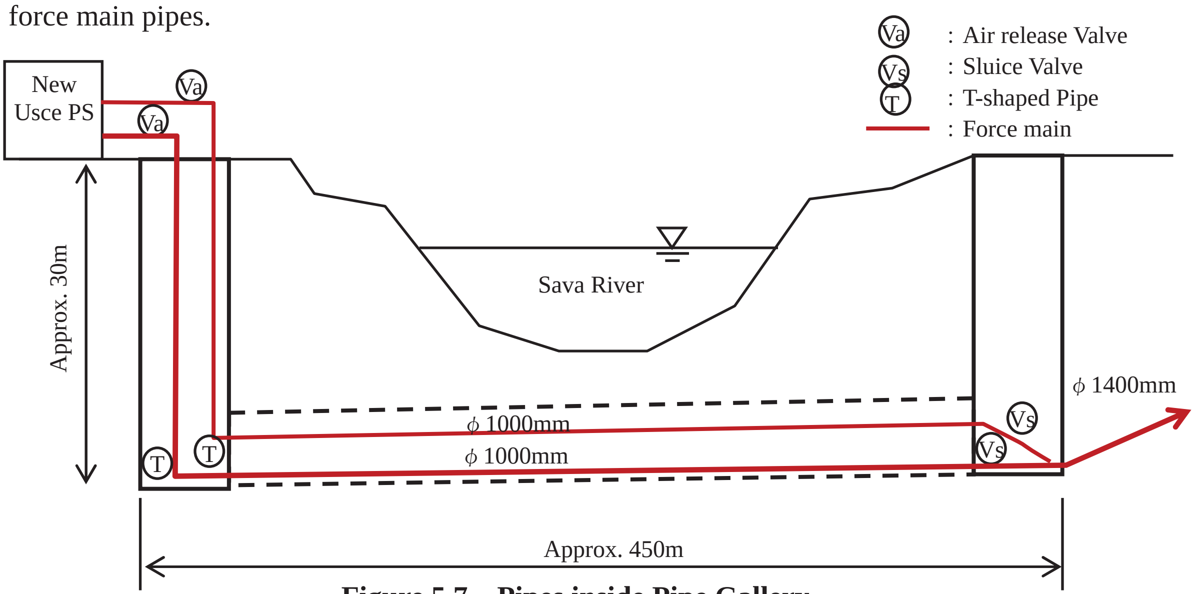


Figure 5.7 Pipes inside Pipe Gallery

＜Reference: Time for drainage＞

When drainage pumps of 0.3 m^3/min are selected, time required for draining one pipeline (Dia. 1000 mm) will be about a day.

Amount of sewage inside pipe: 0.79 m^2 x (30+30+450 m) = 403 m^3

Drainage time：403 m^3/ (0.30 m^3/min x 60 x 24) = approx. 1day

Electric power will be supplied from New Ušće PS.

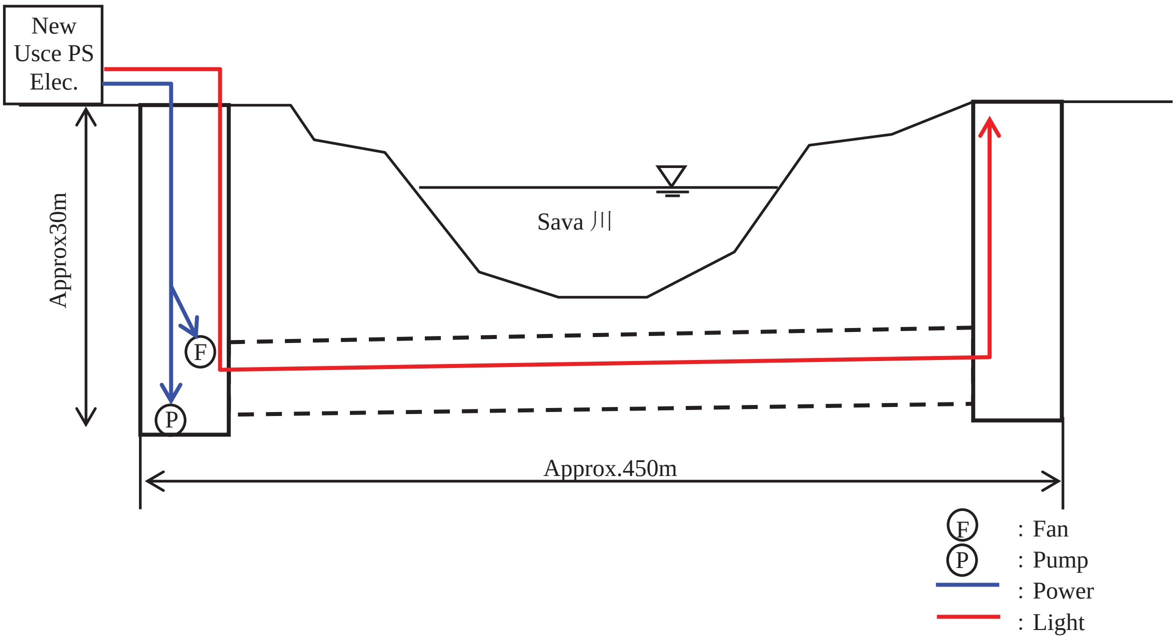


Figure 5.8 Equipments for Meintenance inside Pipe Gallery

(7) Planning for Environmental Consideration

This pumping station is located near the confluence of Danube River and Sava River. Since there are some commercial facilities and parks also located in this area, New Ušće PS has to take countermeasures to keep surrounding environment in appropriate condition. These countermeasures include; “Odor control”, “Insulation”, “Smoke exhaust”, “Green plan”, “Hauling road”, “Drainage” and “Structure”.

Odor control: Compliance with regulations and standards related to odor. EU regulation of “EN 12255 Part 9: Wastewater treatment plants -Odor control and ventilation” mentions that inflow chamber at treatment plant emit strong offensive odor and consideration is needed for the deodorization. Therefore, deodorization equipment is required to treat bad smells in pumping station. When grit and screenings are moved to the disposal site, containers or cars or ships are required to take care of odor release.

Insulations: If the operation of equipment is expected to generate noise beyond permitted level, such equipment need to be inside concrete wall structures in order to minimize the noise.

Smoke exhaust: The release of exhaust gases from generator containing high level of soot need to be controlled and handled appropriately.

Green plan: Area around the pump station need to be planted to suit the surrounding environment.

Hauling road: Asphalt road is adopted. The width of road should be more than 4.0 m to have enough working space for maintenance, etc. Hence, Official Gazette No. 8/95 “Regulation on technical standards for access roads, plateau and turntable for fire trucks nearby objects with higher risk of fires” mentions that the minimum width of road should be 3.5 m for single lane.

Drainage for storm water: Storm water should be collected by storm water collector and connected into existing manhole near pumping station.

Structure: Compliance with regulations and standards related to the surrounding environment. EU regulation of Eurocode-2 “Concrete structure” categorizes the requirement for concrete specification. Fence need to be installed around site boundary for security.

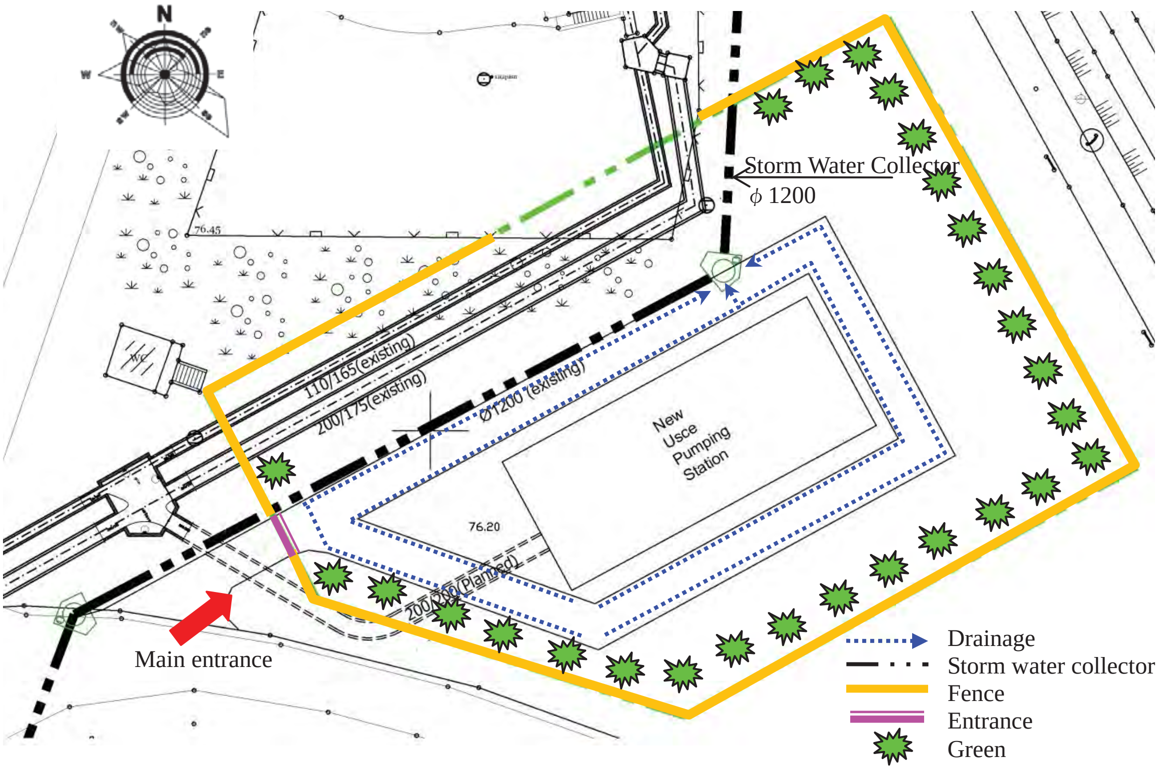


Figure 5.9 Layout of New Ušće PS

5.2.3 Facility Planning for Mostar Pumping Station

(1) Evaluation of Mostar PS

The following inspections are conducted in order to evaluate the existing conditions of Mostar PS.

- Visual inspection
- Trial short operation of the pump unit
- Hearing to the operators
- Analyzing of the documents
- Availability of spare parts

The evaluation and required works for rehabilitation and renovation of the building and equipment of Mostar Pumping Station are summarized in Table 5.5 and Table 5.6, respectively.

Table 5.5 Evaluation of the Building

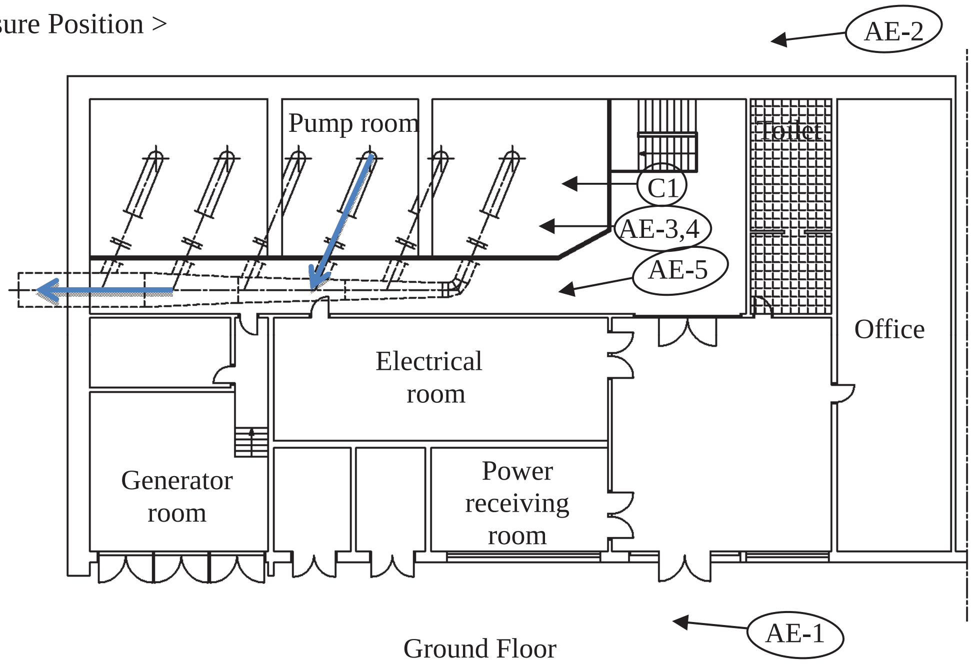
Item	Evaluation	Required works
Concrete structure	Sewage is blocked at the inflow chamber by using rubber plugs to prevent the pumping station from receiving sewage. Hence, concrete of civil structures has not been exposed to corrosive gases. It seems that concrete has not been seriously damaged since the pump well has been filled with water in order to prevent concrete from cracking. Nevertheless, it is recommended that concrete diagnosis by taking core samples and analyzing them is conducted to evaluate the conditions of deterioration of concrete in detail design stage. The concrete diagnosis is only method to evaluate the conditions of concrete and judge the necessity of renovation works since there is possibility that internal concrete may be corroded by high humidity. Anti-sulfate coating for inlet chamber, inlet channels and pump well which will be exposed to sewage is also recommended to be applied for preventing corrosion. Concrete of architectural structures has not been damaged at all. However, finishing works of the building require the rehabilitation and renovation works. Tiling and plastering are cracked. Waterproofing of the roof is deteriorated by aging. Hand rails in the pump well are seriously corroded. Fixtures such as doors, shutters and covers are in rust. Pressured discharge pipes from the pumping station to the manhole are required to be inspected by using TV camera to evaluate the conditions of deterioration of ductile pipes in detail design stage. According to the results of the inspection, the countermeasures such as poly-pig are decided to restore the proper function.	Concrete diagnosis - Inlet chamber - Inlet channels - Pump well TV camera inspection - pressure pipes (dia.700 mm x 2 lines) Anti-sulfide coating - Inlet chamber - Inlet channels - Pump well Finishing works to be replaced or renovated - Tiling and plastering - Waterproofing - Hand rails - Fixtures (doors, shatters and covering)

Item	Evaluation	Required works
Building service	Some parts of lighting system and ventilation system are left nonfunctional since the pumping station has never been operated. Air conditioning system for operator's room is out of date. Fixtures for sanitary system including water supply and sanitation are also required to be replaced. The operators can use building services of the office building located next to the pumping station. However, it is required to restore function of building services of the pumping station to provide proper working place for operation and maintenance after rehabilitation of the pumping station.	Equipment to be replaced or renovated - Lighting system - Ventilation system - Air conditioning system - Sanitary system

Table 5.6 Evaluation of the Equipment

Item	Evaluation	Required works
Mechanical equipment	The pumps are periodically operated without pumping sewage for short time to maintain and check the conditions of equipment. However, overhaul of the pumps has never been conducted since the pumps have never been used for intended purpose. The impellers inside of the pump casings were inspected from the hand holes and serious damage caused by corrosion was observed. It is also confirmed from the supplier of the existing pumps that manufacturing of spare parts is already finished and spare parts are not supplied any more. The operators can't maintain equipment properly and conduct reliable operation without spare parts. Discharge and suction valves can't be closed completely and cause leakage inside the pipelines. The movement of check valves is insufficient due to rusting. The crane for dismantling the pumps has never been used for long time. Hence, it should not be used for the safety's sake. Considering the existing conditions of corrosion, functions and maintenance, it is evaluated that replacement of these equipment is inevitable for restoring effective and reliable operation.	Equipment to be replaced - Pump: 6 nos. - Discharge valve: 6 nos. - Check valve: 6 nos. - Suction valve: 6 nos. - Traveling crane: 1 no. - Pipes: 1 set
Electrical equipment	The electric switchgears for the pumps are periodically used to operate the pumps. The generators are also periodically operated for short time without load to maintain and check the conditions of equipment. The transformers are maintained by power company since the property of transformers is owned by power company. The panels including switchgears are operational. However, the conditions of wear-out and rusting are serious. As the same as the pump units, the spare parts of those electrical equipment are not available in the market since the parts used in the equipment are old fashion. The capacity of the existing equipment will not be enough after renovation of the pumping station. Considering the existing conditions of corrosion, maintenance and deficiency of capacity after renovation, replacement of these equipment is required to coordinate and operate renovated mechanical equipment properly.	Equipment to be replaced - Generator: 2 nos. - Transformer: 2 nos. - Electric panels: 1 set - Incidentals: 1 set

<Exposure Position >



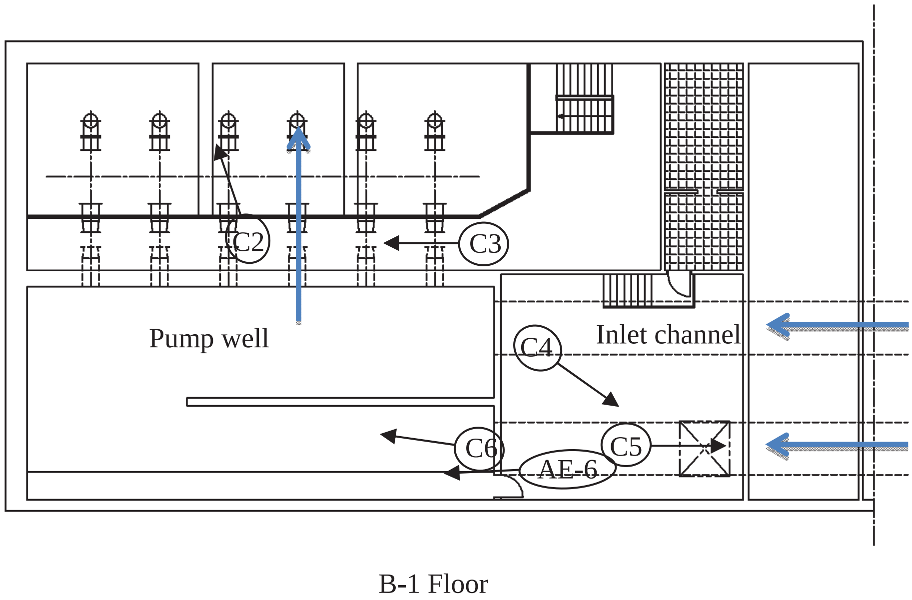


Figure 5.10 Exposure Position in Mostar PS

Table 5.7 Current State of Civil Structure

C-1: Ground floor	C-2: Beam and Wall
	
C-3: Floor at pump room	C-4: Floor above inlet channel
	
C-5: Inlet Channel	C-6: Pump Pit
	

Table 5.8 Current State of Architectural Structure and Equipments

AE-1: Outside view front side	AE-2: Outside view back side
	
AE-3: Ceiling	AE-4: Wall and handrail
	
AE-5: Ventilation system and hoist rail	AE-6: Handrail in Pump pit
	

Table 5.9 Current State of Mechanical Equipments

M-1: Lift pump at pump room	M-2: Hand hole of pump
	
M-3: Impeller of pump	M-4: Base of pump
	
M-5: Suction valve at pump room	M-6: Discharge valve and check valve
	

Table 5.10 Current State of Electrical Equipments

E-1: 11kV Incoming Panel at power receiving room	E-2: Two kVA Generators at generator room
	
E-3: Pump Control Panel at control room	E-4: Gate Control Box
	
E-5: SCADA System for Pump Stations	E-6: Maintenance Center
	

(2) Installing the Mechanical Screens

During the site inspection, introduction of the mechanical screens is requested from BVK. Hence, the possibility of installing the mechanical screens in the existing structure is studied. As the results of detailed layout planning, it is confirmed that the mechanical screens can be installed above the channels leading sewage to the pump suction wells by modifying the concrete top slab of the channels as shown in Figure 5.11.

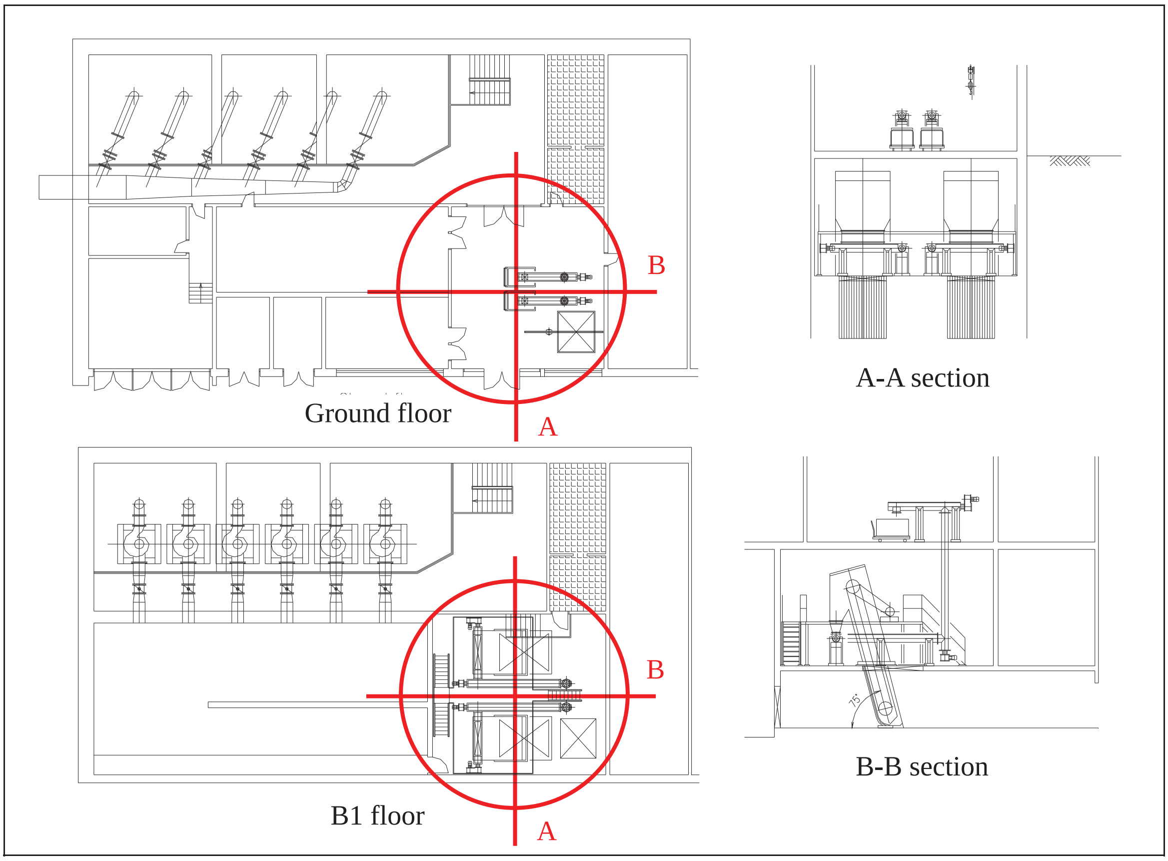


Figure 5.11 Layout of Mechanical Screens

Installation of the mechanical screens is recommended considering the following reasons.

- The Mostar PS is the main pumping station to convey sewage generated from south area of the central system to the interceptor
- The pumping stations located at upstream of sewage collection system do not have mechanical screens
- Prevention of the pumps from clogging by garbage is required for reliable operation
- It is desirable to remove garbage at the Mostar PS since the pumping station is key station for operation and maintenance staff

5.2.4 Specification and Quantity of Pumping Station Works as the Optimum Project in JICA Study

Specification and quantity of the optimum project in this study are shown in Table 5.11.

Table 5.11 Specification and Quantity of Pumping Station Works as Optimum Project

Name	Status	Main Facilities			
		Pump	Sand removal	Screen	SCADA Generator
New Ušće PS	Planned	Newly (50.2 m^3/min x 5 nos)	Newly	Newly	Newly
Mostar PS	Rehabilitation	Replace (42.0 m^3/min x 6 nos)	—	Newly	Replace

6. Facilities Planning of Veliko Selo Wastewater Treatment Plant

6.1 Basics for Planning

6.1.1 Outline of Veliko Selo WWTP

Outline of Veliko Selo WWTP are summarized in Table 6.1.

Table 6.1 Outline of Veliko Selo WWTP

Item	Value / Remark
Serviced area	13,600 ha
Type of collection system	Separate system (partial combined system)
Serviced population	1,239,000 in 2031
Location of WWTP site	Northeast of Veliko Selo village
Area of planned site	Total planned area: 114 ha (Purchased area: 39 ha)
Existing ground level of site	Average +72.5m
Receiving water body	Danube River (H.W.L +76.5m)
Final disposal of sludge	Sludge cake
Disposal site of sludge	Vinca landfill site

6.1.2 Design Water Quality

Design influent wastewater characteristics and effluent standards which are applied for Veliko Selo WWTP are summarized in Table 6.2. To satisfy effluent standards, advanced treatment which can remove nutrient, i.e. nitrogen and phosphorous, is required for Veliko Selo WWTP.

Table 6.2 Design Water Quality

Item	Influent characteristic	Effluent standard
BOD_5	192 mg/l	25 mg/l
COD_{Cr}	385 mg/l	125 mg/l
SS	224 mg/l	35 mg/l
T-nitrogen	35 mg/l	10 mg/l
T-phosphorus	8 mg/l	1 mg/l

Note: Influent characteristic is calculated dividing projected mass load in 2031 shown in Table 2.35 by daily average flow in 2031 shown in Table 2.34
Effluent standard refers to Table 2 ELV for Communal Wastewater Discharge to the Recipient

6.1.3 Design Flow

Projected influent flows from 2015 until 2031 to Veliko Selo WWTP are shown as Table 6.3.

Table 6.3 Projected Influent Flow

Year	2015	2021	2031
Daily average flow	394,000 m^3/day	409,000 m^3/day	448,700 m^3/day
Daily maximum flow	464,000 m^3/day	474,000 m^3/day	521,200 m^3/day
Hourly maximum flow	696,000 m^3/day	717,100 m^3/day	788,800 m^3/day
Wet weather flow	1,209,600 m^3/day	1,252,800 m^3/day	1,341,100 m^3/day

Note: Refer to Table 2.34

6.2 Selection of Sewage Treatment Process

Sewage treatment process is chosen from treatment processes which ensure removal of pollutant loading to satisfy all items of water qualities specified in effluent standards. As for Pre-F/S with M/P, the process comprised of anaerobic anoxic oxic process (A2O) and sand filtration process is adopted for sewage treatment process of Veliko Selo WWTP as the result of comparison with the alternatives. Sewage treatment process chosen in Pre-F/S with M/P is shown in Figure 6.1.

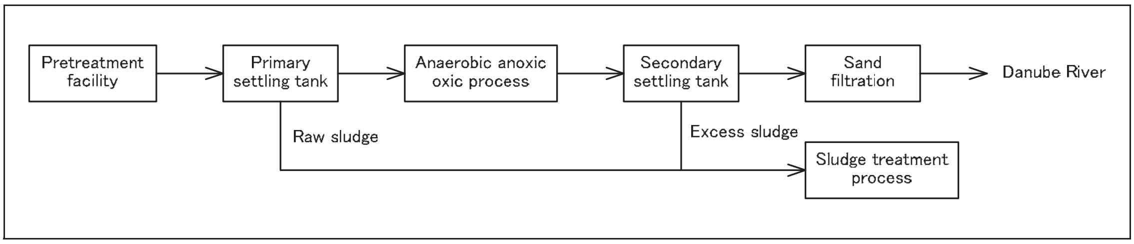


Figure 6.1 Sewage Treatment Process of Pre-F/S with M/P

There are newly developed technologies which can be beneficial for Veliko Selo WWTP. In order to optimize sewage treatment process, the following alternative comparisons including newly developed technologies, which were not considered in Pre-F/S with M/P, are conducted from the viewpoints of efficiency, sustainability and environmental aspect. Explanation and importance of these alternative studies are shown in Table 6.4.

- Alternative study of secondary treatment process
- Alternative study of filtration process
- Alternative study of aeration equipment

Table 6.4 Explanation and Importance of Alternative Studies

Item	Explanation
Secondary treatment process	Sewage is biologically treated by activated sludge in secondary treatment process following primary treatment process by sedimentation. Biological treatment, which consists of bioreactors and secondary settling tanks, is critical process for removal of organic substances and nutrient. There are newly developed technologies such as carrier, membrane and step feeding especially for advanced treatment, which removes nitrogen and phosphorus. Hence, alternatives of secondary treatment process including newly developed technologies are compared to optimize sewage treatment process.
Filtration process	Sewage is physically treated by filtration following biological treatment in secondary treatment process. Filtration process is the last treatment process polishing effluent prior to discharging final effluent to receiving water body. There was only conventional process of sand filtration for filtration process. However, at present there are newly developed technologies such as disc filter and fiber filtration. Hence, alternatives of filtration process including newly developed technologies are compared to optimize sewage treatment process.
Aeration equipment	Aeration equipment supplies oxygen which is required by activated sludge to remove pollutant load and mixes sewage and activated sludge. Aeration equipment consumes significant portion of total electricity used in sewage treatment. In addition, its role is vital in activated sludge process. There are newly developed technologies such as ultrafine bubble diffuser and submersible aeration device. Hence, alternatives of aeration equipment including newly developed technologies are compared considering all factors regarding the efficiency of dissolving oxygen, economical aspect, operation and maintenance, etc.

6.2.1 Sewage Treatment Process with Nutrient Removal

Veliko Selo WWTP is required to adopt treatment process which ensures removal of nutrient, i.e. nitrogen and phosphorous, to satisfy effluent standards. Firstly, outline of nitrogen removal process and applied treatment processes of nitrogen removal are explained. And then, outline of phosphorous removal process and applied treatment process are explained.

There is only biological process which is applied to treatment processes for communal sewage to remove nitrogen. Outline of biological nitrogen removal process is shown in Table 6.5.

Table 6.5 Outline of Nitrogen Removal Process

Process	Explanation
Biological nitrogen removal	Biological nitrogen removal process decomposes nitrogen contained in sewage to nitrogen gas by combined processes of nitrification and denitrification. Ammonia nitrogen is oxidized to nitrate nitrogen and nitrite nitrogen by nitrifying bacteria such as Nitrosomonas and Nitrospira in oxic tanks. These oxidation processes are shown as the following reaction stoichiometry. $NH_4^+ + 1.5\ O_2 \rightarrow NO_2^- + H_2O + 2\ H^+$ $NO_2^- + 0.5\ O_2 \rightarrow NO_3^-$ Nitrate nitrogen and nitrite nitrogen is deoxidized to nitrogen gas by denitrifying bacteria such as Pseudomonas, Micrococcus, Achromobacter and Bacillus in anoxic tanks. These deoxidation processes are shown as the following reaction stoichiometry. $2\ NO_2^- + 3\ (H_2) \rightarrow N_2 + 2\ OH^- + 2\ H_2O$ $2\ NO_3^- + 5\ (H_2) \rightarrow N_2 + 2\ OH^- + 4\ H_2O$

There are sewage treatment processes to which biological nitrogen removal process can be applied and enable removal of nitrogen to satisfy the level of effluent standards. The categorization of sewage treatment processes is shown in Figure 6.2.

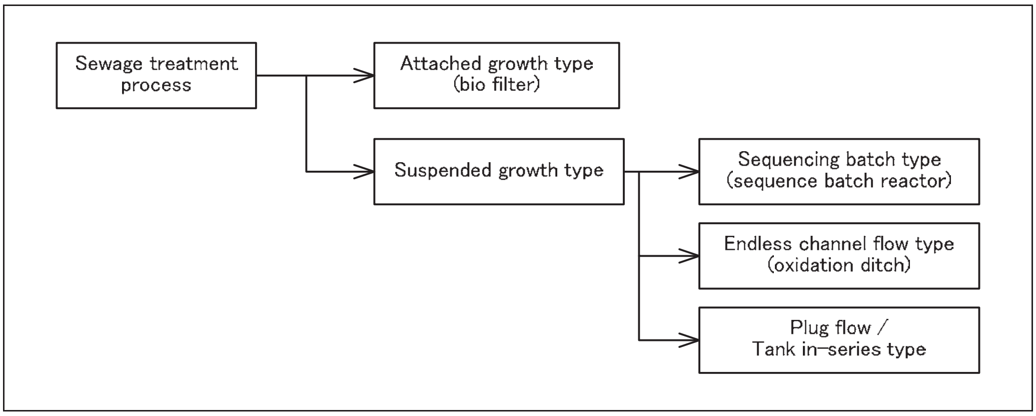
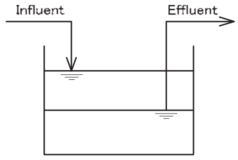
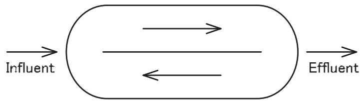
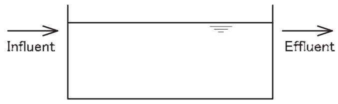


Figure 6.2 Categorization of Sewage Treatment Process

Sewage treatment processes are categorized into attached growth type and suspended growth type. Attached growth type removes pollutant loading utilizing microbes fixed to filter media. On the other hand, suspended growth type removes pollutant loading utilizing microbes suspended in the sewage. Suspended growth type is also subcategorized into sequencing batch, endless channel flow and plug flow/tank in-series according to the feeding types as shown in Table 6.6.

Table 6.6 Categorization of Suspended Growth Type

Sequence batch	Endless channel flow	Plug flow/tank in-series
		

Taking these categorizations into consideration, sewage treatment processes which can remove nitrogen are categorized as below and explanations of these processes are shown in Table 6.7.

- Bio filter
- Sequencing batch reactor
- Oxidation ditch
- Plug flow/tank in-series type

Table 6.7 Explanations of Processes

Process	Explanation
Bio filter	Bio filter is the process to remove pollutant loading by passing sewage thorough filter media. Sewage flows in top of aerobic filters filled with media. Organic contents are removed by aerobic microbes fixed to media and suspended solids are traps at the same time. Nitrification of nitrogen is expected since bio filter can retain nitrifying bacteria. However, denitrification is not expected.
Sequencing batch reactor	Sequencing batch reactor has functions of bioreactor and settling tank in one tank. This process removes pollutant loading by repeating the cycle comprising of removal by activated sludge, solid-liquid separation, discharging supernatant and withdrawing sludge. Biological removal of nitrogen and phosphorous are possible if the conditions of anaerobic, anoxic and aerobic can be incorporated by operation.
Oxidation ditch	Oxidation ditch is the process comprised of endless channels and mechanical aeration/mixing equipment. This process removes pollutant loading in endless channels under low organic loading. Solid-liquid separation of activated sludge and effluent is conducted in the final settling tanks. Removal of nitrogen is expected by operating with proper time control of aerobic and anoxic conditions.
Plug flow/ tank in-series type	Activated sludge processes of plug flow/tank in-series type are the conventional processes in which sewage flows from inlet to outlet in the bioreactors. These processes remove pollutant loading in the bioreactors and solid-liquid separation is conducted in the final settling tanks. These processes can remove nitrogen by having anoxic tanks and aerobic tanks and circulation of nitrified mixed liquor. Nitrogen is removed by nitrification in oxic tanks and denitrification in anoxic tanks.

Within these processes, alternatives of bio filter, sequencing batch reactor and activated sludge process of plug flow/tank in-series type were already compared in Pre-F/S with M/P and activated sludge process of plug flow/tank in-series type was chosen as a result of comparison. Hence, bio filter and sequencing batch reactor are not considered for the alternatives of comparison in this Study. Oxidation ditch is not suitable for Veliko Selo WWTP from the aspect of scale of plant since oxidation ditch is generally applied for small scale of WWTPs. Hence, sewage treatment process of Veliko Selo WWTP should be selected from activated sludge process of plug flow/tank in-series type.

Recycled denitrification nitrification process (RDNP) is the basic process of plug flow/tank in-series type which combines biological removal of organic substances and biological removal of nitrogen. Schematic flow of RDNP is shown in Figure 6.3. In this process, nitrogen is removed by combined processes of nitrification in oxic tanks and denitrification in anoxic tanks by circulation of nitrified mixed liquor while removing organic substances.

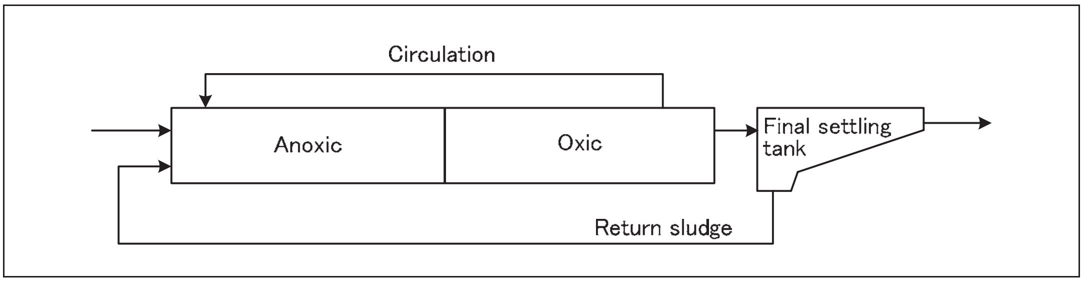


Figure 6.3 Schematic Flow of RDNP

Veliko Selo WWTP is also required to remove phosphorous. There are two processes which are applied to treatment processes for communal sewage to remove phosphorous. Outline of phosphorous removal process are shown in Table 6.8.

Table 6.8 Outline of Phosphorous Removal Process

Process	Explanation
Enhanced biological phosphorus removal	Enhanced biological removal process removes phosphorus by luxury phosphorus uptake phenomenon of activated sludge microbes. Microbes release phosphorus in anaerobic condition and uptakes more phosphorus than released amount in the following aerobic condition. Phosphorus concentration contained in sewage is reduced by uptake of activated sludge microbes and activated sludge which contains phosphorus is removed from the final settling tanks. Anaerobic condition has effect to prevent the increase of aerobic filamentous bacteria. Hence, this process is also effective in preventing bulking caused by aerobic filamentous bacteria.

Process	Explanation
Physical-chemical phosphorus removal (simultaneous precipitation)	Physical-chemical removal process removes phosphorus by adding coagulant such as aluminum sulfate and poly aluminum chloride. Phosphorus turns into insoluble substance by the reaction with coagulant. Reaction process between trivalent metallic ions and phosphoric acids is shown as the following reaction stoichiometry. $M^{+3} + PO_4^{3-} \rightarrow MPO_4$ Mixing coagulant with sewage and flocculation is done by turbulence of bioreactors and removal of insoluble substance is done by solid-liquid separation in the final settling tanks.

There are sewage treatment processes which combined the basic process of biological nitrogen removal, i.e. RDNP, and phosphorous removal. And also, there are newly developed technologies which enhance the performance of removal. Taking combination of nutrient removal and newly developed technologies into consideration, sewage treatment processes which can remove both nitrogen and phosphorous are listed below and explanations of these processes are shown in Table 6.9.

- Recycled denitrification nitrification process with coagulant (RDNP)
- Anaerobic anoxic oxic process (A2O)
- Step feed type denitrification nitrification process with coagulant (SFDNP)
- Carrier added activated sludge process (CAASP)
- Membrane bioreactor (MBR)

Table 6.9 Explanations of Processes

Process	Explanation
Recycled denitrification nitrification process with coagulant (RDNP)	Recycled denitrification nitrification process with coagulant (RDNP) is the combined process of biological nitrogen removal and physical-chemical phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by adding coagulant such as aluminum sulfate and poly aluminum chloride. RDNP with coagulant is the conventional process of nitrogen and phosphorous removal.
Anaerobic anoxic oxic process (A2O)	Anaerobic anoxic oxic process (A2O) is the combined process of biological nitrogen removal and enhanced biological phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. Physical-chemical phosphorus removal process is also installed for backup of biological process since biological process becomes frequently unstable due to difficulties to maintain anaerobic condition on wet weather condition.
Step feed type	Step feed type denitrification nitrification process with coagulant (SFDNP) is the

Process	Explanation
denitrification nitrification process with coagulant (SFDNP)	combined process of biological nitrogen removal and physical-chemical phosphorus removal. SFDNP has been developed to improve the removal efficiency of nitrogen. In this process multistage, normally two or three stage, of anoxic tanks and oxic tanks are allocated in series. Step feeding of sewage to each stage and solid contents of the tanks of each stage are equalized in this process. Then, equalization of organic loading and nitrogen loading against solid contents results in improvement of efficiency of nitrogen removal.
Carrier added activated sludge process (CAASP)	Carrier added activated sludge process (CAASP) enables to increase concentration of microbe in bioreactors tanks by adding carriers which contains microbes. Hydraulic retention time can be reduced owing to increase of microbe. CAASP is usually adopted for biological nitrogen removal process since it requires longer hydraulic retention time and sludge retention time. Stable nitrification is achieved owing to nitrifying bacteria contained in carriers since carriers are retained in bioreactors. Phosphorous is removed by applying enhanced biological removal process which removes phosphorus by luxury uptake phenomenon of activated sludge microbes.
Membrane bioreactor (MBR)	Membrane bioreactor (MBR) directly separates effluent from activated sludge liquid by membranes which are submerged in the bioreactors. Hydraulic retention time can be reduced since MLSS is retained much higher from 8,000 mg/l to 15,000 mg/l owing to the way of solid-liquid separation. Effluent is expected to be better quality than those of conventional processes since effluent does not include suspended solid. Phosphorous is removed by applying enhanced biological removal process which removes phosphorus by luxury uptake phenomenon of activated sludge microbes.

Both recycled denitrification nitrification process with coagulant (RDNP) and step feed type denitrification nitrification process with coagulant (SFDNP) are combined processes of biological nitrogen removal and physical-chemical phosphorus removal. RDNP is not considered for the alternatives of the comparison instead of taking SFDNP as one of the alternatives since SFDNP is better alternative considering the following merits of SFDNP and demerits of RDNP.

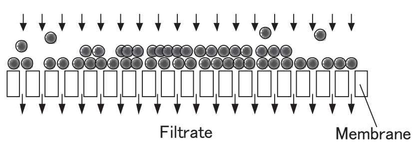
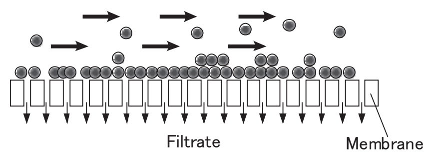
- SFDNP has advantage on higher removal efficiency of nitrogen, i.e. 75-85% comparing to removal efficiency of RDNP, i.e. 65-75%
- SFDNP does not required circulation of nitrified mixed liquor while RDNP requires high circulation rate even though removal efficiency is lower than SFDNP
- Energy consumption of SFDNP is lower since RDNP consumes a lot of energy circulating nitrified mixed liquor by pumps
- Operation of SFDNP is easier since all stages of tanks can be operated with the same conditions due to equalization of pollutant loading against solids content
- Operation of RDNP requires frequent adjustment based on operation conditions

since the gradients of water qualities and reaction rate depending on the location in flow direction are inevitable

- SFDNP requires less volume of bioreactor owing to higher MLSS concentration due to step feeding

Membrane bioreactor (MBR) is explained in Table 6.10.

Table 6.10 Explanations of Membrane Bioreactor

<table>
<tr><th>Item</th><th>Explanation</th></tr>
<tr><td>Category of membrane</td><td>Membrane process is technology to separate substances using membrane by driving forces such as pressure difference, concentration difference and potential difference. Membrane is categorized as the followings.
Category of Membrane
<table>
<tr><th>Category</th><th>Separation target</th><th>Operating pressure</th></tr>
<tr><td>Microfiltration (MF)</td><td>Particle size:
From 0.01 to 10 nm</td><td>To Several*100 kPa</td></tr>
<tr><td>Ultrafiltration (UF)</td><td>Molecular mass:
From 1,000 to 200,000</td><td>From Several*10 kPa
To Several*100 kPa</td></tr>
<tr><td>Nanofiltration (NF)</td><td>Molecular mass:
From 200 to 1,000</td><td>From Several*100 kPa
To Several MPa</td></tr>
<tr><td>Reverse osmosis (RO)</td><td>Molecular mass:
To 350</td><td>From Several MPa
To Several*10 MPa</td></tr>
</table></td></tr>
<tr><td>Filtration method</td><td>Membrane process has the following filtration methods.
Filtration Methods of Membrane
<table>
<tr><th>Dead-end filtration</th><th>Cross-flow filtration</th></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>Dead-end filtration filtrates raw water by blocking foreign substances with the membrane. Dead-end filtration requires periodical suspension of operation in order to remove accumulated foreign substances since blocked substances are continuously accumulated while filtration.</td><td>Cross-flow filtration filtrates raw water while cleaning membrane surfaces by parallel flow to the surface. Cross follow filtration is possible to conduct continuous operation and maintain high filtration rate. However, cross-flow filtration consumes more energy comparing dead-end filtration due to increase of supply of influent.</td></tr>
</table></td></tr>
</table>

<table>
<tr><th>Item</th><th>Explanation</th></tr>
<tr><td>Cleaning methods</td><td>Performance decrement of membrane is caused by degradation and fouling. Degradation is noninvertible decrement caused by change of membrane itself. Fouling is apparent decrement caused by accumulation of foreign substances on the surfaces of membrane. Performance decrement caused by fouling can be recovered by cleaning of membrane. Membrane requires the followings cleaning methods.
Cleaning Methods of Membrane
<table>
<tr><th>Physical cleaning</th><th>Chemical cleaning</th></tr>
<tr><td>Physical cleaning is comprised of back washing, air washing and flushing of membrane. Physical cleaning of membrane is periodically conducted with the combination of these cleanings.</td><td>Foreign substances, which cannot be completely removed by physical cleaning, accumulates on the surfaces and internal while operating long period. In this case chemical cleaning using acid and chorine is conducted.</td></tr>
</table>
</td></tr>
</table>

Membrane bioreactor (MBR) is not considered for alternatives of comparison since MBR has the following demerits.

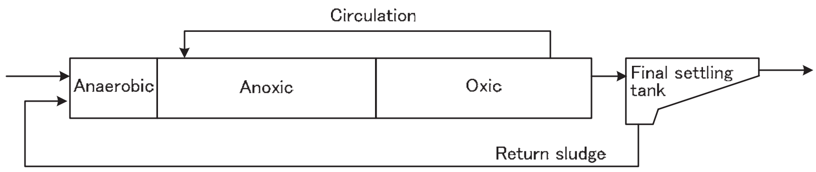
- Initial cost of membrane is still very expensive even though the price of membrane modules is getting cheaper
- Membrane module requires periodical replacement due to degradation which results in rather high maintenance cost
- Aeration requirement is considerably high due to air washing of membrane and demand for endogenous respiration of high MLSS which results in rather high operating cost
- MBR cannot accommodate more than the designed flow since membrane has physical limit on flux rate which causes troubles in rainy day since collection system of Veliko Selo WWTP is partially combined system
- Membrane modules requires periodical chemical washing of the membrane modules by using chemicals such as acid and choline
- MBR is generally applied for the plants which have strict constraint on land area availability

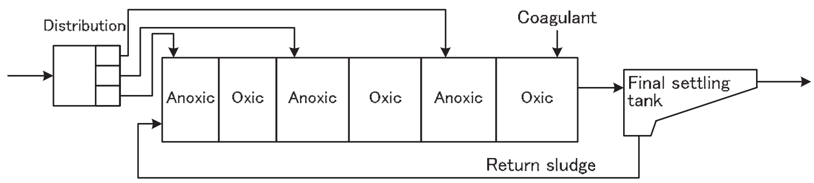
6.2.2 Alternatives of Sewage Treatment Process

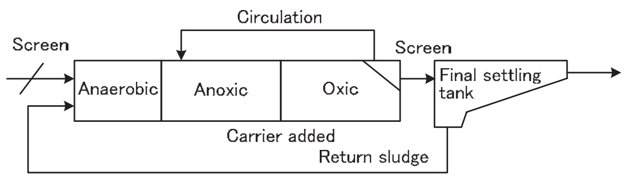
(1) Alternative Processes

Alternative processes, which have been chosen for comparison, are listed below and schematic flows of alternative processes are shown in Figure 6.4.

- Anaerobic anoxic oxic process (A2O)
- Step feed type denitrification nitrification process with coagulant (SFDNP)
- Carrier added activated sludge process (CAASP)

<table>
<tr><th>Process</th><th>Schematic flow of sewage treatment process</th></tr>
<tr><td>Anaerobic anoxic oxic process (A2O)</td><td>


</td></tr>
<tr><td>Step feed type denitrification nitrification process (SFDNP)</td><td>


</td></tr>
<tr><td>Carrier added activated sludge process (CAASP)</td><td>


</td></tr>
</table>

Figure 6.4 Schematic Flows of Alternative Processes

(2) Phosphorous Removal

A2O and CAASP removes phosphorous by enhanced biological removal process while SFDNP removes phosphorous by physical-chemical process. Biological phosphorous removal becomes unstable in rainy day. Hence, dosing equipment of coagulant is usually installed for backup of biological removal process to ensure the stable removal of phosphorus.

SFDNP requires continuous dosing of coagulant for phosphorus removal while A2O and CAASP require dosing of coagulant only when biological phosphorous removal is unstable due to rainfall. Number of heavy rainfall in which precipitation is more than 10mm in Belgrade is shown in Table 6.11.

Table 6.11 Number of Heavy Rainfall in Belgrade (More Than 10 mm)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1	1	1	2	2	3	2	2	2	2	2	2	21

In this comparison, it is assumed that dosing of coagulant is necessary for heavy rainfall in which precipitation is more than 10 mm for A2O and CAASP. Influence of rainfall continues after end of rainfall and recovery of enhanced biological removal usually takes several days. Hence, it is assumed that dosing of coagulant is continued for three days after heavy rainfall.

Hence, expense of coagulant for SFDNP is estimated based on continuous dosing and added to operation cost. Meanwhile, expense of coagulant for A2O and CAASP is estimated based on number of heavy rainfall and added to operation cost.

6.2.3 Explanation of A2O

(1) Outline of Process

Anaerobic anoxic oxic process (A2O) is the combined process of biological nitrogen removal and enhanced biological phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. This process has anaerobic tank, anoxic tank and oxic tank in-series. Influent and return sludge inflow into anaerobic tanks. Nitrified mixed liquor is circulated from oxic tanks to anoxic tanks by circulation pumps. The schematic flow of A2O is shown in Figure 6.5 and the process of each tank is summarized in Table 6.12.

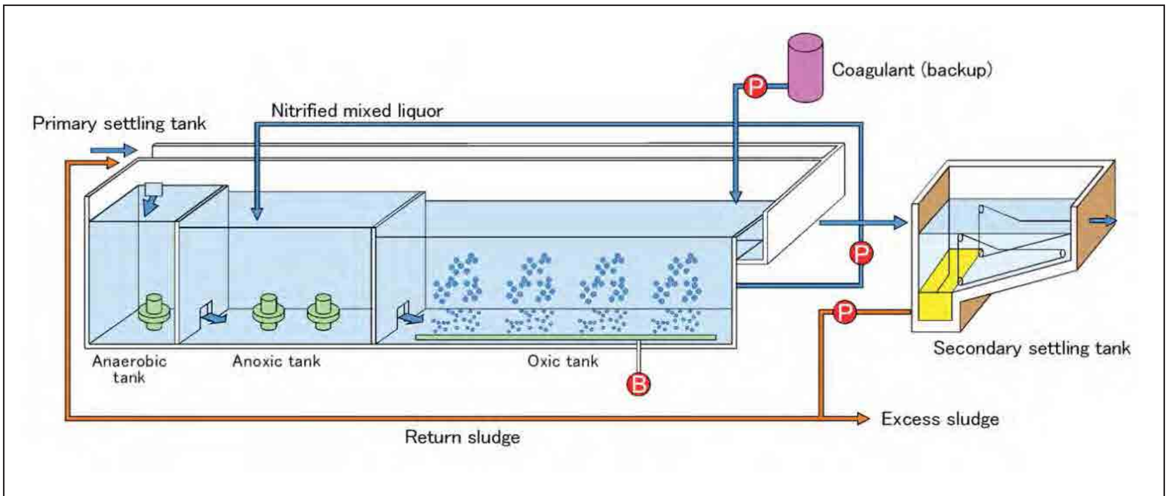


Figure 6.5 Schematic Flow of A2O

Table 6.12 Process in Each Tank

Anaerobic tank	Anoxic tank	Oxic tank
➢ Release of phosphorous ➢ Decomposing organic substances to lower fatty acid under anaerobic condition ➢ Storage of organic substances as PHA (polyhydroxyl fatty acid) inside the cell	➢ Deoxidation of nitrate nitrogen and nitrite nitrogen to nitrogen gas using BOD contained in sewage as hydrogen donor	➢ Uptake of phosphorous by decomposing PHA stored in the cell ➢ Oxidation of organic nitrogen to ammonia nitrogen ➢ Oxidation of ammonia nitrogen to nitrate nitrogen and nitrite nitrogen

(2) Characteristics

Approximately 60-70% of nitrogen removal efficiency and 70-80% of phosphorous removal efficiency are expected for treating usual communal wastewater.

Ammonia nitrogen is oxidized to nitrate nitrogen and nitrite nitrogen by nitrifying bacteria in oxic tanks. Nitrate nitrogen and nitrite nitrogen is deoxidized to nitrogen gas by denitrifying bacteria in anoxic tanks. This process utilizes organic contents contained in sewage as hydrogen donor. Portion of alkalinity consumed by nitrification is recovered by denitrification circulating nitrified mixed liquor to anoxic tanks.

Removal of phosphorus is decided by amount of excess sludge and phosphorous content of excess sludge. Those are influenced by BOD/TN ratio, STR and BOD-SS loading. In general, removal efficiency of A2O is lower than removal efficiency of Anaerobic oxic process since it is necessary for A2O to maintain longer SRT for keeping nitrifying bacteria. Removal efficacy of phosphorus often deteriorates in rainy day because of dissolved oxygen brought by rainfall and lowering of organic concentration. Hence, coagulant dosing equipment is usually installed for backup of biological process.

The particular requirements and attentions of the process are summarized as the followings.

- ➢ Excess removal in primary settling tanks cause deterioration of phosphorous removal efficiency since organic substances contained in sewage are utilized for phosphorous removal.
- ➢ Mixers are required for enhancing biological reaction and preventing sedimentation of sludge in anaerobic tanks and anoxic tanks.
- ➢ Circulation pumps are required for circulating nitrified mixed liquor.
- ➢ Bridge wall is required to prevent back flow of mixed liquor so as to maintain anoxic

condition in anoxic tanks

- It is required to shred scum since scum is usually generated in anaerobic tanks and anoxic tanks.
- Removal of scum in final settling tanks is required to prevent from deterioration of effluent qualities due to outflow of scum since generation of scum and flotation of sludge by denitrification sometime happens in final settling tanks.
- Phosphorous taken by activated sludge microbes is easily re-discharged under anaerobic condition in sludge treatment process

6.2.4 Explanation of SFDNP

Step feed type denitrification nitrification process (SFDNP) is the application of biological nitrogen removal using activated sludge for purifying communal sewage. The following advantages are achieved by multistage of anoxic-oxic units and step feeding of influent to each anoxic tank equally.

- Higher removal efficiency of nitrogen
- Reducing the tank volumes of bioreactor
- Simplified operation

There are applications of process which has multistage of anoxic-oxic units with step feeding in the world. However, it is rather complicated to optimize the process on design and operation of plants because the parameters such as step feed rate and tank volumes of bioreactor are needed to be determined appropriately considering the given conditions such as influent characteristics and water temperature. SFDNP is the process which optimizes distribution of inflow to each stage and tank volumes of each stage of bioreactor. The process fulfills the following requirements and the schematic flow of SFDNP is as shown in Figure 6.6.

- Multistage of anoxic and oxic tanks in series
- Step feeding of inflow to each of anoxic tank equally
- Setting of tank volumes to make solid contents retained in each tank equal

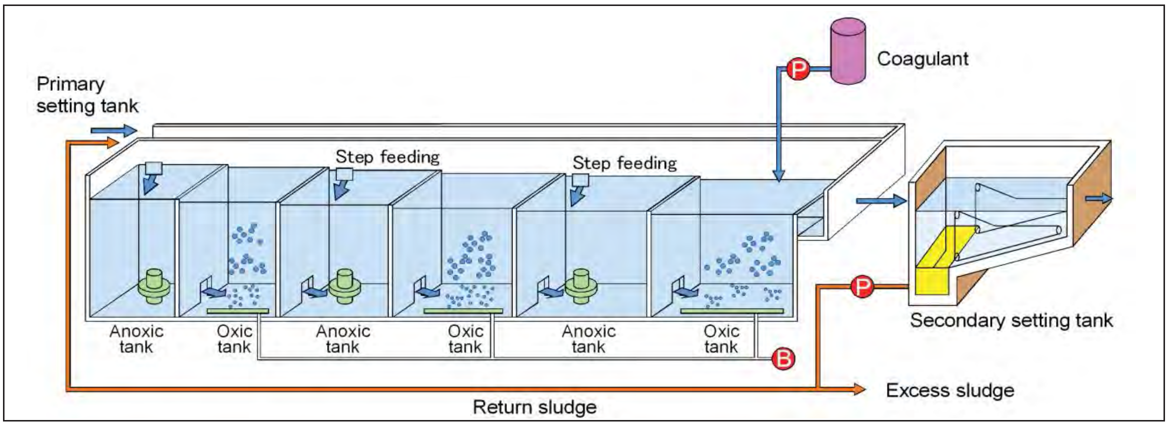


Figure 6.6 Schematic Flow of SFDNP

(1) Higher Removal Efficiency of Nitrogen

Biological removal process removes nitrogen by two methods. One is to remove nitrogen by reaction of nitrification and denitrification and the other is to remove nitrogen as excess sludge. The amount of nitrogen removed as excess sludge is not significantly different between SFDNP and other biological nitrogen removal processes such as RDNP as long as there are similar operation conditions in terms of pollutant loading and aerobic solids retention time. On the other hand, the amount of nitrogen removed by nitrification and denitrification varies among the processes and SFDNP can achieve higher removal efficiency comparing to other biological nitrogen removal processes.

Nitrogen removal process of SFDNP is shown in Figure 6.7. Nitrogen, which inflows into the stages except for the final stage, is nitrified to NO_3-N in oxic tanks. Then, NO_3-N inflows into anoxic tanks of the following stages, and is denitrified and released into atmosphere as nitrogen gas. Nitrogen, which inflows into the final stage, is also nitrified to NO_3-N in oxic tanks. Partial NO_3-N is returned to the beginning of bioreactors as return sludge and denitrified. The rest of NO_3-N remains in effluent and is discharged as NO_3-N.

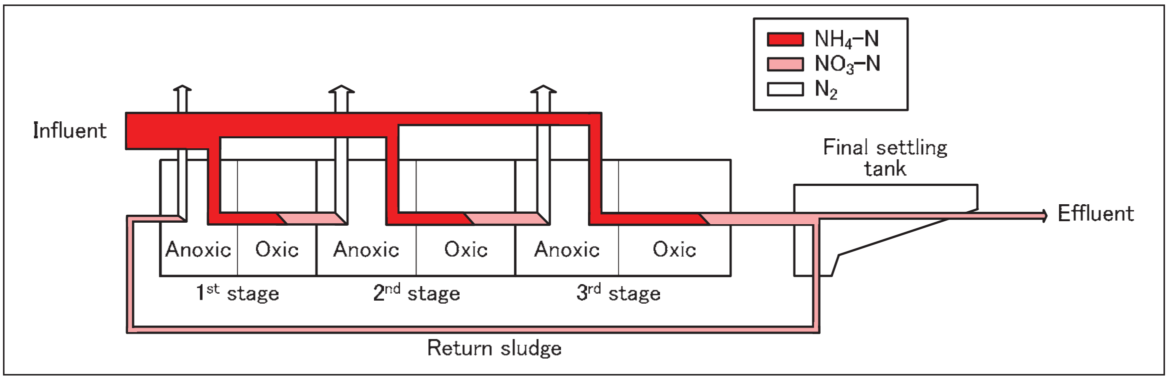


Figure 6.7 Removal Process of Nitrogen

Hence, the removal efficiency of nitrogen depends on the number of stage and return sludge rate. Theoretical removal efficiencies of nitrogen are summarized in Table 6.13 in the condition that return sludge rate is assumed as 0.5.

Table 6.13 Theoretical Removal Efficiencies of Nitrogen

Process	Stage	Circulation rate	Return sludge rate	Removal efficiency
RDNP	1	100 %	50 %	60 %
	1	150 %	50 %	67 %
SFDNP	2	0 %	50 %	67 %
	3	0 %	50 %	78 %
	4	0 %	50 %	83 %

(2) Reducing the Tank Volumes of Bioreactor

Actual flow of the later stages in the bioreactor increases since inflow is distributed into each stage by step feeding in the process of SFDNP. Hence, MLSS concentration of the earlier stages in the bioreactor increases. The ratio of MLSS concentration of stages is 1.8:1.3:1.0 in the conditions that return sludge rate is 0.5 and number of stages is three stages. MLSS concentration of the last stage influences solid-liquid separation in the final settling tanks. The tank volume of the earlier stages is reduced owing to higher MLSS concentration of bioreactor.

(3) Simplified Operation

The gradients of water qualities and reaction rate depending on the location in flow direction are inevitable for the conventional processes of plug flow/tank in-series type. However, SFDNP does not have these gradients depending on the location in flow direction since each anoxic and oxic tank is regarded as completely mixed tank. This feature makes it easy to monitor the conditions of each tank. Furthermore, pollutant loading against solids content is the same among the stages because influent is equally distributed into the stages while each stage has the same amount of solids content. This feature makes it possible to operate all stages with the same conditions. For example, it is possible to control dissolved oxygen of all stages in block by installing the same capacity of aeration equipment in each oxic tank since aeration requirement of each oxic tank is the same.

6.2.5 Explanation of CAASP

(1) Outline of Process

Carrier added activated sludge process (CAASP) enables to increase concentration of microbes in bioreactor tanks by adding carriers which contain microbes. Immobilization methods are categorized into the following two methods as shown in Figure 6.8. The schematic flow of CAASP is shown in Figure 6.9.

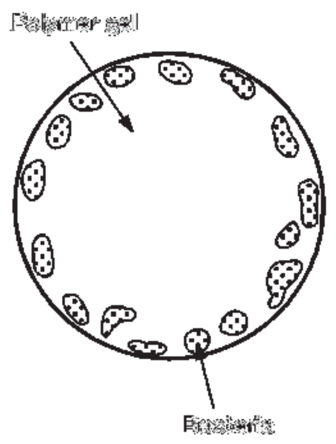
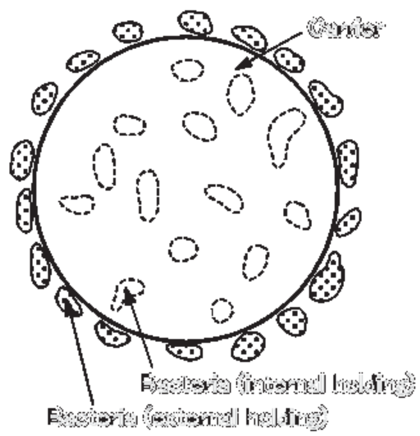
Entrapping immobilization method	Binding immobilization method
	
Entrapping bacteria by incorporating bacteria into fine lattice structure of gel	Binding bacteria by accreting and holding bacteria in or on insoluble carriers

Figure 6.8 Immobilization of Bactria

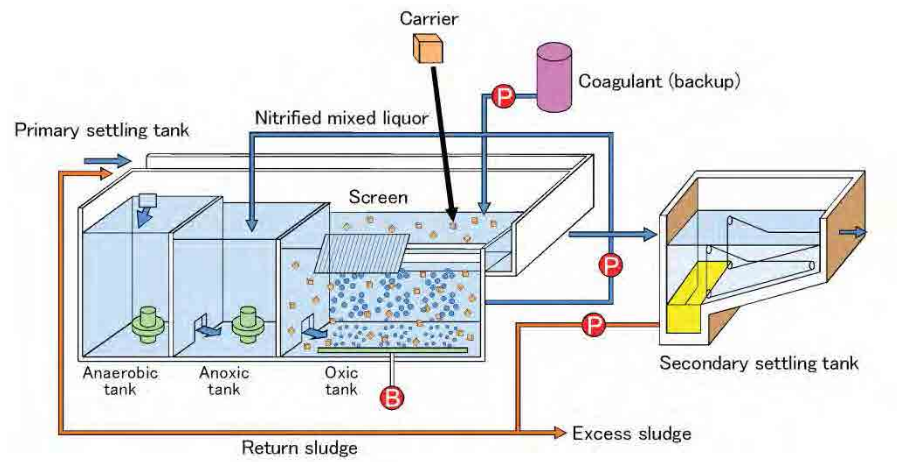


Figure 6.9 Schematic Flow of CAASP

(2) Advantages of CAASP

Advantages of CAASP are summarized as shown in Table 6.14.

Table 6.14 Advantages of CAASP

Item	Explanation
Treatment of high nitrogen loading	CAASP enables to hold high concentration of nitrifying and denitrifying bacteria in bioreactors owing to carriers. This makes possible to treat sewage of high nitrogen loading.
Space saving	The volume of bioreactors is reduced comparing to conventional biological nitrogen removal process owing to increase of bacteria. This results in space saving of bioreactors.
Stable nitrogen removal efficiency	Stable performance of nitrification is achieved by adjusting concentration of nitrifying bacteria by adding carriers.
Easy management of ASRT	Management of ASRT is easy since nitrifying bacteria is immobilized in the carriers.
High flexibility to fluctuation	CAASP has high flexibility to fluctuation of pollutant loading since carriers are retained in the bioreactors and microbe can be kept always for removal of pollutant loading.

(3) Operation of CAASP

Operation of CAASP requires management of carrier in addition to operation and water quality management for conventional process utilizing suspended activated sludge. Operation of CAASP is summarized in Table 6.15.

Table 6.15 Operation of CAASP

Item	Explanation
Water quality management	This process requires monitoring of quality items of nitrogen and phosphorous in addition to quality items of conventional activated sludge process.
	Attention is required in rainy day since removal efficiency tends to deteriorate due to dilution of sewage and reduction of retention time.
	Circulation rate is adjusted considering target removal efficiency of nitrogen, circulation flow and operation condition.
Operation of bioreactors	Oxidation-reduction potential (ORP) is maintained low as much as possible in anaerobic tanks and anoxic tanks.
	MLSS concentration is controlled properly since this process can operate in the condition of high BOD-SS loading comparing conventional processes.
	Periodical inspection of inlet screens is required.
	Periodical maintenance of mixers installed in anaerobic tanks and anoxic tanks such as removing screening is required to prevent mixers from deterioration of mixing performance.
	Removal of scum is required since this process generates more scum than conventional process in anaerobic tanks.
	Insufficient dissolved oxygen causes deterioration of decomposition of organic substances and nitrification. Excess dissolved oxygen causes interruption of denitrification by bringing oxygen to anoxic tanks. Therefore, dissolved oxygen is maintained 3.0-4.0 mg/l.
	Periodical inspection of wear-out of carriers is required. If required, supplementary carrier is added to bioreactors.

6.2.6 Comparison of Alternatives

Basic planning of sewage treatment facilities is prepared for each alternative processes to compare financial aspects including the initial investment, O&M cost and major replacement cost. Environmental and social aspects are also studied and each process has both advantages and disadvantages such as amount of generated sludge and energy consumption.

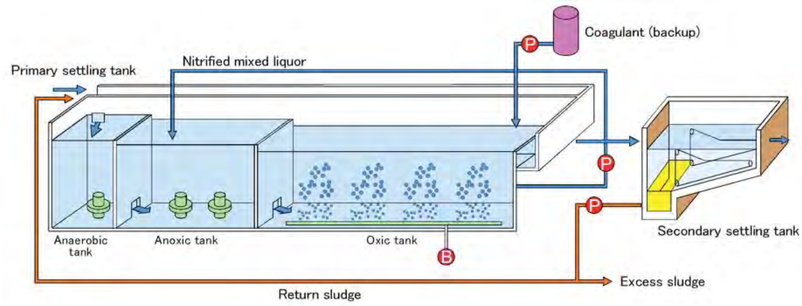
Comparisons of alternatives are summarized in Table 6.16. As a result of comparison, step feed type denitrification nitrification process (SFDNP) is recommended due to the following advantages.

- Operation of SFDNP is easier since all stages of tanks can be operated with the same conditions due to equalization of pollutant loading against solids content.
- High removal efficiency of nitrogen is achieved without internal circulation comparing to A2O.
- Stable removal efficiency of phosphorous is achieved comparing to the other processes owing to physical-chemical process.
- Operation of A2O has difficulty to maintain the balance of microbes for removing nitrogen and phosphorous at the same time.
- Phosphorous removed by biological process will be easily discharged again in anaerobic digestion.
- A2O has difficulty to satisfy effluent standard of nitrogen considering contribution of nitrogen from digestion process due to limitation of circulation ratio.
- Initial investment of SFDNP is the least owing to less hydraulic retention time comparing to A2O.
- SFDNP is the most economical in terms of Net Present Value

Special Notes on Facilities Planning:

It was presupposed that the facilities planning is carried out based on the consent of the Serbian side represented by LDA. Most of facilities planning was carried out in accordance with this presupposition, it was made known, however, that the consent regarding the sewage treatment process can be only given by the Revision Committee which includes the ministerial level based on documents prepared by consultants hired by Serbian authorities. Consequently it became difficult to obtain the consent to the facilities planning of the sewage treatment process within time frame of the Survey. Therefore, LDA and the JICA Study Team agreed to proceed to the subsequent works, such as the cost estimates, economic and financial analysis and project evaluation, with Study Team's conclusion (SFNDP), leaving the final consent to the Revision Committee to be organized in future as early as possible.

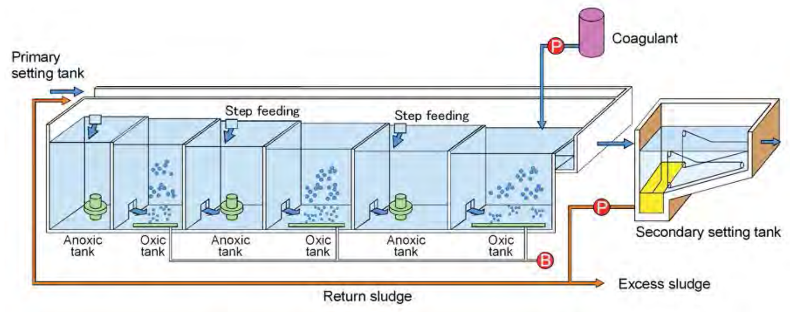
Table 6.16 Comparison of Sewage Treatment Processes

	Anaerobic Anoxic Oxic process (A2O)
Schematic flow of process	
Outline of process	Anaerobic anoxic oxic process (A2O) is the combined process of biological nitrogen removal and enhanced biological phosphorus removal. Nitrogen is removed by combined processes of nitrification and denitrification. Phosphorus is removed by luxury phosphorus uptake phenomenon of activated sludge microbes. Physical-chemical phosphorus removal process is also installed for backup of biological process.
Removal of Nitrogen	Increase of circulation ratio from oxic tanks to anoxic tanks improves the removal efficiency of nitrogen. However, increase of circulation ratio has limitation due to the running cost of circulation pumps. Approximately 65-75% of removal efficiency is expected.
Removal of Phosphorus	Biological process becomes frequently unstable on wet weather condition. Hence, dosing equipment of coagulant is installed for backup of biological process to ensure the stable removal of phosphorus. Approximately 70-80% of removal efficiency is expected.
Operation and maintenance	Operation of A2O requires proper control of circulation ratio of nitrified mixed liquor for keeping adequate removal efficiency of nitrogen and proper monitoring of ORP for adequate performance of biological phosphorus removal, respectively. Operation of A2O has difficulty to maintain the balance of microbes for removing nitrogen and phosphorous at the same time.
Monitoring items of operation	MLSS, solid retention time (SRT), circulation ratio, return sludge ratio, oxidation-reduction potential (ORP), sludge volume index (SVI), dissolved oxygen (DO) and excess sludge withdrawal
Advantage	Generation of excess sludge is less than the other processes owing to enhanced biological phosphorus removal and self-digestion of sludge by longer SRT. At the same time, chemical expense of coagulant is less comparing to SFDNP.
Disadvantage	Both anaerobic tanks and dosing equipment for phosphorus removal are required. Biological phosphorus removal frequently becomes unstable in wet weather condition. HRT of bioreactor is the most. Phosphorous removed by biological process will be easily discharged again in anaerobic digestion.

	Anaerobic Anoxic Oxic process (A2O)
Aeration requirement	Aeration is less compared to CAASP. Aeration is gradually decreased from the beginning to the end of oxic tanks to prevent excess aeration since the gradients of water qualities and reaction rate depending on the location in flow direction are inevitable.
Dosing of coagulant	A2O require dosing of coagulant only during biological phosphorous removal is unstable due to rainfall. Expense of coagulant for A2O is estimated based on number of heavy rainfall and added to operation cost.
Environmental and social consideration	Generation of excess sludge is less than the other processes. Energy consumption is high.
HRT	HRT of bioreactor: 21.3 hours
Outline of tanks	Anaerobic tank: 10 mW×9.7 mL×6 mD×48tanks Anoxic tank: 10 mW×68.0 mL×6 mD×48tanks Oxic tank: 10 mW×60.8 mL×6 mD×48tanks
Outline of equipment	Mixers for anaerobic and anoxic tanks Aeration equipment for oxic tanks Circulation pumps for circulating nitrified mixed liquor Blowers for supplying air to aeration system
Initial investment	Civil work: 44.23 Million Euro Equipment: 38.55 Million Euro Total: 82.78 Million Euro (122 %)
O&M cost	Electricity: 3.42 Million Euro/ year (Electricity: 42.7 MW/year, Unit price: 0.08 Euro/kW) Coagulant: 0.27 Million Euro/ year (Aluminum sulfate: 2,050 ton/year, Unit price: 132 Euro/ton) Maintenance: 0.46 Million Euro/ year Total: 4.15 Million Euro/ year (91 %)
Net present value	105.47 Million Euro (112 %)
Evaluation	B

Net present value: Discount rate = 10% / period = 30year

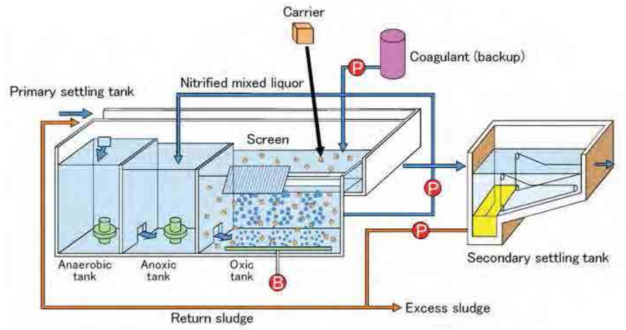
Table 6.16 Comparison of Sewage Treatment Processes

	Step feed type denitrification nitrification process (SFDNP)
Schematic flow of process	
Outline of process	Step feed type denitrification nitrification process with coagulant (SFDNP) is the combined process of biological nitrogen removal and physical-chemical phosphorus removal. SFDNP has been developed to improve the removal efficiency of nitrogen. In this process multistage, normally two or three stage, of anoxic tanks and oxic tanks are allocated in series.
Removal of Nitrogen	Equalization of organic loading and nitrogen loading against solid contents results in improvement of efficiency of nitrogen removal. Internal circulation of nitrified mixed liquor is not necessary. Approximately 75-85% of removal efficiency is expected.
Removal of Phosphorus	The removal efficiency of physical-chemical process by adding coagulant is more stable than biological process especially in wet weather condition when anaerobic condition is difficult to maintain. Approximately 70-80% of removal ratio is expected.
Operation and maintenance	Operation of SFDNP is relatively easy since equalization of pollutant loading against solids contents of each stage makes possible to operate all stages of tanks with the same operation conditions. Monitoring of circulation ratio of nitrified mixed liquor is not required, which makes operation of SFDNP easier while saving energy consumption. Monitoring of ORP is also not required.
Monitoring items of operation	MLSS, solid retention time (SRT), return sludge ratio, sludge volume index (SVI), dissolved oxygen (DO), step feeding of swage, dosing rate of coagulant and excess sludge withdrawal
Advantage	High removal efficiency of nitrogen is achieved without circulation of nitrified mixed liquor, which results in saving of energy. HRT of bioreactors is less compared to A2O owing to step feeding of sewage. Stable removal efficiency of phosphorous is achieved.
Disadvantage	Generation of excess sludge is more than A2O because of adding coagulant for phosphorus removal. At the same time, chemical expense of coagulant is constantly required.
Aeration requirement	Aeration is less compared to CAASP. Aeration requirement for each stage is the same due to equalization of pollutant loading. Control of aeration is easy since adjustment of air flow depending on the location in flow direction is not necessary.

	Step feed type denitrification nitrification process (SFDNP)
Dosing of coagulant	SFDNP requires continuous dosing of coagulant for phosphorus removal. Hence, expense of coagulant for SFDNP is estimated based on continuous dosing and added to operation cost.
Environmental and social consideration	Generation of excess sludge is more than A2O. Energy consumption is less than the others.
HRT	HRT of bioreactor: 17.8 hours
Outline of tanks	1st stage : Anoxic / Oxic tank: 10mW×13.7mL×6mD×48tanks 2nd stage : Anoxic / Oxic tank: 10mW×19.2mL×6mD×48tanks 3rd stage: Anoxic / Oxic tank: 10mW×25.7mL×6mD×48tanks
Outline of equipment	Mixers for anoxic tanks Aeration equipment for oxic tanks Blowers for supplying air to aeration system
Initial investment	Civil work: 37.02 Million Euro Equipment: 31.10 Million Euro Total: 68.12 Million Euro (100 %)
O&M cost	Electricity: 2.62 Million Euro/ year (Electricity: 32.7 MW/year, Unit price: 0.08 Euro/kW) Coagulant: 1.57 Million Euro/ year (Aluminum sulfate: 11,900 ton/year, Unit price: 132 Euro/ton) Maintenance: 0.37 Million Euro/ year Total: 4.56 Million Euro/ year (100 %)
Net present value	94.53 Million Euro (100 %)
Evaluation	A

Net present value: Discount rate = 10% / period = 30year

Table 6.16 Comparison of Sewage Treatment Processes

	Carrier added activated sludge process (CAASP)
Schematic flow of process	
Outline of process	Carrier added activated sludge process (CAASP) enables to increase concentration of microbe in bioreactors tanks by adding carriers which contains microbes. Stable nitrification is achieved owing to nitrifying bacteria contained in carriers. Phosphorous is removed by applying enhanced biological removal process which removes phosphorus by luxury uptake phenomenon of activated sludge microbes.
Removal of Nitrogen	Stable performance and efficiency of nitrogen removal is expected under the adverse conditions such as wet weather condition owing to the nitrifying bacteria contained in the carriers. Approximately 65-75% of removal efficiency is expected.
Removal of Phosphorus	Biological process becomes frequently unstable on rainy day. Hence, dosing equipment of coagulant is installed for backup of biological process to ensure the stable removal of phosphorus. Approximately 70-80% of removal ratio is expected.
Operation and maintenance	CAASP has high flexibility to fluctuation of pollutant loading since carriers are retained in the bioreactors and microbe can be kept always for removal of pollutant loading. Periodical inspection of wear-out of the carriers is required. If required, supplementary carrier is added to the bioreactors. Inspection of inlet screens, which removes screenings, and outlet screens, which prevent carriers from outflow, is required.
Monitoring items of operation	MLSS, solid retention time (SRT), circulation ratio, return sludge ratio, oxidation-reduction potential (ORP), sludge volume index (SVI), dissolved oxygen (DO) and excess sludge withdrawal
Advantage	Stable performance of purification of organic substances and nitrification is achieved owing to nitrifying bacteria and microbe contained in the carriers. HRT of bioreactors is the least. Chemical expense of coagulant is less comparing to SFDNP.
Disadvantage	Generation of excess sludge is more than A2O because self-digestion of sludge is less because of shorter SRT. Wastage of carriers is required to be carefully monitored. Phosphorous removed by biological process will be easily discharged again in anaerobic digestion. Inspections of inlet screens and outlet screens are required.
Aeration requirement	Carrier need to float in order to efficiently contact with pollutant loading. Additional aeration is required for floating and diffusing the carriers, which results in higher energy consumption. Aeration is more than the other processes.

	Carrier added activated sludge process (CAASP)
Dosing of coagulant	CAASP require dosing of coagulant only during biological phosphorous removal is unstable due to rainfall. Expense of coagulant for CAASP is estimated based on number of heavy rainfall and added to operation cost.
Environmental and social consideration	Generation of excess sludge is more than A2O. Energy consumption is high.
HRT	HRT of bioreactor: 8.1 hours
Outline of tanks	Anaerobic tank: 10mW×9.7mL×6mD×48tanks Anoxic tank: 10mW×22.5mL×6mD×48tanks Oxic tank: 10mW×19.5mL×6mD×48tanks
Outline of equipment	Mixers for anaerobic and anoxic tanks Aeration equipment for oxic tanks Circulation pumps for circulating nitrified mixed liquor Blowers for supplying air to aeration system Inlet screens for removing screenings Outlet screens for preventing carriers from outflow
Initial investment	Civil work: 17.50 Million Euro Equipment: 119.21 Million Euro Total: 136.71 Million Baht (201 %)
O&M cost	Electricity: 3.28 Million Euro/ year (Electricity: 41.0 MW/year, Unit price: 0.08 Euro/kW) Coagulant: 0.27 Million Euro/ year (Aluminum sulfate: 2,050 ton/year, Unit price: 132 Euro/ton) Maintenance: 1.17 Million Euro/ year Total: 4.72 Million Euro/ year (104 %)
Net present value	159.51 Million Euro (169 %)
Evaluation	C

Net present value: Discount rate = 10% / period = 30year

6.2.7 Cost Analysis

Initial investment of alternatives is analyzed as shown in Figure 6.10. Initial investment of SFDNP is the lowest among alternatives owing to less hydraulic retention time comparing to A2O. Initial investment of CAASP is the highest since cost of carrier and equipment for carrier is rather expensive.

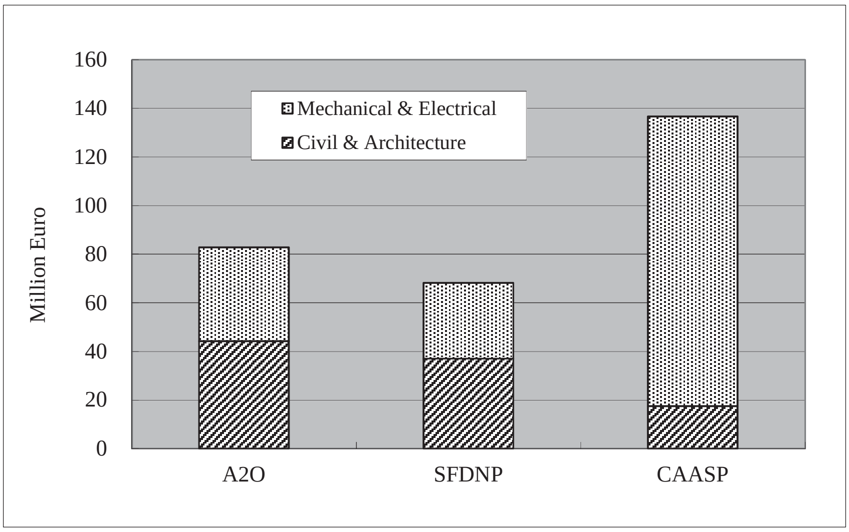


Figure 6.10 Initial Investment

O&M cost of alternatives is analyzed as shown in Figure 6.11. Electricity expense of SFDNP is the lowest since SFDNP does not require circulation of nitrified mixed liquor. However, SFDNP requires more chemical expense than the other processes for phosphorous removal.

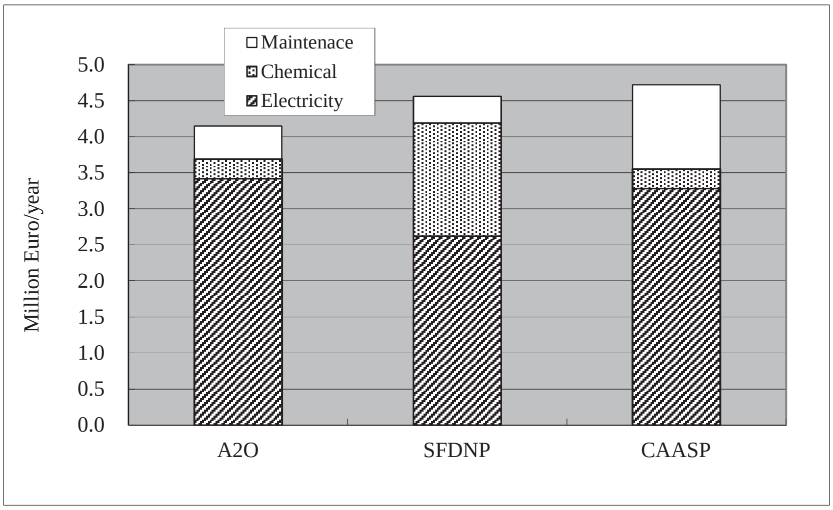


Figure 6.11 O&M Cost

Net present value of alternatives is calculated to compare financial advantage for long time of period considering the initial investment, O&M cost and major replacement cost. Net present value of alternatives is analyzed as shown in Figure 6.12. SFDNP is the most economical in terms of net present value.

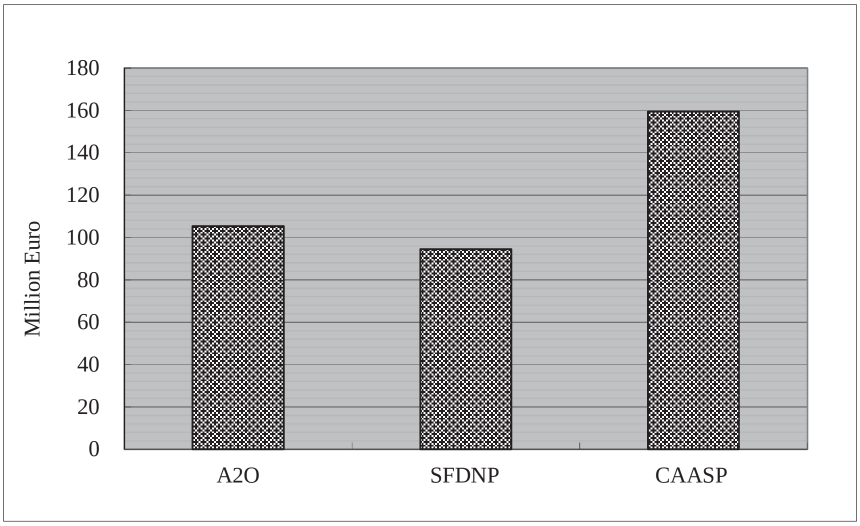


Figure 6.12 Net Present Value

6.2.8 Performance Analysis

(1) Comparison of Removal Efficiency

The performance analysis of SFDNP and A2O is conducted since there is no significant difference in the cost analysis among these processes. The performances of these processes are evaluated by analyzing the records of actual operation of WWTPs which operate these processes in Japan.

There are 51 WWTPs which operate SFDNP and 63 WWTPs which operate A2O in Japan. Names of these WWTPs with the design capacities and annual average values of water qualities of these WWTPs are summarized in Appendix.

Average values of effluent qualities of these WWTPs for each quality item are calculated as shown in Table 6.17.

Table 6.17 Average Values of Effluent Qualities

Item	BOD_5	COD_{Mn}	SS	TN	TP
SFDNP	2.5 mg/l	7.7 mg/l	1.8 mg/l	6.9 mg/l	0.6 mg/l
A2O	2.3 mg/l	8.2 mg/l	1.5 mg/l	9.3 mg/l	0.7 mg/l

Cumulative distribution curves of these WWTPs for each quality item is calculated to compare the performances of these processes and shown in Figure 6.13, Figure 6.14, Figure 6.15, Figure 6.16 and Figure 6.17, respectively.

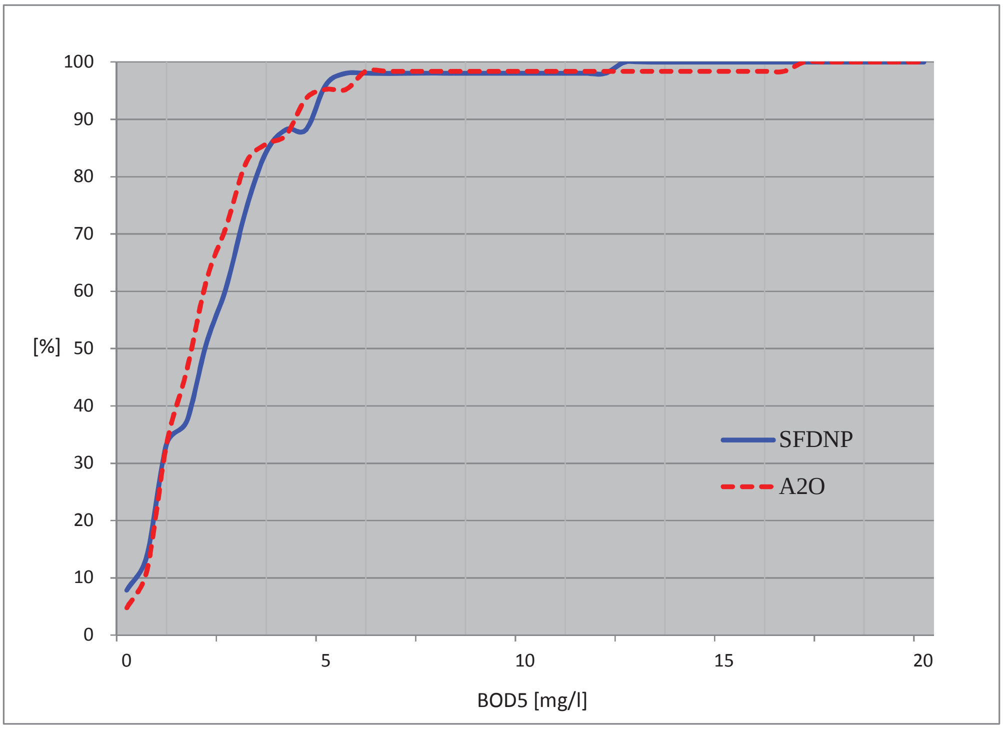


Figure 6.13 Cumulative Distribution Curve of BOD_5

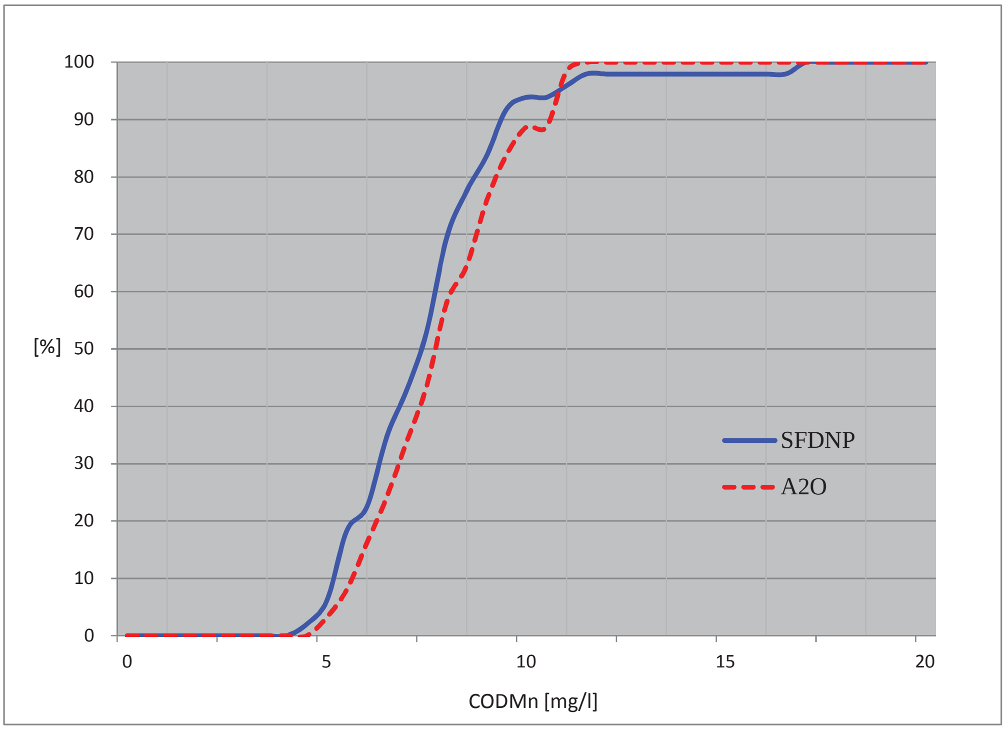


Figure 6.14 Cumulative Distribution Curve of COD_{Mn}

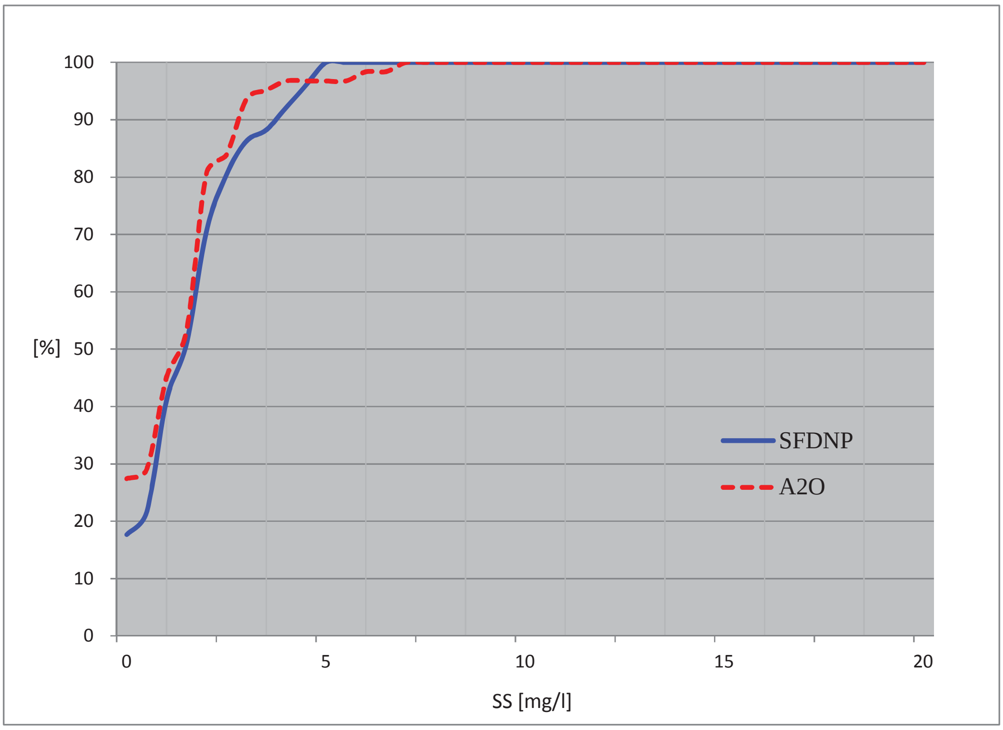


Figure 6.15 Cumulative Distribution Curve of SS

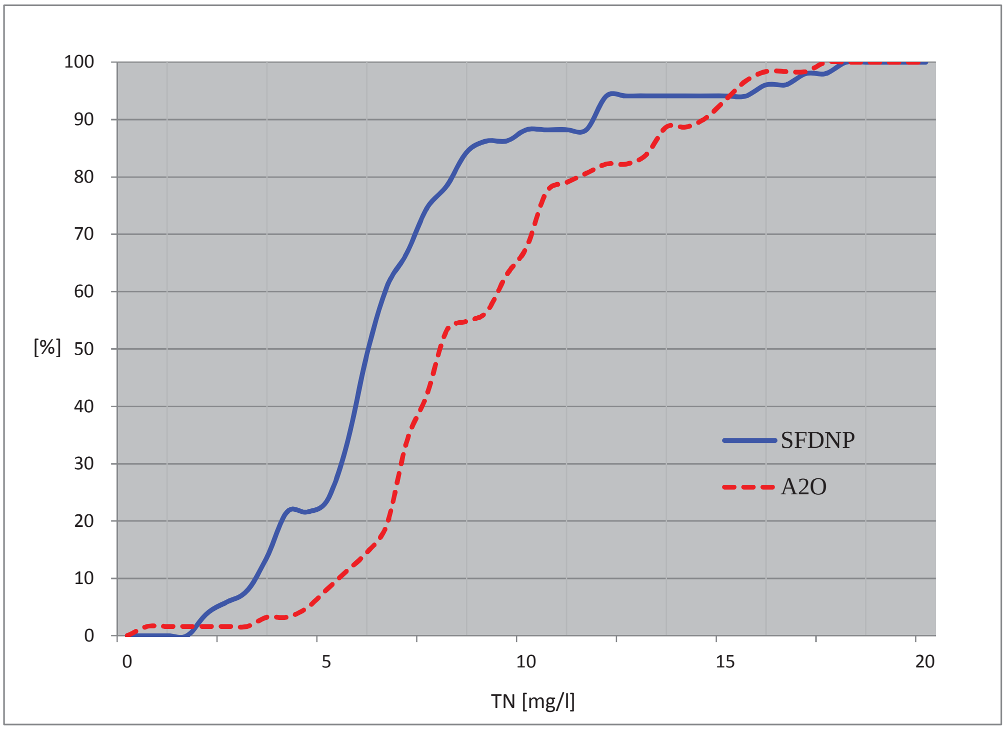


Figure 6.16 Cumulative Distribution Curve of TN

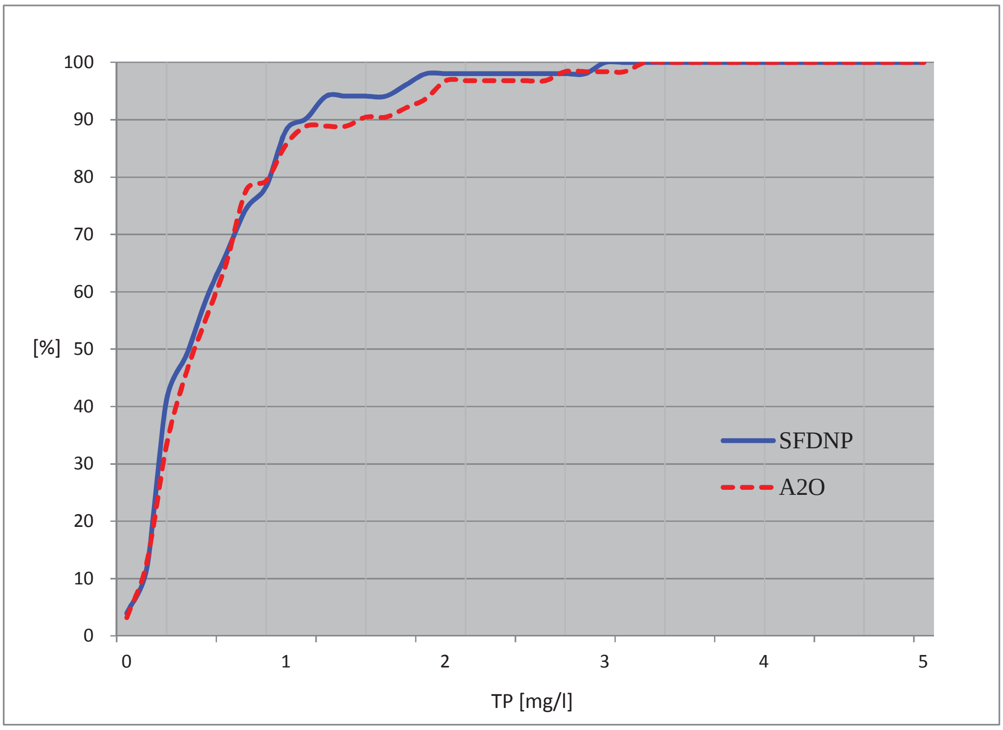


Figure 6.17 Cumulative Distribution Curve of TP

The performances of these processes are compared by calculating removal efficiencies of quality items based on influent and effluent qualities of these WWTPs. The removal efficiencies of each process are summarized in Table 6.18. Fluctuations of the removal efficiencies depending on WWTPs for each process are shown in Figure 6.18 and Figure 6.19, respectively.

Table 6.18 Removal Efficiencies of Processes

		BOD_5	COD_{Mn}	SS	TN	TP
SFDNP	Average	98.4 %	91.3 %	98.6 %	76.4 %	83.6 %
	Minimum	92.4 %	78.9 %	94.1 %	32.0 %	45.5 %
	Maximum	100 %	96.1 %	100 %	95.1 %	100 %
A2O	Average	98.6 %	90.9 %	99.0 %	70.4 %	82.8 %
	Minimum	91.0 %	78.6 %	96.2 %	39.4 %	21.4 %
	Maximum	100 %	96.0 %	100 %	98.7 %	100 %

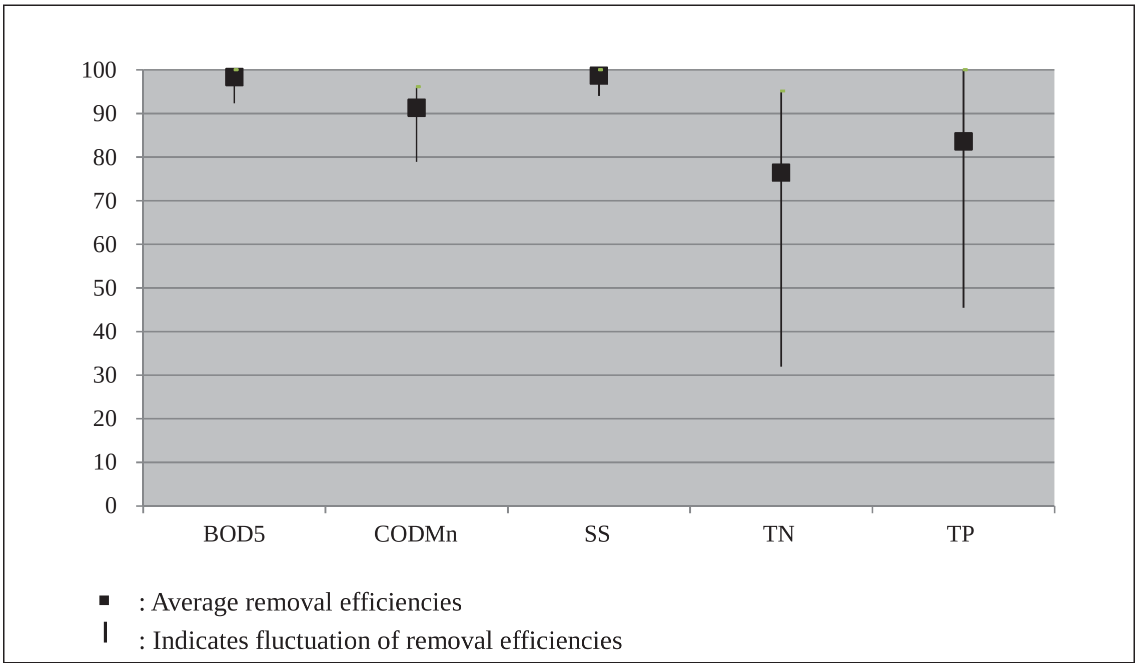


Figure 6.18 Removal Efficiencies of SFDNP

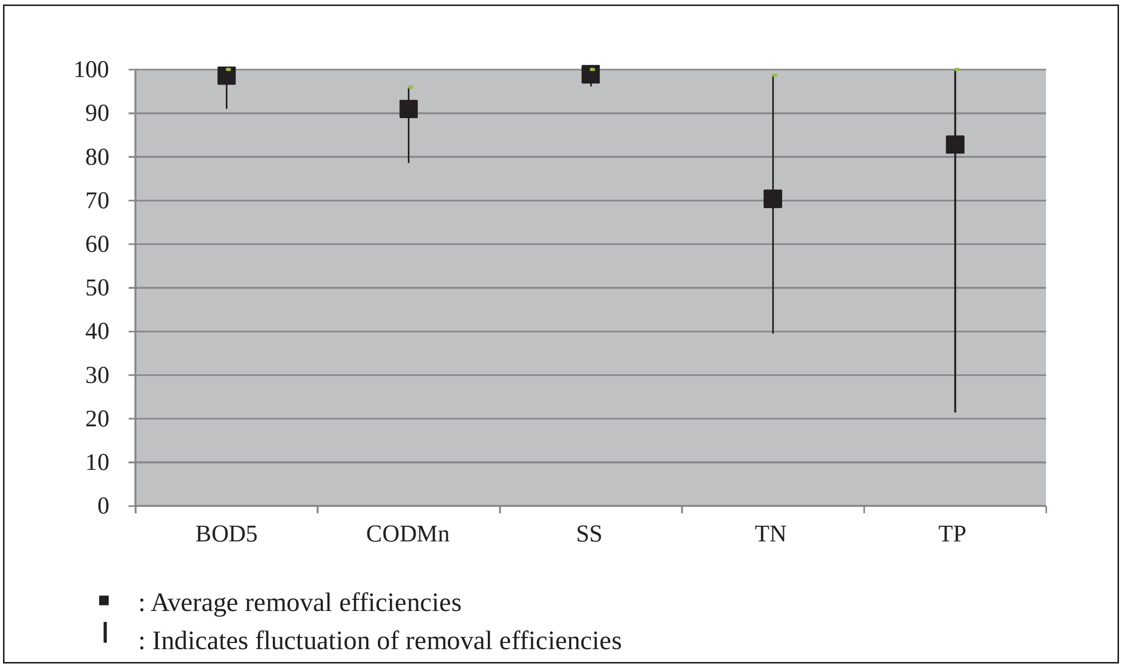


Figure 6.19 Removal Efficiencies of A2O

The followings are evaluated from the results of the performance analysis of operation experiences of SFDNP and A2O.

- It is evaluated that both processes can satisfy the effluent standards
- Performances of removal of organic substances and solid contents have no significant differences
- Average removal efficiency of nitrogen of SFDNP is approximately 6% higher than A2O
- Average removal efficiencies of phosphorous of both processes are comparable

Nitrogen removal efficiency of SFDNP is higher than A2O since SFDNP has been developed aiming to the improvement of nitrogen removal efficiency. On the other hand, phosphorous removal efficiencies have no significant differences. Biological phosphorous removal process of A2O is generally unstable comparing to physical-chemical phosphorus removal process of SFDNP. However, the WWTPs of A2O have coagulant dosing equipment for the backup of biological process in general. Hence, it is supposed that the removal efficiencies of phosphorous have no significant difference owing to the backup.

(2) Influence of Water Temperature

Veliko Selo WWTP requires removal of nitrogen. Both SFDNP and A2O remove nitrogen by biological process which combines the process of nitrification and denitrification.

Bacteria used in wastewater treatment are categorized into heterotrophs and autotrophs. Heterotrophs are majority of bacteria used in wastewater treatment. Heterotrophs consume organic carbon, not inorganic carbon. On the other hand, autotrophs consume inorganic substances and utilize those for organic synthesis. Nitrifying bacteria which oxidizes ammonia nitrogen belongs to autotrophs. The variety of autotrophs is not so much and growth rate of autotrophs is slow.

The growth rate of nitrifying bacteria such as Nitrosomonas and Nitrospira is considerably slow comparing to heterotrophs which remove BOD loading. Activeness of nitrifying bacteria is critically affected by water temperature. The suitable temperature is around 35 degree Celsius and activeness rapidly decelerates under 15 degree Celsius.

Monthly average of sewage temperature from 2007 to 2011 at Istovori monitoring point, i.e. the largest discharge point of raw sewage, is shown in Table 6.19.

Table 6.19 Sewage Temperature at Istovori Monitoring Point

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
11.3	10.2	14.6	16.7	20.8	24.1	22.8	23.9	19.5	16.2	15.7	11.9

Considering the records of the monitoring points, the lowest temperature of receiving sewage to Veliko Selo WWTP is expected to be around 10 degree Celsius in winter. Hence, the volume of bioreactor is required to be considerably bigger since longer SRT is necessary for maintaining nitrifying bacteria.

(3) Influence of Rainfall

A2O removes phosphorus by enhanced biological removal process. Removal efficacy of phosphorus often deteriorates in rainy day. The main reasons are dissolved oxygen brought by rainfall and lowering of organic concentration. These results in preventing discharge of phosphorous in the anaerobic tank and luxury phosphorus uptake in the following aerobic tank.

(4) Re-elution of Phosphorous

Phosphorous cannot be released as phosphorous gas like nitrogen under the operating conditions of sewage treatment and sludge treatment. Hence, phosphorous which inflows to WWTPs is discharged as effluent and sludge cake.

Anaerobic digestion is adopted for the sludge treatment process of Veliko Selo WWTP aiming stabilization of sludge, reduction of sludge amount and utilization of biomass energy. Phosphorous taken by activated sludge microbes is easily re-discharged under anaerobic condition of anaerobic digestion.

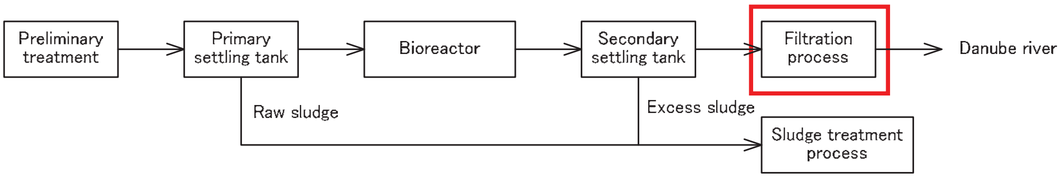
SFDNP removes phosphorous by physical-chemical removal process. Hence, re-elution of phosphorous will not happen since phosphorous is stabilized by coagulant. On the other hands, A2O removes phosphorous by enhanced biological removal process. Re-elution of phosphorous is inevitable in anaerobic digestion. Hence, there is concern that phosphorous is accumulated in the WWTPs since phosphorous removed in sewage treatment process is re-eluted in sludge treatment process.

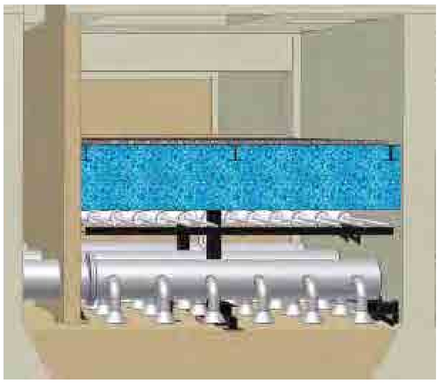
6.2.9 Alternatives of Filtration Process

As for Pre-F/S with M/P, sand filtration is adopted for tertiary sewage treatment process of Veliko Selo WWTP. There are newly developed filtration technologies which have equivalent performance with high speed filtration rate. Newly developed filtration processes, which can be potential alternatives for Veliko Selo WWTP, are listed below together with the convention process of sand filtration. Brief explanations of newly developed technologies are shown in Table 6.20.

- Sand filtration
- Fiber filtration
- Disc filter

Table 6.20 Explanation of Newly Developed Technologies

<table>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">

Filtration process treats effluent from secondary settling tanks. Filtration process removes mainly suspended solids before discharging final effluent to the receiving water body.</td></tr>
<tr><td>Fiber filtration</td><td>Fiber filtration is the technology to remove pollutant loading by filtering secondary effluent with filter of fiber media in upward direction. Space saving is achieved owing to high filtration rate comparing to the conventional process of sand filter. Removal ratio of SS and BOD is expected to be approximately 70% and 30%, respectively, in non-chemical adding condition.</td><td></td></tr>
<tr><td>Disc filter</td><td>Disc filter is the technology to remove pollutant loading contained in secondary effluent such as SS and BOD by filtration through the filters with fine slits. Disc filter has advantage which requires little head owing to less hydraulic loss compared to the conventional sand filtration. Removal ratio of SS and BOD is expected to be approximately 60% and 40%, respectively, in non-chemical adding condition.</td><td></td></tr>
<tr><td>Application in EU counties</td><td colspan="2">There are manufacturers that produce disc filters in EU countries. On the other hand, there is no technology similar to fiber filtration, which is applicable to treatment of communal sewage, in EU countries. Principles of technologies used in disc filters between European products and Japanese products are basically the same. Regarding accessories such as covers and washing pumps of filters, modification is made according to the manufactures. Sand filtration is the conventional process for filtration process in EU countries. Recently, application of disc filter is increasing to polish secondary effluent prior to discharging final effluent to the receiving water bodies as application in Japan increases.</td></tr>
</table>

6.2.10 Comparison of Alternatives

Basic planning of wastewater treatment facilities is prepared for each alternative to compare financial aspects including the initial investment, O&M cost and major replacement cost. Environmental and social aspects are also considered, however there is no significant differences among the alternatives.

Comparisons of alternatives are summarized in Table 6.21. As a result of comparison, disc filter is recommended due to the following advantages.

- Intermediate pumps can be omitted due to low head loss required for filtration and power consumption is less comparing to the other filtration.
- Initial investment in case of disc filter is the least since disc filter can be installed in the channel and does not required major concrete structures.
- Stage development of tertiary treatment is easy since the prior investment for channels in which disc filter will be installed is minor.
- Disc filter is the most economical in terms of Net Present Value.

Table 6.21 Comparison of Filtration

	Sand Filtration
Explanation of filtration process	Sand filter is comprised of sand media, catchment system, troughs, valves and gates in the tanks made of reinforced concrete. Blowers, back wash pumps and drainage pumps are required for flushing of sand filters.
Treatment process	Sand filtration removes pollutant loading by filtering secondary effluent with filter of sand and gravel usually in downward direction. Sand filter requires larger space due to relatively lower filtration rate.
Removal efficiency of pollutant loading	SS: Approximately 70% BOD: Approximately 30%
Operation and maintenance	Flushing of sand filter can affect effluent quality from sand filter. Hence, effectiveness and interval of flushing and hydraulic loss of filters is required to be monitored to maintain proper performance of filtration. Addition of sand media may be required due to outflow of sand media caused by flushing.
Environmental and social consideration	Energy consumption is high.
Filtration rate	300 m/day
Required head	4.0 m
Filtration	Downward
Flushing method	Aeration and back wash
Washing water	4 % (filtered water)
Flow of back wash	Approximately 0.8 m^3/min m^2
Flow of aeration	Approximately 1.2 m^3/min m^2
Flushing frequency	Once per day
Flushing time	Approximately 10-15 minutes
Thickness of filter media	0.8 m
Filtration facility	Filtration tank: Area 72 m^2 x 24 tanks
Intermediate pump	92 m^3/min x 7 nos. (1 standby)
Initial investment	20.85 Million Euro (150 %)
O&M cost	Electricity: 0.42 Million Euro/year Maintenance: 0.12 Million Euro/year Total: 0.54 Million Euro/year (123 %)
Net present value	22.87 Million Euro (134 %)
Evaluation	B

Net present value: Discount rate = 10% / period = 30year

Table 6.21 Comparison of Filtration

	Fiber Filtration
Explanation of filtration process	Fiber filter is comprised of fiber media, catchment system, troughs, valves and gates in the tanks made of reinforced concrete. Blowers, drainage pumps and mixers are required for flushing of fiber filters.
Treatment process	Fiber filtration removes pollutant loading by filtering secondary effluent with filter of fiber media in upward direction. Space saving is achieved owing to high filtration rate comparing to the conventional sand filter.
Removal efficiency of pollutant loading	SS: Approximately 70% BOD: Approximately 30%
Operation and maintenance	Flushing of fiber filter can affect effluent quality from fiber filter similar to sand filter. Hence, effectiveness and interval of flushing and hydraulic loss of filters is required to be monitored to maintain proper performance of filtration. Wear-out and degradation is required to be checked annually.
Environmental and social consideration	Energy consumption is high.
Filtration rate	1,000 m/day
Required head	4.0 m
Filtration	Upward
Flushing method	Mechanical mixing, aeration and back wash
Washing water	1 % (secondary treated water)
Flow of back wash	Approximately 0.5 m^3/min m^2
Flow of aeration	Approximately 0.3 m^3/min m^2
Flushing frequency	Once per day
Flushing time	Approximately 12 minutes
Thickness of filter media	1.5 m
Filtration facility	Filtration tank: Area 66 m^2 x 8 tanks
Intermediate pump	92 m^3/min x 7 nos. (1 standby)
Initial investment	22.05 Million Euro (159 %)
O&M cost	Electricity: 0.35 Million Euro/year Maintenance: 0.12 Million Euro/year Total: 0.47 Million Euro/year (107 %)
Net present value	22.95 Million Euro (134 %)
Evaluation	B

Net present value: Discount rate = 10% / period = 30year

Table 6.21 Comparison of Filtration

	Disc Filter
Explanation of filtration process	Disc filter is comprised of center drum, discs with filter segments, frames, washing device and driving unit. Disc filter is installed in the channels made of reinforced concrete.
Treatment process	Disc filter removes pollutant loading such as SS and BOD by filtration through the filters with fine slits. Disc filter has advantage which requires little head owing to less hydraulic loss.
Removal efficiency of pollutant loading	SS: Approximately 60% BOD: Approximately 40%
Operation and maintenance	Condition of filter can affect effluent quality from disc filter. Hence, clogging and damage of filter is required to be checked regularly to maintain proper performance of filtration. Spray nozzles and washing pumps are also regularly inspected in order to keep proper cleaning efficiency of filters.
Environmental and social consideration	Energy consumption is less than the others.
Filtration rate	500 m/day
Required head	0.5 m
Filtration	Horizontal
Flushing method	Spray
Washing water	6 % (filtered water)
Flow of back wash	-
Flow of aeration	-
Flushing frequency	Half of operation time
Flushing time	-
Thickness of filter media	-
Filtration facility	Disc filter: 16 nos. (2 standby)
Intermediate pump	Not required
Initial investment	13.90 Million Euro (100 %)
O&M cost	Electricity: 0.20 Million Euro/year Maintenance: 0.24 Million Euro/year Total: 0.44 Million Euro/year (100 %)
Net present value	17.11 Million Euro (100 %)
Evaluation	A

Net present value: Discount rate = 10% / period = 30year

6.2.11 Cost Analysis

Initial investment of alternatives is analyzed as shown in Figure 6.20. Initial investment of disc filter is the lowest among alternatives since disc filter can be installed in the channels while sand and fiber filtration require major concrete tanks and omit intermediate pump facility.

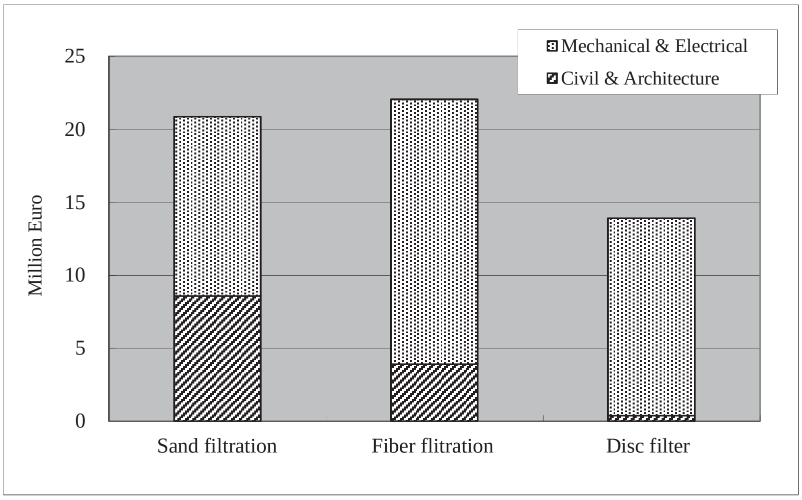


Figure 6.20 Initial Investment

O&M cost of alternatives is analyzed as shown in Figure 6.21. Electricity expense of disc filter is the lowest since disc filter can save power consumption of the intermediate pumps. Disc filter requires maintenance expense for replacing filters. Total O&M cost of disc filter is still the lowest and it is possible to save maintenance expense conducting high pressure cleaning of the filter by the operators.

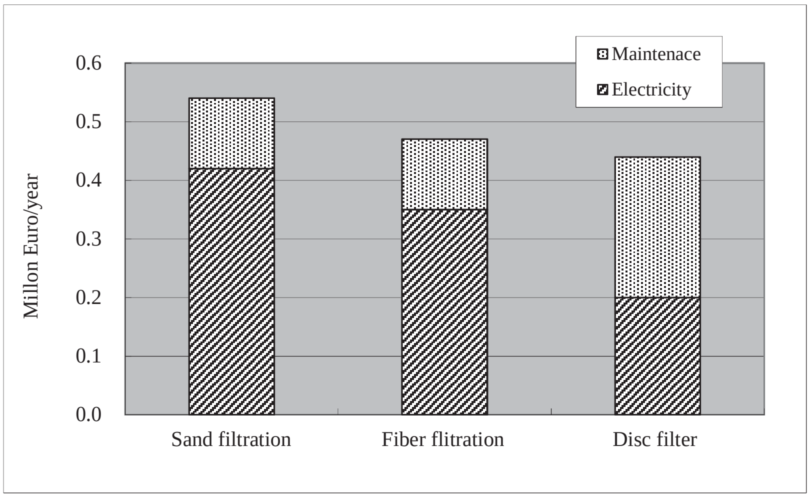


Figure 6.21 O&M Cost

Net present value of alternatives is analyzed as shown in Figure 6.22. Disc filter is the most economical in terms of net present value.

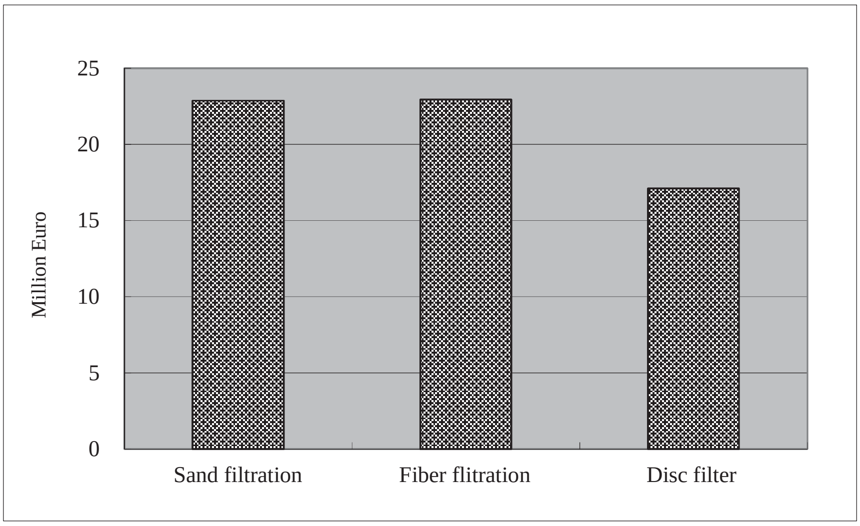


Figure 6.22 Net Present Value

6.2.12 Alternatives of Aeration Equipment

Removal of pollutant load in activated sludge process is carried out by the action of microbes those are present in activated sludge. Activated sludge removes pollutant load by absorption, ingestion, oxidization and elaboration in the presence of appropriate amount of oxygen. Therefore, aeration equipment that supplies oxygen to activated sludge and mixes sewage and activated sludge, is vital for sewage treatment.

In diffuser method, airlift function is used by injecting air supplied from blowers in shape of bubbles into sewage in order to supply oxygen and mixing at the same time. In mechanical mixing method, breaking up function and mixing function is used by rotating blades with supplying air from blowers in order to supply oxygen and mixing at the same time.

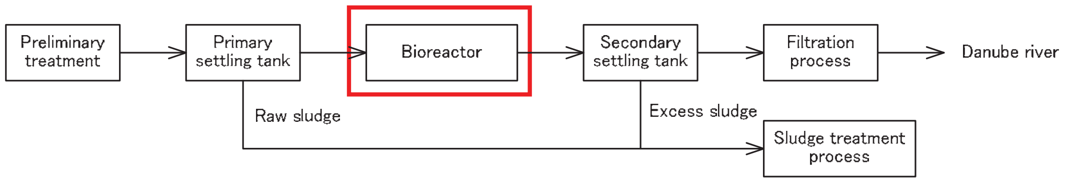
Aeration equipment consumes significant portion, usually 30-60%, of total electricity used in sewage treatment. In addition, its role is vital in activated sludge process. Therefore, aeration method should be selected considering all factors regarding the efficiency of dissolving oxygen, economical aspect, operation and maintenance, etc.

As for Pre-F/S with M/P, fine bubble diffuser is adopted for aeration of Veliko Selo WWTP. There are newly developed technologies which has higher efficiency than the conventional technologies. Newly developed aeration devices, which can be potential alternatives for Veliko Selo WWTP, are listed below together with the conventional method of fine bubble diffuser.

Brief explanations of newly developed technologies are shown in Table 6.22.

- Fine bubble diffuser
- Ultrafine bubble diffuser
- Submersible aeration devices

Table 6.22 Explanation of Newly Developed Technologies

<table>
<tr><th colspan="3">Explanation</th></tr>
<tr><td colspan="3">

Aeration equipment is installed in bioreactors. Aeration equipment supplies oxygen which is required by activated sludge to remove pollutant load and mixes sewage and activated sludge.</td></tr>
<tr><td>Ultrafine bubble diffuser</td><td>Ultrafine bubble diffuser is the latest energy saving technology. This diffuser has high oxygen transfer efficiency owing to producing ultrafine bubbles which are smaller than fine bubbles produced from the conventional diffusers by membranes with fine slips.</td><td></td></tr>
<tr><td>Submersible aeration devices</td><td>Submersible aeration device can produce fine bubbles by mechanically mixing air supplied from the blowers with impellers. This device can be operated as a mixer by stopping air supply, which makes it possible to operate as both aerobic and anaerobic conditions.</td><td></td></tr>
<tr><td>Application in EU counties</td><td colspan="2">There are manufacturers to produce ultrafine bubble diffusers in EU countries. Application of ultrafine bubble diffusers are encouraged also in EU countries in order to save energy consumption. Quality of European products and Japanese products are equivalent regarding oxygen transfer efficiency. However, there is difference between European products and Japanese products regarding grade of materials. European products generally use resinous materials for baseplates of membrane in order to reduce the price. On the other hand, Japanese products use high quality materials such as stainless steel for baseplates of membrane to extend life time of the products and make the products physically strong.</td></tr>
</table>

6.2.13 Comparisons of Aeration Equipment

Comparisons of alternatives are summarized in Table 6.23. Environmental and social aspects are also considered, however there is no significant differences among the alternatives. As a result of comparison, ultrafine bubble diffuser device is recommended due to the following advantages.

- It is most effective in terms of energy saving due to its high efficiency of dissolving oxygen.
- It can be utilized for relatively longer time due to its non-clogging feature by adequate operation.
- It has high level of flexibility for various operations due to its feature of wide operational range of air flow.
- It is the most economical in terms of life cycle cost since it requires the lowest O&M cost due to its high efficiency.

Table 6.23 Comparison of Aeration Equipment

	Fine bubble diffuser
Explanation of equipment	Fine bubble diffuser is comprised of diffusers made of ceramic or synthetic resin and holders made of stainless or synthetic resin. This diffuser produces fine bubbles from small opening on diffusers.
Efficiency	Oxygen transfer efficiency is generally 20-32%. The diffusers do not consume electricity. Hence, total energy consumption is less than submersible aeration devices.
Operation	Adjustable range of air flow amount is relatively narrow because of limitation on the minimum flow. The minimum flow is required to be maintained in order to avoid clogging of diffusers.
Maintenance	Fine bubble diffuser requires periodical replacement of diffusers within 5-10 years due to clogging of diffusers caused by aged deterioration. Efficiency decreases due to clogging without replacement.
Intermittent operation	Intermittent aeration is impossible since invasion of sewage occurs and results in clogging without air supply. It is required to remove diffusers from sewage for suspension of operation.
Air flow resistance	Less than 2.4 kPa (Increase of 0.3-0.8kPa/year is expected due to aging)
Aeration requirement	2,245 m^3/min (152 %)
Environmental and social consideration	Emission of greenhouse gas is more than ultrafine bubble diffuser because of less efficiency.
Outlines of equipment	Fine bubble diffuser 1 set x 12 tanks Turbo blower: 410 m^3/min x 64 kPa x 580 kW x 8 nos. (2 standby)
Initial investment	Aeration equipment: 10.48 Million Euro Blower: 4.21 Million Euro Electrical cost: 1.68 Million Euro Total: 16.38 Million Euro (94 %)
O&M cost	Electricity: 2.10 Million Euro/ year Maintenance: 0.26 Million Euro/ year Total: 2.36 Million Euro/ year (131 %)
Net present value	42.07 Million Euro (111 %)
Evaluation	B

Net present value: Discount rate = 10% / period = 30year

Table 6.23 Comparison of Aeration Equipment

	Ultrafine bubble diffuser
Explanation of equipment	Ultrafine bubble diffuser is comprised of membranes, baseplates, fixing frames and air supply opening. This diffuser produces ultrafine bubbles from fine slips by supplying air between membranes and baseplates.
Efficiency	Oxygen transfer efficiency is generally 28-35%. The diffusers do not consume electricity. Hence, total energy consumption is the least and its energy saving effect is considerable.
Operation	Adjustment range of air flow amount is wider compared to conventional fine bubble diffuser since invention of sewage is prevented due to higher internal pressure of diffusers.
Maintenance	Ultrafine bubble diffuser does not require periodical replacement of diffusers by conducting appropriate operation due to its non-clogging feature.
Intermittent operation	Intermittent aeration and suspension of operation is possible since the invention of sewage is prevented by closing slips. Membranes cohere to baseplates by water pressure when air supply is stopped.
Air flow resistance	Less than 11 kPa (Increase of resistance is not expected due to aging)
Aeration requirement	1,473 m^3/min (100 %)
Environmental and social consideration	Emission of greenhouse gas is the least since energy consumption is the least owing to high oxygen transfer efficiency.
Outlines of equipment	Ultrafine bubble diffuser 1 set x 12 tanks Turbo blower: 270 m^3/min x 70 kPa x 420 kW x 8 nos. (2 standby)
Initial investment	Aeration equipment: 12.10 Million Euro Blower: 3.78 Million Euro Electrical cost: 1.51 Million Euro Total: 17.39 Million Euro (100 %)
O&M cost	Electricity: 1.52 Million Euro/ year Maintenance: 0.28 Million Euro/ year Total: 1.80 Million Euro/ year (100 %)
Net present value	38.03 Million Euro (100 %)
Evaluation	A

Net present value: Discount rate = 10% / period = 30year

Table 6.23 Comparison of Aeration Equipment

	Submersible aeration device
Explanation of equipment	Submersible aeration device is comprised of motors, reduction gears, impellers and casings. This device produces fine bubbles by mechanically mixing air supplied from the blowers with impellers.
Efficiency	Oxygen transfer efficiency is generally 20-30%. Submersible aeration device also consumes electricity. Considering power consumption of aeration devices, energy saving effect is not so expected.
Operation	There is no limitation on air flow amount. Hence, widest range of adjustment of air flow amount is possible. Adjustment by speed of rotating impellers is also possible adopting VVVF control.
Maintenance	Submersible aeration device requires periodical overhaul of reduction gears, greasing of submerged aerator/rotating impellers and replacement of spare parts such as mechanical seals.
Intermittent operation	Intermittent aeration and suspension of operation is possible since there is no limitation on air supply. This device is also capable of mixing operation without air supply.
Air flow resistance	Less than 1.0 kPa (Increase of resistance is not expected due to aging)
Aeration requirement	2,100 m^3/min (143 %)
Environmental and social consideration	Emission of greenhouse gas is the most since total energy consumption including blowers and aeration devices is the most.
Outlines of equipment	Submersible aeration device: 15 kW x 120 nos. Turbo blower: 385 m^3/min x 58 kPa x 490 kW x 8 nos. (2 standby)
Initial investment	Aeration equipment: 7.57 Million Euro Blower: 4.10 Million Euro Electrical cost: 4.67 Million Euro Total: 16.34 Million Euro (94 %)
O&M cost	Electricity: 2.86 Million Euro/ year Maintenance: 0.26 Million Euro/ year Total: 3.12 Million Euro/ year (174 %)
Net present value	49.14 Million Euro (129 %)
Evaluation	C

Net present value: Discount rate = 10% / period = 30year

6.2.14 Cost Analysis

Initial investment of alternatives is analyzed as shown in Figure 6.23. Initial investment of ultrafine bubble diffuser is slightly higher than the other alternatives.

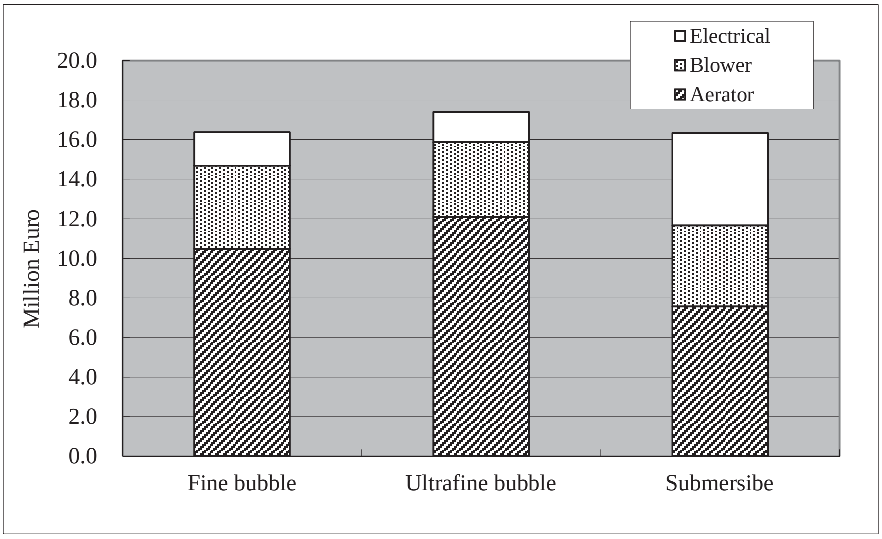


Figure 6.23 Initial Investment

O&M cost of alternatives is analyzed as shown in Figure 6.24. Electricity expense of ultrafine bubble diffuser is the lowest owing to the highest efficiency of oxygen transfer. The difference of the initial investment among fine bubble diffuser is recovered within only two years of operation by saving electricity expense.

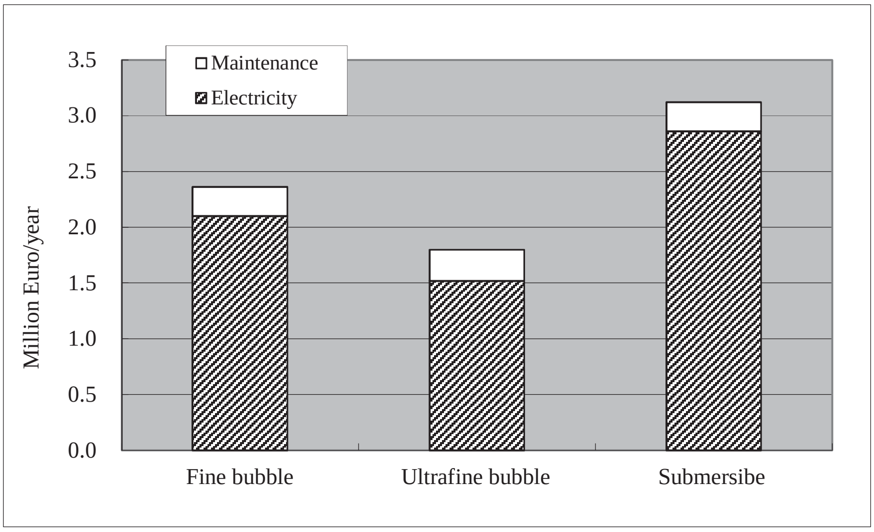


Figure 6.24 O&M Cost

Net present value of alternatives is analyzed as shown in Figure 6.25. Ultrafine bubble diffuser is the most economical in terms of net present value.

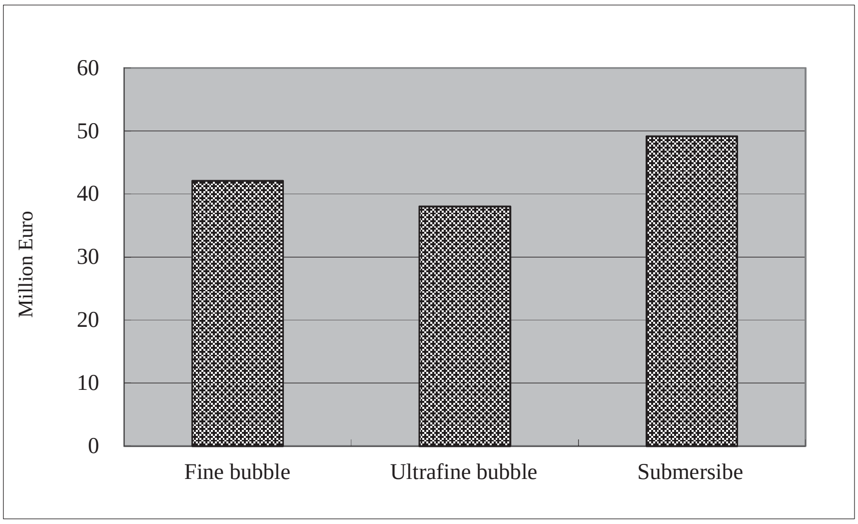


Figure 6.25 Net Present Value

6.3 Selection of Sludge Treatment Process

One of the principles of sewage treatment is to treat sludge produced from sewage treatment stably and efficiently on a permanent basis. In the Pre-F/S with M/P, application of the following processes was studied from the viewpoints of process complexity, sludge handling, energy utilization, sludge disposal and adverse environmental impacts.

- Thickening process of primary and secondary sludge
- Anaerobic digestion process for sludge stabilization
- Biogas utilization as power production and heat energy
- Incineration process of dewatered sludge

As the results of alternative comparisons, the process comprised of thickening, anaerobic digestion with biogas utilization and mechanical dewatering is adopted for sludge treatment process of Veliko Selos WWTP. Sludge cake is planned to be transported to the appropriate disposal sites such as sanitary landfill site. Utilization of digestion gas is planned introducing cogeneration system which generates electricity and utilizes recovered heat for warming the digesters. Sludge treatment process chosen in the Pre-F/S with M/P is shown in Figure 6.26.

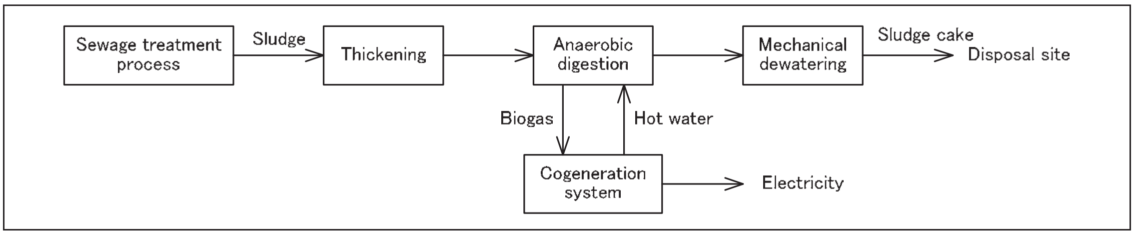


Figure 6.26 Sludge Treatment Process of Pre-F/S with M/P

In the Pre-F/S with M/P, alternative studies including the conventional technologies were sufficiently conducted for the selection of sludge treatment process of Veliko Selo WWTP. Hence, introduction of the following newly developed technologies which are not included in the Pre-F/S with M/P and can be beneficial for Veliko Selo WWTP are studied in this Study.

- Study on introduction of energy utilization technologies
- Alternative study of mechanical dewatering machine

6.3.1 Energy Utilization of Sewage Sludge

In the past, sewage sludge was subjected to the disposal and disposal of sewage sludge is considered mainly from the viewpoints of efficiency and mitigation of environmental impact. However, nowadays, energy value of sewage sludge has been reevaluated since approximately 80% of sewage sludge is composed of organic contents and sewage sludge is stable energy resources in terms of quality and quantity. Therefore, utilization of sewage sludge is encouraged to contribute to counter energy and global warming problems.

Due to these social backgrounds, development of energy utilization technologies of sewage sludge has been confronted. In recent years, biogas utilization technology and sludge fuelization technology are established and the applications to sewage treatment plants are encouraged. Energy utilization of sewage sludge has the following major social contributions.

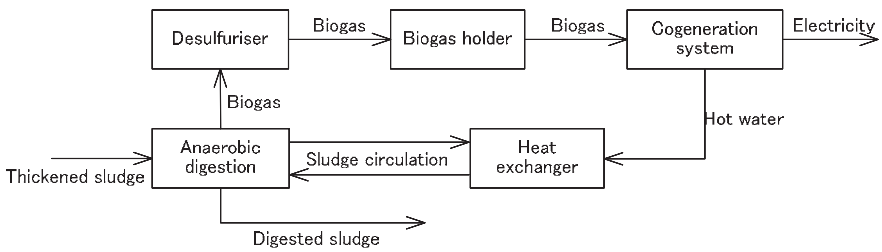
- Reduction of dependency to the fossil fuel
- Acquisition of stable energy resources
- Realization of low carbon society

Furthermore, energy utilization of sewage sludge has the following major advantages to improve sustainability of the operating public company.

- Long-term and stable utilization of sewage sludge as biomass
- Improvement of financial capability by selling utilized energy
- Reduction of greenhouse effect gas

Energy utilization of sewage sludge has biogas utilization and sludge fuelization. Introduction of biogas utilization is planned in the Pre-F/S with M/P. Technologies recommended to apply for biogas utilization of Veliko Selo WWTP are summarized in Table 6.24.

Table 6.24 Biomass Utilization Technology and Energy Balance

Explanation of process
[Biogas recovery technology] The most prevailing technology which recoveries energy of sewage sludge is anaerobic digestion process. Anaerobic digestion process decomposes organic contents by the function of anaerobic microbes in the digesters kept in anaerobic condition. Adequate retention time of sludge is kept according to the sludge temperature inside of digesters. 40 - 60 % of organic contents are decomposed. This process contributes reduction, stabilization of sludge and improvement of safety as the result. Biogas which is produced in anaerobic digestion is mainly composed of methane and utilized.
[Biogas power generation technology] Recovered biogas is utilized introducing cogeneration system. Power is generated by driving generators with biogas engines. Meanwhile, heat recovered from exhausted gas and cooling water is utilized to warm digesters. In general, efficiency of biogas engine generators is approximately 35 % and efficiency of heat recovery is approximately 30 %. Hence, total efficiency is approximately 80 %.
[Biogas utilization process] 

The case studies to introduce sludge fuelization technologies, which have potential to apply to Veliko Selo WWTP, are summarized in Table 6.25 and Table 6.26.

Table 6.25 Case Study of Carbonization Process

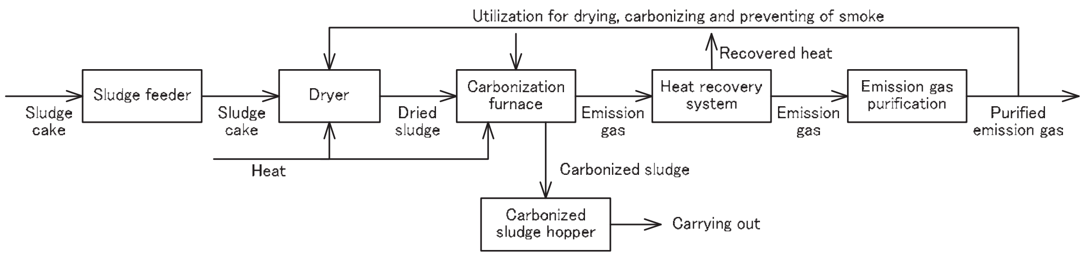
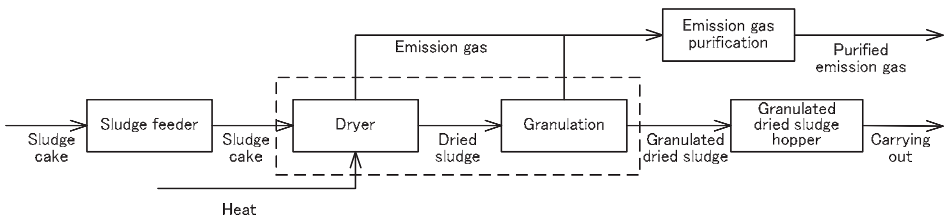
Explanation of process	
Carbonization process is the technology to produce carbonized sludge by thermally decomposing sewage sludge. This process releases decomposed gas from sewage sludge by heating sludge in anoxic condition. Carbonized sludge which is produced by carbonizing in high temperature has had less value as fuel because of more ash content and less calorific value. Currently the technology which increases the calorific value of carbonized sludge by carbonizing in lower temperature has been developed. In general, carbonization is comprised of drying process and carbonizing process. Sludge cake is dried by removing water content in drying process. Dried sludge is carbonized by thermally decomposed in the following carbonizing process.	
	
Production	Carbonized sludge: 15,900 ton/year
Moisture content	Less than 4 %
Shape	Cylinder (Dia.5mm x 5 - 10mm)
Calorific value	13 - 16 MJ/kg
Ash content	40 - 44 % (dry)
Spontaneous combustibility	Relatively low
Odor	Little
Outline of facility	Carbonization facility: Capacity 120 ton/day x 3 units
Greenhouse gas emission	-1,037 ton-CO_2/year
Initial investment	79 Million Euro
O&M cost	7.0 Million Euro/year
Net present value	151 Million Euro

Table 6.26 Case Study of Granulation Drying Process

Explanation of process	
Granulation drying process is the technology to produce granulated dried sludge by coating the surface of dried sludge with the help of adherence of sludge. Granulated sludge is dried with heated air. Organic contents of sludge are not decomposed since granulation drying is basically the process to remove water contents of sludge. Calorific valve of granulation dried sludge is relatively high since organic contents of sludge are concentrated in the pellet. The handleability of sludge is improved by granulating dried sludge.	
	
Production	Granulated dried sludge : 34,500 ton/year
Moisture content	30 -40 %
Shape	Agglomerate (20 – 30mm)
Calorific value	13 - 16 MJ/kg (dry)
Ash content	36 -38 % (dry)
Spontaneous combustibility	Low
Odor	Strong
Outline of facility	Granulation Drying facility: Capacity 90 ton/day x 4 units
Greenhouse gas emission	-3,174 ton-CO_2/year
Initial investment	38 Million Euro
O&M cost	6.4 Million Euro/year
Net present value	134 Million Euro

6.3.2 Potential Users of Sludge Fuel in Serbia

Introduction of sludge fuelization processes requires the pre-condition to ensure the users in neighborhood who can receive these sludge fuels in long-term and stable conditions to be met before actually implementing the project. Hence, the survey results conducted to the potential users for each of product are summarized in Table 6.27.

Table 6.27 Survey Results of Potential Users of Sludge Fuel

	Survey results
Carbonized sludge	The power company, which owns coal power plants, is the potential user of carbonized sludge since carbonized sludge has little smell and can be utilized as substitute of coal. According to the existing Energy Law in the Republic of Serbia, the products originated from communal wastewater are not considered as biomass and legally still considered as waste. Hence, the power company is required to be registered as waste disposal plants and have to comply with registrations of waste disposal in order for coal power plants to utilize carbonized sludge as a substitute of coal. There is registration which allows selling electricity generated from the renewable sources with higher price comparing to electricity generated from fossil fuel in the Republic of Serbia. However, the power company can’t get benefits of the regulation since sludge fuel is not legally considered as biomass under the current legislative conditions. Therefore, it is not encouraged for the power company to accept sludge fuel since they can’t get any benefit for renewable energy and have to comply with registrations of the waste disposal according to the current legislative conditions.
Granulated dried sludge	Potential users of granulated dried sludge are limited to the users who do not have restriction in odor since granulated dried sludge has strong smell. The City of Belgrade has formulated waste management plan to deal with waste generated in the city. The City has the strategy to generate power and supply hot water by combusting refuse derived fuel (RDF) produced from flammable waste and sewage sludge. The operator of this project is the public sanitary company of the City of Belgrade. Hence, the public sanitary company does not have any constraint for utilizing sewage fuel even under the current legislative conditions since the company is already registered as the waste disposer. The granulated dried sludge is considered as suitable form of receiving sludge due to low cost and high calorific value from the aspect of similarity with RDF. The City of Belgrade is searching for financial assistance to conduct the feasibility study to move ahead with its waste management plan. However, financial assistant has not been found so far and perspective to implement the feasibility study is unclear.

Therefore, it is difficult to ensure the stable and reliable users for both of carbonized sludge and granulated dried sludge in order to introduce fuelization process according to the current circumstances.

6.3.3 Proposal on the Timing to Introduce Fuelization Process

Introduction of sludge fuelization process is encouraged from the aspects of sustainability and environmental consideration. Nevertheless, implementation in the future is recommended rather than the first phase project due to the following reasons. The challenges for realizing of sludge fuelization process are summarized in Table 6.28.

- Uncertainty of stable and reliable users
- Optimization of facility designing
- Establishment of operation and maintenance structure
- Constraint of project financing

Table 6.28 Challenges for Realizing Sludge Fuelization Process

Problems	Explanation
Uncertainty of stable and reliable users	Stable and reliable users, who utilize produced sludge fuel, are not assured at this moment. In case that the legislative conditions are not modified for utilization of sludge fuel and the facilities planned in the waste management plan are not implemented, sludge fuel is not utilized and disposed. In that case investment will be wasted.
Optimization of facility designing	Designing of sludge fuelization facilities is conducted considering the sludge characteristics of the WWTP since characteristics such as organic contents are vary in each WWTP. Hence, it is desirable to design the facilities after acquiring sludge characteristics through the actual operation in order to optimize designing of facilities.
Establishment of operation and maintenance structure	Veliko Selo will be the first WWTP implemented in the City of Belgrade. Sludge fuelization facilities are comprised of complex processes and safety management is important since the facilities produce fuel. Hence, it is desired to introduce the facilities after establishing operation and maintenance structure of WWTP.
Constraint of project financing	Sludge fuelization facilities require large amount of investment since the facilities are comprised of complex technologies to produce fuel. Hence, it may cause constraint for project financing if implementation of the facilities is included in the first phase project.

Therefore, disposal of sludge cake in the sanitary landfill site is recommended in accordance with Pre-F/S with M/P at the beginning of operation of Veliko Selo WWTP. Vinca landfill site is located about 5 km south of Veliko Selo WWTP. According to the current regulations regarding the acceptance conditions of waste, sludge cake is allowed to be landfilled in Vinca landfill site as long as hazardous substances contained in sludge cake do not exceed the limit values shown in Table 6.29 and cost of disposal per cubic meter is 1,400 RSD.

Table 6.29 Limit Values of Hazardous Substances

Item	Limit value (mg/l)
Antimony (Sb)	15
Arsenic (As)	5
Barium (Ba)	100
Copper (Cu)	25
Vanadium (V)	24
Mercury (Hg)	0.2
Cadmium (Cd)	1
Molybdenum (Mo)	350
Nickel (Ni)	20
Lead (Pb)	5
Selenium (Se)	1
Silver (Ag)	5
Chromium (Cr)	5
Zinc (Zn)	250

Introduction of sludge fuelization facilities is encouraged once the pre-conditions are met in the future. These pre-conditions are acquisition of sludge characteristics, establishing operation and maintenance structure and ensuring suitable and reliable users. The technology which produces sludge fuel accepted from the users is selected from the established technologies in the future since the development of technologies in this field is enhanced nowadays.

The Pre-F/S with M/P is formulated with four WWTPs including Veliko Selo WWTP in the City of Belgrade. The other three WWTPs are small scale WWTPs. It is difficult for small scale WWTPs to introduce sludge fuelization facilities due to the following reasons.

- Unprofitability for small scale WWTPs to introduce the facilities due to disadvantage of scale merit
- Difficulty of establishing the operation structure for small scale WWTPs since sludge fuelization facilities are subjected to 24 hours operation due to the necessity of time and fuel for starting and closing of the facilities
- Difficulty of ensuring safety assurance with the operation structure of small scale WWTPs

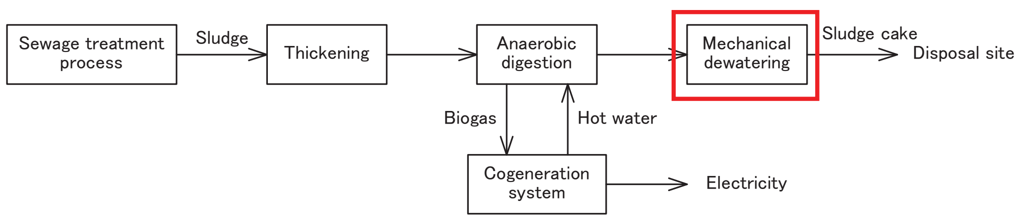
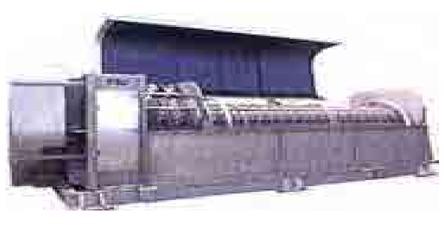
Hence, the centralized treatment of sludge fuelization in Veliko Selo WWTP is recommended considering the advantage of scale merit and operation of the facilities. In this case, sludge cake generated from the other three WWTPs is transported to Veliko Selo WWTP by boats. It is required to decide the capacity of sludge fuelization facilities introduced in Veliko Selo WWTP considering the development of the other three WWTPs in the City of Belgrade.

6.3.4 Alternatives of Mechanical Dewatering Machine

As for Pre-F/S with M/P, centrifugal dewatering machine is adopted for mechanical dewatering of Veliko Selo WWTP. There are other types of mechanical dewatering machines which can be potential alternatives for Veliko Selo WWTP. Alternatives including the newly developed technology of screw press dewatering machine and the conventional types of dewatering machine are listed below. Brief explanation of newly developed technology is shown in Table 6.30.

- Belt press dewatering machine
- Centrifugal dewatering machine
- Screw press dewatering machine

Table 6.30 Explanation of Newly Developed Technology

Explanation		
 Dewatering machine produces sludge cake by removing water contents contained in liquid sludge from anaerobic digesters in order to carry out sludge to the disposal sites.		
Screw press dewatering machine	Screw press dewatering machine requires less energy compared to other conventional dewatering machines. This machine can thicken, filter and compress the conveyed sludge by low-speed rotation so that the sludge can be dewatered using low energy and in efficient way.	
Application in EU counties	There is no technology similar to screw press dewatering machine, which is applicable to dewater sludge generated from communal sewage, in EU countries. Belt press dewatering machines and centrifugal dewatering machines are dominant in sewerage sector in EU countries. Especially, centrifugal dewatering machines are usually installed in large scale WWTPs. However, centrifugal dewatering machines have disadvantages on energy consumption, maintenance, noise and vibration because of high speed rotation. Recently, screw press dewatering machines, which are manufactured by Japanese manufacture, are installed in several plants including sewerage sector in EU countries and expected to gain recognition among EU counties.	

6.3.5 Comparison of Mechanical Dewatering Machine

Comparisons of alternatives are summarized in Table 6.31. Environmental and social aspects are also considered, however there is no significant differences among the alternatives. As a result of comparison, screw press dewatering machine is recommended due to the following advantages.

- Operation and maintenance cost is the least owing to lowest energy consumption and maintenance cost.
- Maintenance is relatively easy since belt press requires periodical replacement of belts and centrifugal requires to be taken to factories to replace edges.
- Screw press can optimize the operation by adjusting rotating speed of screws, dosing rate of coagulant, mixing speed of flocculation devices, feeding pressure, pressure of presser and feeding amount of sludge according to fluctuation of sludge characteristics.
- It is the most economical in terms of Net Present Value.

Table 6.31 Comparison of Mechanical Dewatering Machine

	Belt press dewatering machine
Dewatering mechanism	Belt press dewatering machines dewater sludge by squeezing and shearing flocculated sludge with two belts, which are pressurized by rollers. Belt press dewatering machines are comprised of filtration devices, flocculation devices and control panels.
Outline of design criteria	Moisture content of sludge cake: 79 % Filtration ratio: 110 kg Dry Solid /m hour Recovery rate of sludge: 90 % Dosing rate of coagulant: 1.6 %
Outline of dewatering machine	Width of belt 3.0 m Number: 10 nos. (1 standby)
Required space	936 m^2 (Dewatering machine only)
Operation	Belt press dewatering machines can adjust speed of belts, dosing rate of coagulant, feeding amount of sludge according to fluctuation of sludge characteristics.
Maintenance	Belt press dewatering machines require replacement of belts every 8,000 of operation hours. The replacement of belts can be carried out at the site by the maintenance staffs.
Washing water	Belt press dewatering machines require washing belts continuously during the operation. Therefore, belt press dewatering machines consume much more water comparing the other machines.
Noise and vibration	Belt press dewatering machines do not cause noise and vibration owing to slow speed movement.
Environmental and social consideration	Emission of greenhouse gas is less since energy consumption is low. Odor problem is bigger than the others.
Initial investment	Equipment: 2.02 Million Euro Building: 1.31 Million Euro Total: 3.33 Million Euro (128 %)
O&M cost	Electricity: 0.05 Million Euro/ year Coagulant: 1.22 Million Euro/ year Maintenance: 0.14 Million Euro/ year Total: 1.41 Million Euro/ year (119 %)
Net present value	17.02 Million Euro (120 %)
Evaluation	C

Net present value: Discount rate = 10% / period = 30year

Table 6.31 Comparison of Mechanical Dewatering Machine

	Centrifugal dewatering machine
Dewatering mechanism	Centrifugal dewatering machines dewater sludge by centrifugal force which is generated by rotating external cylinders at a high speed. Centrifugal dewatering machines are comprised of external cylinders, screws, differential driving devices and control panels.
Outline of design criteria	Moisture content of sludge cake: 79 % Dewatering capacity: 30 m^3/hour Recovery rate of sludge: 95 % Dosing rate of coagulant: 1.5 %
Outline of dewatering machine	Dewatering capacity: 30 m^3/h Number: 5 nos. (1 standby)
Required space	606 m^2 (Dewatering machine only)
Operation	Centrifugal dewatering machines can adjust rotating speed of cylinders, dosing rate of coagulant, pressure of presser, feeding amount of sludge according to fluctuation of sludge characteristics.
Maintenance	Centrifugal dewatering machines require replacement of edges every 12,000 of operation hour. The machines need to be taken to factories for replacement of edges.
Washing water	Centrifugal dewatering machines require washing inside of cylinders once a day. Washing time is around ten minutes. Therefore, centrifugal dewatering machines consume little water.
Noise and vibration	Centrifugal dewatering machines required preventive measures for noise and vibration because of high speed rotation of cylinders.
Environmental and social consideration	Emission of greenhouse gas is most since energy consumption is high comparing the other machines. Noise problem is bigger than the others.
Initial investment	Equipment: 0.89 Million Euro Building: 0.85 Million Euro Total: 1.74 Million Euro (67 %)
O&M cost	Electricity: 0.15 Million Euro/ year Coagulant: 1.14 Million Euro/ year Maintenance: 0.15 Million Euro/ year Total: 1.43 Million Euro/ year (121 %)
Net present value	15.37 Million Euro (109 %)
Evaluation	B

Net present value: Discount rate = 10% / period = 30year

Table 6.31 Comparison of Mechanical Dewatering Machine

	Screw press dewatering machine
Dewatering mechanism	Screw press dewatering machines dewater sludge by squeezing flocculated sludge with screws and perforated metal screens. Screw press dewatering machines are comprised of screws, outer screens, presser, driving devices, flocculation devices and control panels.
Outline of design criteria	Moisture content of sludge cake: 79 % Filtration ratio: 836 kg Dry Solid /hour Recovery rate of sludge: 95 % Dosing rate of coagulant: 1.5 %
Outline of dewatering machine	Diameter of screw: 1000 mm Number: 5 nos. (1 standby)
Required space	387 m^2 (Dewatering machine only)
Operation	Screw press dewatering machines can adjust rotating speed of screws, dosing rate of coagulant, mixing speed of flocculation devices, feeding pressure, pressure of presser and feeding amount of sludge according to fluctuation of sludge characteristics.
Maintenance	Screw press dewatering machines require replacement of screens every 30,000 of operation hour. The replacement of screens can be carried out at the site but require supervision of manufacturer.
Washing water	Screw press dewatering machines require washing screens every 6-8 hours. Washing time is around thirty minutes. Therefore, screw press dewatering machines consume little water.
Noise and vibration	Screw press dewatering machines do not cause noise and vibration owing to slow speed movement.
Environmental and social consideration	Emission of greenhouse gas is least since energy consumption is least.
Initial investment	Equipment: 2.07 Million Euro Building: 0.54 Million Euro Total: 2.61 Million Euro (100 %)
O&M cost	Electricity: 0.01 Million Euro/ year Coagulant: 1.14 Million Euro/ year Maintenance: 0.03 Million Euro/ year Total: 1.19 Million Euro/ year (100 %)
Net present value	14.16 Million Euro (100 %)
Evaluation	A

Net present value: Discount rate = 10% / period = 30year

6.3.6 Cost Analysis

Initial investment of alternatives is analyzed as shown in Figure 6.27. Initial investment of centrifugal dewatering machine is the lowest.

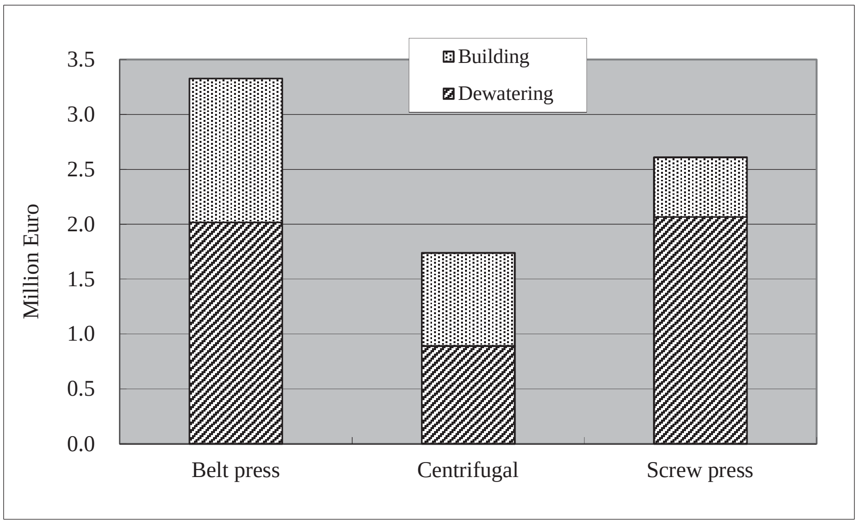


Figure 6.27 Initial Investment

O&M cost of alternatives is analyzed as shown in Figure 6.28. O&M cost of screw press dewatering machine is the lowest owing to the least electricity and maintenance expenses. The difference of the initial investment among centrifugal dewatering machine is recovered within seven years of operation by saving electricity and maintenance expenses. Screw press dewatering machine can be functional more than fifteen years with proper maintenance.

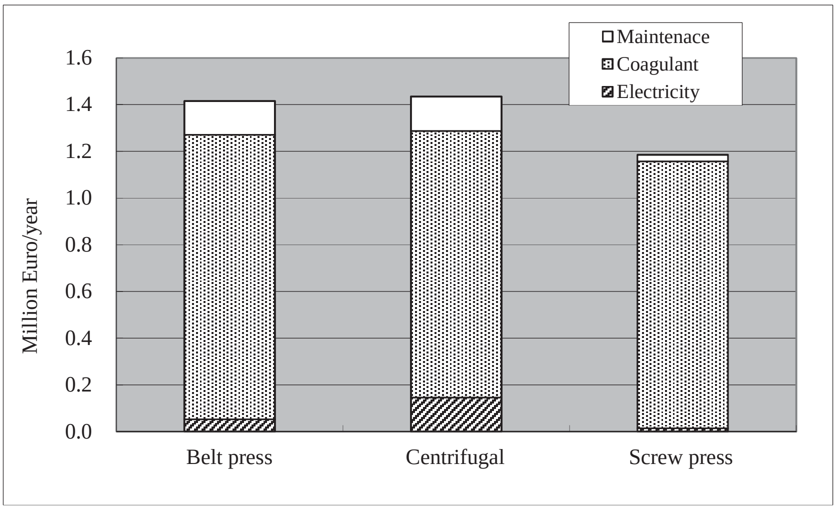


Figure 6.28 O&M Cost

Net present value of alternatives is analyzed as shown in Figure 6.29. Screw press dewatering machine is the most economical in terms of net present value.

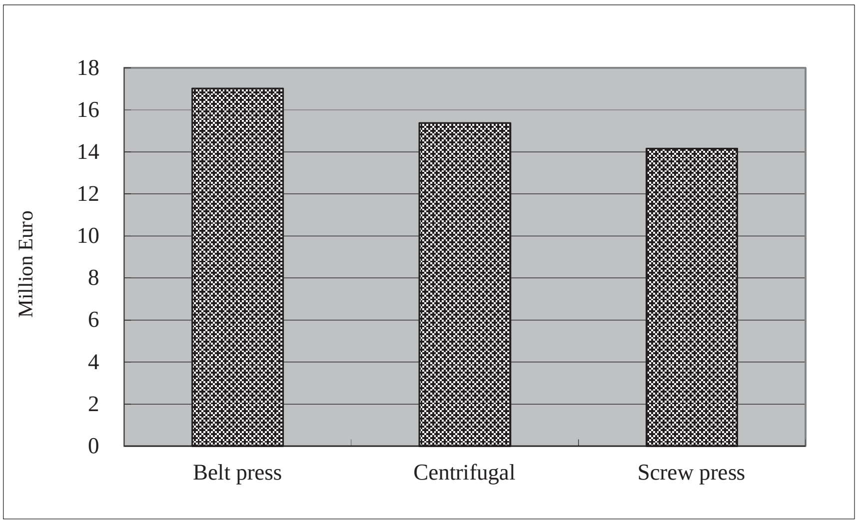


Figure 6.29 Net Present Value

6.4 Proposed Optimum Plan

The schematic flow of the optimized treatment process recommended for Veliko Selo WWTP considering the results of alternative comparisons is shown in Figure 6.30 and explanation of treatment process is summarized in Table 6.32.

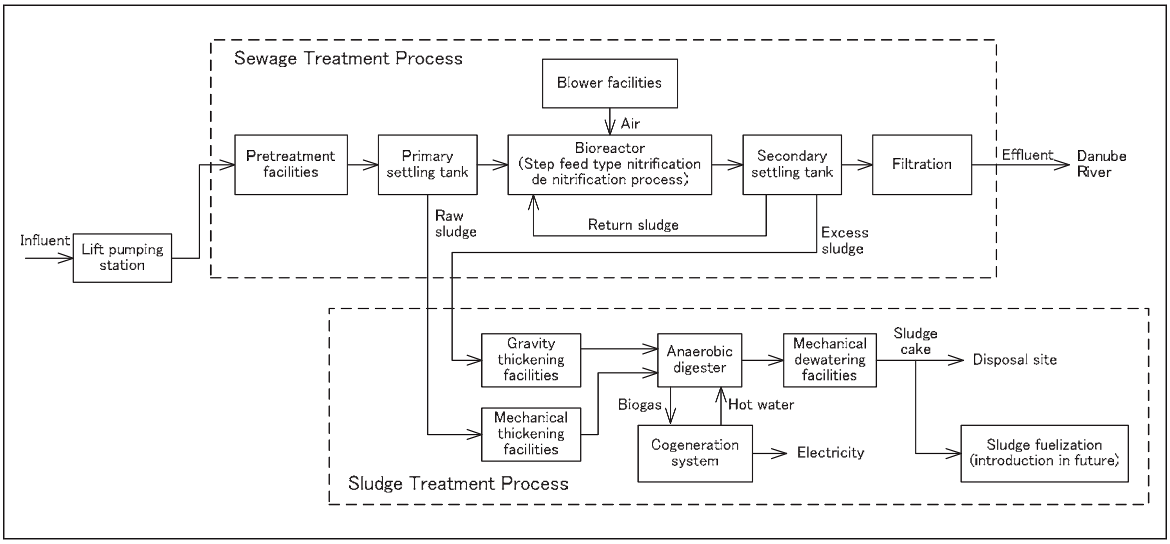


Figure 6.30 Schematic Flow of Treatment Process

Table 6.32 Outline of Treatment Process

Treatment process	Explanation
Lift pumping station	Inlet gates are installed in order to protect the facilities from flooding in the event of an emergency. Coarse screens are installed so as to prevent lift pumps from being clogged by garbage. Lift pumps are operated by unit control according to the level of pump suction well. Flow is controlled by the number of operated pumps.
Pretreatment facility	Fine screens and aerated grit chambers are installed to pretreat raw sewage prior to biological treatment. Screenings removed by fine screens are dewatered, stored in containers and carried out. Grit, oil and grease are separated from raw sewage by mixing air. Sediment grit is removed by airlift pump, stored in containers after dewatering and carried out. Floating oil and grease are removed from the surface.
Primary settling tank	Pollution loading, mainly heavier organic substances, is separated by gravity and removed. Sludge collectors are installed in primary settling tanks. Raw sludge withdrawn from primary settling tanks is transferred to gravity thickeners.
Bioreactor	Bioreactor is comprised of three stages of anoxic-oxic units in series. Each anoxic tank receives step feeding of influent equally. Top-entry agitators are installed in anoxic tanks and ultrafine bubble diffusers are installed in oxic tanks. Coagulant is added in later stage of bioreactors to remove phosphorous.
Blower facility	Air required for aeration of bioreactor is supplied by blowers. Air flow is adjusted by introducing inlet vane control according to aeration requirement in order to save energy consumption.
Secondary settling tank	Solid-liquid separation of activated sludge and effluent is conducted. Sludge collectors are installed in secondary settling tanks. Return sludge is transferred to bioreactors and excess sludge is transferred to sludge holding tanks for mechanical thickening.
Filtration	Disc filters are installed for polishing of secondary effluent before discharge to the receiving water body. Filtrated effluent is also utilized inside of the WWTP.
Gravity thickening facility	Raw sludge is thickened by gravity in gravity thickeners. Sludge collectors are installed in gravity thickeners. Thickened sludge is transferred to sludge holding tanks for mixing thickened sludge.
Mechanical thickening facility	Excess sludge is thickened by belts thickeners after coagulation. Sludge supply system, polymer preparation system and sludge holding tanks are installed for mechanical thickening. Thickened sludge is transferred to sludge holding tanks for mixing thickened sludge.
Anaerobic digester	Mixed thickened sludge is transferred to anaerobic sludge digesters. Digesters are heated single stage type and sludge heating system is installed. Digested sludge is transferred to sludge holding tanks for mechanical dewatering. Biogas is utilized by cogeneration system for generation of power and heating of sludge digesters.
Mechanical dewatering facility	Digested sludge is dewatered by screw press dewatering machines after flocculation by adding polymer. Sludge supply system, polymer preparation system and sludge holding tanks are installed for mechanical dewatering. Sludge cake is stored in the stockyard and transferred to the disposal site.
Sludge fuelization (future)	Sludge fuelization facilities will be introduced in future. Sludge fuelization facilities produce sludge fuel which can be utilized as a substitute of coal. There are several technologies for producing sludge fuel from sludge cake.

Purpose of thickening process of sludge is to conduct following process such as anaerobic digestion and dewatering efficiently by thickening low concentration sludge generated from sewage treatment process. Raw sludge generated from primary settling tanks is thickened by gravity thickeners, which require less investment and easier operation, since raw sludge is easily settled by gravity. On the other hand, Excess sludge generated from secondary settling tanks is thickened by mechanical thickening, which can ensure stable performance, since excess sludge is difficult to be settled by gravity.

6.5 Facility Planning

6.5.1 Concepts of Facilities Planning

BVK expects to introduce reliable technologies in order to enable steady and secured treatment for Veliko Selo WWTP. At the same time, BVK expects to introduce technologies that would result in resource saving and energy saving from the view point of sustainability. Concepts adopted for facility planning are summarized below.

- Consideration of life cycle cost including initial investment, costs for operation & maintenance and replacement
- Stable and easy operation by introducing necessary backup and automation by SCADA system and instrument
- Total energy saving by introducing highly efficient technology, optimizing operation and minimizing hydraulic loss
- Reduction of initial investment by applying phased development
- Consideration of environmental and social impact

6.5.2 Design Criteria

Design criteria which are applied for facility calculation of sewage treatment facilities and sludge treatment facilities of Veliko Selo are summarized in Table 6.33.

Table 6.33 Design Criteria

No	Item	Design Criteria	
1.	Pretreatment facility		
1-1	Hydraulic overflow rate	1,800	m^3/m^2/day
1-2	Average velocity	0.3	m/second
1-3	HRT (hydraulic retention time)	30-60	second
2.	Primary settling tank		
2-1	Hydraulic surface loading	50	m^3/m^2/day

No	Item	Design Criteria	
2-2	Effective depth	3.5	m
2-3	Weir overflow rate	250	$m^3/m/day$
2-4	Solid concentration of raw sludge	2.0	%
3	Bioreactor		
3-1	MLSS concentration	3,000	mg/l
3-2	Dissolved oxygen	2.5	mg/l
3-3	HRT (hydraulic retention time)	17.7	hour
3-4	Solid concentration of return sludge	0.9	%
3-5	Return sludge ratio	50	%
3-6	Circulation ratio	0	%
3-7	SRT (sludge return time)	10.7	day
4.	Secondary settling tank		
4-1	Hydraulic surface loading	20	$m^3/m^2/day$
4-2	Effective depth	4.0	m
4-3	Weir overflow rate	150	$m^3/m/day$
4-4	Solid concentration of excess sludge	0.9	%
5.	Filtration		
5-1	Filtration speed	500	m/day
6.	Gravity thickener		
6-1	Solid surface loading	50	$kg/m^2/day$
6-2	Solid concentration of thickened sludge	4.0	%
6-3	Solid recovery rate	85	%
6-4	Effective depth	4.0	m
7.	Mechanical thickener		
7-1	Solid concentration of thickened sludge	4.0	%
7-2	Solid recovery rate	95	%
7-3	Polymer dosing rate	0.3	%
8.	Anaerobic sludge digester		
8-1	HRT (hydraulic retention time)	20	day
8-2	Sludge heating temperature	35	degree Celsius
8-3	Volatile total solid	70	%
8-4	Digestion rate	50	%
8-5	Solid concentration of digested sludge	2.6	%
8-6	Gas calorific value	21,000	kJ/m^3
8-7	Gas production rate	0.50	m^3/kg
9.	Sludge dewatering		
9-1	Operation hour	24	hour
9-2	Moisture content of sludge cake	79	%
9-3	Solid recovery rate	95	%
9-4	Polymer dosing rate	1.5	%

6.5.3 Hydraulic Profiling Planning

Hydraulic profile has been arranged considering the following hydraulic conditions and concepts.

- The last part of interceptors to Veliko Selo WWTP is currently under construction and the bottom level of the last interceptor is planned to be plus 68.72m.
- High water level of the receiving water body, i.e. Danube River, is planned to be plus 75.60m considering the Dam in the downstream of discharge point.
- The number of lift pumping stations is minimized in order to reduce energy consumption and initial investment and to make operation easier.
- Risk of flooding inside of the WWTP by operating errors and troubles is reduced by omitting intermediate lifting during the treatment process.
- Distribution tanks with free weirs are planned to distribute even flow to each tank of sewage treatment process.
- Hydraulic profile is planned so as not to be affected by downstream condition.

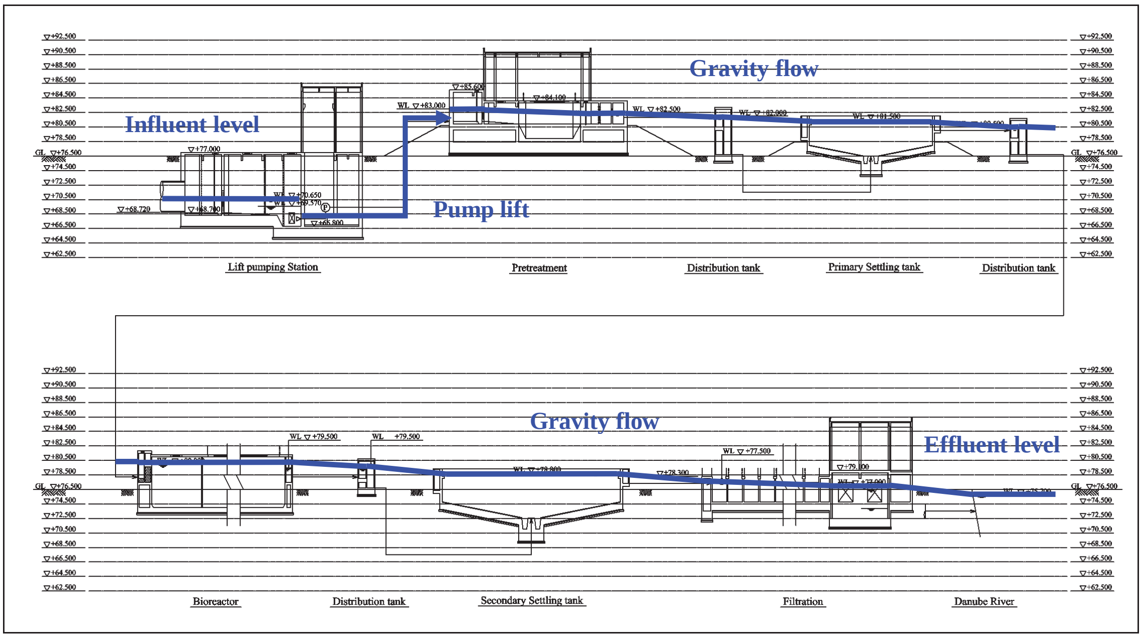


Figure 6.31 Hydraulic Profile Planning

6.5.4 General Layout Planning

General layout of the facilities in the site has been arranged considering the following conditions and concepts.

- The last part of interceptors to Veliko Selo WWTP, i.e. the inlet of influent, is located at northwest of the site.

- The receiving water body, i.e. Danube River, is located in north of the site.
- The proposed facilities are grouped considering the treatment process so that the efficient working line is secured for the workability of daily operation and maintenance of the facilities.
- The proposed facilities are placed so that sewage flow line and sludge flow line during treatment are optimized.

Zoning of the facilities, sewage flow and sludge flow are shown in Figure 6.32, Figure 6.33 and Figure 6.34, respectively.

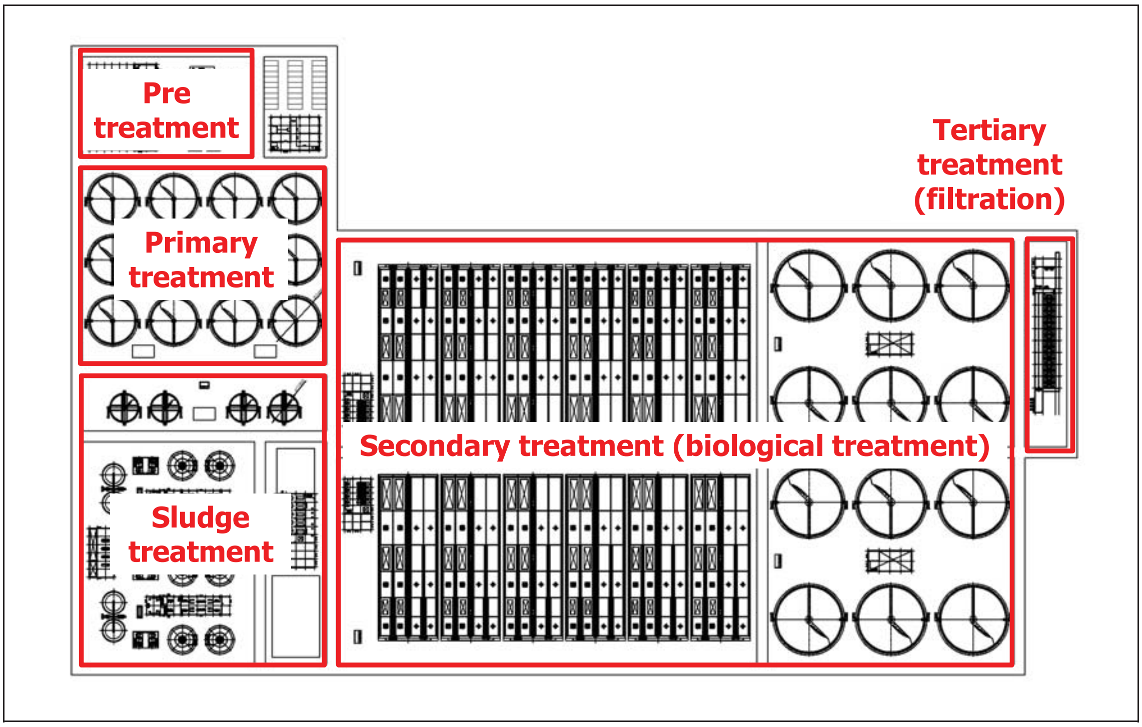


Figure 6.32 Zoning of the Facilities

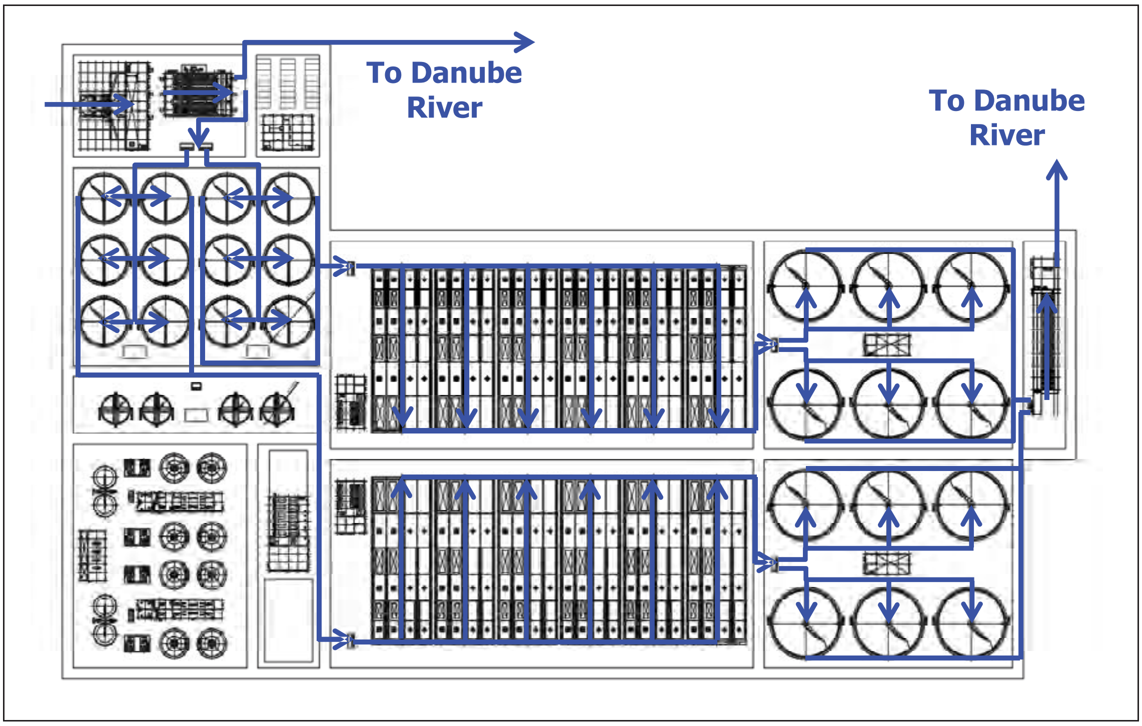


Figure 6.33 Sewage Flow Line

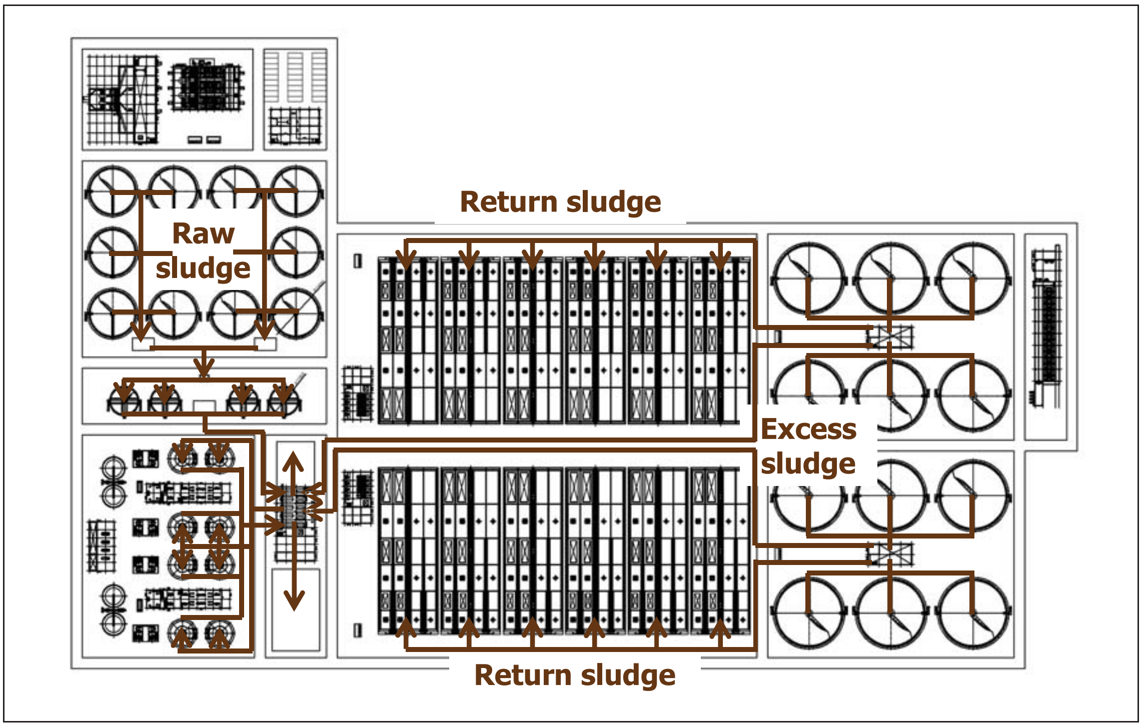


Figure 6.34 Sludge Flow Line

Landscape planning of the WWTP site has been arranged considering the following hard and soft landscaping works.

- The proposed facilities are placed so that margin of green belt along the boundary of the WWTP is secured in order to mitigate undesirable effect on the surrounding environment.
- Embankments which are four meter higher than high water level of Danube River, are constructed along the river in order to protect the facilities from inundation caused by the river.
- Width of roads in the site are planned to be not less than 4 meter considering the workability of operation and maintenance.
- Two access roads are planned in order to secure safety and construction road for future expansion of the WWTP.
- Access to Danube River and loading place are planned in order to carry in consumables such as chemical and carry out sludge cake in the operation stage.
- Rainwater in the site is discharged to Danube River.
- Sewage generated in the site is discharged to the inlet of pumping station.

Landscape planning of the WWTP site is shown in Figure 6.35.

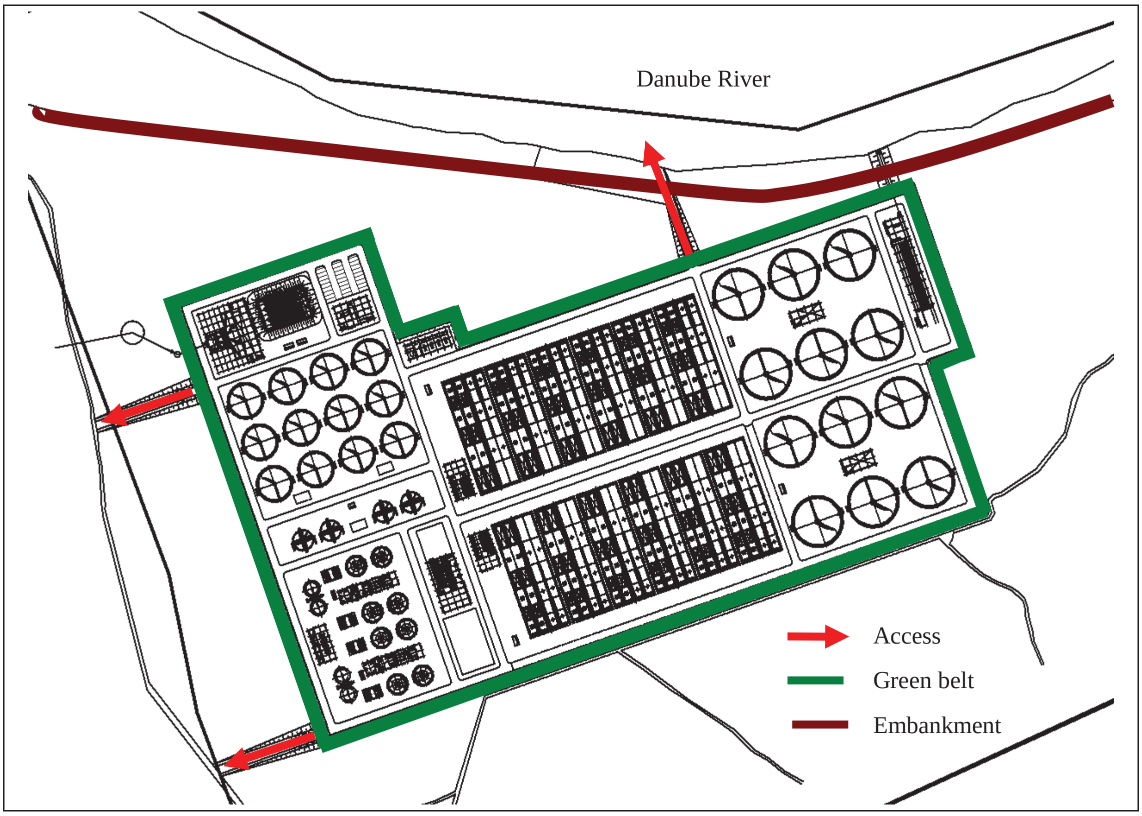


Figure 6.35 Landscape Planning

6.5.5 Electrical System Planning

(1) Introduction

Electrical system at Veliko Selo WWTP, consuming approximately 9000kW electric power, shall be designed carefully with high reliability, high efficiency, operational flexibility and reasonable construction/operational cost. The design concept of the electrical system is the followings;

- Efficient power distribution to all loads/equipments located in a wide area
- Implementation of 400V motor for all loads, including twelve (12) numbers of Lift pump
- Two bank system for transformer, having 100% standby capacity in each
- Two line system for power distribution feeder
- Implementation of standby power generator(s) with enough capacity for a day-to-day operation
- Introduction of biogas generators as a co-generation (CHP) system

(2) Options of Electrical System

Options of power distribution system shown in Table 6.34 are considered to optimize electrical system of Veliko Selo WWTP. It is also necessary to obtain agreement from the distribution company.

Table 6.34 Options of Power Distribution System

System	Explanation
Centralized substation system	Main transformer(s) is installed at the main substation. And it was selected 10kV as an intermediate distribution voltage, so the city line 35kV is isolated from the internal distribution line.
Distributed substation system	Main transformers are installed at each local substation. And 35kV, same as the incoming voltage from the distribution company, is selected as a distribution voltage in the WWTP. And the city line and the WWTP's distribution lines are connected directly. Therefore, the protective systems must work correctly with high-reliability, to intercept a fault spread. Because this system does not have the intermediate voltage, an efficiency of power distribution is better than Centralized Substation System.
Two-line network system	Above mentioned Distributed Substation System can be modified to this system. The distribution feeder and the primary circuit of transformer have been simplified. Taking consideration of the regulations of power distribution in Belgrade, the distribution company has management responsibility for the receiving circuit and transformers. This system is simple and easy to operate the electric facility.

Standby generator system is a required feature in the WWTP for a high reliability of electric supplying. As for higher reliable system, an electric generator must be located near the load. On the other hand, maintenance man-power is according to the numbers of generator sets, and the numbers of generator houses in the WWTP premises. The voltage of generator shall be 0.4kV system or same as an intermediate distribution voltage. In selecting the standby generator system, it is necessary to consider the frequency and continuation hours of a power outage experienced in Belgrade. Options of standby generator system shown in Table 6.35 are considered to optimize electrical system of Veliko Selo WWTP.

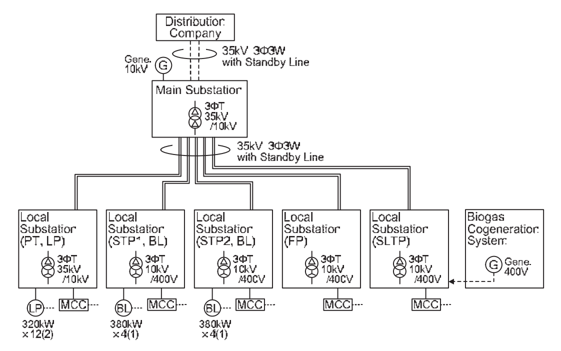
Table 6.35 Options of Standby Generator System

System	Explanation
Centralized standby generator system	Standby generators which have enough capacity to supply all facilities are located in or near the main substation. Generated electricity is connected to 10 kV bus line of the main substation.
Site-by-site standby generator system	Standby generators which have capacity to supply each facility are located in the local substations. Standby generators installed in each local substation are independently operated and mutual backup is not considered.

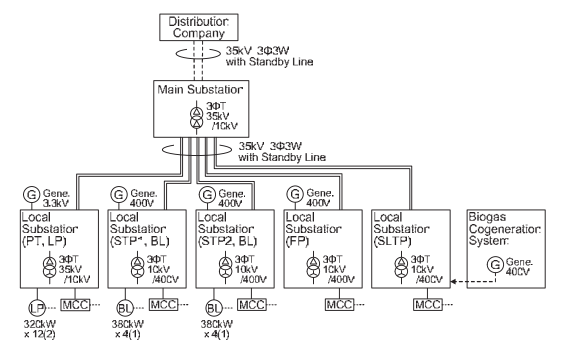
Alternatives of electrical system combining options for power distribution system and standby generator system and engineering procedure for electrical system are shown in Table 6.36 and Figure 6.36, respectively.

Table 6.36 Alternatives of Electrical System

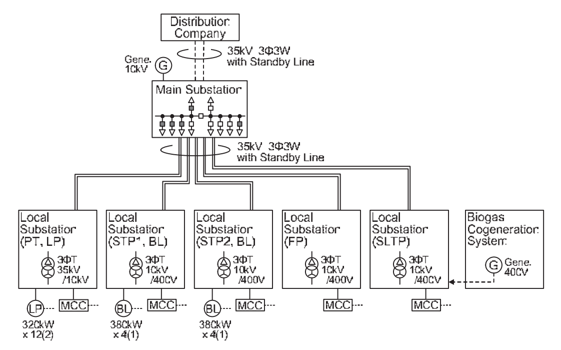
Alternative-1



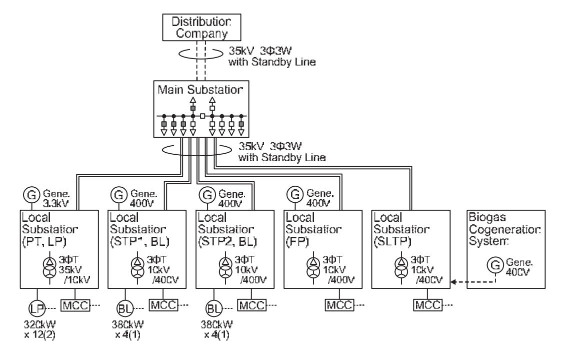
Alternative-2



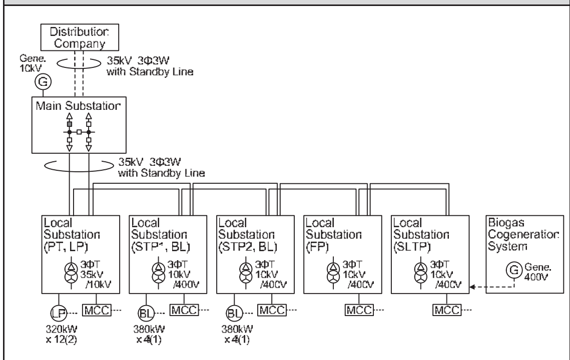
Alternative-3



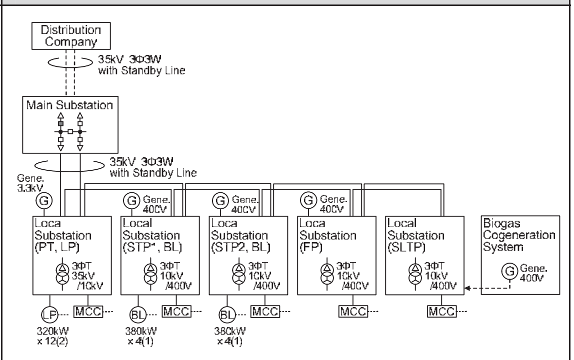
Alternative-4



Alternative-5



Alternative-6



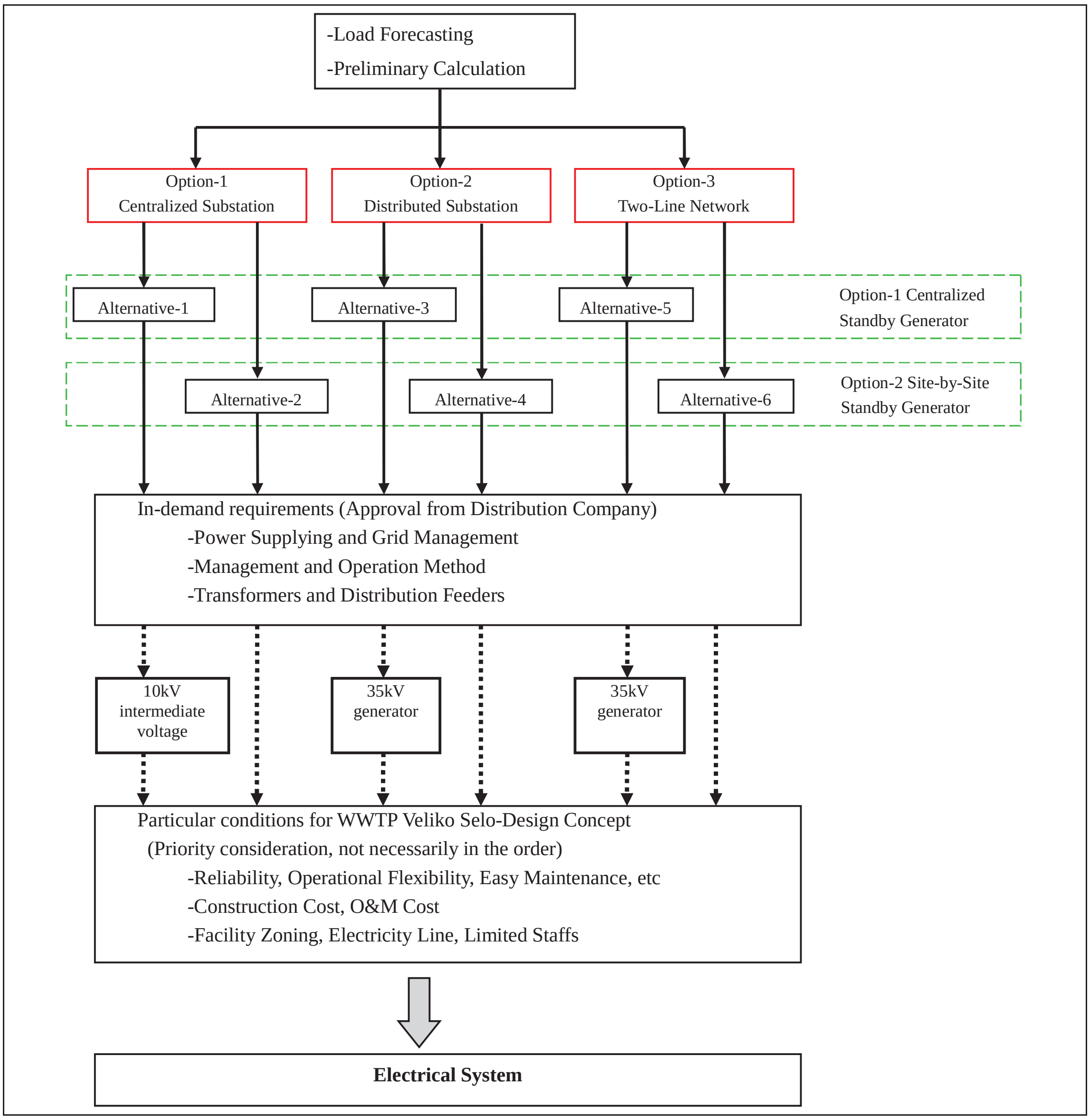


Figure 6.36 Engineering Procedure for Electrical System

(3) Optimized Electrical System

The following combined system has been drawn from technological considerations as the electrical system. Step-down transformer(s) is installed at the main substation, and 10kV is selected for the intermediate distribution voltage. Distribution system for each local substation is the followings.

- Lift Pump and Grit Chamber (Since the local substation is close to the main substation, only transformers are installed at the electrical room and the necessary switches are installed at the main substation)
- WWTP(1), WWTP(2) and Filter Facility (Electricity is supplied by 2-line network

system same as the city grid)

- Sludge Treatment Facility (Electricity is supplied by dedicated 10kV parallel line)

The distribution line between the main substation and the local substation at sludge treatment facility can supply the electric power in both directions, from (to) the bus line to (from) the biogas generators. Centralized standby power generators are located next to the main substation. 10kV is selected for the output voltage of generator same as the intermediate distribution voltage. Optimized electrical system is shown in Figure 6.37.

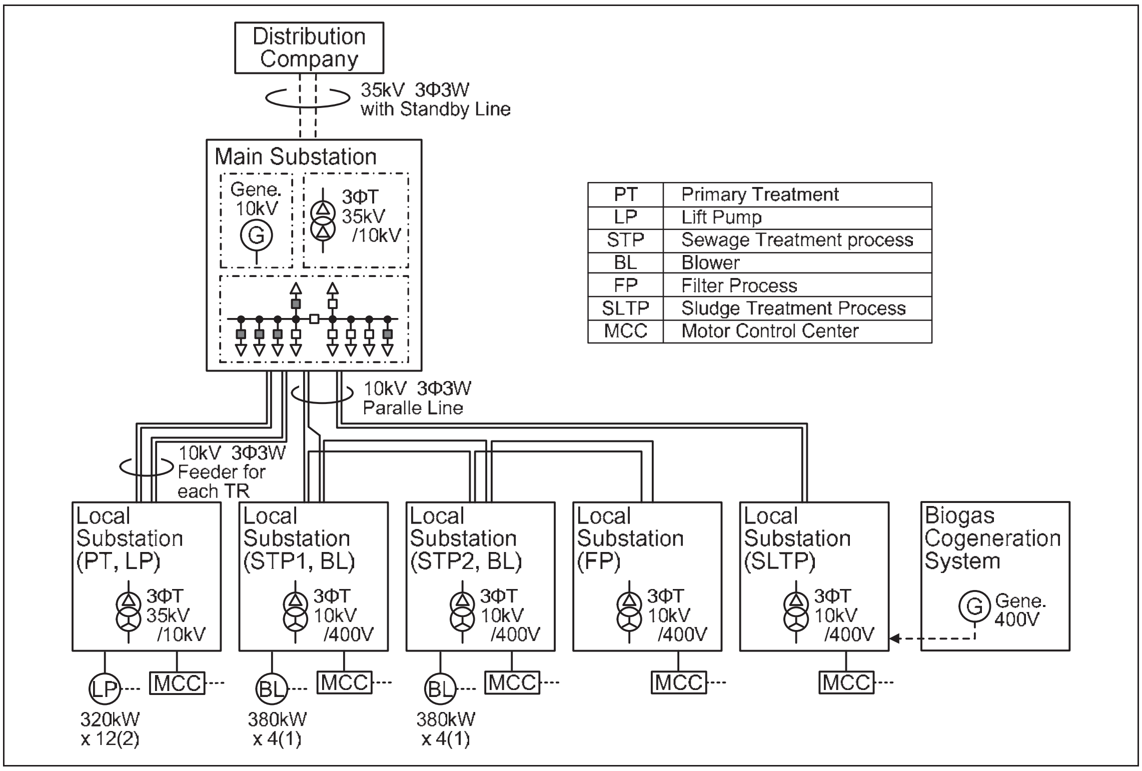


Figure 6.37 Optimized Electrical System

6.5.6 SCADA System Planning

(1) Introduction

In Belgrade, a SCADA for sewage collecting system has been installed at Mostar Pump Station. Almost 30 pump stations are connected to the SCADA center for monitoring or operation via various communication lines. Another SCADA system has started to work in 2010 at Makis Water Treatment Plant. JICA Study team has visited Subotica WWTP where SCADA system is installed. These SCADAs are functioning appropriately. In this project, the SCADA system will be surely designed not only as a basic function, but trying to introduce more advanced technology.

(2) Purpose of SCADA System

It is imperative that the necessary data is collected and stored, and the required information is provided for operators and engineers. This is the starting step of the information utilization for effective and efficient operation. Therefore, it is essential that all data is accessible to any operators and anyone concerned. This will also provide an opportunity for the engineers/operator/chemists to access the information from outside of his/her narrow domain and give them rich and varied exposure which will enable them to manage the resources in a most efficient way. It will also facilitate mining of the historical data for reference and overall improvement. In case of WWTP operation, "collection of information - analysis of the information - operation of the facilities - evaluation of the operation result“, this operation cycle is important. The first two steps can be realized by the data acquisition system. The next step, in which the engineer operates facilities and determines the control parameters according to the judgment immediately, requires automatic control system wherein the remote electrical control of drives and valves by electric actuation is possible. The normal operation is automatic control by analog calculation logic or sequential operation. The PLC (programmable logic controller) which is the component of SCADA system has these control functions programmed into it. Also, the engineer attains the facilities to effect urgent remote operation through the client PC according to his/her judgment whenever necessary. With such a supervisory control and above-mentioned data acquisition system, the original feature of the SCADA system can be fully realized.

(3) Data Acquisition

Information required for the plant operation is operation status (on/off/fault) of the facility equipment and analog sensing signals which are proportional to flow, level, turbidity etc. These signals are sent to signal input unit of PLC. After screening errors, all signals are recorded as information of the plant operation in the server computer. According to the data formats of information, the Database is created in the server computer. As for the analog measuring values, data bases are built with time frames in-minute, hour and day. As for the others, the status data is stored as events. These data are provided for the engineer as the status indication in the graphic-screen, the trend graph in the display and the report generation for the printer.

(4) Control and Operation

The collected and stored information is used in the automatic control or the remote operation which operates through interfacing relays. For these automatic control or remote operation through the SCADA system, the facility equipment must be electrically actuated or motor driven machine. The control system and control logic is to be designed carefully so as to include all relevant parameters and enough information must be provided for the engineer who decides the operation and the adjustment of control at central control room. The same concepts apply for the sludge treatment / dewatering site operation also at sub-control room.

(5) Changing Role of the Operator

The operator of the past: The manual demands of yesterday’s operator required an in-depth knowledge of process and machine operations. These operators often learned from previous operators, sometimes through trial and error. They made decisions based on the way they were trained to comply with established guidelines and procedures.

Today's operator: The modern operator has evolved into a multi-faceted employee, which has drastically increased the role’s responsibilities as a “generalist,” solving problems in real time and not specifically being an expert in merely one section of the process. Today, the operator is one of the key members of the team, and enhancing the efficiency of this role through improved operator response provides an advantage. Operators need the ability to reason, plan, and solve problems quickly, and to use a wide set of software tools to present data, collaborate, and automate advanced intelligent analysis. The latest SCADA system is easy-to-use decision-making tool for above mentioned purpose.

(6) Video Monitoring System

Image data contains various information such as shape, color, motion, surroundings, sound, flame, unusual state and uninvited person/animal. The cost of purchasing cameras and peripherals has become widely market available with the benefit of IT evolution. Moreover the CPU's performance is changing higher at a rapid rate, therefore VMS (video monitoring system) or CCTV (closed circuit TV) is having a wide field of application, not only for watching purpose. In Veliko Selo WWTP, the potential function of SCADA system is improved by vigorously introducing VMS. When considering such developing technology, it is important not to focus on current needs but looking at plans for the future. Of course, one of the purposes of VMS is still as WWTP's security system and visual monitoring at the control room. Each network camera has the control function of pan /zoom /focus /lighting and presetting control parameters. "Virtual site tour" function can realize the walk around inspection or patrol of the control room, For performing this, a camera is controlled one by one from the start point, and is selected along =the inspection way. The camera can be controlled to focus on the objective by the preset function. When the camera reaches to the goal point, "Virtual site tour" of approximately 3km will be completed. Using this function, the visitor can be safely guided to WWTP.

(7) Automatic Control

Main purpose of the automatic control is ensuring stable quality of the effluent water and managing the appropriate WWTP operation. 24 hours automatic control and monitoring system is essential technology for the fully automated WWTP. Meanwhile, the judgments of well experienced engineer are also absolutely necessary for operation of WWTPs. For the efficient operation of WWTP, it is necessary to assess quantity and quality of the every point sewage/effluent/sludge/cake daily. The electric power parameters are also monitored for the purpose of energy conservation. The automation of wastewater treatment plants has become a necessity. Rather than simply following prevailing trends, it is important to closely analyze the objectives of automation and to reflect on why and where automation is required.

- Improving operating conditions (The primary function of an automated system is to remove the need for repetitive and difficult operator tasks, by installing actuators on important or frequently used valves, or motorized equipment, etc.)
- Improving plant performance (The first aim is to improve treatment quality by adjusting internal procedures and regulations concerning the process. Automating such procedures also reduces the risk of human error, thus increasing reliability and operational safety.)
- Assisting supervision (This type of assistance includes the installation of sensors, alarm detectors, etc. up to fully SCADA system. Automation is not an end in itself, but automation must be regarded as a tool of WWTP management.)

In treatment plant, the fluctuation of the quality is generally a relatively slow process. However, there are often large variations in the quantity of wastewater to be treated. Hence flow rate is an essential factor when introducing the automation of such plant. The entirely automated treatment plant, devoid of human intervention, does not exist. Even if no operators are physically present on site on full-time, technicians/engineers are necessary for certain adjustments, routine monitoring, maintenance tasks, and diagnoses.

(8) Instrumentation

Flow measurement is important in order to manage the operation of WWTPs. Two kinds of flowmeter, i.e. ultrasonic type flowmeter and electromagnetic type flowmeter, are often used for measuring the flow in general. Electromagnetic type flowmeter can be used mostly for sludge and coagulant measurement. Level sensing is also important for the WWTP operation and control. For the level sensing, microwave type or ultrasonic type is used. These types have the feature of measurement without actual contact with sewage/sludge or chemicals. At the sludge facility, the sludge contains micro bubbles and the sludge adheres to the sensor in the sludge. The laser beam type sludge density meter is used for measuring sludge turbidity, because of simple measurement method without moving part. Influent sewage temperature and pH, DO and SS, etc. in reactor, and another index are measured for the purpose to judge the condition for activated sludge. Measuring temperature, pH, turbidity and COD/UV of effluent water is useful to confirm the effluent water quality for observing the environmental protection.

(9) Optimized SCADA System

Optimized SCADA system for Veliko Selo WWTP is shown in Figure 6.38.

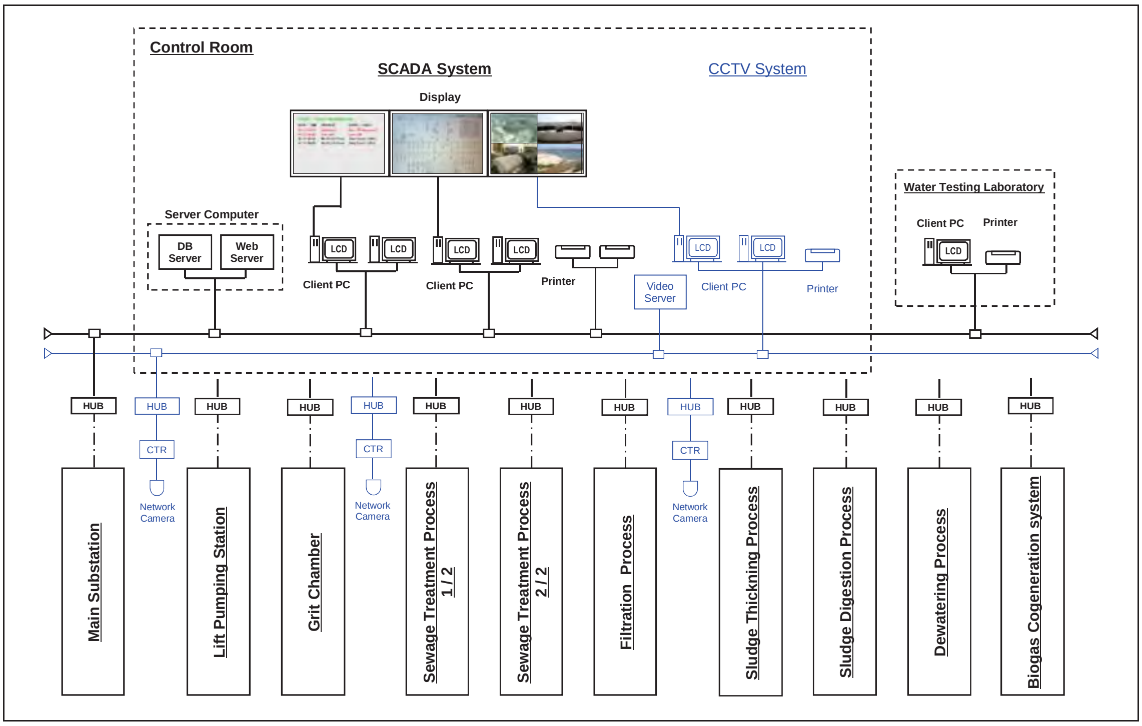


Figure 6.38 Optimized SCADA System

6.5.7 Cogeneration System

Biogas produced by the anaerobic digestion process which constitutes 50-75 % of methane (CH_4), is useful green fuel and cost-free energy source. Now, in many sewage treatment plants, the biogas is used for heating the sludge in a digester as the priority use. Also in this project, the sludge heating system is proposed. The biogas is combusted in the water heater and the sludge can be heated through the heat exchanger.

The biogas is actually methane-rich gaseous fuel. In recent years, there is a social trend to use biogas not only for heating the sludge but also as a fuel for the electricity generator. Since electricity can be easily distributed or transmitted, its use is easier and more efficient. Moreover, in a CHP (combined heat and power) gas engine, the waste heat from the engine is conveniently used for heating the digester.

The cogeneration system is proposed to heat the digester, in order to make efficient use of biogas. Also the biogas cogeneration system can generate an electric power, and the electric power can be adjusted up to the specific capacity for the peak power limitation, because the gas holder functions as a temporary storage of biogas. On the other hand, a frequent start/stop operation causes some hyperthermic stress and shortens the operating life. It is therefore necessary to consider the operation plan in the detail design of implementation stage. Biogas generation system works in the following two operation modes.

- Synchronized operation with city line
- Individual operation from other emergency generators

Because the biogas electric power will be connected to the electrical bus line, all the biogas from digester can be used effectively in the biogas generation system. The electricity generated by biogas system can be transmitted to the upstream of the sludge treatment facility, but not into the city grid. WWTP has enough power consumption than biogas generation at all times.

Outlines of design are shown in Figure 6.39, Figure 6.40 and Figure 6.41.

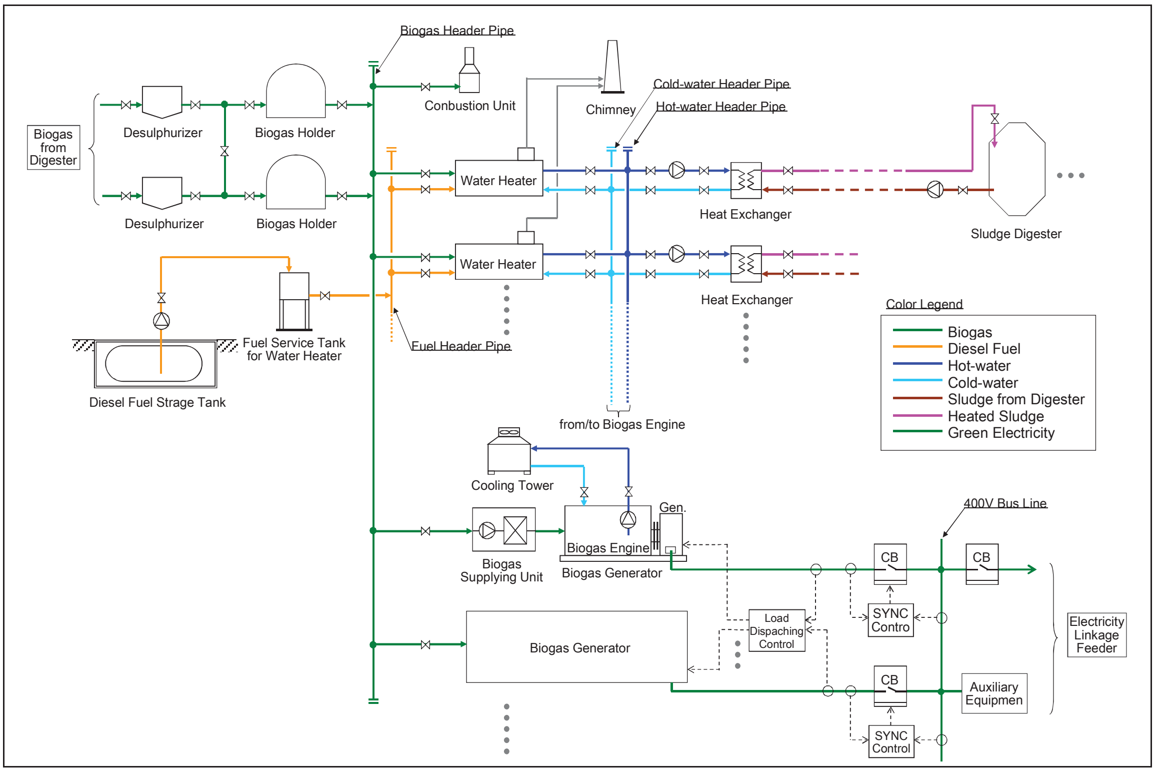


Figure 6.39 Utilization of Biogas

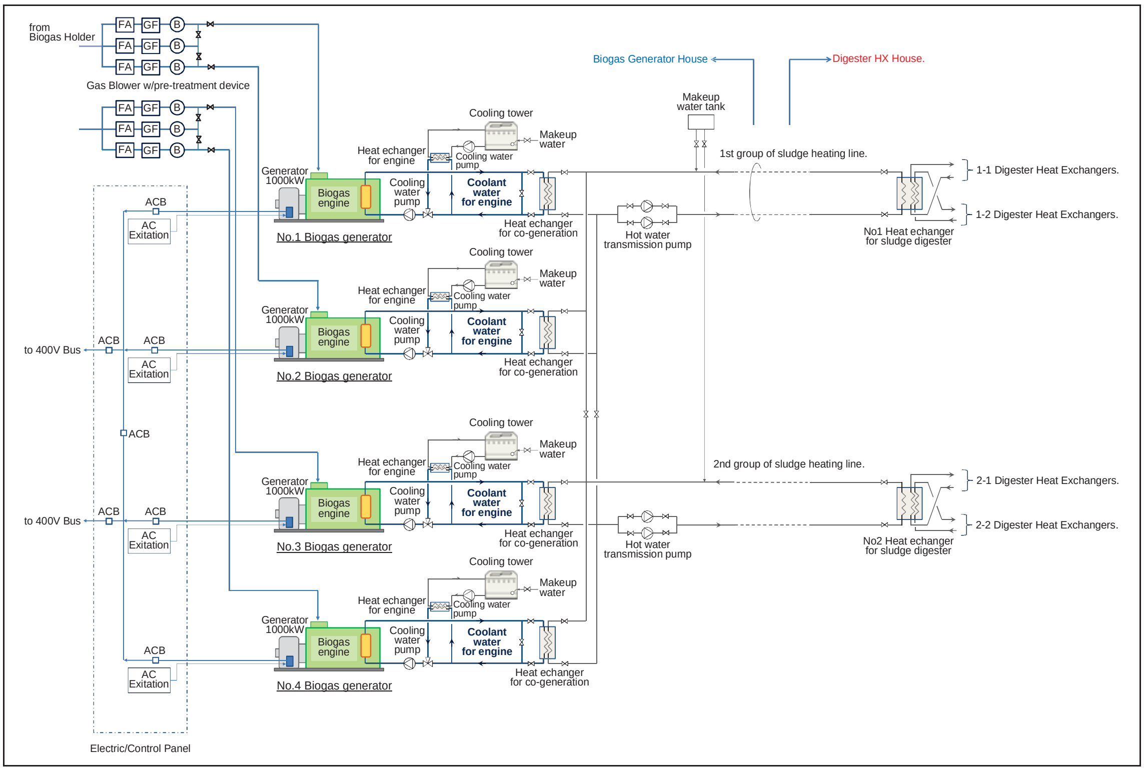


Figure 6.40 Cogeneration System

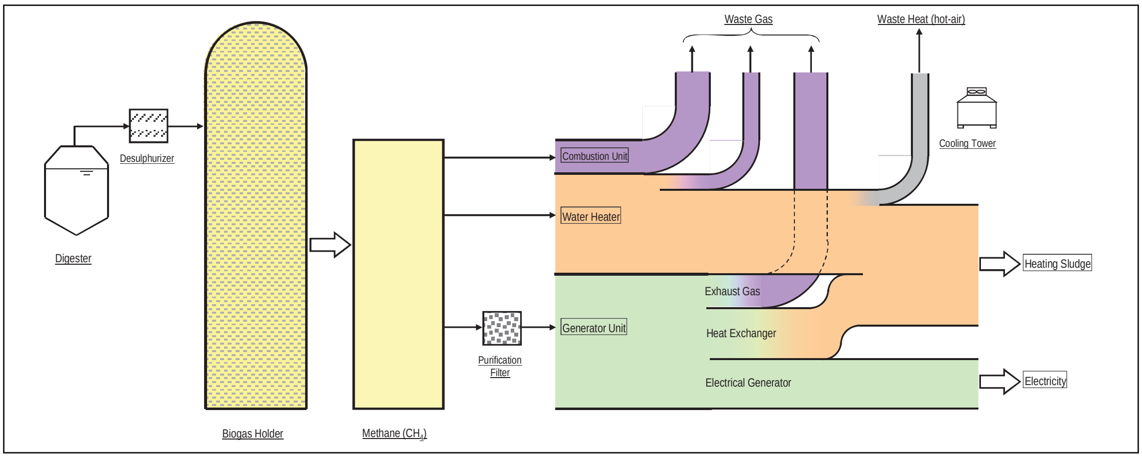


Figure 6.41 Heat Balance of Biogas

6.5.8 Operation of Biological Treatment Process

Physical-chemical and biological reactions, which occur in the bioreactor of SFDNP, are the same as those of the conventional biological nitrogen removal processes from the aspects of removal of organic substances and nitrogen by utilizing activated sludge. Hence, required attentions for operating SFDNP are the same as those of the conventional processes. Important points which particularly require attention and additional points of this process are the followings.

- Confirmation of equal distribution of influent
- Sludge management to ensure the proper ASRT to keep nitrifying bacteria
- Management of dissolved oxygen required for nitrification process and confirmation of status of nitrification process by measuring NH_4-N concentration in oxic tanks
- Confirmation of status of denitrification process by measuring NO_3-N concentration in anoxic tanks

Taking above points into consideration, instrumentation planning required for operating the bioreactors properly under SFDNP is shown in Figure 6.42 and monitoring items are summarized in Table 6.37.

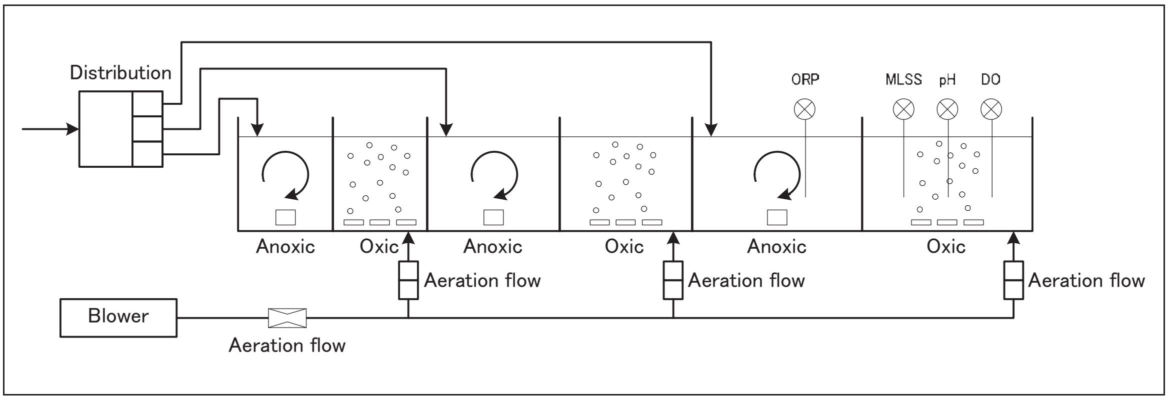


Figure 6.42 Instrumentation Planning

Table 6.37 Monitoring Items

Item	Management
Dissolved oxygen	It is important to ensure the proper ASRT to keep nitrifying bacteria and maintain dissolved oxygen, i.e. DO, in order not to deteriorate nitrification process. Target value of dissolved oxygen in the oxic tanks should be optimized considering the economic aspect and influence for denitrification process by carrying dissolved oxygen to anoxic tanks. 1-2 mg/l is generally sufficient. DO meter is generally installed in oxic tanks of the last stage since pollutant loading and capacity of aeration equipment are the same among all stages.
Oxidation reduction potential	It is effective to measure oxidation reduction potential, i.e. ORP, in order to confirm anoxic condition in anoxic tanks. Target valve of ORP should be optimized by considering the relation between ORP and remaining NO_3-N in effluent from actual operation of each wastewater treatment plant.
pH	Low pH condition caused from consumption of alkalinity by nitrification deteriorates nitrification process. It is required to maintain pH in oxic tanks more than 6.5 to prevent from deteriorating nitrification process. Hence, pH meter is installed to monitor pH.

Item	Management
Aeration flow	Flow meters for aeration are required for each tank in order to control dissolved oxygen in the oxic tanks and operation of aeration equipment, i.e. amount and balance of flow.
MLSS	Target valve of MLSS concentration should be optimized considering maintenance of proper ASRT and solid-liquid separation in the final settling tanks. MLSS concentration in the bioreactor of the final stage is generally 2,000-3,000 mg/l. It is especially important to control ASRT in winter since the growth rate of nitrifying bacteria is affected by water temperature. It is also required to optimize operation against fluctuation of pollutant lording by adjusting MLSS concentration.

6.5.9 Outline of Facilities Planning

Dimensions of main facilities and specifications of equipment are calculated according to design criteria shown in Table 6.33 and European Standard EN 12255. Outlines of facilities are summarized in Table 6.38. Facility and process calculation of planned facilities is shown in Appendix. The general layout of proposed facilities, the hydraulics profile and the process flow are shown in Figure 6.43, Figure 6.44, Figure 6.45 and Figure 6.46, respectively. The drawings of proposed facilities are presented in Appendix.

Table 6.38 Outlines of Facilities Planning

No	Facilities / Dimension / Specification	Number
1.	Lift pump facilities	
1-1	Lift pump (94m^3/min × 18m × 400kW)	12 nos. (2 standby)
1-2	Mechanical screen (channel: 4.5m)	3 nos.
2.	Pretreatment facilities	
2-1	Aerated grit chamber (3.5mW × 18mL)	6 channels
2-2	Fine screen (channel: 2.5m)	6 nos.
3.	Primary settling tank facilities	
3-1	Primary settling tank (diameter 34m × 3.5mD)	12 tanks
3-2	Sludge collector (circular type)	12 nos.
4.	Bioreactor facilities	
4-1	Anoxic tank (10mW × (13.7 + 19.2 + 25.7)mL × 6mD)	48 tanks
4-2	Oxic tank (10mW × (13.7 + 19.2 + 25.7)mL × 6mD)	48 tanks
4-3	Air blower (270m^3/min × 70kPa × 420kW)	8 nos. (2 standby)
4-4	Return sludge pump (16.5m^3/min × 8m × 37kW)	24 nos.
5.	Secondary settling tank facilities	
5-1	Secondary settling tank (diameter 49m × 4mD)	12 tanks
5-2	Sludge collector (circular type)	12 nos.
6.	Filtration	
6-1	Disc filter (filtration area: 114m^2)	16 nos. (2 standby)
7.	Gravity thickener	
7-1	Gravity thickener (diameter 21m × 4mD)	4 tanks
7-2	Sludge collector (circular type)	4 nos.
8.	Mechanical thickener	
8-1	Belt thickener (capacity: 40m^3/hour)	7 nos. (1 standby)
8-2	Polymer preparation tank (botch type)	2 nos.
9.	Anaerobic sludge digester	
9-1	Heated sludge digester (capacity: 6,600m^3)	8 tanks
9-2	Digester mixer (top-entry agitator type)	8 nos.
9-3	Gas holder (volume: 3,000m^3)	4 nos.
10.	Mechanical dewatering	
10-1	Screw press dewatering machine (diameter: 1000mm)	5 nos. (1 standby)
10-2	Polymer preparation tank (botch type)	4 nos.
11.	Electrical facilities	
11-1	SCADA system	1 set
11-2	CCTV system	1 set
11-3	Standby generator (capacity: 2,500kVA)	4 nos.
11-4	Cogeneration system (capacity: 1,000kW)	4 nos.

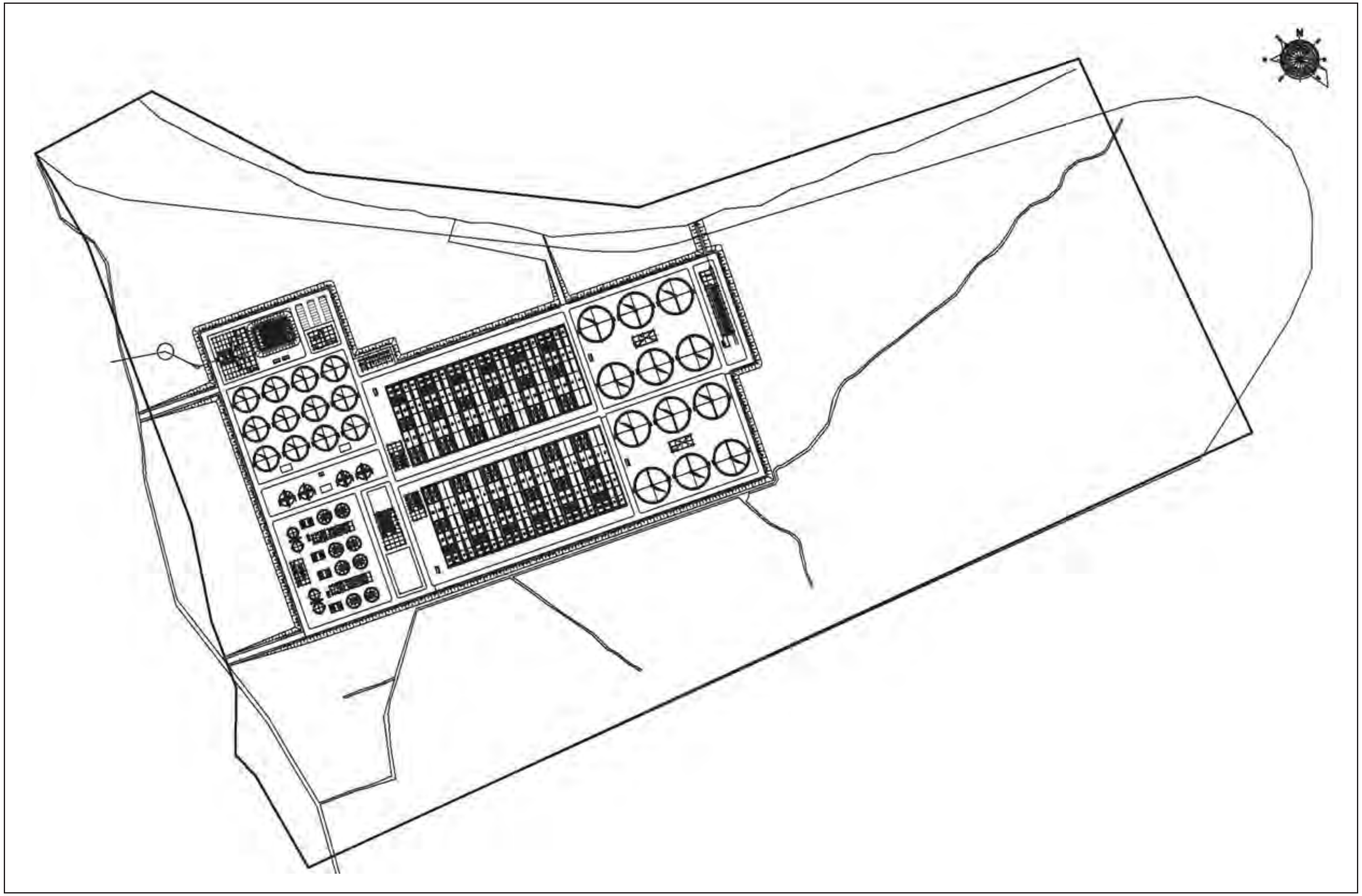


Figure 6.43 General Layout

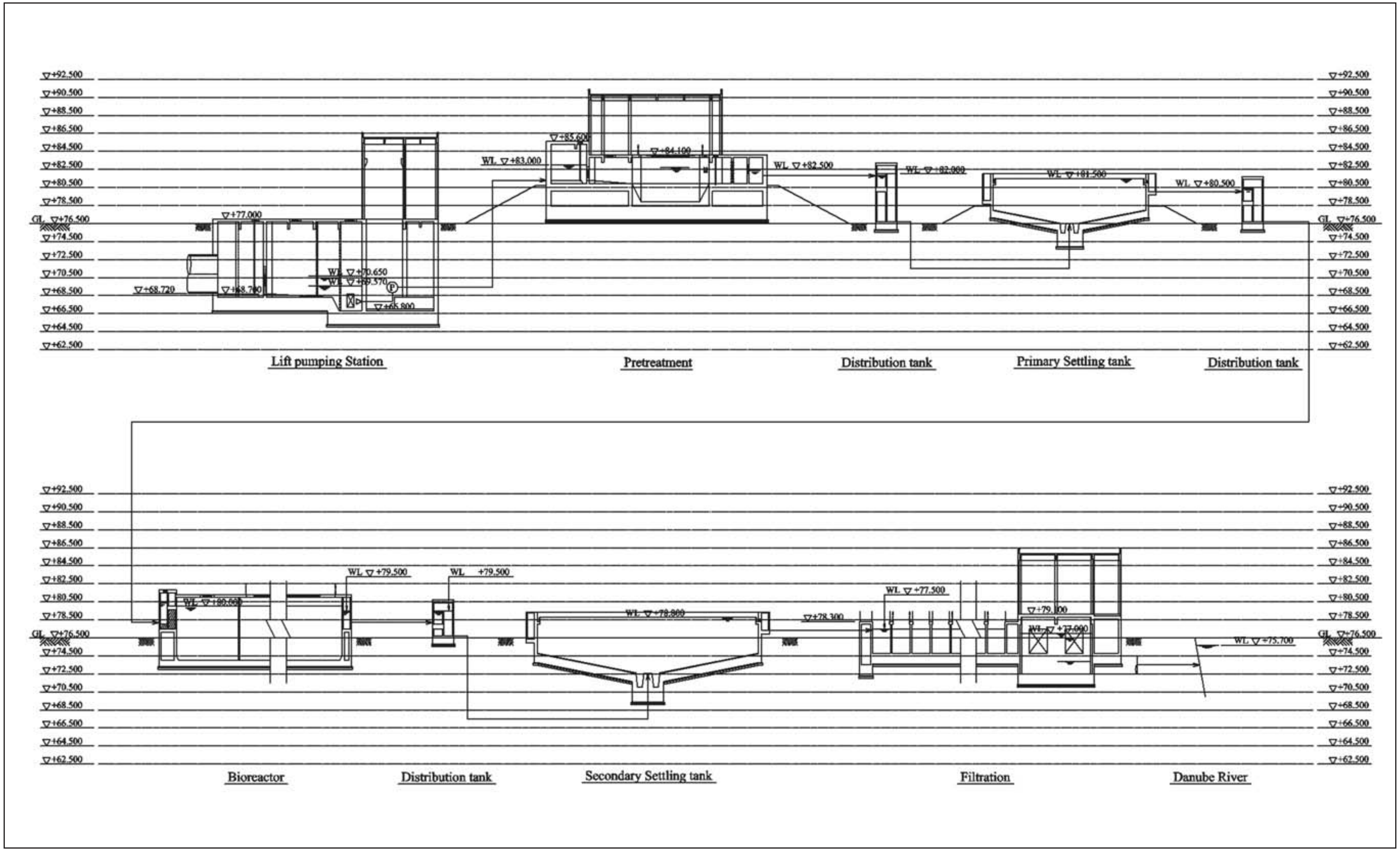


Figure 6.44 Hydraulic Profile

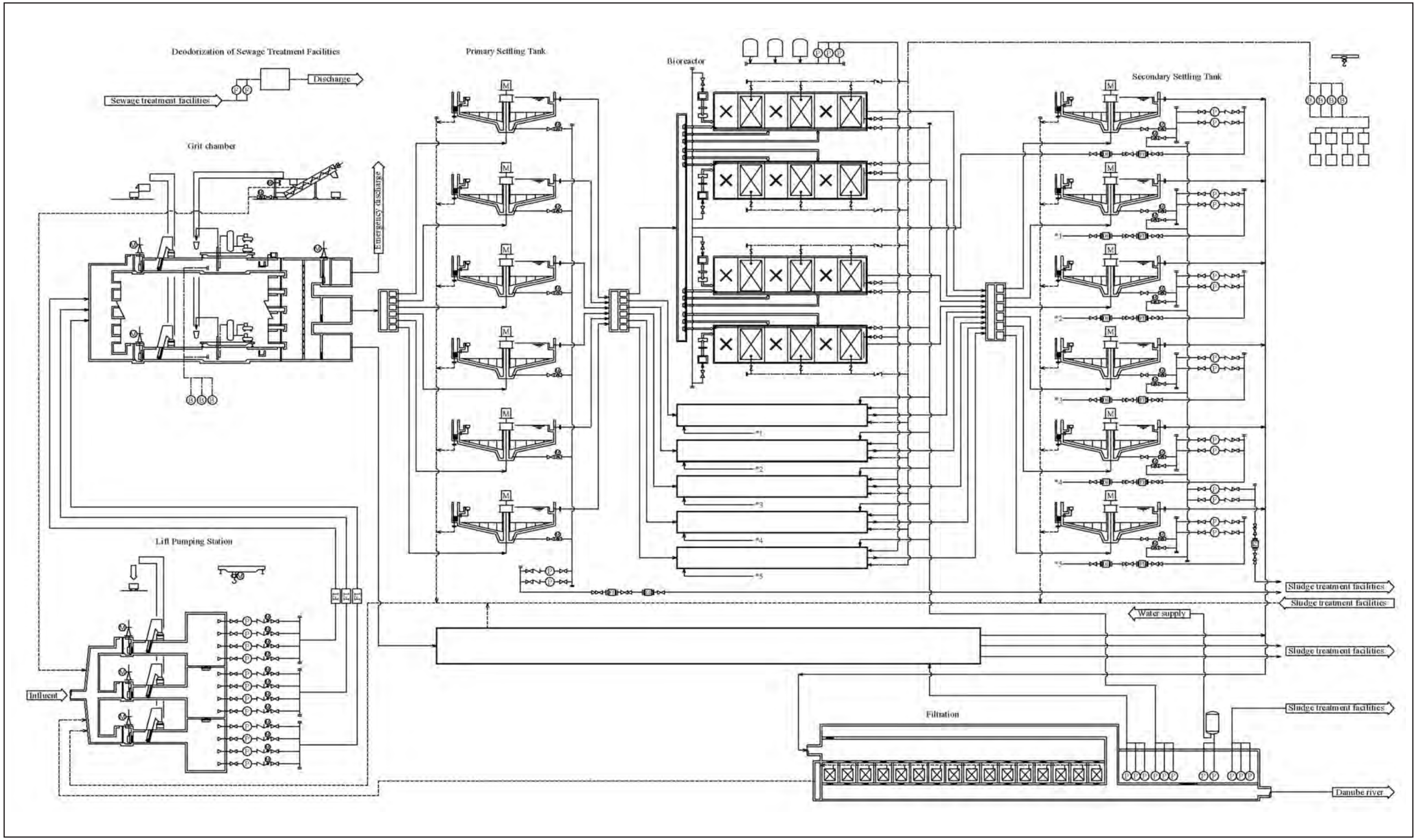


Figure 6.45 Process Flow of Sewage Treatment

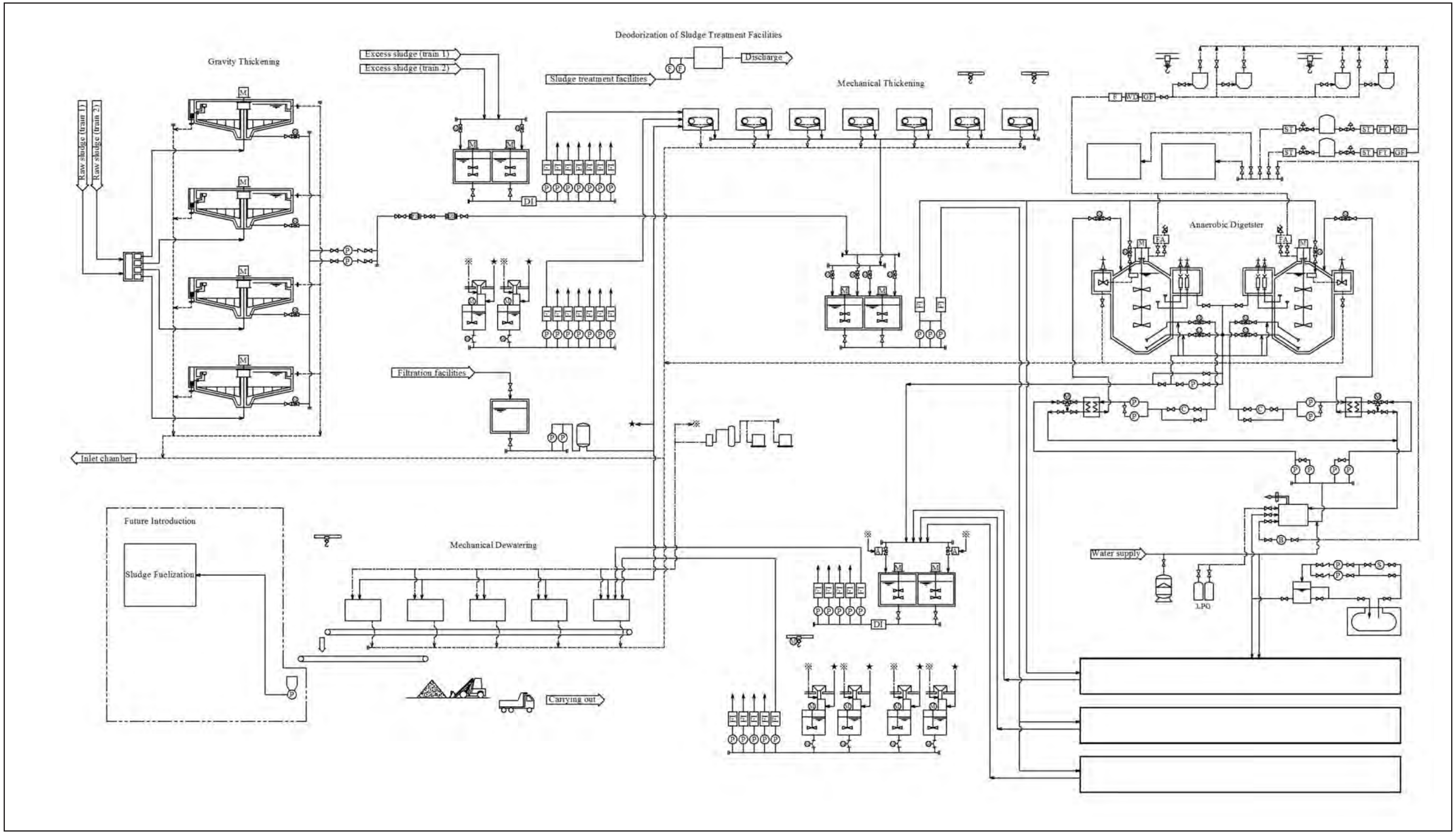


Figure 6.46 Process Flow of Sludge Treatment

7. Cost Estimation and Implementation Schedule

7.1 Project Cost

7.1.1 Condition of Cost Estimation

The project cost is estimated based on the conditions stated below.

- The project cost comprises construction cost, administration cost, consulting cost, contingency (physical and price escalation), land acquisition and compensation, interest during construction, commitment charge and relevant tax.
- The project cost is composed of the local currency potion (L.C.) and foreign currency portion (F.C.).
- Administration cost in recipient country is assumed to be 5.0 percent of the construction cost.
- Consulting cost is estimated based on man-months of consulting services shown in Table 7.17.
- Physical contingency is considered as 5.0 percent of total of construction cost, consulting cost, land acquisition and compensation.
- Price escalation of 2.0 percent per annum for the local currency portion and 2.1 percent per annum for the foreign currency portion are applied estimated based on implementation schedule shown in Table 7.12.
- The base period of cost estimation is January in 2013 and the exchange rate considered is 1 RSD=0.913 Yen, 1 Euro=105 Yen and 1Euro=115 RSD.
- The cost for land acquisition and compensation is based on estimation conducted by LARAP.
- Interest during construction is estimated taking into consideration that Project cost is financed by Japanese ODA loan. (Loan condition: Preferential terms / Standard, Interest rate of main components=1.2%, Interest rate of consulting services=0.01%, Repayment period=25year, Grace period=7year)
- Commitment charge is 0.1% of the amount of unused balance (loan commitment amount minus already disbursed amount) in order to promote the early realization of the project effects and to increase the incentive of implementation of the project.
- Tax rate, i.e. value added tax, in Serbia is 20 %.
- Construction cost, consulting cost, contingency (physical and price escalation), interest during construction and commitment charge are eligible portions while administration cost, land acquisition and compensation, and relevant tax are non-eligible portions taking into consideration that Project cost is financed by Japanese ODA loan.

7.1.2 Condition of Estimating the Construction Cost

The construction cost is estimated based on the conditions listed as follows.

- The materials for civil and building works, labor and construction machineries except tunnel boring machines are basically procured from the local market.
- Mechanical and electrical equipment are basically procured from abroad such as EU countries and Japan. Procurement is decided considering factors such as quality, economical aspect and maintenance.
- Utilization of local contractors is considered for planning of execution since they have enough experiences and abilities.
- The ground level of the WWTP site is filled up to plus 76.50m to protect the facilities from inundation caused by Danube River.
- Local physical conditions such as geographical, geological and meteorological conditions and local regulations and customs are taken into consideration.

7.1.3 Estimated Project Cost

Cost estimation has been carried out considering factors mentioned above and is shown in Table 7.1. The estimated project cost for the Project is Euro 437 million (JPY 45.9 billion) including taxes and Euro 370 million (JPY 38.9 billion) excluding taxes. The breakdown of the estimates is presented in Appendix.

Table 7.1 Estimated Project Cost

No	Items	L.C. (1,000 Euro)	F.C. (1,000 Euro)	Total (1,000 Euro)
1.	Construction cost			
A	Veliko Selo WWTP			
A-1	Site preparation work	15,386	0	15,386
A-2	Lift pump facilities	2,524	6,100	8,624
A-3	Pretreatment facilities	2,254	1,402	3,656
A-4	Primary settling tank	5,847	Ĉ,612	7,459
A-5	Bioreactor	27,725	10,786	38,511
A-6	Blower facilities	1,844	4,194	6,038
A-7	Secondary settling tank	9,081	3,414	12,495
A-8	Filtration	2,351	6,913	9,264
A-9	Gravity thickener	842	427	1,269
A-10	Anaerobic digester	26,422	11,408	37,830
A-11	Sludge treatment facilities	2,277	4,925	7,202
A-12	Pipe works	6,418	14,386	20,804
A-13	Administration building	1,886	3,937	5,823
A-14	Substation and generator building	1,625	5,275	6,900
A-15	Cogeneration building	673	1,853	2,526
A-16	Landscaping work	2,015	0	2,015
	Sub-total of A	109,170	76,632	185,802
B	Interceptor			
B-1	Interceptor No. 1	6,416	4,623	11,039
B-2	Interceptor No. 2	3,981	351	4,332
B-3	Interceptor No. 3	7,752	0	7,752
B-4	Interceptor No. 4	9,752	0	9,752
B-5	Interceptor No. 6	3,874	10,587	14,461
B-6	Interceptor No. 10 including collector	5,957	18,906	24,863
	Sub-total of B	37,732	34,467	72,199
C	Pumping station			
C-1	Ušće pumping station	3,208	2,806	6,014
C-2	Mostar pumping station	1,152	2,300	3,452
	Sub-total of C	4,360	5,106	9,466
	Sub-total of 1	**151,262**	**116,205**	**267,467**
2.	Administration cost	16,799	0	16,799
3.	Consulting cost*1	7,282	8,800	16,082
4.	Physical contingency for construction cost	8,456	6,562	15,018
5.	Price escalation for construction cost	16,726	13,522	30,248
6.	Land acquisition and compensation*1	7,300	0	7,300
7.	Interest during construction	0	14,116	14,116
8.	Commitment charge	0	2,742	2,742
9.	Tax and duty	67,198	0	67,198
	Sub-total of (2-9)	**123,761**	**45,742**	**169,503**
	Total including Tax and Duty	**275,023**	**161,947**	**436,970**
	Total excluding Tax and Duty	**207,825**	**161,947**	**369,772**

Note *1; Physical contingency and price escalation of this item are included in the cost

The percentage of the estimated construction cost of the wastewater treatment plant, pumping stations and interceptors is shown in Figure 7.1. The construction costs of Veliko Selo WWTP, interceptors and pumping stations constitute about 69 %, 27 % and 4 % of the total construction costs, respectively.

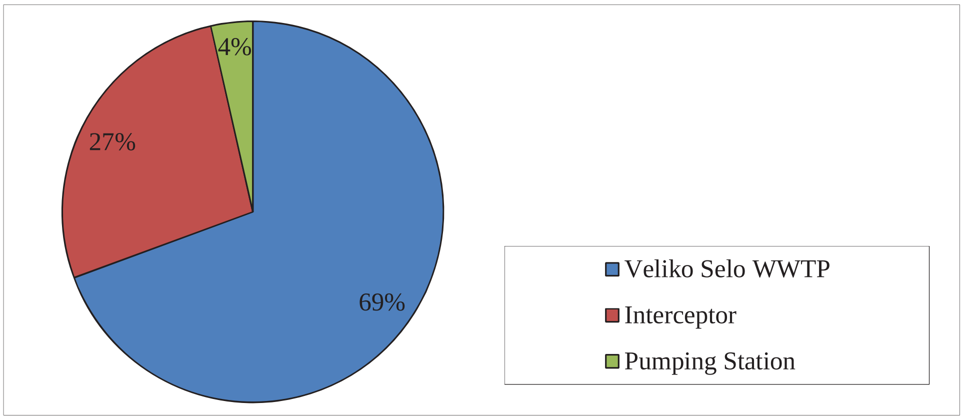


Figure 7.1 Percentage of the Construction Cost

The percentage of the estimated project cost by components is analyzed as shown in Figure 7.12. The direct construction cost accounts for 60 % of the total project cost and indirect construction cost including remaining costs accounts for 40 %.

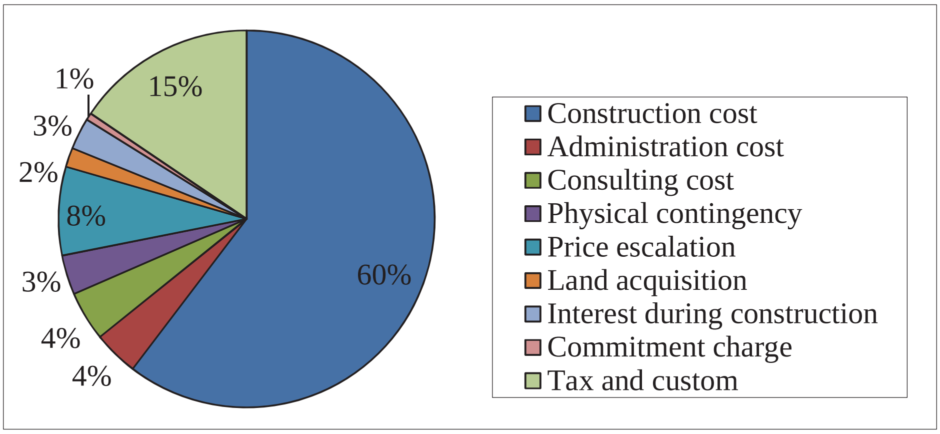


Figure 7.2 Percentage of Component of Project Cost

7.1.4 Estimated Operation and Maintenance Cost

The operation and maintenance cost required for operating facilities after implementation of the

Project is estimated and summarized in Table 7.2. The operation and maintenance cost comprises of expenses on salary, electricity, maintenance including spare parts, disposal of sludge cake, consumable including chemical, cleaning of interceptors and others. Annual operation and maintenance cost is 9.4 million Euro/year (988 million Yen/year).

Table 7.2 Estimated Operation and Maintenance Cost

No	Items	Total (1,000 Euro/year)
1.	Salary	510
2.	Electricity	2,111
3.	Maintenance	1,238
4.	Disposal of sludge cake	1,656
5.	Consumable	2,878
6.	Cleaning of interceptors	213
7.	Others	807
	Total	**9,414**

7.2 Phased Development of the Project

7.2.1 Necessity of Phased Development

The Project requires a large amount of investment to complete. In general, such a large project becomes feasible for implementation if they are implemented through several construction phases with appropriate development steps. Further, the phased development is needed for investment decision by financial or investment institutions.

Sewerage system is composed of sewer network, conveyance system such as pumping stations and interceptors and wastewater treatment plant. These facilities have different functions and these series of facilities are required to perform as a system to treat wastewater collected from users. Therefore, in each development stage, the capacity of facilities has to be coordinated and physically balanced to perform as a system in order to make constructed facilities function effectively and efficiently.

7.2.2 Phased Development Plan of Sewerage System

(1) Making Process of Phased Development Plan

First of all catchment area are divided into the appropriate groups taking configuration of the interceptors into consideration. These groups are evaluated qualitatively and quantitatively from the viewpoints of project effect, environment assessment and development effect and prioritized.

In the second step, the combinations of these groups are evaluated from the viewpoints of size and effectiveness of the capital investment. In the last step, comprehensive evaluation is conducted to decide the catchment areas targeted in the Phase-I Project.

(2) Sewerage Development Plan in Central System

Schematic diagram of sewerage system in Central system, which consists of the existing pipe network and improvement works, and hydraulic load of each sub-basin are shown in Figure 7.3 and Table 7.3, respectively.

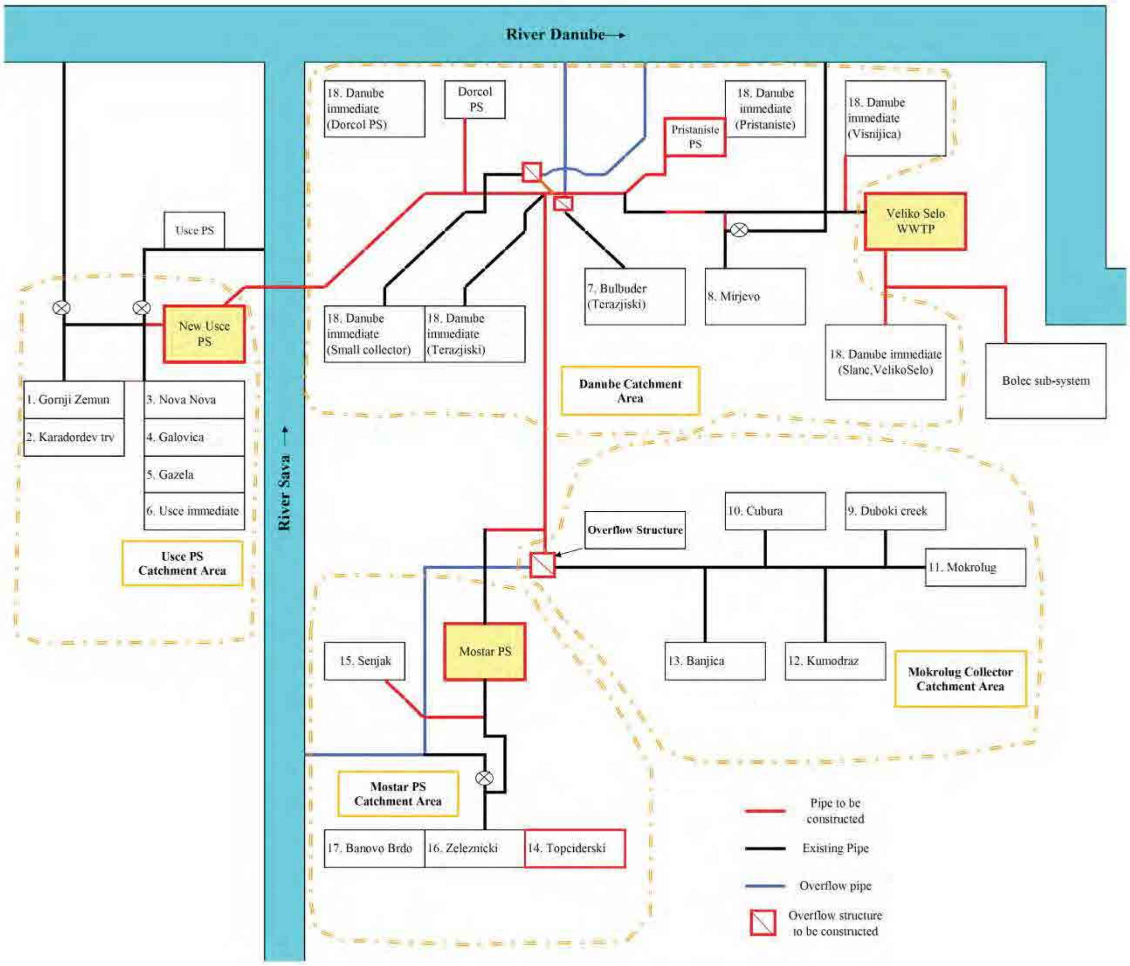


Figure 7.3 Schematic Diagram of Sewerage System in Central System

Table 7.3 Projected Hydraulic Load of Each Sub-basin

Sub-basin	Daily ave. (m^3/day)	
	2021	**2031**
1. Gornji Zemun	29,700	31,000
2. Karađorđev trg	26,000	26,500
3. Nova Nova	15,400	16,000
4. Glavica	26,600	27,600
5. Gazela	6,100	6,400
6. Ušće immediate basin	2,700	2,900
Total of Ušće PS catchment area	**106,500**	**110,400**
14. Topčider collector	55,100	58,400
15. Senjak	2,100	2,200
16. Železnički	37,600	39,300
17. Banovo Brdo	25,600	26,300
Total of Mostar PS catchment area	**120,400**	**126,200**
9. Duboki creek	13,900	14,300
10. Čubura collector	12,700	13,000
11. Mokrolug collector	15,400	15,900
12. Kumodraz collector	15,900	16,400
13. Banjica collector	22,000	22,800
Total of Mokrolug collector catchment area	**79,900**	**82,400**
7. Bulbuderski collector	39,100	40,300
8. Mirijevski collector	15,600	15,900
18. Danube immediate basin (Of these, Dorcol PS) (Of these, Pristaniste PS, Slanc & Veliko Selo)	47,500 (14,400) (7,200)	49,800 (15,100) (7,600)
Total of Danube catchment area	**102,200**	**106,000**
Sub-total	**409,000**	**425,000**
Bolec catchment area	**-**	**23,700**
Total	**409,000**	**448,700**

(3) Existing Conditions of the Major Sewage Outlets

Catchment areas are classified according to each major sewage outlet in order to evaluate effect of improvement resulting from the connection of each outlet to interceptors. Catchment areas and locations of the existing eight major sewage outlets are shown in Table 7.4 and Figure 7.4, respectively.

Table 7.4 Catchment Areas of the Major Sewage Outlets

Catchment area	Major outlet	Sub-basin
Ušće PS catchment area	Discharge point 1	Gornji Zemun Karađorđev trg
	Discharge point 2	Nova Nova Glavica Gazela Ušće immediate basin
Mostar PS catchment area	Discharge point 3-1	Topčider Železnički Banovo Brdo Senjak
Mokrolug catchment area	Discharge point 3-2	Mokrolug
Danube catchment area	Discharge point 5	Bulbuderski
	Discharge point 8	Mirjevski
	Discharge point 4	Part of Danube immediate basin/ Dorcol PS catchment area
	Discharge point 7	Part of Danube immediate basin/ Pristaniste PS
	Discharge point 6	Part of Danube immediate basin/ Treazjiski collector and Other small collector
	Existing stream into Danube	Part of Danube immediate basin/ Slanci, Veliko Selo

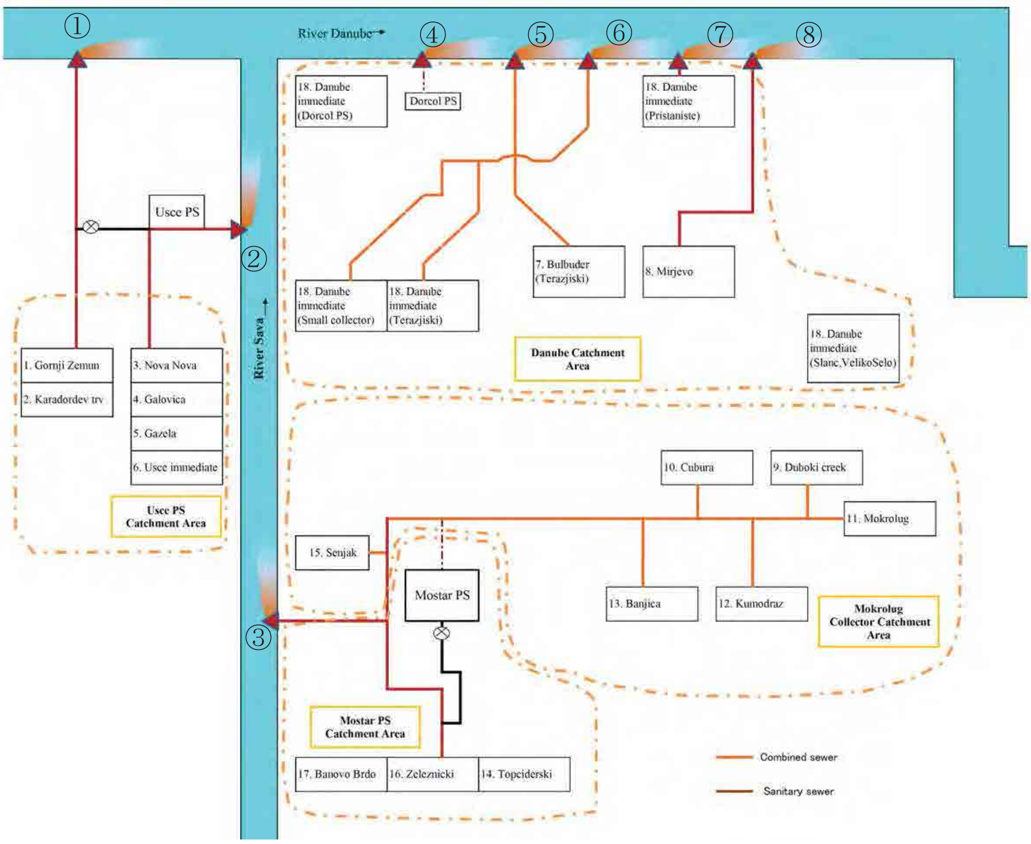


Figure 7.4 Locations of Major Sewage Outlets

(4) Grouping of Catchment Areas

Catchment areas of the Central system are divided into the following five groups taking configuration of the interceptors into consideration.

- Group I: Mostar PS Catchment Area (separate system)
- Group II: Mokrolug Catchment Area (combined system)
- Group III: Usche PS Catchment Area (separate system) and Upper Danube Catchment Area (basically combined system)
- Group IV: Lower Danube Catchment Area (basically combined system)
- Group V: Lowermost Danube Catchment Area (another trunk line)

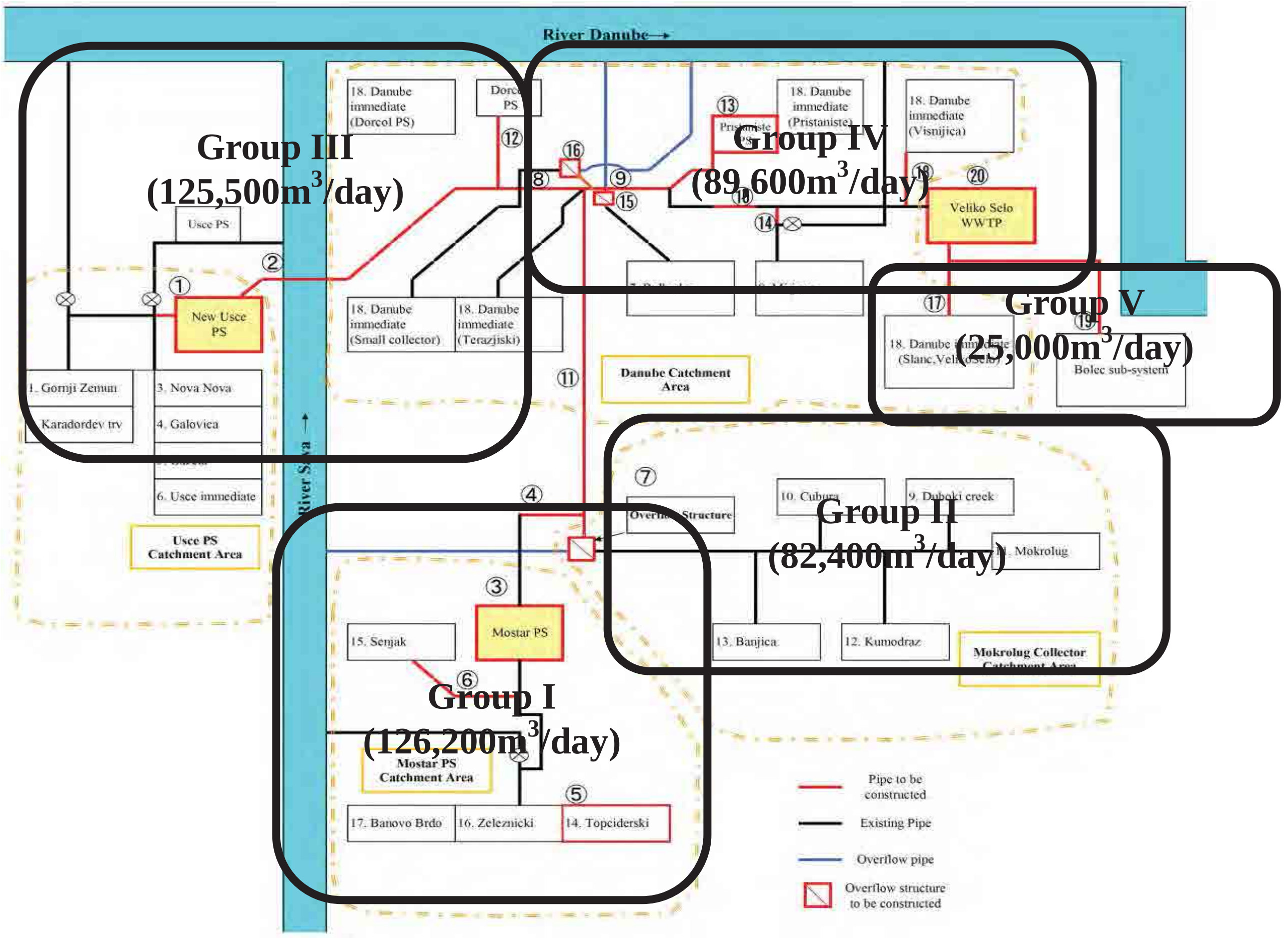


Figure 7.5 Grouping of Catchment Areas

(5) Evaluation of Prioritization

Project effect, environment assessment and development effect are evaluated as described below.

(A) Project Effect

Mitigation of Flood Damage

Flood often occurs in the area along Sava River and Danube River in case of high level of Danube River. When inundation occurs around the sewage outlet, blowing up of sewage from manhole, not only flood damage but also sanitation problem arise in the area due to drainage defect. It is possible to relieve that damage/problem by draining sewage into interceptor connected to sewage treatment plant.

Figure 7.6 Flood Condition around Mostar Pumping Station

Conservation of Water Resources for Water Supply

River-bed water along Sava River is utilized as water resources for water supply in the City of Belgrade. If sewage discharged from outlet located at upper stream of the water resources is drained into interceptor connected to sewage treatment plant, it is expected to supply safe and secure water more than ever to citizens and reduce the treatment cost due to improvement of water quality of resources. This is conducive to better performance of water supply works.

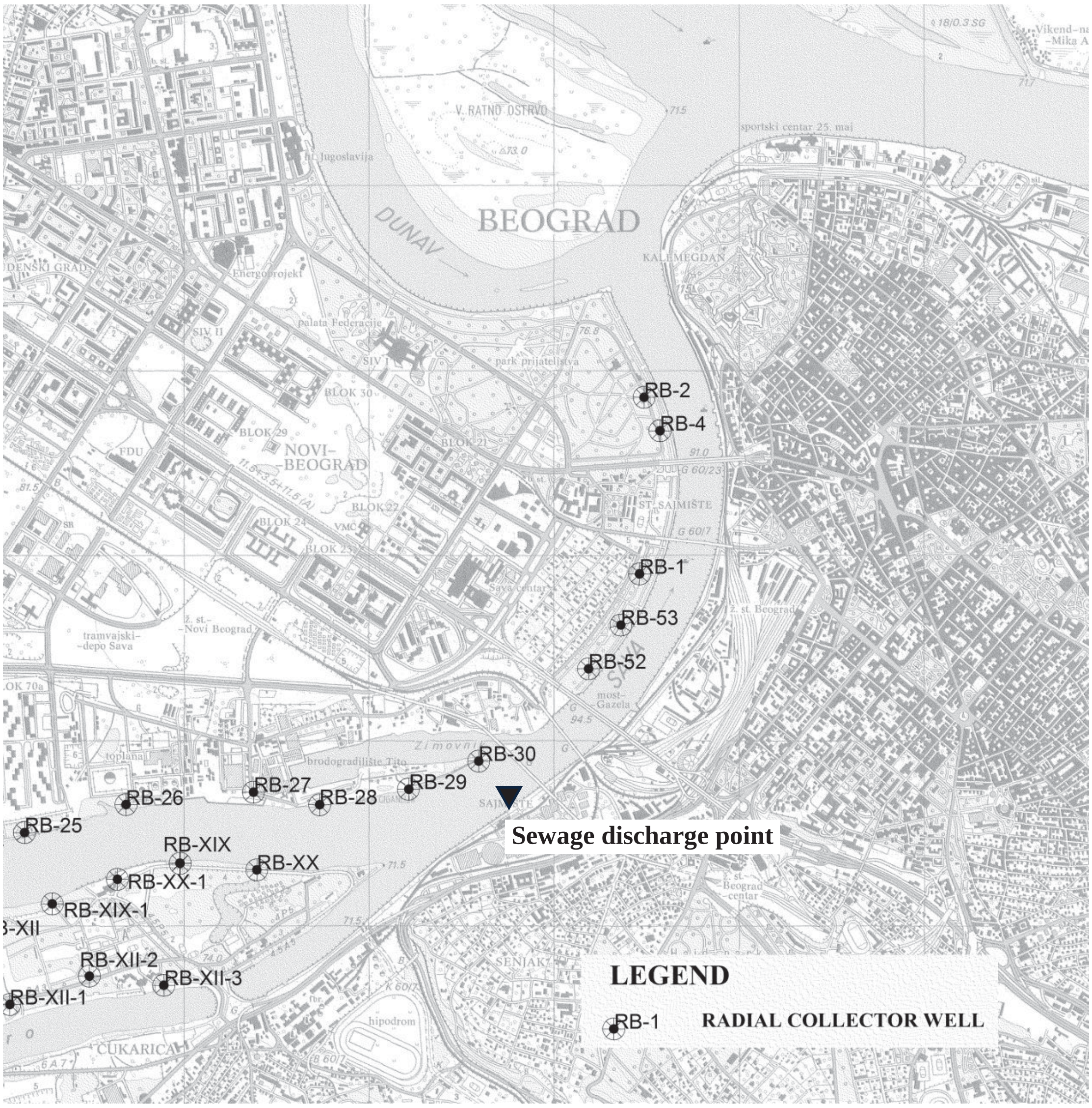


Figure 7.7 Location of Water Resources for Water Supply along Sava River

Contribution to Vitalizing Tourism

There are many tourism resources in Belgrade along Sava River and Danube River, such as cultural and historical heritage, old town and street, park and bathing area for people, waterfront for watersport and floating restaurant, and so on. If sewage, trash and screenings discharged from sewage outlet located at upper stream of tourism resources are removed, it is possible to contribute to vitalizing tourism.

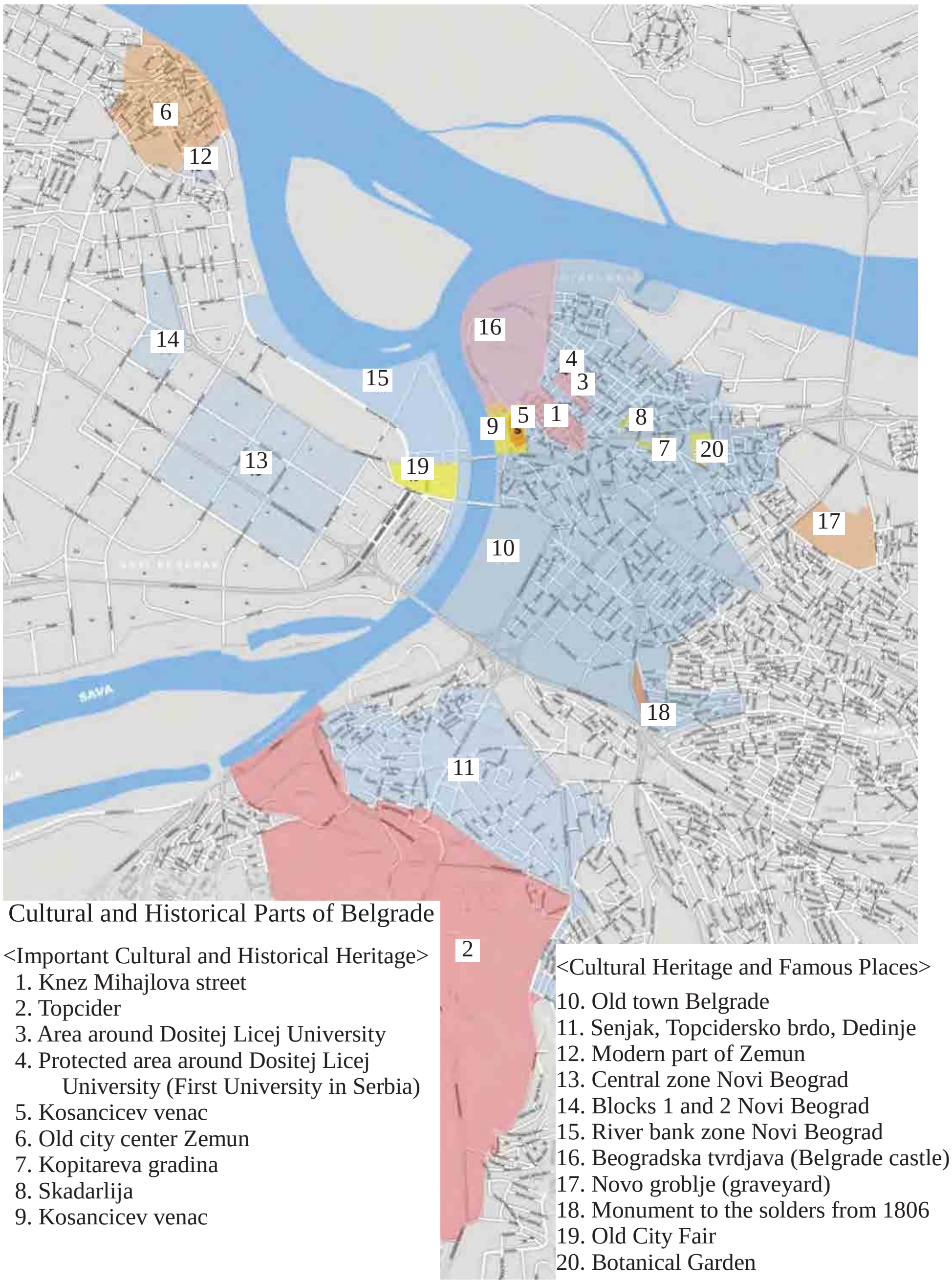


Figure 7.8 Cultural and Historical Heritage of Belgrade City

(B) Environment Assessment (Contribution to Water Quality Improvement)

Discharge of untreated sewage to river becomes water pollution source for water and materials of river bed. It has a serious impact on water quality of Sava River in particular, because Sava River has less quantity of water in comparison to Danube River. The factory does not exist in the area of Central System, which discharge a large amount of pollution loads and most pollution load is derived from human being. Therefore the ratio of the quantity of discharged sewage to the river flow rate is evaluated as the contribution ratio to water quality improvement.

Main points for calculation of this ratio are:

- The ratio is calculated from the quantity of discharged sewage divided by the river flow rate.
- The quantity of discharged sewage is shown in Table 7.3
- Flow rate of Danube River: 5,215m3/sec = 450,576,000m3/day (average in 2006 ~ 2011)
- Flow rate of Sava River: 1,461m3/sec = 126,230,400 m3/day (average in 2006～2011)

The above ratio is evaluated as follows;

A: the ratio is more than 0.05%
B: the ratio is 0.05～ 0.01%
C: the ratio is less than 0.01

(C) Development Effect

Interceptor is constructed from downstream in general. Therefore from the view point of development effect it is evaluated that it is effective to connect to interceptor sequentially from the area of the downstream side.

A: Connect to downstream interceptor from Interceptor No. 4
B: Connect to Interceptor No. 1 - No. 3 and No. 10
C: Connect to another inflow trunk sewer

(D) Priority Ranking of Groups

The results of the above mentioned evaluations are shown in Table 7.5. As a result of evaluation, the priority ranking is as below:

- First priority: Group I (Mostar PS Catchment Area) and Group II (Mokrolug Catchment Area)
- Second priority: Group IV (Lower Danube Catchment Area)
- Third priority: Group III (Ušće PS Catchment Area and Upper Danube Catchment Area)
- Last priority: Group V (Lowermost Danube Catchment Area)

Table 7.5 Project Effect and Priority Ranking for Catchment Areas and the Groups

Catchment area	Mostar PS Catchment Area	Mokrolug Catchment Area	Ušće PS Catchment Area		Danube Catchment Area				
					Upper Stream	Down Stream			
Discharge point	Discharge point 3-1	Discharge point 3-2	Discharge point 1	Discharge point 2	Discharge point 4	Discharge point 5, 8	Discharge point 6	Discharge point 7	existing stream into Danube
Sub-basin	Topčider Železnički Banovo Brdo Senjak	Mokrolug	Gornji Zemun Karađorđev trg	Nova Nova Glavica Gazela Ušće imme. basin	Dorcol PS catchment area	Bulbuderski Mirjevski	Treazjiski collector and small colletor	Pristaniste PS	Slanci, Veliko Selo
Projected hydraulic load in 2031 (m3/day)	126,200	82,400	110,400		15,100	56,200	27,100	6,300	1,300
Grouping of catchment area	**Group I**	**Group II**	**Group III**			**Group IV**			**Group V**
Mitigation of flood damage and urgent need	A	A	B		C	C			C
Conservation of water resources (presence or absence of downstream water resources)	A	A	B		C	C			C
Vitalizing tourism	A	A	A		B	B			C
A) Project Effect	**A**	**A**	**B**		**C**	**C**			**D**
B) Environment Assessment	**0.100% A**	**0.065% A**	**0.025% B**		**0.003% C**	**0.016% C**			**0.000% D**
C) Development Effect	**B**	**B**	**B**			**A**			**C**
Priority ranking	**1**	**1**	**3**			**2**			**4**

(6) Evaluation of Combinations of Groups

Combinations of catchment groups are set as options. Considering the combinations of groups Group II (Mokrolug Catchment Area) and Group V (Lowermost Danube Catchment Area) are excluded for the following reasons.

Group II (Mokrolug Catchment Area), which is combined sewer area along Mokrolug creek with several steep and narrow valleys, has an inundation problem in downstream and also a problem that separation of the rainwater is incomplete in the upper stream and a large amount of rainwater flows into Mokrolug interceptor. For solving these problems, there is a plan to construct more than 8 reservoirs in the upper stream. Thus it is required for the Mokrolug catchment area to give priority to a rainwater inflow restraint facility in the upper stream.

If a large amount of rainwater flows into sewage treatment plant, even if rainwater inflow is regulated by diversion tank, it causes deterioration of treatment performance especially for nitrogen removal. On this account it is required to resolve this problem by developing the rainwater inflow restraint facility (construction of reservoirs) as a precondition of the connection to sewage treatment plant.

Group V (Lowermost Danube Catchment Area) is the least priority ranking and also sewer network has not been developed to collect sewage from users.

Then, investment cost and investment effect are evaluated for the following options;

- Option 1: Group I (Mostar PS Catchment Area) and Group IV (Lower Danube Catchment Area)
- Option 2: Group III (Ušće PS and Upper Lower Danube Catchment Area) and Group IV (Lower Danube Catchment Area)
- Option 3: Group IV (Lower Danube Catchment Area)
- Option 4 (Reference): Group I (Mostar PS Catchment Area) and Group II (Mokrolug Catchment Area) and Group IV (Lower Danube Catchment Area)

Table 7.6 Comparison of Investment Cost and Investment Effect

	Option 1	Option 2	Option 3	Option 4 (Reference)
Projected hydraulic load in 2031 (except Bolec area)	215,800 m^3/day (51% of total)	215,100 m^3/day (51% of total)	89,600 m^3/day (21% of total)	298,200 m^3/day (70% of total)
Total investment cost (Million Euro)	161.2	162.0	98.4	203.3
WWTP	108.7	108.7	74.2	150.7

	Option 1	Option 2	Option 3	Option 4 (Reference)
Interceptors	49.1 (Interceptor 4, 6,10)	47.3 (Interceptor 1-4, 6)	24.2 (Interceptor 4, 6)	49.1 (Interceptor 4, 6,10)
Pumping Station	3.4 (Mostar PS)	6.0 (Usche PS)	-	3.5 (Mostar PS)
Investment effect (Hydraulic load/Cost)	1,339 m3/M Eur	1,328m3/M Eur	911m3/M Eur	1,467m3/M Eur
Evaluation	A	A	B	—

From this comparison Option 1 and 2 are evaluated as A rank with almost the same investment cost and investment effect.

(7) Comprehensive Evaluation

Finally the priority catchment area is selected among option 1, 2 and 3 based on the above first and second evaluation in a comprehensive manner, as shown in Table 7.7.

Table 7.7 Comprehensive Evaluation

	Option 1	Option 2	Option 3	Option 4 (Reference)
Projected hydraulic load in 2031 (except Bolec area)	215,800 m^3/day (51% of total)	215,100 m^3/day (51% of total)	89,600 m^3/day (21% of total)	298,200 m^3/day (70% of total)
Project effect	A	B	C	A
Priority ranking	1	3	2	-
Investment effect	A	A	B	-
Comprehensive evaluation	Project effect and investment effect are excellent. Investment cost is appropriate and equalized. **This option is recommended.**	Project effect is lower than Option 1 and priority ranking also low. Investment cost is appropriate and equalized.	Project effect is lower than other options. Investment cost is lowest and investment effect is also lowest.	Project effect and investment effect are best, but investment cost is biggest. (For the Mokrolug catchment area, it is necessary to develop the rainwater inflow restraint facility.)

In case of Option 1, drainage and sanitation condition in Mostar catchment area is improved. This brings direct benefit to local inhabitants. It is also expected that water quality of Sava River is improved more because there is less flow rate in case of Sava River than Danube River. This water quality improvement contributes to water supply works which depends on wells of river-bed water as water resources along Sava River and water environment improvement of water front, such as tourism resources around river mouth of Sava River and Sava Lake which is citizen’s oasis and bathing area.

In addition, Option 1 and Option 2 are suitable for the stage construction of the sewage treatment plant because both projected hydraulic load is just half of the whole.

As for Option 3, investment becomes lowest, but the investment effect is also lowest.

Option 4 (reference) is the most superior in the project effect and investment effect, but it is not with the top priority, because the investment becomes biggest and it is necessary for the Mokrolug catchment area to give priority to a rainwater inflow restraint facility in the upper stream.

From the above-mentioned examination result, Option 1 is recommended to choose as the top priority development area.

7.2.3 Phased Development Plan of Veliko Selo WWTP

Taking into account expected amount of influent to the WWTP, phased development of Veliko Selo WWTP is planned. The facilities of half capacity, which can accommodate 21,580 m^3/day for Option 1, should be constructed in Phase-I Project. The civil structures which are difficult to be constructed in phase such as lift pumping station, pretreatment facilities, sludge building, effluent channel, etc. are included in the Phase-I Project. The facilities included in Phase-I Project are showed in Figure 6.3.

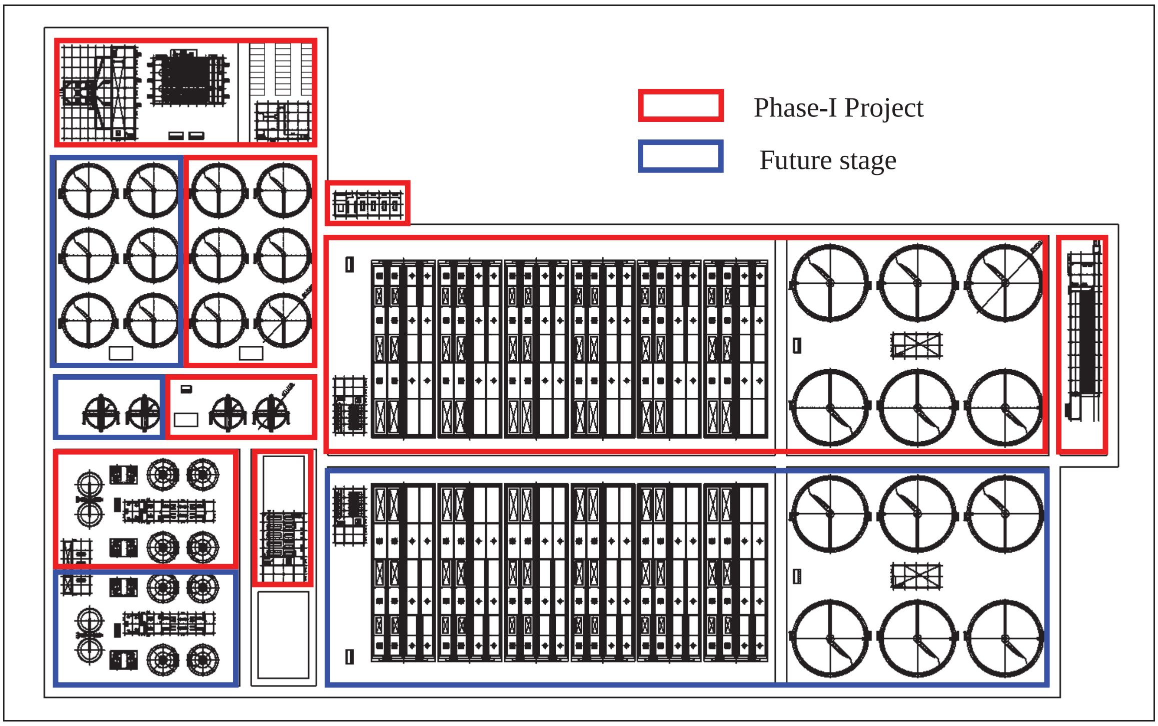


Figure 7.9 Phase-I Project of Veliko Selo WWTP

7.2.4 Components of Phase-I Project

According to the phased development plan, the following components of the Project will be implemented in the Phase-I Project.

- Construction of Veliko Selo WWTP (half of capacity)
- Construction of Interceptor No. 4, No. 6 and No. 10
- Rehabilitation of Mostar pumping station

The components which will be implemented in the Phase -I Project are shown in Figure 7.10.

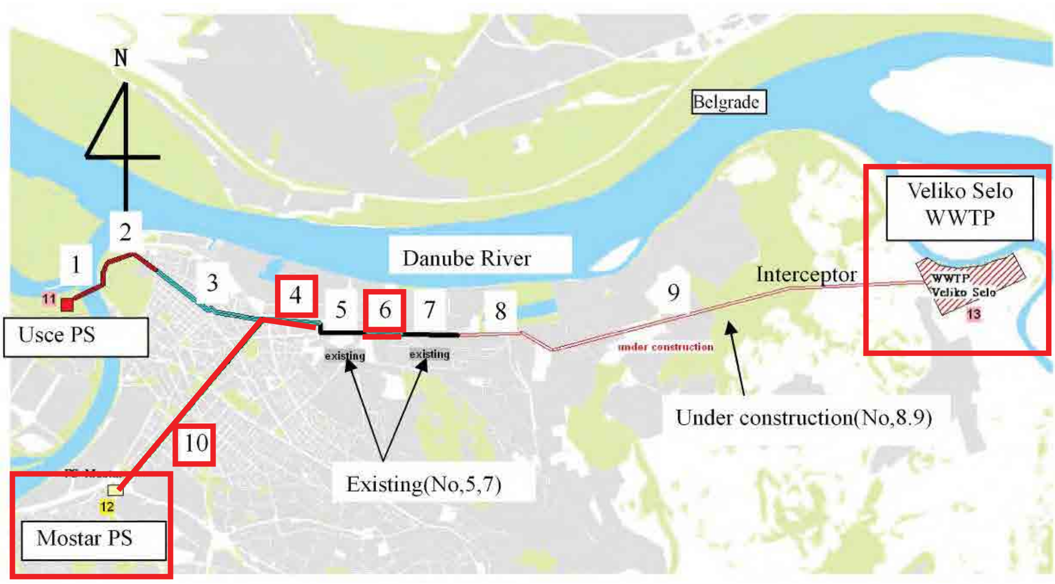


Figure 7.10 Components of Phase-I Project

7.3 Project Cost of Phase-I Project

7.3.1 Estimated Cost of Phase-I Project

Cost estimation for Phase I Project is shown in Table 7.8. The estimated project cost for Phase-I Project is Euro 275 million (JPY 28.9 billion) including taxes and Euro 233 million (JPY 24.5 billion) excluding taxes. The breakdown of the estimates is presented in Appendix.

Table 7.8 Estimated Project Cost of Phase-I Project

No	Items	L.C. (1,000 Euro)	F.C. (1,000 Euro)	Total (1,000 Euro)
1.	Construction cost			
A	Veliko Selo WWTP			
A-1	Site preparation work	12,163	0	12,163
A-2	Lift pump facilities	1,983	3,246	5,229
A-3	Pretreatment facilities	2,212	1,025	3,237
A-4	Primary settling tank	3,027	806	3,833
A-5	Bioreactor	14,498	5,393	19,891
A-6	Blower facilities	937	2,096	3,033
A-7	Secondary settling tank	4,803	1,708	6,511
A-8	Filtration	1,783	3,699	5,482
A-9	Gravity thickener	437	224	661
A-10	Anaerobic digester	13,323	5,704	19,027
A-11	Sludge treatment facilities	2,033	3,432	5,465
A-12	Pipe works	4,601	7,119	11,720
A-13	Administration building	1,831	2,745	4,576
A-14	Substation and generator building	1,271	3,438	4,709
A-15	Cogeneration building	495	927	1,422
A-16	Landscaping work	2,015	0	2,015
	Sub-total of A	67,412	41,562	108,974
B	Interceptor			
B-1	Interceptor No. 4	9,752	0	9,752
B-2	Interceptor No. 6	3,874	10,587	14,461
B-3	Interceptor No. 10 including Collector	5,957	18,906	24,863
	Sub-total of B	19,583	29,493	49,076
C	Pumping station			
C-1	Mostar pumping station	1,152	2,300	3,452
	Sub-total of C	1,152	2,300	3,452
	Sub-total of 1	**88,147**	**73,355**	**161,502**
2.	Administration cost	10,608	0	10,608
3.	Consulting cost*1	7,282	8,800	16,082
4.	Physical contingency for construction cost	4,895	4,095	8,990
5.	Price escalation for construction cost	9,747	8,536	18,283
6.	Land acquisition and compensation *1	7,300	0	7,300
7.	Interest during construction	0	8,523	8,523
8.	Commitment charge	0	1,707	1,707
9.	Tax and duty	42,430	0	42,430
	Sub-total of (2-9)	**82,262**	**31,661**	**113,923**
	Total including Tax and Duty	**170,409**	**105,016**	**275,425**
	Total excluding Tax and Duty	**127,979**	**105,016**	**232,995**

Note *1; Physical contingency and price escalation of this item are included in the cost.

The percentage of the estimated construction cost of the wastewater treatment plant, pumping stations and interceptors is shown in Figure 7.11. The construction costs of Veliko Selo WWTP, interceptors and pumping station contribute about 67 %, 31 % and 2 % of the total construction costs, respectively.

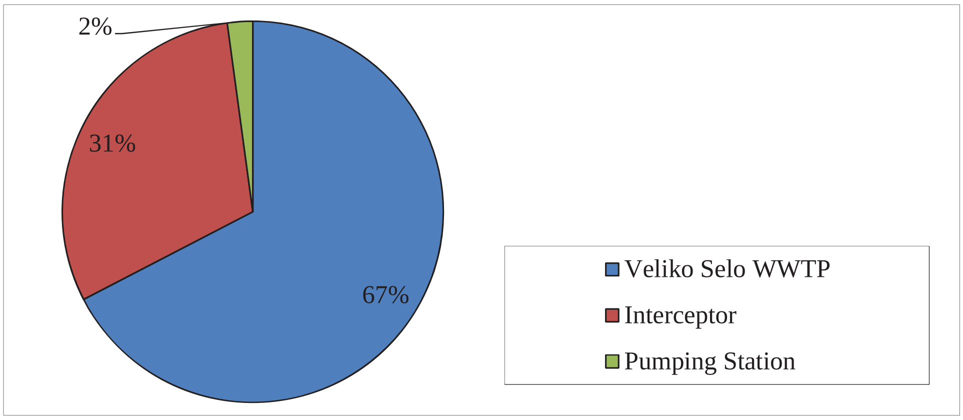


Figure 7.11 Percentage of the Construction Cost

The percentage of the estimated project cost by components is analyzed as shown in Figure 7.12. The direct construction cost accounts for 57 % of the total project cost and indirect construction cost including remaining costs accounts for 43 %.

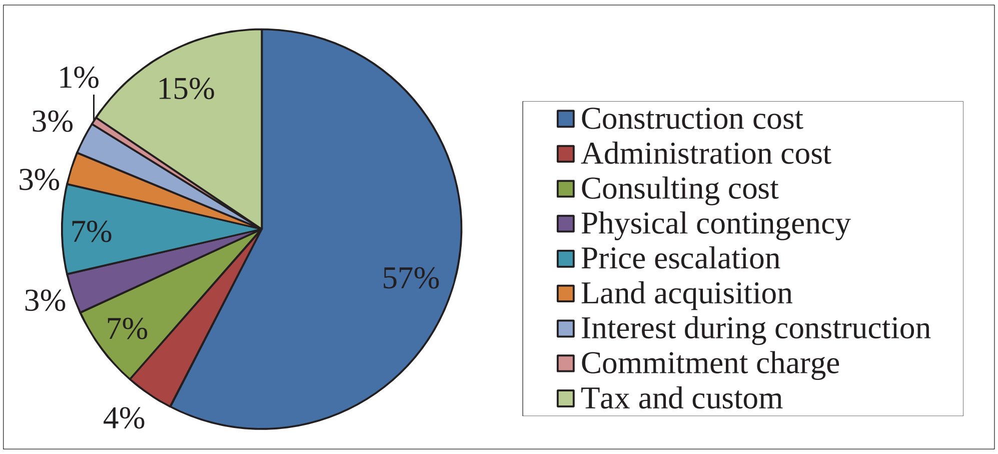


Figure 7.12 Percentage of Component of Project Cost

Taking into consideration that Project cost is financed by Japanese ODA loan, eligible portions, non-eligible portions and percentage of eligible and non-eligible portions are shown in Table 7.9, Table 7.10 and Figure 7.13, respectively. Budget for non-eligible portions of Project cost is required to be prepared by Serbian government.

Table 7.9 Eligible Portions of Project Cost

No	Items	L.C. (1,000 Euro)	F.C. (1,000 Euro)	Total (1,000 Euro)
1.	Construction cost	88,147	73,355	161,502
2.	Consulting cost	7,282	8,800	16,082
3.	Physical contingency, for construction cost	4,895	4,095	8,990
4.	Price escalation, for construction cost	9,747	8,536	18,283
5.	Interest during construction	0	8,523	8,523
6.	Commitment charge	0	1,707	1,707
	Total	**110,071**	**105,016**	**215,087**

Table 7.10 Non-eligible Portions of Project Cost

No	Items	L.C. (1,000 Euro)	F.C. (1,000 Euro)	Total (1,000 Euro)
1.	Administration cost	10,608	0	10,608
2.	Land acquisition and compensation	7,300	0	7,300
3.	Tax and duty	42,430	0	42,430
	Total	**60,338**	**0**	**60,338**

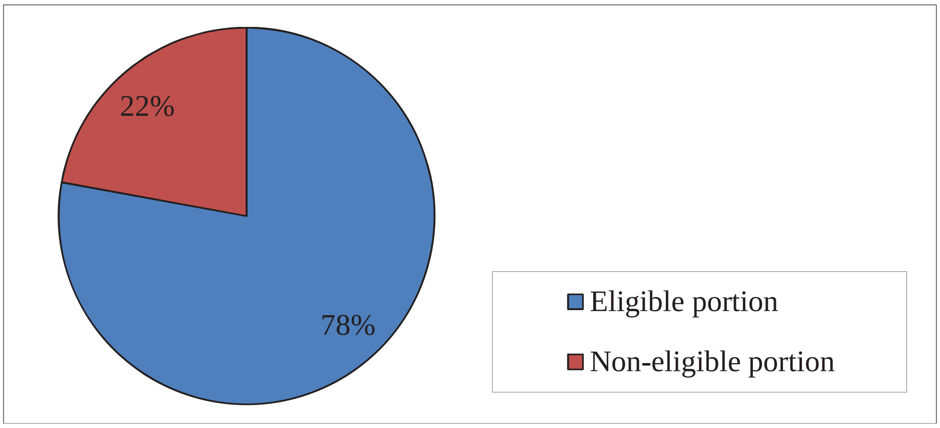


Figure 7.13 Percentage of Eligible and Non-eligible Portions

7.3.2 Estimated Operation and Maintenance Cost for Phase-I Project

The operation and maintenance cost required for operating facilities after implementation of the Phase-I Project is estimated and summarized in Table 7.11. Annual operation and maintenance cost is 4.9 million Euro/year (515 million Yen/year).

Table 7.11 Estimated Operation and Maintenance Cost for Phase-I Project

No	Items	Total (1,000 Euro/year)
1.	Salary	332
2.	Electricity	1,081
3.	Maintenance	676
4.	Disposal of sludge cake	828
5.	Consumable	1,439
6.	Cleaning of interceptors	129
7.	Others	420
	Total	**4,905**

7.4 Implementation Schedule and Disbursement Schedule of Phase-I Project

7.4.1 Implementation Schedule

If Phase-I Project is financed through Japanese ODA loan, the Government of the republic of Serbia must follow JICA procurement guidelines for the selection of the consultants and contractors to implement the Project.

Implementation schedule starting from signing of Loan Agreement has been developed as shown in Table 7.12 taking into account necessary steps that would be required. Implementation of the project has been estimated to extend over 90 months (7.5 years) in total. Herewith Loan Agreement should be signed in the beginning of 2015 for operation to start in 2021. Also land acquisition should be completed before taking of "Building Permit" for construction.

Table 7.12 Implementation Schedule

	Period	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8
Signing of L/A	-								
Selection of Consultant	9 months								
Detailed Design	12 months								
Preparation of Specifications & Bidding Documents	(6) +3 months			Land Acquisition					
Selection of Contractor	12 months							Operation Start	
Construction Works	42 months								
Trial Operation Period	12 months								

Duration necessary for selection of the consultant and the contractor has been decided considering the JICA's standard procedures and estimated as 9 months for selection of the consultants and 12 months for selection of the contractor, respectively. Detailed implementation schedule are shown in Table 7.13 and Table 7.14.

Table 7.13 Detailed Implementation Schedule of Selection of Consultant

Month	Period	1	2	3	4	5	6	7	8	9
Preparation of shortlist and request for proposal	2 months									
Concurrence to request for proposal by JICA	1 month									
Issuing request for proposal to consultant	1.5 months									
Evaluation of proposals	1.5 months									
Concurrence to evaluation by JICA	1 month									
Contact negotiation with candidate	1 month									
Concurrence to contract by JICA	1 month									
Contract award	-									

Table 7.14 Detailed Implementation Schedule of Selection of Contractor

Year	Month	1	2	3	4	5	6	7	8	9	10	11	12
Concurrence to bidding documents by JICA	1 month												
Bidding period	3 months												
Technical evaluation	2 months												
Concurrence to technical evaluation by JICA	1 month												
Price evaluation	2 months												
Concurrence to price evaluation by JICA	1 month												
Contract negotiation with candidate	1 month												
Concurrence to contract by JICA	1 month												
Contract award	-												

Duration necessary for construction works has been planned to ensure the proper execution of the work considering conditions including ability of contractors, procurement of materials and labor force, manner of construction in the Republic of Serbia and construction scale. The construction schedule is mainly estimated according to procedure and working volume of construction such as excavation and concrete casting since there is rarely restriction regarding procurement. Implementation schedule of the construction has been estimated to extend over 42 months in total and shown in Table 7.15.

Table 7.15 Detailed Implementation Schedule of Construction Works

Year	Year 1	Year 2	Year 3	Year 4
Wastewater treatment plant				
Mobilization and land formation				
Lift pumping station				
Pretreatment facility				
Primary settling tank				
Bioreactor				
Secondary settling tank				
Filtration				
Pipe works				
Gravity thickener				
Anaerobic digester				
Sludge treatment building				
Administration building				
Substation and generator building				
Interceptors				
Mobilization				
No. 4 Interceptor				
No. 6 Interceptor				
No. 10 Interceptor				
Pumping stations				
Mostar pumping station				
Test				
Testing and commissioning				

One year of trial operation period including on the job training is planned after the construction so that BVK, which is responsible for operation and maintenance, takes over operation of the constructed facilities smoothly.

7.4.2 Disbursement Schedule

The disbursement schedule based on the implementation schedule has been prepared as shown in Table 7.16.

Table 7.16 Disbursement Schedule

(Million Euro)

		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Total
Direct Project cost (A)										
WWTP	L.C	0	0	0	19.26	19.26	19.26	9.63	0	67.41
	F.C	0	0	0	11.87	11.87	5.94	0	0	41.56
	Sum	0	0	0	31.14	31.14	31.14	15.57	0	108.97
Interceptor No. 4 & 6	L.C	0	0	0	3.89	3.89	3.89	1.95	0	13.63
	F.C	0	0	0	3.02	3.02	3.02	1.51	0	10.59
	Sum	0	0	0	6.92	6.92	6.92	3.46	0	24.21
Mostar P/S & Interceptor No. 10 including collector	L.C	0	0	0	2.03	2.03	2.03	1.02	0	7.11
	F.C	0	0	0	6.06	6.06	6.06	3.03	0	21.21
	Sum	0	0	0	8.09	8.09	8.09	4.05	0	28.32
Sub Total of (A)	L.C	0	0	0	25.18	25.18	25.18	12.59	0	88.15
	F.C	0	0	0	20.96	20.96	20.96	10.48	0	73.36
	Sum	0	0	0	46.14	46.14	46.14	23.07	0	161.50
Indirect Project cost (B)										
Consulting cost (including Contingency fee)	L.C	0.21	1.27	0.36	1.37	1.43	1.49	0.97	0.16	7.28
	F.C	0.39	2.16	0.52	1.56	1.30	1.45	1.18	0.25	8.80
	Sum	0.60	3.43	0.88	2.92	2.73	2.95	2.16	0.41	16.08
Contingency fee for construction cost	L.C	0	0	0	3.44	4.01	4.60	2.60	0	14.64
	F.C	0	0	0	2.96	3.46	3.97	2.25	0	12.63
	Sum	0	0	0	6.39	7.47	8.57	4.84	0	27.27
Other indirect cost	L.C	9.28	0.86	0.22	13.87	14.09	14.41	7.52	0.10	60.34
	F.C	0.21	0.21	0.21	0.84	1.50	2.17	2.53	2.55	10.23
	Sum	9.49	1.07	0.43	14.71	15.58	16.58	10.04	2.66	70.57
Sub total of (B)	L.C	9.49	2.13	0.58	18.67	19.53	20.50	11.09	0.27	82.26
	F.C	0.60	2.37	0.73	5.36	6.25	7.59	5.96	2.80	31.66
	Sum	10.09	4.50	1.32	24.03	25.78	28.10	17.04	3.07	113.92
Direct cost (A) + Indirect cost (B)										
Grand Total	L.C	9.46	2.13	0.58	43.86	44.72	45.69	23.68	0.27	170.41
	F.C	0.60	2.37	0.73	26.31	27.21	28.55	16.44	2.80	105.02
	Sum	10.09	4.50	1.32	70.17	71.92	74.24	40.11	3.07	275.43

7.5 Consulting Services

7.5.1 Required Consulting Services

If this Project is financed through Japanese ODA loan, the procurement procedure of Design-Bid-Build contract applying "FIDIC Conditions of Contract for Construction

Multilateral Development Bank (MDB) Harmonized Edition for Building and Engineering Works Designed by the Employer" is a common practice for the construction project. In the procurement of Design-Bid-Build contract, detailed design and supervision of the construction works is done by the consultants. Consulting services including the followings will be required for smooth implementation of the Project by assisting LDA, the executing agency.

- Implementation of detailed design
- Preparation of tender documents for the contract
- Assistance in tender/qualification evaluation and contract negotiation
- Supervision of the construction works
- Technical assistance of management, operation and maintenance

The consultants are composed of international and local experts. The local experts should support international experts in all the activities of the Project. The proposed work schedule of the consultants should accord with the implementation schedule as shown in Table 7.12. Required international and local experts along with man-months for consulting services for the implementation of the Project are presented in Table 7.17. Based on the estimation of required man-months, 254 man-months of international experts and 493 man-months of local experts would be required for assisting the executing agency for the Project.

Table 7.17 Consulting Services

	International			Local		
	No.	Month	MM	No.	Month	MM
Consultants and experts						
Team leader	1	59	59	0	0	0
Deputy team leader	0	0	0	1	61	61
Process engineer	1	6	6	0	0	0
Civil engineer (WWTP)	1	26	26	0	0	0
Civil engineer (Pumping station and Interceptor)	1	27	27	0	0	0
Civil engineer	0	0	0	1	53	53
Structural / civil engineer	1	5	5	1	5	5
Mechanical engineer	1	21	21	1	20	20
Electrical engineer	1	21	21	1	20	20
Building engineer	0	0	0	1	16	16
Building service engineer	0	0	0	1	13	13
Cost estimator	2	6	12	3	6	18
Environmental specialist	1	4	4	1	5	5
Social assessment specialist	1	4	4	1	4	4
GIS specialist	0	0	0	1	5	5
Contract engineer	1	4	4	0	0	0
Quantity surveyor	1	47	47	1	42	42
Surveyor	0	0	0	1	50	50
Inspector	0	0	0	4	42	168
Operation expert	1	6	6	0	0	0
Mechanical & Electrical facilities maintenance expert	1	6	6	1	6	6
Laboratory expert	1	6	6	1	7	7
Total	-	-	254	-	-	493
Supporting staff and office management staff						
Office administration, account and driver	0	0	0	3	81	243
Office staff and secretary	0	0	0	2	69	138
CAD operator	0	0	0	2 to 4	15	50
Translator	0	0	0	1	71	71
Total	-	-	0	-	-	502

Consultant office should be set up in Belgrade for carrying out the consulting services of the Project and executing agency office is proposed to be stationed full time at the consultant Belgrade office for smooth implementation of the Project.

7.5.2 Technical Assistances

Veliko Selo WWTP, which is constructed in this Project, will be the first large-scale WWTP in the City of Belgrade. Hence, it is recommended to include the technical assistances shown in Table 7.18 in consulting services to ensure effectiveness of the facilities after implementation of the Project.

Table 7.18 Technical Assistances

Training program	Contents
Training program for operation and institutional setup (Operation expert)	Theories of biological treatment including removal of organic substances and nutrient are lectured. Following the lectures, on-job trainings for operation of plant and emergency handling are conducted. It requires considerable time and experiences of operation to startup biological treatment by activated sludge and sludge treatment. Initial operation, optimization of treatment processes and adjustment according to seasonal changes are trained. Preparation of operation records is encouraged. General management including setup of O&M organization, procurement procedures of consumables and chemicals, safety management and human resource development are advised.
Training program for M&E equipment maintenance (M&E maintenance expert)	It is important to maintain equipment in proper condition so that the facilities perform effectively. New kinds of mechanical and electrical equipment will be introduced due to the first large-scale of WWTP in the City of Belgrade. Maintenances of new equipment are trained. Ex-post / reactive maintenances, in which maintenance and repair are conducted after problems, are common practice. Hence, concept of planned / proactive maintenance is introduced. Planned / proactive maintenances contribute reduction of life cycle cost by early detection of abnormal points, prevention of major breakdown and life extension of equipment. Preparation of maintenance records is encouraged.
Training program for water quality analysis (Laboratory expert)	Operating agencies of WWTPs are obligated to ensure water quality of effluent by conducting water quality analysis at regular interval and keeping records. It is necessary to monitor water quality of influent and sewage during treatment processes in order to monitor and improve the performance of WWTPs. It is also necessary to monitor contents of toxic substances in sludge cake. On-the job trainings for water and sludge quality analysis are implemented since the results of those analyses are basic indicators to know performances of WWTPs. Preparation of water and sludge quality records is encouraged.

8. Financial Analysis and Economic Analysis and Institution

8.1 Revenue and Economic Benefit

8.1.1 Treatment Volume

The planned treatment volumes of sewerage for phase I and II are shown in Table 8.1. The treatment volumes are almost equal between the phases. Given the current level of the sewer network development, theoretically the treatment plant will collect the total volume of generated sewage. However, the uptake of sewerage connection within each zone is assumed to gradually improve to reach 100% within five years after the commissioning of the treatment plant with the initial connection of 80%.

In addition to the major works to be undertaken by the proposed scope of the Project, some additional work is needed to restructure the current sewage disposal system (river discharge) to the planned system of connecting trunk sewers to the interceptors, adding some smaller pumps.

Table 8.1 Waste Water Treatment Volume Plan

Unit: m^3/day

	First Year	Five Years
Phase I	172,640	215,800
Phase II	186,320	232,900

8.1.2 Willingness-To-Pay Survey

A street interview survey was undertaken in November 2012 to collect information on the willingness-to-pay of the citizens for the development of centralized sewerage treatment plant at Veliko Selo using the questionnaire as shown in Appendix. The summary of the survey results is shown in Appendix. The interviews were conducted in two parts of the city at Zemun and Republic Square where citizens from most diverse localities tend to congregate for various economic and administrative reasons. The interviewers explained the current disposal system of sewage in Belgrade and asked for the willingness to pay more (in percentage) in addition to the current payment for water and sewerage service. The overall result of willingness to pay was 46% more than the current payment on the average.

8.1.3 Tariff Increase and Economic Benefit

(1) Tariff for Sewerage Treatment

To address the question of what is the acceptable tariff increase for sewerage treatment capacity developed by the Project, the Willingness-To-Pay (WTP) Survey results will be used as a benchmark. As mentioned in the previous section, the average WTP is 46%. The tariff cannot be set at the average WTP because around half of the customers will feel that it would be too expensive. Figure 8.1 shows the cumulative distribution of WTPs from the Survey. Instead of a normal cumulative distribution starting from the minimum value to the highest, this particular graph is structured to start from the maximum WTP to the minimum because the customer with a higher WTP is likely to accept a lower tariff to constitute the satisfied customer base for the Project. From Figure 8.1, if we set the cut off point at 80% of the population, the maximum tariff that the BVK can increase is 25% of the current payment according to the results of the WTP Survey.

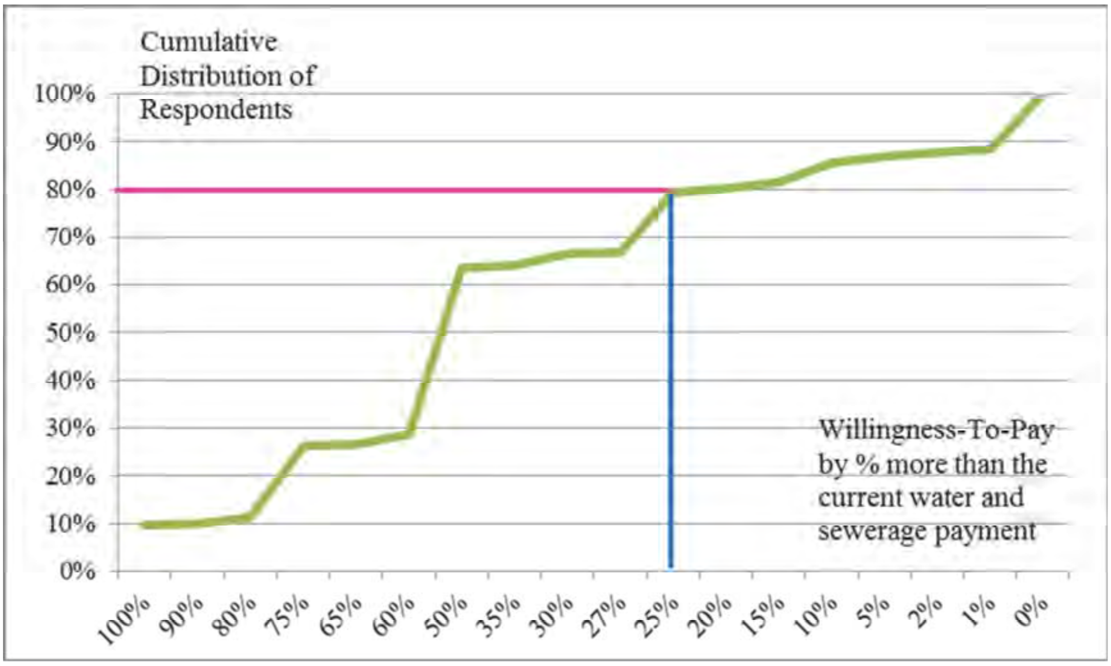


Figure 8.1 Distribution of Willingness-To-Pay Response For Project

The financial tariff increase is RSD 23 on the average for the Project.

Table 8.2 shows the tariff increases by the category that will corresponds to the 25% increase on the average. The increment is very similar to that is charged in Subotica as sewerage treatment fee. The feasibility of implementation is deemed high.

Table 8.2 Financial Tariff Increase With Average 25% Increase

Consumer	Current		New	
	Drinking water (RSD/m^3)	Wastewater (RSD/m^3)	Wastewater Treatment (RSD/m^3)	Total (RSD/m^3)
Households	37.12	15	13.03	65.15
Sport and Recreation Centers	40.56	15	13.89	69.45
Others	74.97	40.35	28.83	144.15

(2) Economic Benefit

Regardless of the level of tariff increment that the BVK imposes in the future, the satisfaction that the Project conferred on the average individual is the amount expressed as WTP. The question for willingness-to-pay was addressed in terms of percentage increase to the current payment, resulting in 46% on the average. The percentage increment was translated into tariff increment by multiplying the weighted average tariff for all type of customers, i.e., RSD $91.9/m^3$ by 46%. The absolute value of tariff increment or WTP is RSD $42/m^3$.

8.2 Investment

8.2.1 Scope of Investment

The investment costs for phase I will cover the sewage collection by Mostar Pumping Station System and the half of the planned capacity of the Veliko Selo Wastewater Treatment Plant. For the purpose of financial evaluation, the investment costs include all the implementation costs including the following

- project construction,
- consulting services,
- administration charge,
- land acquisition,
- physical contingencies,
- VAT and other taxes

Price escalations and interest and other financial charges are excluded since the financial evaluation derives the return on the project investment at the current price regardless of mode of financing.

In the case of economic evaluation, all the pure financial transfers among national entities are excluded since the benefit or cost accrual does not take place in view of national economy.

Therefore, all the taxes, and land acquisition costs are eliminated.

The investment costs modified for financial and economic evaluations are shown in Table 8.3.

Table 8.3 Financial and Economic Investment Costs- Phase I

EUR '000

Item		Financial Cost	Economic Cost
A. ELIGIBLE PORTION			
I)	Procurement / Construction	170,487	170,487
	Veliko selo WWTP	108,971	108,971
	Interceptor No. 4 & 6	24,212	24,212
	Mostar P/S and Interceptor No.10 & collector	28,315	28,315
	Base cost for JICA financing	161,498	161,498
	Price escalation		
	Physical contingency	8,989	8,989
II)	Consulting services	14,768	14,768
	Base cost	14,003	14,003
	Price escalation		
	Physical contingency	766	766
Total (I + II)		185,255	185,255
B. NON ELIGIBLE PORTION			
a	Procurement / Construction	0	0
		0	0
	Base cost for JICA financing	0	0
	Price escalation	0	0
	Physical contingency	0	0
b	Land Acquisition	7,163	0
	Base cost	6,815	
	Price escalation		
	Physical contingency	348	
c	Administration cost	10,608	10,608
d	VAT	42,430	
e	Import Tax	0	0
Total (a+b+c+d+e)		60,200	10,608
TOTAL (A+B)		245,456	195,863

The disbursement schedule for the investments follows the schedule shown in Table 7.16 in Chapter 7.

8.2.2 Reinvestment

Normally mechanical and electrical equipment does not endure the entire project life of 40-50 years. These devices need to be replaced between 15 to 25 years. Therefore, it is assumed that the replacement of entire mechanical and electrical equipment will take place 20 years after the commissioning of the facilities.

8.3 Operation and Maintenance Costs

The operation and maintenance costs are comprised of fixed costs and variable costs. The former costs are required regardless of the volume of treatment whereas the latter is more or less proportional to the processed volume. Under each category, included are the components as follows;

Fixed Costs

- Salary and wages
- Spare parts
- Cleaning of interceptors

Variable Costs

- Electricity
- Coagulants
- Sludge Disposal
- Other costs

8.3.1 Salary and Wages

The manpower allocation requirements and salaries are assumed for each facility as shown in Table 8.4 and Table 8.5.

.

Table 8.4 Salary Phase I

		Phase I					
Positions	Wage (EUR/Month)	WWTP		Mostar PS		Total	
		Number	Salary (EUR /Year)	Number	Salary (EUR /Year)	Number	Salary (EUR /Year)
Engineers	1,200	7	100,800	0	0	7	100,800
Technicians	700	11	92,400	8	67,200	19	159,600
Common Workers	500	12	72,000	0	0	12	72,000
Total		30	265,000	8	67,200	38	332,400

Table 8.5 Salary Phase II

		Phase II				Total	
Positions	Wage (EUR/Month)	WWTP phase II		Ušće PS			
		Number	Salary (EUR /Year)	Number	Salary (EUR /Year)	Number	Salary (EUR /Year)
Engineer	1,200	0	0	0	0	7	100,800
Technicians	700	11	92,400	8	67,200	38	319,200
Common Worker	500	3	18,000	0	0	15	25,200
Total		14	110,400	8	67,200	60	510,000

Table 8.6 shows the unemployment data for Serbia between 2005 and 2013. The unemployment rate had declined as low as 15% is now back to 25% level, indicating a large number of underutilized labor force in Serbia. The economic costs of idle workers can be regarded as costless to national economy. Therefore, for the sake of economic evaluation, a labor conversion factor of 0.75 is applied to all manpower costs to derive true economic costs.

Table 8.6 Unemployment Rates 2005-2013 Serbia

Unemployment Rate (% of Labor Force)	2005	2006	2007	2008	2009	2010	2011	2012	2013
	21.83	21.56	18.8	14.7	17.4	20	24.4	25.552	25.6

Notes: Figures after 2011 are IMF staff estimates

Source: IMF, World Economic Outlook, Oct. 2012.

Table 8.7 Annual Spare Parts Requirement for Mechanical and Electrical Equipment

		Phase I		Phase II		Total
Equipment		WWTP Phase I	Mostar	WWTP Phase II	Ušće	
Original Investment	Mechanical	21,000	1,000	19,000	1,200	40,000
	Electrical	11,000	1,100	6,000	1,200	17,000
	Total	32,000	2,100	25,000	2,400	57,000
Annual Spare parts Requirement		512	34	400	38	912

Particular equipment to be installed for sewage treatment are the filters and screw presses to dewater sludge at the end of the process. Estimated 941 sets of filters need to be replaced every year and spare parts for screw press would cost EUR 5677 per set every year.

Table 8.8 Sludge Filter and Screw Press Spare Parts

Spare parts	Phase	Quantity	Unit	Price	Unit	Cost (EUR)
Filter	I	941	Sets	120	EUR/SET	112,920
	II	941	Sets	120	EUR/SET	112,920
Screw Press	I	3	Sets	5,677	EUR/SET	17,031
	II	2	Sets	5,677	EUR/SET	11,354

8.3.2 Cleaning of Interceptors

The large diameter interceptors are the backbone for collecting sewage to the treatment plant. Due to the nature of sewage, it is necessary to clean the pipes occasionally. Unit cost of cleaning of the interceptor is assumed to be EUR 26.5/m. The costs for interceptor cleaning are shown in Table 8.9.

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Table 8.9 Cleaning of Interceptors

	Length (m)	Phase	Cost (EUR)
Interceptor No. 1	425	II	11,300
Interceptor No. 2	950	II	25,200
Interceptor No. 3	1,810	II	48,000
Interceptor No. 4	950	I	25,200
Interceptor No. 6	850	I	22,500
Interceptor No. 10	3,080	I	81,600
Phase I	4,880		129,300
Phase II	3,185		84,400
Sum	8,065		213,700

Note: Unit Cost = 26.5 (EUR/m)

8.3.3 Electricity

The power consumption for WWTP and pump stations is estimated by listing all the power capacity of the required machinery and then assigning average utilization factors to each. The estimated unit consumptions per processed volume of cubic meters are listed in Table 8.10.

Table 8.10 Energy Requirement For Facilities

	Unit Consumption (kWh/m^3)	Electricity Tariff (EUR/kWh)	Unit Cost (EUR/m^3)
WWTP	0.140	0.08	0.011
Mostar PS	0.031	0.08	0.002
Ušće PS	0.033	0.08	0.003

8.3.4 Coagulants

The coagulants are used for advanced treatment as well as for dewatering thickened sludge. The requirements per unit of treated water are shown in Table 8.11 below.

Table 8.11 Coagulants Costs

	Requirement (kg/m^3)	Unit Price (EUR/kg)	Unit Cost (EUR/m^3)
Alum	0.05988	0.16	0.00958
Polymer (Thickening)	0.00028	3.55	0.00099
Polymer (Dewatering)	0.00197	3.55	0.00699

8.3.5 Sludge Cake Disposal

The generated sludge cakes need to be transported to proper sites for final disposal. The unit cost of such disposal is estimated at EUR 16.8 per ton. The output ratio to the treated water leads to the cost per treated water as shown in Table 8.12.

Table 8.12 Sludge Disposal Unit Cost

	Generation (ton/m^3)	Unit Price (EUR/kg)	Unit Cost (EUR/m^3)
Sludge Cake Disposal Cost	0.000602	16.8	0.0101

8.3.6 Miscellaneous O&M Costs

Other costs incurred for operation and maintenance is assumed to be 10% of the major operation and maintenance costs listed above.

8.3.7 Summary of O&M Costs

The summary of all the operation and maintenance costs are summarized in Table 8.13.

Table 8.13 Summary of Operation and Maintenance Costs

Cost Breakdown	Phase	Financial Cost	Economic Cost	Unit	Components
Fixed Cost	Phase I	1,137	1,110	EUR '000/Year	Salary, Spare parts, Pipe Cleaning
	Phase II	825	809	EUR '000/Year	
Variable Cost	Phase I	0.041	0.040	EUR/m3	Electricity Sludge Cake Disposal Coagulant
	Phase II	0.042	0.041	EUR/m3	

8.4 Financial Evaluation

Table 8.14 shows the financial cash flow of the phase I project. The project life was set at 40 years after the commissioning of the facilities in 2021. The financial internal rate of return on investment (FIRR) is a return on the financial investment assuming the full cost borne by the Project implementation agency. The evaluation is based on constant prices thus involves no inflation. The FIRR is derived at 2.3% with which financing of the project with market rate borrowing is deemed difficult. Given the opportunity of low interest rate financing, the entire project financing without government subsidy is theoretically possible. The FIRR for the entire project (Phase I + II) has come to be 4.3% indicating somewhat improved financial returns. The financing of the project with market rate borrowing still has a marginal prospect. Given the opportunity of low interest rate financing, the entire project financing without government subsidy is theoretically possible.

The summary of preconditions for financial evaluation is as follows;

- Project life: 40 years after the commissioning of the Project;
- Inflation: no price escalation is included as per the standard financial analysis;
- Revenue is treated volume multiplied by the assumed tariff increase of RSD 23/m3 with no increase in the future;
- Investment Cost components: project construction, consulting services, administration charge, land acquisition, physical contingencies, VAT and other taxes;
- Excluded investment cost components: interest during construction, commitment fee, and price escalation, any financial subsidy from government;
- Operation and maintenance cost: fixed costs of phase I with EUR 1.137 million/year, phase II EUR 0.825 million/year and variable costs of phase I with EUR 0.041/m^3, phase II 0.042/m^3, miscellaneous OM costs is 10 of the total major OM costs;
- FIRR is derived by solving the equation for discount rate d : $\sum_{i=1}^{n} \frac{R_i - C_i}{(1+d)^i} = 0$, n: the final year of the project life, i : i-th year of the project, Ri: Revenue value for the year i, Ci: Cost(Investment + OM cost) for the year i, d : Discount rate;

Table 8.14 Financial Cash Flow Analysis –Phase I

Year	Treatment Volume (m3/day)	Investment (EUR ' 000)	Operation Cost (EUR ' 000)	Revenue (EUR ' 000)	Operation Net Cash Flow (EUR ' 000)	Total Net Cash Flow (EUR ' 000)	Note
2014		9,730				-9,730	Engineering Start
2015		4,157				-4,157	
2016		1,053				-1,053	
2017		65,213				-65,213	Construction Start
2018		65,260				-65,260	
2019		65,788				-65,788	
2020		33,800				-33,800	
2021	172,640	455	4,070	12,589	8,519	8,064	Operation Start
2022	181,272		4,211	13,218	9,008	9,008	
2023	189,904		4,352	13,848	9,496	9,496	
2024	198,536		4,492	14,477	9,985	9,985	
2025	207,168		4,633	15,107	10,474	10,474	
2026	215,800		4,775	15,736	10,961	10,961	
2027	215,800		4,775	15,736	10,961	10,961	
2028	215,800		4,775	15,736	10,961	10,961	
2029	215,800		4,775	15,736	10,961	10,961	
2030	215,800		4,775	15,736	10,961	10,961	
2031	215,800		4,775	15,736	10,961	10,961	
2032	215,800		4,775	15,736	10,961	10,961	
2033	215,800		4,775	15,736	10,961	10,961	
2034	215,800		4,775	15,736	10,961	10,961	
2035	215,800		4,775	15,736	10,961	10,961	
2036	215,800		4,775	15,736	10,961	10,961	
2037	215,800		4,775	15,736	10,961	10,961	
2038	215,800		4,775	15,736	10,961	10,961	
2039	215,800		4,775	15,736	10,961	10,961	
2040	215,800	34,100	4,775	15,736	10,961	-23,139	
2041	215,800		4,775	15,736	10,961	10,961	
2042	215,800		4,775	15,736	10,961	10,961	
2043	215,800		4,775	15,736	10,961	10,961	
2044	215,800		4,775	15,736	10,961	10,961	
2045	215,800		4,775	15,736	10,961	10,961	
2046	215,800		4,775	15,736	10,961	10,961	
2047	215,800		4,775	15,736	10,961	10,961	
2048	215,800		4,775	15,736	10,961	10,961	
2049	215,800		4,775	15,736	10,961	10,961	
2050	215,800		4,775	15,736	10,961	10,961	
2051	215,800		4,775	15,736	10,961	10,961	
2052	215,800		4,775	15,736	10,961	10,961	
2053	215,800		4,775	15,736	10,961	10,961	
2054	215,800		4,775	15,736	10,961	10,961	
2055	215,800		4,775	15,736	10,961	10,961	
2056	215,800		4,775	15,736	10,961	10,961	
2057	215,800		4,775	15,736	10,961	10,961	
2058	215,800		4,775	15,736	10,961	10,961	
2059	215,800		4,775	15,736	10,961	10,961	
2060	215,800		4,775	15,736	10,961	10,961	
Total		279,556	188,887	620,009	431,123	151,567	
NPV(@10%)		167,289	44,989	146,274	101,285	-103,453	

IRR =	2.29%

8.5 Economic Evaluation

Table 8. 15 shows the economic cash flow of the phase I project. The economic internal rate of return on investment (EIRR) is a return on the economic investment assuming the full costs of investment and operation borne by the government from a perspective of national economy. The evaluation is based on constant prices thus involves no inflation. The economic internal rate of return on investment (EIRR) is derived to be 9.5%. The EIRR for the entire project (Phase I + II) turns out to be 12%. Both subprojects indicate sound economic viability of the project from national economic viewpoint.

The summary of preconditions for economic evaluation is as follows;

- Project life: 40 years after the commissioning of the Project;
- Inflation: no price escalation is included as per the standard economic analysis;
- Standard Conversion Factor: the foreign exchange market distortion is deemed within the statistical errors, thereby set at 1[1]。
- Revenue is treated volume multiplied by the assumed tariff increase of RSD 46/m3 with no increase in the future;
- Investment cost components: project construction, consulting services, administration charge, physical contingencies,;
- Excluded investment cost components: interest during construction, commitment fee, and price escalation, VAT and other taxes, land acquisition, any financial subsidy from government;
- Operation and maintenance cost: fixed costs of phase I with EUR 1.11 million/year, phase II EUR 0.809 million/year and variable costs of phase I with EUR 0.04/m^3, phase II 0.041/m^3, miscellaneous OM costs is 10% of the total major OM costs;
- EIRR is derived by solving the equation for discount rate d : $\sum_{i}^{n} {}_{1} \frac{R_i \quad C}{(\quad +d)^i} =$, n: the final year of the project life, i : i-th year of the project, Ri: Revenue value for the year i, Ci: Cost(Investment + OM cost) for the year i, d : Discount rate;

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[1] Serbia imported EUR 11,309 million with the statistical errors of EUR 124 million. During the same period, the import duties levied was EUR 320 million at the average of 3% rate. Given the size of distortion comparable to the statistical errors, it was judged there is no need for the use of Standard Conversion Factor. In other words, it is set at 1.

Table 8. 15 Economic Cash Flow Analysis - Phase I

Year	Treatment Volume (m3/day)	Investment (EUR ' 000)	Operation Cost (EUR ' 000)	Revenue (EUR ' 000)	Operation Net Cash Flow (EUR ' 000)	Total Net Cash Flow (EUR ' 000)	Note
2014		986				-986	Engineering Start
2015		3,471				-3,471	
2016		877				-877	
2017		54,121				-54,121	Construction Start
2018		53,992				-53,992	
2019		54,257				-54,257	
2020		27,786				-27,786	
2021	172,640	373	3,997	23,164	19,166	18,794	Operation Start
2022	181,272		4,136	24,322	20,186	20,186	
2023	189,904		4,275	25,480	21,206	21,206	
2024	198,536		4,414	26,638	22,224	22,224	
2025	207,168		4,553	27,797	23,244	23,244	
2026	215,800		4,692	28,955	24,263	24,263	
2027	215,800		4,692	28,955	24,263	24,263	
2028	215,800		4,692	28,955	24,263	24,263	
2029	215,800		4,692	28,955	24,263	24,263	
2030	215,800		4,692	28,955	24,263	24,263	
2031	215,800		4,692	28,955	24,263	24,263	
2032	215,800		4,692	28,955	24,263	24,263	
2033	215,800		4,692	28,955	24,263	24,263	
2034	215,800		4,692	28,955	24,263	24,263	
2035	215,800		4,692	28,955	24,263	24,263	
2036	215,800		4,692	28,955	24,263	24,263	
2037	215,800		4,692	28,955	24,263	24,263	
2038	215,800		4,692	28,955	24,263	24,263	
2039	215,800		4,692	28,955	24,263	24,263	
2040	215,800	34,100	4,692	28,955	24,263	-9,837	
2041	215,800		4,692	28,955	24,263	24,263	
2042	215,800		4,692	28,955	24,263	24,263	
2043	215,800		4,692	28,955	24,263	24,263	
2044	215,800		4,692	28,955	24,263	24,263	
2045	215,800		4,692	28,955	24,263	24,263	
2046	215,800		4,692	28,955	24,263	24,263	
2047	215,800		4,692	28,955	24,263	24,263	
2048	215,800		4,692	28,955	24,263	24,263	
2049	215,800		4,692	28,955	24,263	24,263	
2050	215,800		4,692	28,955	24,263	24,263	
2051	215,800		4,692	28,955	24,263	24,263	
2052	215,800		4,692	28,955	24,263	24,263	
2053	215,800		4,692	28,955	24,263	24,263	
2054	215,800		4,692	28,955	24,263	24,263	
2055	215,800		4,692	28,955	24,263	24,263	
2056	215,800		4,692	28,955	24,263	24,263	
2057	215,800		4,692	28,955	24,263	24,263	
2058	215,800		4,692	28,955	24,263	24,263	
2059	215,800		4,692	28,955	24,263	24,263	
2060	215,800		4,692	28,955	24,263	24,263	
Total		229,963	185,578	1,140,817	955,239	725,277	
NPV(@10%)		134,435	44,200	269,145	224,945	-7,142	

IRR =	9.46%

8.6 Financial Sustainability

8.6.1 Assumptions

Another financial aspect of the Project is to test the loan repayment possibilities through tariff increases while covering 100% of the costs for operation and maintenance by the revenue generated from the additional tariff. For this exercise the following assumptions for the yen loan are made:

1) Loan grace period: 7 years
2) Repayment period: 25 years
3) Interest rate: 1.2%

In the initial years, due to shortfall of revenue, it may not be possible to pay the designated amount for the repayment from the net surplus of the sewerage revenue after meeting the obligations for the operation expenditures. In such cases, the additional borrowing needs to be undertaken to meet the yen repayment obligation. This additional borrowing is assumed to have following assumptions:

1) loan term: 1 year
2) interest rate: 5% (The real interest rate by taking the market rate interest of 10% and subtracting 5% inflation rate)
3) revolving terms: in the case of shortfall of funds for repayment, the shortfall is borrowed again every year under the same condition above automatically.

8.6.2 Table Structure

There are additional columns added for the purpose of debt repayment simulation. Column No. 3 shows the outstanding balance of the debt to JICA which accumulates during the grace period. Once the repayment starts, it starts to diminish for the amount repaid. Column No. 4 is added to calculate the debt balance outstanding for additional borrowing. Columns No. 5 and No. 6 are repayment to JICA and additional lender respectively. Total Operation Flow, Column No. 9, shows the net cash flow from operation to the formula of Revenue (8) – Operation Cost (7) – Investment (2). Column No. 10, Total Cash Flow is the net cash inclusive of capital in and outflow, with the formula, Revenue (8) – Operation Cost (7) – Investment (2) + Borrowing from JICA (2) – Repayment to JICA (5) – Repayment to Additional Lenders (6).

8.6.3 Full Debt Repayment Break-Even Tariff

Table 8.18 shows the results of the financial simulation and the required tariff for meeting all the debt obligations but leaving EUR 29 million surplus to the operator at the end of the project period. The zero surplus break-even tariff increase is 23.3% or RSD 21.5/m^3 on the average. A sensitivity analysis conducted in addition is to assume a bill recovery rate since in reality not all the bills are paid in time. There is a constant lag in payment and sometimes forfeiting such bills. A bill recovery rate of 90% is assumed for this exercise. In this case the appropriate tariff increase is 25.9% or RSD 23.8/m^3 on the average as shown in the first column and the second row of Table 8. 16. Also, by the end of the 25th year, there will be a need for the replacement of mechanical and electrical equipment. Assuming the total surplus needed at the end of the period is EUR 40 million in total, the required increases of tariff are shown in the second column of Table 8. 16. The required increments are 25.7% increase of RSD 23.6/m^3 with recovery rate of 100% and 28.5% increase of RSD 26.2/m^3 with a recovery rate of 90%.

All the results are summarized in Table 8. 16.

Table 8. 16 Full Debt Repayment Break-Even Tariff Summary

	Surplus in 2045, zero	Surplus in 2045 EUR 40 million
Bill Recovery 100%	23.3% Increase (RSD 21.5 /m^3)	25.7% Increase (RSD 23.6/m^3)
Bill Recovery 90%	25.9% Increase (RSD 23.8/m^3)	28.5% Increase (RSD 26.2/m^3)

8.6.4 Debt Repayment With Capital Subsidy Break-Even Tariff

Another angle to inquire break-even tariffs under the provision that a certain proportion of the investment is subsidized by the city government. The subsidized break-even tariffs of varying degrees are summarized in Table 8. 17. Even with 90% Bill Recovery, the tariff increase are so much lower due to subsidies.

Table 8. 17 Subsidized Debt Repayment Break-Even Tariff – Bill Recovery 90%

	Surplus in 2045, zero	Surplus in 2045 EUR 40 million
Capital Subsidy To Debt 20%	22.4% Increase (RSD 20.6/m^3)	25.1% Increase (RSD 23.1/m^3)
Capital Subsidy To Debt 40%	19% Increase (RSD 17.4/m^3)	21.7% Increase (RSD19.9/m^3)
Capital Subsidy To Debt 80%	12.0% Increase (RSD11.0/m^3)	14.8% Increase (RSD 13.6/m^3)

Table 8. 18 Financial Simulation: Case 1 – Tariff RSD 23/m^3 and full repayment of Yen Loan

Year	1.Treatment Volume (m3/day)	2.Investment (EUR ' 000)	3.JICA Debt Outstanding (EUR '000)	4.Additional Borrowing (EUR '000)	5.Repayment To JICA (EUR '000)	6.Repayment to Additional Lenders (EUR '000)	7.Operation Cost (EUR ' 000)	8.Revenue (EUR ' 000)	9. Operation Cash Flow (EUR ' 000)	10.Total Cash Flow (EUR ' 000)	11.Note
2014		816	816						-816		Engineering Start
2015		3,644							-3,644		
2016		1,096	1,096						-1,096		
2017		55,671	56,767						-55,671		Construction Start
2018		56,555	113,322						-56,555		
2019		57,870	171,192						-57,870		
2020		30,282	201,474						-30,282		
2021	172640	624	192,599	980	9,499	-980	4,070	12,589	7,895	0	Operation Start
2022	181272		185,412	1,520	9,499	-491	4,211	13,218	9,008	0	
2023	189904		178,138	1,598	9,499	-2	4,352	13,848	9,496	0	
2024	198536		170,777	1,192	9,499	486	4,492	14,477	9,985	0	
2025	207168		163,328	276	9,499	975	4,633	15,107	10,474	0	
2026	215800		155,789	0	9,499	290	4,775	15,736	10,961	1,173	
2027	215800		148,160	0	9,499	0	4,775	15,736	10,961	1,463	
2028	215800		140,439	0	9,499	0	4,775	15,736	10,961	1,463	
2029	215800		132,626	0	9,499	0	4,775	15,736	10,961	1,463	
2030	215800		124,719	0	9,499	0	4,775	15,736	10,961	1,463	
2031	215800		116,717	0	9,499	0	4,775	15,736	10,961	1,463	
2032	215800		108,619	0	9,499	0	4,775	15,736	10,961	1,463	
2033	215800		100,423	0	9,499	0	4,775	15,736	10,961	1,463	
2034	215800		92,130	0	9,499	0	4,775	15,736	10,961	1,463	
2035	215800		83,737	0	9,499	0	4,775	15,736	10,961	1,463	
2036	215800		75,243	0	9,499	0	4,775	15,736	10,961	1,463	
2037	215800		66,647	0	9,499	0	4,775	15,736	10,961	1,463	
2038	215800		57,948	0	9,499	0	4,775	15,736	10,961	1,463	
2039	215800		49,145	0	9,499	0	4,775	15,736	10,961	1,463	
2040	215800		40,236	0	9,499	0	4,775	15,736	10,961	1,463	
2041	215800		31,220	0	9,499	0	4,775	15,736	10,961	1,463	
2042	215800		22,096	0	9,499	0	4,775	15,736	10,961	1,463	
2043	215800		12,863	0	9,499	0	4,775	15,736	10,961	1,463	
2044	215800		3,518	0	9,499	0	4,775	15,736	10,961	1,463	
2045	215800		-5,938	0	9,499	0	4,775	15,736	10,961	1,463	
Total		206,558			237,467		117,260	383,965	60,147	28,960	
NPV(@10%)		126,214					41,637	135,227	-78,187	7,568	

JICA Interest	1.20%
Additional Borrowing Interest	5%
Tariff Increase	23.0
Tariff Recovery	100%

IRR =	1.76%

Table 8. 19 Financial Simulation: Case 2- Zero Total Surplus, 100% Bill Recovery and Full Repayment of Yen Loan

Year	1.Treatment Volume (m3/day)	2.Investment (EUR ' 000)	3.JICA Debt Outstanding (EUR '000)	4.Additional Borrowing (EUR '000)	5.Repayment To JICA (EUR '000)	6.Repayment to Additional Lenders (EUR '000)	7.Operation Cost (EUR ' 000)	8.Revenue (EUR ' 000)	9. Operation Cash Flow (EUR ' 000)	10.Total Cash Flow (EUR ' 000)	11.Note
2014		816	816						-816		Engineering Start
2015		3,644							-3,644		
2016		1,096	1,096						-1,096		
2017		55,671	56,767						-55,671		Construction Start
2018		56,555	113,322						-56,555		
2019		57,870	171,192						-57,870		
2020		30,282	201,474						-30,282		
2021	172640	624	192,599	1,810	9,499	-1,810	4,070	11,759	7,065	0	Operation Start
2022	181272		185,412	3,262	9,499	-1,362	4,211	12,347	8,136	0	
2023	189904		178,138	4,341	9,499	-915	4,352	12,935	8,583	0	
2024	198536		170,777	5,026	9,499	-468	4,492	13,523	9,031	0	
2025	207168		163,328	5,298	9,499	-21	4,633	14,111	9,478	0	
2026	215800		155,789	5,138	9,499	425	4,775	14,699	9,924	0	
2027	215800		148,160	4,970	9,499	425	4,775	14,699	9,924	0	
2028	215800		140,439	4,793	9,499	425	4,775	14,699	9,924	0	
2029	215800		132,626	4,607	9,499	425	4,775	14,699	9,924	0	
2030	215800		124,719	4,413	9,499	425	4,775	14,699	9,924	0	
2031	215800		116,717	4,208	9,499	425	4,775	14,699	9,924	0	
2032	215800		108,619	3,994	9,499	425	4,775	14,699	9,924	0	
2033	215800		100,423	3,768	9,499	425	4,775	14,699	9,924	0	
2034	215800		92,130	3,531	9,499	425	4,775	14,699	9,924	0	
2035	215800		83,737	3,283	9,499	425	4,775	14,699	9,924	0	
2036	215800		75,243	3,022	9,499	425	4,775	14,699	9,924	0	
2037	215800		66,647	2,748	9,499	425	4,775	14,699	9,924	0	
2038	215800		57,948	2,460	9,499	425	4,775	14,699	9,924	0	
2039	215800		49,145	2,158	9,499	425	4,775	14,699	9,924	0	
2040	215800		40,236	1,841	9,499	425	4,775	14,699	9,924	0	
2041	215800		31,220	1,508	9,499	425	4,775	14,699	9,924	0	
2042	215800		22,096	1,158	9,499	425	4,775	14,699	9,924	0	
2043	215800		12,863	790	9,499	425	4,775	14,699	9,924	0	
2044	215800		3,518	405	9,499	425	4,775	14,699	9,924	0	
2045	215800		-5,938	0	9,499	425	4,775	14,699	9,924	0	
Total		206,558			237,467		117,260	358,653	34,835	0	
NPV(@10%)		126,214					41,637	126,313	-82,762	0	

JICA Interest	1.20%	
Additional Borrowing Interest	5%	
Tariff Increase	21.5	
Tariff Recovery	100%	

IRR =	1.06%

Table 8. 20 Financial Simulation: Case 3 - Zero Surplus, 90% Bill Recovery and Full repayment of Yen Loan

Year	1.Treatment Volume (m3/day)	2.Investment (EUR ' 000)	3.JICA Debt Outstanding (EUR '000)	4.Additional Borrowing (EUR '000)	5.Repayment To JICA (EUR '000)	6.Repayment to Additional Lenders (EUR '000)	7.Operation Cost (EUR ' 000)	8.Revenue (EUR ' 000)	9. Operation Cash Flow (EUR ' 000)	10.Total Cash Flow (EUR ' 000)	11.Note
2014		816	816						-816		Engineering Start
2015		3,644							-3,644		
2016		1,096	1,096						-1,096		
2017		55,671	56,767						-55,671		Construction Start
2018		56,555	113,322						-56,555		
2019		57,870	171,192						-57,870		
2020		30,282	201,474						-30,282		
2021	172640	624	192,599	1,810	9,499	-1,810	4,070	11,759	7,065	0	Operation Start
2022	181272		185,412	3,262	9,499	-1,362	4,211	12,347	8,136	0	
2023	189904		178,138	4,341	9,499	-915	4,352	12,935	8,583	0	
2024	198536		170,777	5,026	9,499	-468	4,492	13,523	9,031	0	
2025	207168		163,328	5,298	9,499	-21	4,633	14,111	9,478	0	
2026	215800		155,789	5,138	9,499	425	4,775	14,699	9,924	0	
2027	215800		148,160	4,970	9,499	425	4,775	14,699	9,924	0	
2028	215800		140,439	4,793	9,499	425	4,775	14,699	9,924	0	
2029	215800		132,626	4,607	9,499	425	4,775	14,699	9,924	0	
2030	215800		124,719	4,413	9,499	425	4,775	14,699	9,924	0	
2031	215800		116,717	4,208	9,499	425	4,775	14,699	9,924	0	
2032	215800		108,619	3,994	9,499	425	4,775	14,699	9,924	0	
2033	215800		100,423	3,768	9,499	425	4,775	14,699	9,924	0	
2034	215800		92,130	3,531	9,499	425	4,775	14,699	9,924	0	
2035	215800		83,737	3,283	9,499	425	4,775	14,699	9,924	0	
2036	215800		75,243	3,022	9,499	425	4,775	14,699	9,924	0	
2037	215800		66,647	2,748	9,499	425	4,775	14,699	9,924	0	
2038	215800		57,948	2,460	9,499	425	4,775	14,699	9,924	0	
2039	215800		49,145	2,158	9,499	425	4,775	14,699	9,924	0	
2040	215800		40,236	1,841	9,499	425	4,775	14,699	9,924	0	
2041	215800		31,220	1,508	9,499	425	4,775	14,699	9,924	0	
2042	215800		22,096	1,158	9,499	425	4,775	14,699	9,924	0	
2043	215800		12,863	790	9,499	425	4,775	14,699	9,924	0	
2044	215800		3,518	405	9,499	425	4,775	14,699	9,924	0	
2045	215800		-5,938	0	9,499	425	4,775	14,699	9,924	0	
Total		206,558			237,467		117,260	358,653	34,835	0	
NPV(@10%)		126,214					41,637	126,313	-82,762	0	

Capital Subsidy	0%	JICA Interest	1.20%	IRR =	1.06%
		Additional Borrowing Interest	5%		
		Tariff Increase	23.8		
		Tariff Recovery	90%		

Table 8. 21 Financial Simulation: Case 4 – EUR 40 million Surplus, 90% Bill Recovery and Full repayment of Yen Loan

Year	1.Treatment Volume (m3/day)	2.Investment (EUR ' 000)	3.JICA Debt Outstanding (EUR '000)	4.Additional Borrowing (EUR '000)	5.Repayment To JICA (EUR '000)	6.Repayment to Additional Lenders (EUR '000)	7.Operation Cost (EUR ' 000)	8.Revenue (EUR ' 000)	9. Operation Cash Flow (EUR ' 000)	10.Total Cash Flow (EUR ' 000)	11.Note
2014		816	816						-816		Engineering Start
2015		3,644							-3,644		
2016		1,096	1,096						-1,096		
2017		55,671	56,767						-55,671		Construction Start
2018		56,555	113,322						-56,555		
2019		57,870	171,192						-57,870		
2020		30,282	201,474						-30,282		
2021	172,640	624	192,599	624	9,499	-624	4,070	12,945	8,251	0	Operation Start
2022	181,272		185,412	772	9,499	-117	4,211	13,592	9,381	0	
2023	189,904		178,138	422	9,499	389	4,352	14,239	9,888	0	
2024	198,536		170,777	0	9,499	443	4,492	14,887	10,394	452	
2025	207,168		163,328	0	9,499	0	4,633	15,534	10,901	1,402	
2026	215,800		155,789	0	9,499	0	4,775	16,181	11,406	1,907	
2027	215,800		148,160	0	9,499	0	4,775	16,181	11,406	1,907	
2028	215,800		140,439	0	9,499	0	4,775	16,181	11,406	1,907	
2029	215,800		132,626	0	9,499	0	4,775	16,181	11,406	1,907	
2030	215,800		124,719	0	9,499	0	4,775	16,181	11,406	1,907	
2031	215,800		116,717	0	9,499	0	4,775	16,181	11,406	1,907	
2032	215,800		108,619	0	9,499	0	4,775	16,181	11,406	1,907	
2033	215,800		100,423	0	9,499	0	4,775	16,181	11,406	1,907	
2034	215,800		92,130	0	9,499	0	4,775	16,181	11,406	1,907	
2035	215,800		83,737	0	9,499	0	4,775	16,181	11,406	1,907	
2036	215,800		75,243	0	9,499	0	4,775	16,181	11,406	1,907	
2037	215,800		66,647	0	9,499	0	4,775	16,181	11,406	1,907	
2038	215,800		57,948	0	9,499	0	4,775	16,181	11,406	1,907	
2039	215,800		49,145	0	9,499	0	4,775	16,181	11,406	1,907	
2040	215,800		40,236	0	9,499	0	4,775	16,181	11,406	1,907	
2041	215,800		31,220	0	9,499	0	4,775	16,181	11,406	1,907	
2042	215,800		22,096	0	9,499	0	4,775	16,181	11,406	1,907	
2043	215,800		12,863	0	9,499	0	4,775	16,181	11,406	1,907	
2044	215,800		3,518	0	9,499	0	4,775	16,181	11,406	1,907	
2045	215,800		-5,938	0	9,499	0	4,775	16,181	11,406	1,907	
Total		206,558			237,467		117,260	394,817	71,000	40,000	
NPV(@10%)		126,214					41,637	139,049	-76,226	11,262	

Capital Subsidy	0%	JICA Interest	1.20%	
		Additional Borrowing Interest	5%	
		Tariff Increase	26.2	
		Tariff Recovery	90%	

IRR =	2.05%

8.6.5 Affordability To Pay

Another dimension of tariff is to check whether it is affordable for the consumer to pay the tariff. An international standard of the maximum ceiling to the payment for water and sewerage is 3%-5% of household income. According to the statistics of the city of Belgrade, the average household size is 2.7 persons per household in 2011. Assuming per capita daily consumption needed in Belgrade is 200 liters/day/person, and the monthly consumption per household is 16.2 m^3/month/household. The labor force in the city was 576,905 persons in 2011. The total number of households in the city was 604,154 in the same year. This means there was 0.95 income-earners in the house on the average. On the other hand, average monthly income was RSD 59,174 per worker in the city of Belgrade. The average income for the city is RSD 57,023 per household per month and the maximum budget for water and sewerage service is RSD 1686-2,851 per month per household. Dividing the maximum budget by the estimated consumption of 16.2 m^3/month will arrive at the maximum price of RSD 104-176 per m^3. Given the current tariff for the household of RSD 52.12 per m^3, the additional tariff of RSD 10 to 30 per m^3 will fall below these limits. Therefore the discussed tariff increases will fall within the range of affordability of the majority of population in Belgrade theoretically. Nevertheless, the economic difficulties, represented by unemployment rate as high as 30% that some citizens face are quite severe. Some economic impact mitigation is much needed for the economically handicapped class such as progressive tariff system introduction and capital subsidies discussed.

8.6.6 Financial Sustainability of Project For BVK and City of Belgrade

Although the responsibility of the loan repayment rests with the executing agency of the Project, i.e., the city of Belgrade, the basic intension of the city is to have BVK responsible for the repayment of the loan through additional tariff collection for sewage treatment. The above analysis indicates that BVK will be able to manage the financial obligation of loan repayment without any capital subsidy. However, The plausibility of the above financial sustainability hinges on the acceptability of the recommended level of tariff increases. Given the nature of water supply as basic lifeline, it may not be feasible to raise tariff to a level to meet the loan repayment requirements, particularly at the time of economic situations now faced by Serbia. The financial return on investment of 2.3% is not any lucrative financial opportunity for the project undertaker. In implementation of any project there will be unforeseen contingencies that deteriorates the financial conditions of the operation of the project. To preserve the proper maintenance of the implemented project and full materialization of the project benefits, pragmatic financial safeguarding for the operator is recommended. There may be three recommendations in this regard:

1) Capital Subsidy: The project implementation body for the Project is the city of Belgrade itself. The city may not transfer all the debt obligations of the project to BVK but rather withhold certain proportion to the city itself to buffer the financial impact. Given a broad

political mandate of environmental protection as well as compliance to EU environmental standards, some public capital assistance is quite plausible.

2) Tariff Increase: The proposed tariff increase is 25% of the current water/sewerage bill. In order to mitigate the impacts on the poor or unemployed and maintain the affordability, it is recommended to adopt some progressive tariff system where the unit tariff rates increase in proportion to the volume of consumption as exemplified in Table 8. 22.

Table 8. 22 Sample Progressive Tariff

Consumer	Consumption Level (m^3)	Drinking water (RSD/m^3)	Wastewater	Wastewater Treatment	Total
			(RSD/m^3)	(RSD/m^3)	(RSD/m^3)
Household	10	19	8	7	33
	15	37	15	13	65
	20	45	18	16	78
	50	56	23	20	98
	100	81	30	28	139
Others	100	60	32	23	115
	200	90	48	35	173
	300	112	61	43	216

Note: Sports and Recreation category is eliminated, as there is marginal difference with domestic category.

3) Transfer of current employees and training: There is a strong policy guidance to BVK to reduce its workforce for rationalization of expenditures. By further reforming the organization, 30-50% of the new positions required for the Project may be filled by the transfer of existing personnel within BVK. On the other hand, BVK does not have any operational experience in a wastewater treatment plant, yet. The proper training is absolutely necessary and also some recruitment of young staff is also mandatory to maintain the institutional capacity on a continued basis.

The loan repayment responsibility, tariff increase and affordability, and sustainability of operations are all integral parts of the project finance as shown above. The consensus on the arrangements among the concerned authorities needs to be agreed upon prior to the loan agreement to ensure sound project execution.

8.7 Institution and Management of Water and Sewerage System

8.7.1 Belgrade Water and Sewerage Corporation

(1) Organization and Function

The organization of BVK is shown in Figure 8.2. BVK is a semi-autonomous body under the city of Beograd with a large degree of financial and management independence. The position of Managing Director is a politically appointed position. The total number of workforce is 2,525 as of July 30, 2012. The water production and distribution operation and maintenance have the largest number of staff of 1,131 and the sewer section has 440. Apart from physical operation and maintenance, there are 193 personnel in revenue section including meter reading, billing and payment collection. There are 103 staff members in finance section. There are 153 personnel providing management performance monitoring, reporting and planning directly assisting Deputy Managing Director and Managing Director.

(2) Sewerage System Department

Figure 8.2 shows the detailed organization chart of the Sewerage System Section. The section is divided into four sections. Environment Control & Protection Section (Staff:14) is the central laboratory of the Department to analyze the discharge. The Sector for Control and Management of Sewerage System (Staff:18) is the administrative unit of the Sewerage System Department. There are two larger technical sections. The Sector for Sewerage Network (Staff: 317) is responsible for the maintenance of the sewer networks headed by the Technical Department (Staff: 10). The network maintenance is divided into 3 subunits (Staff: unit1;48, unit 2; 47, unit 3; 45) by the geographical area. The Unit Sewerage Channel Equipment and Material (Staff: 28) is the inventory control section. The Unit for Sanitation of Defects and Reconstructions (Staff: 37) are the unit for repairs and replacements of the network facilities. The Unit Specialized Vehicles (Staff: 97) maintain and operate vehicles and equipment. They are equipped with 9 small drain cleaner, 9 middle drain cleaner, 3 channel cleaner, 6 interceptors cleaner, 2 manual vacuum cleaners, 1 vacuum truck, and container tip truck. The other section is Sector Electro-mechanical Equipment (Staff: 89) which maintains and runs pumping stations throughout the city. The section is comprised of Unit Central Belgrade (Staff: 29), Unit Central System Novi Sad (Staff: 29) and Unit Maintenance of Facilities (Staff: 24).

The control room is located in the office of Mostar Pumping Station. The control office is combined with the customer call center. Upon the notification of anomalies or troubles by the customer or residents, the operator identifies the GPS mounted cleaning vehicle in the vicinity and instructs the crew to attend the problem. The GPS is linked with the control room through GPRS network making possible the real-time location positioning.

Through the KfW assistance, the BVK also introduced the latest asset management database from a Cyprus vendor, which is capable of managing all the facilities such as pipes, valves, WTPs, pumps, reservoirs, sewers, manholes and the customers. The asset database is linked with hydraulic models to simulate the functions and malfunctions of the system and all the maintenance records and work orders are related within the database to maintain the full historic record of maintenance. Although the data collection and compilation in case of the water supply portion is completed, the data collection and compilation for sewerage is only 60% completed. The field work needs to be restarted in conjunction with the Project to utilize the full capacity of the asset database. The set up for MIS and maintenance operation is in general comparable or more advanced to the ones found even in Japan. The issue remains with the financing of the operation.

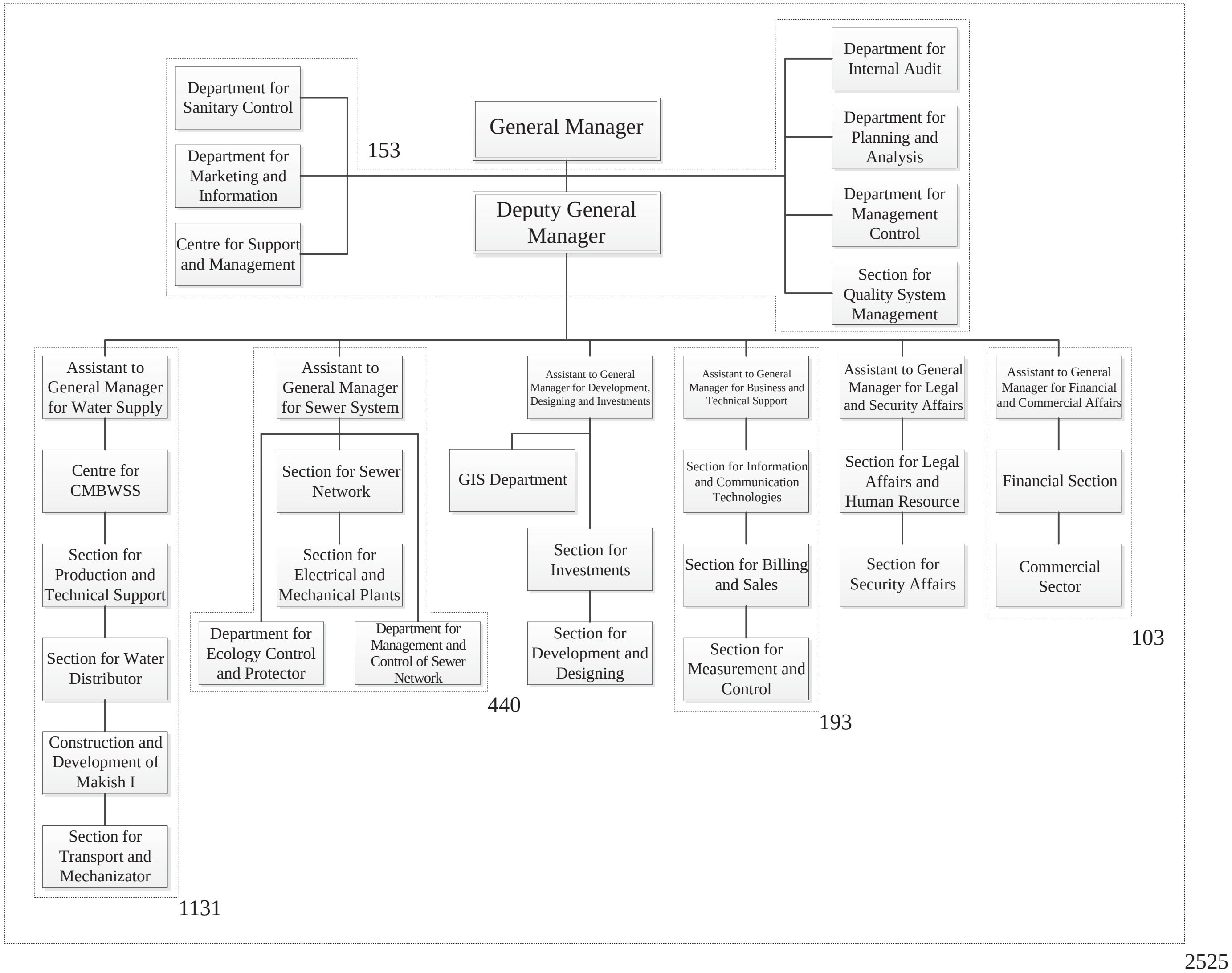


Figure 8.2 Organization Structure of BVK

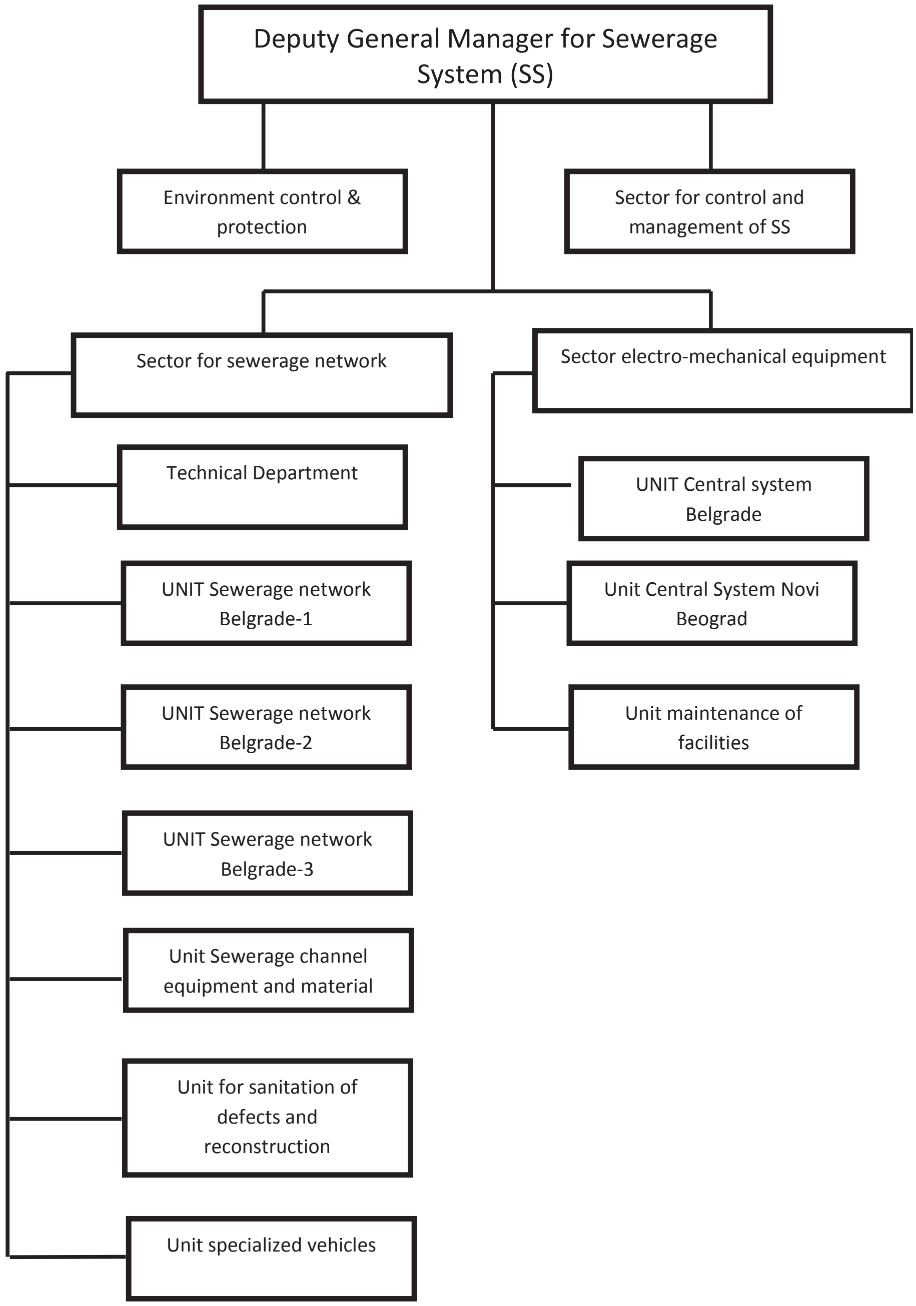


Figure 8.3 Organization Structure of Sewerage System Department

(3) Revenue Structure of BVK

Table 8. 23 and Table 8. 24 show the latest revenue data from water supply and sewerage of BVK during the first quarter of 2012. The total number of connections stood at approximately 420 thousand. The total volume of water supply was approximately 19 million m^3. The average volume consumed per customer per day was 505 liters during this period. The billed volume of sewerage treatment was approximately 12 million cubic meters during the same period. The

ratio between water supply and sewerage was 64%, a slightly lower figure to the normal. The discrepancy may be a reflection of a smaller area of sewer connections compared to water supplied areas. The current design of sewerage disposal accepts the discharge of storm water in some areas. The ratio between billed amounts between water supply and sewerage was 39%.

Table 8. 23 Water Revenue of BVK

Category	Number of connections (Number of invoices)	Volume (m^3)	Billed amount (RSD)	TAX (RSD)	Total (RSD)
Households in Direct Billing	323,543	6,555,513	225,430,953	18,034,655	243,465,608
Household Related to Economy	502	31,251	1,036,059	16,067	1,052,126
Sports and Recreation Centers	104	138,660	5,495,782	439,663	5,935,444
Economy and Institutions	70,716	11,795,511	818,293,801	65,305,120	883,598,921
Economy within Residence Facilities	25,389	590,493	40,993,890	3,279,245	44,273,135
Households with Economy Price	90	3,332	202,554	16,204	218,758
Total	420,344	19,114,759	1,091,453,039	87,090,953	1,178,543,992

Source: BVK

Table 8. 24 Sewerage Revenue of BVK

Unit: RSD (dinars)

Category	Volume (m^3)	Billed amount (RSD)	TAX (RSD)	Total (RSD)
Households in Direct Billing	1,163,202	16,206,000	1,296,478	17,502,478
Household Related to Economy	30,401	412,744	6,017	418,761
Sports and Recreation Centers	138,660	2,137,939	171,035	2,308,974
Economy and Institutions	10,343,257	386,260,141	30,815,590	417,075,731
Economy within Residence Facilities	492,149	18,404,155	1,472,206	19,876,361
Households with Economy Price	2,445	71,989	5,759	77,748
Total	12,170,113	423,492,968	33,767,085	457,260,054

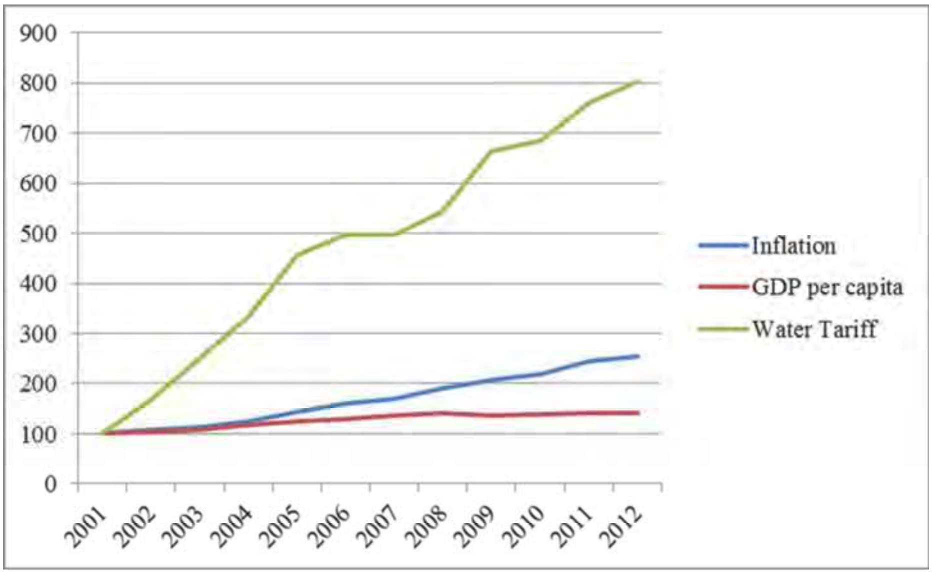
Source: BVK

(4) Tariff Structure

Until the year 2000, the water tariff was set at heavily subsidized rate of RSD 1.55 for both water and sewerage. In 2001 the government increased the water tariff by 400% to RSD 6.0. More gradual increases continued thereafter as shown in

Figure 8.4. The increases in tariff were more than eight-fold between 2001 and 2012. The increases surpassed the combined increases of inflation and GDP per capita. Due to this tariff hike and corresponding austerity measures, the financial sustainability of BVK has largely improved as described in the sections below. The pace of tariff increase has dropped more in

line with the rate of inflation since 2007.



Source: Inflation and GDP per capita from IMF, World Economic Outlook April 2012; Tariff from BVK.
Note: Inflation and GDP figures for 2011, 2012 are estimates/; water tariff includes both water and sewerage tariff before VAT.

Figure 8.4 Changes in Inflation, GDP Per Capita and Water Tariff

As shown in the tariff structure of BVK in Table 8. 25, the sewerage tariffs are lower than water charges in all categories, i.e. the ratio of sewerage charge to the water are 40%, 37%,54% for households, sports and recreation centers, and others respectively. The sewerage tariff was always set at 25% of water tariff till September 2011. At that juncture, the BVK raised only sewerage tariff to set it at 40% of the water tariff. Given an industry norm of almost equivalent price to wastewater treatment, the relatively low tariff reflects the current practice of simple disposal without treatment. It requires a further study to investigate the public acceptance of a higher tariff for full sewerage treatment. The city of Subotica in the north of Beograd provides full sewerage treatment. As shown in Table 8. 26, the city has created another tariff item of sewerage treatment in addition to water supply and sewerage disposal.

Table 8. 25 Tariff Structure of BVK, 2012

Consumer	Drinking water (RSD)	Wastewater (RSD)	Total (RSD)
Households	37.12	15.00	52.12
Sport and Recreation Centers	40.56	15.00	55.56
Others	74.97	40.35	115.32

Source: BVK

Table 8. 26 Tariff Structure of Water and Sewerage Service in Subotica

Ser.no.	Categories/type of service	Tariff without VAT (RSD)	Total (RSD)	Tariff with VAT (RSD)
Households and councils of residential buildings				
1	Clear water	39.90	77.18	83.35
2	Wastewater Collection	18.25		
3	Wastewater Treatment	19.03		
Corporate premises				
1	Clear water	48.11	116.11	125.40
2	Wastewater Collection	30.00		
3	Wastewater Treatment	39.00		
Consumers with benefits and crafts				
1	Clear water	48.11	102.28	110.46
2	Wastewater Collection	26.57		
3	Wastewater Treatment	27.60		

Note: If water consumption in households and individual residential houses exceeds 25m3 a month, the difference will be invoiced at the tariff established for corporate premises.

A similar approach may be effective together with proactive public awareness campaign on the needs for environmental protection.

The current tariff rates of BVK are still much lower compared to those adopted in other European cities and that of Japan. Nevertheless the affordability of tariff increases needs to be further investigated in correspondence to the expansion of sewerage treatment capacity.

(5) Financial Analysis of BVK

The section aims at evaluating the financial sustainability of the BVK with publicly available information, i. e., annual reports and financial statements as given in Table 8. 27 and Table 8. 28.

Apart from water sales, BVK counts internal construction activities as sales which are included under the item of “Revenue resulting from output and merchandize”. The sum is fairly significant, totaling to RSD 300-400 million a year as shown in the Income Statement of Table 8. 28.

Table 8. 27 Balance Sheet of BVK, 2011

Unit: 000 RSD

		31.1.2011	31.12.2010
ASSETS			
Intangible assets	5	137,180	13,.627
Property, plant and equipment	6	87,222,848	80,013,573
Equity investments	7	1,454	2,757
Other long-term financial investments	8	29,329	28,666
Total Non-Current Assets		87,390,811	80,176,623
Inventory	9	604,226	732,202
Receivables	10	2,617,043	1,888,945
Short-term financial investments	11	200,000	987,724
Cash and cash equivalents	12	486,274	943,226
Value-added tax, prepayments and accruals	13	92,234	171,929
Total Current Assets		3,999,777	4,724,026
Deferred income tax assets	14	375,243	375,243
Operating Assets		91,765,831	85,275,892
TOTAL ASSETS		91,765,831	85,275,892
EQUITY AND LIABILITIES			
Initial equity		36,025,996	36,023,927
Revaluation reserves		57,546,003	54,819,952
Unrealised losses on available for sale financial assets		(2,462)	(1,159)
Retained earnings		9,712	44,549
Loss		(7,542,771)	(10,444,885)
Total Equity	15	86,036,478	80,442,384
Long-term provisions	16	34,437	64,563
Long-term loans	17	123,342	290,155
Other long-term liabilities	18	9,757	9,758
Total Long-term Provisions and Liabilities		167,536	364,476
Short-term financial liabilities	19	855,561	280,000
Liabilities from operations	20	1,532,157	1,176,656
Other short-term liabilities	21	130,259	118,548
Liabilities for VAT and other duties and accruals	22	2,668,597	2,518,585
Total Short-term Liabilities	23	5,186,574	4,093,789
Deferred income tax liabilities		375,243	375,243
Total Provisions and Liabilities		5,729,353	4,833,508
TOTAL EQUITY AND LIABILITIES		91,765,831	85,275,892
Off Balance Sheet Liabilities	24	(596)	(596)

Table 8. 28 BVK Income Statement, 2011

Income statement for the period from 01.01.2011 to 31.12.2011				
Group of accounts	Name of item	EDP	Amount in RSD x 1000	
			Current year	Previous year
(1)	(2)	(3)	(4)	(5)
	A. INCOME AND EXPENSES			
	I. OPERATEING REVENUE (202+203+206+204-205)	201		
60 and 61	1. Revenues from sales	202	7,845,745	7,226,179
62	2. Income from the performance of the goods	203	7,235,562	6,708,150
630	3. Increase in inventory performance	204		
631	4. Decrease in inventories effect	205		
64 and 65	5. Other operating income	206	260,366	226,227
	II. OPERATING EXPENSES (208 to 212)	207	7,785,882	7,223,204
50	1. Cost of sold goods	208	113	224
51	2. Cost of materials	209	1,713,462	1,505,612
52	3. Wages, salaries and other personal expenses	210	3,162,193	2,948,790
54	4. Depreciation and amortization	211	1,495,818	1,360,635
53 and 55	5. Other operating expenses	212	1,414,296	1,407,943
	III. OPERATING INCOME (201-207)	213	88,863	2,975
	IV. OPERATING LOSS (207-201)	214		
66	V. FINANCIAL INCOME	215	325,563	244,664
56	VI. FINANCIAL EXPENSES	216	100,527	73,730
67 and 68	VII. OTHER INCOME	217	381,154	422,462
57 and 58	VIII. OTHER EXPENSES	218	650,125	523,106
	IX. PROFIT BEFORE TAX (213-214+215-216+217-218)	219	44,928	73,265
	X. LOSS FROM CONTINUING OPERATIONS BEFORE TAXS (214-213-215+216-217+218)	220		
69-59	XI. NET INCOME FROM DISCONTINUED OPERATIONS	221		
59-69	XII. NET LOSS FROM DISCONTINUED OPERATIONS	222	35,216	28,716
	B. PROFIT BEFORE TAX (219-220+221-222)	223	9,712	44,549
	C. LOSS BEFORE TAX (220-219+222-221)	224		
721	1.Tax expense	225		
722	2. Deferred tax expense	226		
722	3. Deferred income tax benefit	227		
723	D. PAID TO EMPLOYER	228		
	E. NET INCOME (223-2224-225-226+227-228)	229	9,712	44,549
	F. NET LOSS (224-223+225+226-227+228)	230		
	G. NET INCOME ATTRIBUABLE TO EQUITY	231		
	H. NET PROFFIT ATTRIBUTABLE TO EQUITY HOLDERS OF THE PARNET	232		
	1.Bsic earnings per share	233		
	2. Impairment (diluted) earnings per share	234		

Source: BVK

The overall financial indicators of BVK are shown in Table 8. 29. In summary, BVK performance supports the sustainability of its operation over a long run. The basic indicator for utility companies is whether the revenue covers its regular operation and maintenance costs. The revenue exceeds the regular operation and maintenance costs by more than 20% for the last two years. Retained earnings within a company are at the level of 20% to the revenue. The liquidity ratio was kept above 100% till 2010 but worsened to 77% in 2011.

The cash to sales ratio also dropped from 13% to 6% in 2011. At first glance, the profitability and liquidity have both worsened from 2010 to 2011. A closer examination reveals that the profitability from operations itself has improved from 2010 to 2011 from RSD 3 million to RSD 89 million but adjustments of arrears have been recognized as expenditures. The Auditor's Report 2011 shows that the financial balances after operation balances do affect the profitability more than any other items. The transactions are mainly the unrecovered bills from large corporations, subsequent allowances and write offs that incur large expenditures in financial statements. Under the category of "Other Revenues and Expenditures", there are RSD 381 million in income and RSD 650 million in expenditure, both are adjustments and allowances for unrecovered bills. As a result, the net profit remained at RSD 9.7 million.

In terms of cash flow, the operating cash flow increased from RSD 660 million in 2010 to RSD 767 million in 2011. On the other hand, the cash outflow from investing activities increased from RSD 1847 million in 2010 to RSD 3053 million in 2011, surpassing the net inflow from operation. The deficits were supplemented by the inflow from financing activities, namely borrowing and reduction of outstanding cash at hand. However, the borrowing decreased from RSD 1792 million in 2010 to RSD 829 million in 2011. As a result the outstanding cash at the end of the period had reduced from RSD 943 million to RSD 486 million.

The average depreciation ratio was 1.7% in 2011 which would be fully sufficient to replace any machinery and equipment at work if not complete self-financing of the entire assets. The deprecation was 5.5% of the total asset in 2008. It appears that there was a drastic revaluation of the assets and depreciation rules in 2009 and 2010 to make it more pragmatic.

The weaknesses in the finance of BVK are large amount of unpaid bills from restructured or bankrupt companies due to past economic difficulties and the receivables from the utility bill collection company, INFOSTAN. The details of transaction with INFOSTAN is not investigated. However, the two parties make financial transactions twice a year. Definitely 6 months delay in payment collection impairs the cash flow of BVK. Table 8. 30 shows the list of non-performing debts for BVK.

Table 8. 29 Financial Indicators of BVK

Unit: 000 RSD

Financial indicator	2011	2010	2009	2008	2007
Revenue (A)	7,874,745	7,226,179	7,012,697	6,267,384	6,813,389
Operating Cost (B)	7,785	7,223,204	7,225,565	9,923,150	9,889,917
Depreciation (C)	1,495,818	1,360,635	1,859,782	4,406,677	4,644,155
Operation Cost w/o Depreciation (D)	6,290,064	5,862,569	5,365,783	5,516,473	5,245,762
Ope. Exp/Revenue (D)/(A)	79.9%	81.1%	76.5%	88.0%	77%
Net Profit (Loss) (E)	9,712	44,549	172,082	-4,020,181	-4,349,916
Retained Earnings(F) = (E)+(C)	1,505,530	1,405,184	2,031,864	386,496	294,239
Assets (G)	87,222,848	80,013,573	79,592,579	80,286,961	82,057,296
Deprecation Ratio (D)/(G)	1.7%	1.7%	2.3%	5.5%	5.7%
Retained Earn./Sales Ratio (F)/(A)	19.1%	19.4%	29.0%	6.2%	4.3%
Current Asset (H)	3,999,777	4,724,026	3,366,660	2,739,362	2,578,813
Current Liability (I)	5,186,574	4,093,789	1,962,256	1,594,272	1,473,300
Liquidity Ratio (H)/(I)	77.12%	115.39%	171.57%	171.83%	175.0%
Cash at the end of period (J)	486,274	943,226	679,681	647,138	141,697
Cash/Sales Ratio (J)/(A)	6.18%	13.05%	9.69%	10.33%	2.1%

Source: BVK, ratios by JICA Study Team

Table 8. 30 Non-Performing Debts (Unrecovered Bills)

No	Consumer	Balance (RSD)
1	PUC "Infostan"	2,831,867,665
2	Ivo Lola Ribar in AD restructuring	134,323,144
3	IMT AD in restructuring	125,641,211
4	SOEs RECORD HOLDING bankrupt	78,557,451
5	"Foundry" LLC in bankruptcy	74,996,908
6	"VIZAHEM" LLC in bankruptcy	51,091,731
7	Public Enterprise Serbian Railways	46,053,544
8	IMR AD in restructuring	32,180,479
9	"Laborer" from construction materials industry in bankruptcy	31,652,648
10	"21 May" factory Automot LLC in restructuring	25,428,865
11	"Beostan" SOE restructuring	24,726,190
12	Other consumers	2,020,578,166
	Total	5,477,098,002

Source: BVK Annual Report 2011

(6) Bill Recovery

Currently water and sewerage service tariff are collected on the same bill. Table 8. 31 shows the outstanding bills and recovery for major institutions. The current recovery rate is at around 90%.Nearly 50% of domestic bills are collected through a public company, INFOSTAN. However, there is a large outstanding sum with INFOSTAN. The same practice of simultaneous collection of water and sewerage tariff will continue after the completion of the Project.

Table 8. 31 Debts, Bills and Recovery for BVK

Unit: million RSD

	Category	Receivables 2010.12.31	Billed 2011	Collected 2011	Total recovery ratio (%)	Current recovery ratio (%)	Outstanding debt
1	2	3	4	5	5/(3+4)	5/4	8
1	INFOSTAN	2,340	3,794	3,302	53.8	87	2,832
2	Economy and institutions	1,691	3,276	3,045	61.3	92.9	1,922
	Total	4,031	7,070	6,347	57.2	89.8	4,754

Source: BVK Annual Report 2011

(7) Operation Performance Indicator

Apart from financial management of arrears, there are a few performance indicators that can be used as a rule of thumb for performance monitoring. Those are staff numbers per 1000 connections, Non-Revenue Water and Operation Expenditure to Revenue Ratio. For Staff per 1000 connections, 1-2 are excellent while 4-6 are quite acceptable. Non-Revenue Water should be targeted at around 30%. Table 8. 32 shows the tabulation of non-revenue water for the operation in the year 2011 for BVK. Operation Expenditure / Revenue ratio has to be less than 100%, and 50-60% may be considered excellent. In view of these benchmarks as shown in Table 8. 33, the performances of BVK are well above the levels of developing countries if not at par with well managed companies in the world. Given the improvements in the past one decade, there is inertia for improvements within the organization.

Table 8. 32 Analysis of Non-revenue Water

<table>
<tr><th colspan="4">Belgrade waterworks and Sewerage</th><th>Report : Water balance (m^3)</th><th>Year: 2011</th></tr>
<tr><td rowspan="10">Produced water
202,026,490</td><td>Own-consumption
9,970,068</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="9">Released for consumption
192,056,422</td><td rowspan="4">Legal consumption
130,587,825
(68.0%)</td><td rowspan="2">Invoiced consumption
127,834,825
(66.6%)</td><td>Invoiced measured consumption
127,080,210</td><td rowspan="2">Water of revenue
127,834,825</td></tr>
<tr><td>Invoiced not measured consumption
754,615</td></tr>
<tr><td rowspan="2">Uninvoiced consumption
2,753,000
(1.4%)</td><td>Uninvoiced measured consumption
771,000</td><td rowspan="7">Water that does not brings revenues (NRW)
64,221,597</td></tr>
<tr><td>Uninvoiced not measured consumption
1,982,000</td></tr>
<tr><td rowspan="5">Water losses
61,468,597
(32.0%)</td><td rowspan="2">Apparent losses
9,121,998
(4.7%)</td><td>Illegal consumption
960,282</td></tr>
<tr><td>Error in measuring consumption
8,160,716</td></tr>
<tr><td rowspan="3">Actual losses
52,346,599
(27.3%)</td><td>Errors in the processing and handling information</td></tr>
<tr><td>Leaks in the transport and distribution pipelines</td></tr>
<tr><td>Leaking and overflowing in reservoirs</td></tr>
</table>

Source: BVK Annual Report 2011

Table 8. 33 Operation and Performance Indicators for BVK

Indicator	Unit	Value
Staff per 1000 connections	Person per 1000 connections	6.0
Non-revenue water	%	33.4
Operation expenditure / revenue		80%

Source: original data from BVK

In sum, BVK is endowed with some excess manpower which is utilized in construction work and other auxiliary works. Also the overhang of the past unrecovered bills from underperforming companies deteriorates its balance sheets. However, the overall operation is relatively efficiently managed.

8.7.2 Land Development Agency of Belgrade

Land Development Agency is a corporate arm of the city for all the major capital works within the city. Its main responsibilities are to supervise and manage the construction of the works. The works include the Sava Crossing Bridge and a new Danube bridge, as well as the 7 km tunneling work for the collector to the planned Veliko Selo Sewerage Treatment Plant now underway.

The functions of Land Development Agency includes:

- Tender documentation
- Tender and procurement
- Land acquisition
- Project management
- Construction supervision.

The agency has a total of 150 staff members mostly comprised of engineers. Its organization structure is shown in Figure 8.5.

Figure 8.5 Organization Structure of Land Development Agency

The agency receives 99.9% of its revenue from the city's budget and spends 94% on the construction of capital works. The salaries to its employees only comprise 3% of the expenditure. Similarly, the largest portion of the assets and liabilities in the balance sheet is the work in progress, which comprises 94% of the total assets. Apart from its status, the well-documented financial statements for balance sheet and income statements underscore the financial accountability in project management by the city of Beograd.

8.7.3 City of Belgrade

The Law on Territorial Organization and Local Self-Government, adopted in the Assembly of Serbia on 24 July 1991 defines the local government administration of Serbia. Serbia is divided into 195 municipalities and 4 cities, Belgrade, Niš, Novi Sad and Kragujevac. The four cities have its own assembly and budget with more autonomy in legislation and public finance. The city government of Belgrade consisting of 17 municipalities, administer approximately 1.6 million population.

(1) Organization

The city government is organized in 14 secretariats.

The Secretariats:

1) Secretariat for Finance
2) Secretariat for Urban Planning and Construction
3) Secretariat for Utilities and Housing Services
4) Secretariat for Property Rights and Building Inspection
5) Secretariat for Transport
6) Secretariat for Environmental Protection
7) Secretariat for the Economy
8) Secretariat for Culture
9) Secretariat for Education
10) Secretariat for Sport and Youth
11) Secretariat for Health Care
12) Secretariat for Social and Children's Welfare
13) Secretariat for Inspections
14) Secretariat for Administration

There are additional offices, termed "Professional Services", created to provide dedicated functions.

The Professional Services are**:**

1) Assembly Affairs and Regulations Service
2) Service for Information

3) General Affairs Services
4) Services for Communications and Coordination of Public Relations
5) Public Procurement Services
6) City Assembly Chairman’s Office
7) Mayor’s Office

In addition, there are four agencies that are more independent with dedicated functions.

The separate organizations:

1) Institute of Informatics and Statistics
2) Agency for Commercial Space of the City of Belgrade
3) Agency for Budgetary Revision
4) Agency for Cooperation with NGOs and for European Harmonization

The city has the following independent institutions under its authority:

- 11 public utility companies
- 9 public enterprises and 1 organization
- 36 institutions of culture (theaters, halls of culture, museums, libraries, organizations)
- 17 child care institutions (preschool institutions)
- 3 institutions of social welfare
- 3 sports institutions (sports centers)
- 27 health care institutions (municipal clinics, pharmacies, institutes, medical centers)

BVK is one of 11 public utility companies and LDA is one of the 9 public enterprises listed above.

The list of public utilities are as follows;

1) Water Supply and Sewage of Belgrade
2) Funeral Services
3) City Marketplaces
4) District Heating Plants of Belgrade
5) Greenery Belgrade
6) City Sanitation
7) Parking Services
8) Public Lightening
9) Urban Public Transport Enterprise "Beograd"
10) Road Maintenance
11) PUC "Infostan"
12) City Housing

One another related company for sewerage service is INFOSTAN listed as 11) in the above list which collects water and sewerage payments from domestic users on behalf of BVK.

The list of 9 public enterprises are as follows;

1) Belgrade Land Development Public Agency, PE
2) Belgrade Urban Planning Bureau, PE
3) RTV Studio B, Public Broadcast Company
4) Sava Center, PE
5) Ada Ciganlija, PE
6) Belgrade Fortress, PE
7) Arena Beograd d.o.o.
8) Belgrade Racecourse, PE
9) Veterinary Institution Veterina Beograd
10) Belgrade water, PE
11) Belgrade Zoo Garden, PE

(2) PUC Infostan

PUC Infostan was established in 1978 to collect all the municipal service bills by merging them into one bill. The Infostan share the financial billing data with all the public utility companies and public enterprises, and local offices of other organizations under the auspices of the city of Belgrade. The payment collection for the City of Belgrade covers 520,000 beneficiaries of 13 suppliers that provide 18 utility services within the system. The Infostan employs about 230 employees organized in three Departments:

- Aggregated Collection Department,
- Accounting Department, and
- Legal, Technical and Administrative Department.

(3) Financial Analysis of City of Belgrade

Table 8. 34 shows the Revenue and Expenditure of Belgrade, consolidated financial statements of all the municipalities. The balance sheets are shown in Table 8. 35 and Table 8. 36 and the cash flow is shown in Table 8. 37. The overall analyses by the Study Team are summarized in Table 8. 38. The revenue shows 23% growth between 2009 and 2011 while the self generated revenue grew only 11% during the same period. The difference is financed by external borrowing. The need for more financing is rooted in vigorous construction efforts, a growth of 30% in capital work during the same period. However, the financial situation of the city is still quite sound. The *Self Revenue Ratio* is 82%, indicating a high revenue generation capacity with the resulting *Borrowing to Revenue Ratio* of 18%. The *Current Expenditure to Self-Generated Revenue* Ratio remains 70%, indicating the balance 30% can be utilized for capital expenditures. Therefore the Borrowing : *Investment Ratio* is attained at 47%. The *Total Liability to Revenue Ratio* is 63%; the *Total Liability: Self Generated Revenue*, 77%; and *Loan Service to Self*

Generated Revenue, 4%. The *total debt to the revenues are still low and the financing needs for the existing debts* are also very low.

(4) Project Debt Sustainability by City of Belgrade

If the city of Belgrade assumes the total debt responsibility for the Project, it would add another RSD 24 billion approximately liabilities to the balance sheet of the city. The financial analyses undertaken above in Section 8.6 indicate the additional repayment needs of approximately RSD 1.1 billion per year after the grace period. This would increase the current debt service ratio as shown in Table 8. 38 by 1.4%. The debt will be well within the range of the financial capacity of the city of Belgrade. However, due to aggressive capital development including Sava Crossing Bridge financed by EBRD, the debt service level is rising fast and expected to reach close to 10% soon. There are legal constraints on borrowings of local government and budgetary deficits by the national laws. "Law on Public Debt", nr. 61/2005, 107/2009 and 78/2011 (article 33-36) prohibits the debt service of the local government to rise above 15% of the total revenue. Another law, "Law on Budget System" ('Official Gazette RS' nr.54/2009, 73/2010, 101/2010, 101/2011 and 93/2012) (article 27z), restricts the budgetary deficits below 10% of the total revenue. These restrictions could become constraints in future borrowing for the city of Belgrade.

Table 8. 34 Revenue and Expenditures of City of Belgrade

I. Budget Funds	2011	2010	2009
1. Revenues and receipts realized:			
- Current revenues (7)	62,786,286	59,676,158	52,001,310
- Receipts from disposal of non-financial assets (8)	-	-	-
- Borrowings and disposal of financial assets (9)	14,280,909	11,638,291	5,830,612
- Unspent funds carried forward from previous years (3)	1,059,897	1,967,909	5,598,944
Total realized revenues, receipts and funds carried forward 1 (7+8+9+3)	78,127,092	73,282,358	63,430,866
2. Costs and outlays paid:			
- Current expenses (4)	44,562,101	44,042,147	38,105,645
- Cost of non-financial assets procurement (5)	29,841,466	26,414,418	22,866,820
- Principal paid and financial assets procurement (6)	2,332,352	1,765,896	490,492
Total costs and outlays paid 2 (4+5+6)	76,735,919	72,222,461	61,462,957
3. Difference between total revenues, receipts and funds carried forward and total costs and outlays (1-2)	1,391,173	1,059,897	1,967,909
- Surplus in 2011	1,047,996	1,005,840	1,851,918
- Funds carried forward from previous years	343,177	54057	115,991
II. Funds on Earmarked Sub-Accounts of Direct Beneficiaries			
1. Revenues and receipts realized from other sources (7+8+9)	2,709,168	2,405,139	2,335,283
2. Unspent funds carried forward from previous years (3)	95,141	51,701	475,010
3. Total (1+2)	2,804,309	2,456,840	2,810,293
4. Costs and outlays paid from other sources (4+5+6)	2,709,010	2,316,328	2,665,604
5. Difference between total revenues, receipts and total costs and outlays (3-4) - Surplus	95,299	140,512	144,689
III. Funds on Sub-Accounts of IndirectBeneficiaries from Own Sources		-	
1. Revenues and receipts realized from other sources (7+8+9)	3,511,742	3,166,095	2,850,931
2. Costs and outlays paid from other sources (4+5+6)	3,589,095	3,158,246	2,709,047
3. Difference between total revenues, receipts and total costs and outlays (1-2)	77,353	7,849	141,884

Source: City of Belgrade Official Gazette

Table 8. 35 Balance Sheet of City of Belgrade (1)

Economic Classification		Item	2011		2010		2009	
			Amount	Sub-Total	Amount	Sub-Total	Amount	Sub-Total
11		Property and equipment	187,796,716		53,268,496		46,563,942	
14		Natural resources	290,552,289		17,235		17,235	
15		Non-financial assets in progress and prepayments	22,627,046		19,730,756		10,785,214	
16		Intangible assets	477,879		391,837		497,099	
	01	Non-financial assets in non-current assets		501,453,930		73,408,324		57,863,490
21		Inventories		37,295,775		24,705,147	181,917	
22		Inventories of consumables and office supplies	48,162		74,762		16,816	
	02	Non-financial assets on stock				250,237		198,733
	0	**Non-financial assets**		**501,854,699**		**73,658,561**		**58,062,223**
				521,309,431		23,772,503		
111		Long-term domestic financial assets	313,176		5,734		61,233	
112		Long-term foreign financial assets			1,050,344			
	11	Long-term financial assets		313,176		1,107,684		61,233
121		Cash, precious metals, securities	2,786,578		1,828,495		2,941,961	
1221		- Budget sub-account	1,390,597		1,059,287		1,965,960	
1222		- Treasury	1,020		103		3,931	
1223		- Foreign-currency sub-account			421,614		684,742	
1224		- Earmarked sub-accounts of direct beneficiaries	1,394,961		347,491		287,328	
122		Short-term receivables	8,487,281		7,254,762		4,944,252	
123		Short-term investments (prepayments)	67,545		207,035		273,757	
	12	Cash, precious metals, securities, receivables and short-term investments		11,341,404		9,290,292		8,159,970
131		Prepayments and accrued income	7,800,152		8,829,516		6,561,224	
	13	Prepayments and accrued income		7,800,152		8,829,516		6,561,224
	1	**Financial assets**		**19,454,732**		**19,227,492**		**14,782,427**
I		**TOTAL ASSETS:**		**521,309,431**		**92,886,053**		**72,844,650**
351		**OFF-BALANCE ASSETS**		**24,248,950**		**23,772,503**		**5,345,676**

Source: City of Belgrade Official Gazette

Table 8. 36 Balance Sheet of City of Belgrade (2)

EQUITY AND LIABILITIES

Economic Classification		Item	2011		2010		2009	
			Amount	Sub-Total	Amount	Sub-Total	Amount	Sub-Total
212		Long-term liabilities - foreign	30,177,169		20,471,593		13,792,153	
	21	Long-term liabilities						13,792,153
242		Liabilities based on subsidies	24,477		95,781			
243		Liabilities based on donations, grants and transfers	29,060					
244		Liabilities for social security	985					
245		Liabilities related to other expenses	55,332		43,899		613	
	24	Liabilities related to other expenses, except for employee costs		109,854		13,968		613
251		Advances received, deposits and caution money	90,488		103,582		135,341	
252		Trade payables	771,459		578,946		623,386	
254		Other liabilities	68,682		1,006,986		1,017,351	
	25	Operating liabilities		930,629		1,689,514		1,776,078
291		Accruals and deferred payments	10,921,547		9,421,215		5,199,059	
	29	Accruals and deferred payments		10,921,547		9,421,215		5,199,059
	2	**Liabilities**		**49,257,805**		**35,955,556**		**20,767,903**
311		Capital	469,650,491		54,708,535		50,000,936	
	31	Capital		469,650,491		54,708,535		50,000,936
321121		Excess of revenues and receipts - Surplus	1,143,295		1,146,352		1.966.607	
321121a		- Budget sub-account					1.851.918	
321121b		- Earmarked sub-account of direct beneficiaries					145	
321311		Retained excess of revenues and receipts from previous years to the Budget sub-account	1,257,840		1,075,610			
	32	Financial result		2,401,135		2,221,962		2.075.811
	3	**Capital sources, operating results and off-balance records**		**472,051,626**		**56,930,497**		**52.076.747**
II		**TOTAL EQUITY AND LIABILITIES**				**92,886,053**		**72.844.650**
352		**OFF-BALANCE EQUITY AND LIABILITIES**		**24,248,950**		**23,772,503**		**5.345.676**

Source: City of Belgrade Official Gazette

Table 8. 37 Cash Flow Table of City of Belgrade

Economic Classification	Item	2011 Amount	2011 Sub-Total	2010 Amount	2010 Sub-Total	2009 Amount	2009 Sub-Total
	I – Cash inflows include:						
7	Current revenues		65,056,755		61,659,765		53,976,100
	- Budget sub-account	62,786,286		59,676,158		52,001,310	
	- Sub-accounts of direct beneficiaries	2,270,469		1,983,607		1,974,790	
8	Receipts from disposal of non-financial assets		438,699		421,532		360,943
	- Budget sub-account						
	- Sub-accounts of direct beneficiaries	438,699		421,532		360,943	
9	Receipts from borrowings and disposal of financial assets		14,280,909				5,830,612
	- Budget sub-account	14,280,909		11,638,291		5,830,612	
I	**- Total cash inflows(7+8+9)**		**79,776,363**		**73,719,588**		**60,167,205**
	II – Cash outflows include:						
4	Current costs and expenses		46,804,250		45,989,991		40,054,743
	- Budget sub-account	44,562,101		44,042,147		38,105,645	
	- Sub-accounts of direct beneficiaries	2,242,149		1,947,844		1,949,098	
5	Outlays for non-financial assets		30,308,328		26,782,902		23,583,326
	- Budget sub-account	29,841,467		26,414,418		22,866,820	
	- Sub-accounts of direct beneficiaries	466,861		368,484		716,506	
6	Outlays for payment of principal and financial assets acquisition		2,332,352		1,765,896		490,492
	- Budget sub-account	2,332,352		1,765,896		490,492	
II	**– Total cash outflows (4+5+6)**		**79,444,930**		**74,538,789**		**64,128,561**
III	**- Cash inflows Surplusl (I-II)**		**331,433**		**-819,201**		**-3,961,356**
	- Budget sub-account	331,275		-908,012		-3,631,035	
	- Sub-accounts of direct beneficiaries	158		88,811		-329,871	
IV	**- Opening cash balance**		**2,877,716**		**3,965,399**		-
	- Budget sub-account	1,480,901		2,650,702		-	
	- Sub-accounts of direct beneficiaries	1,396,815		1,314,697		-	
V	**– Adjusted inflows for calculated assets received**		**79,883,274**		**74,463,616**		**60,561,660**
	- Budget sub-account	77,067,810		71,738,012		58,171,337	
	- Sub-accounts of direct beneficiaries	2,815,464		2,725,604		2,390,323	
VI	**– Adjusted inflows for calculated assets paid**		**79,975,535**				**64,206,234**
	- Budget sub-account	77,158,115		72,907,813		61,464,906	
	- Sub-accounts of direct beneficiaries	2,817,420		2,643,383		2,741,328	
VII	**CASH BALANCE AT THE END OF THE YEAR (IV+V-VI)**		**2,785,455**		**2,877,819**		**2,938,165**
	- Budget sub-account	1,390,596		1,480,901		2,650,702	
	- Sub-accounts of direct beneficiaries	1,394,859		1,396,918		287,463	

Source: City of Belgrade Official Gazette

Table 8. 38 Financial Performance Analysis of City of Belgrade

Unit: RSD thousand

S.I.	Item	2011	2010	2009
(1)	Total Revenue	78,127,092	73,282,358	63,430,866
(2)	Self Generated Revenue	63,846,183	61,644,067	57,600,254
(3)	Current Expenditure	44,562,101	44,042,147	38,105,645
(4)	Finance Through Borrowing	14,280,909	11,638,291	5,830,612
(5)	Current Surplus	18,252,505	15,669,774	13,921,357
(6)	Investment	30,308,328	26,782,902	23,583,326
(7)	Capital Deficits	12,055,823	421,532	360,943
(8)	Loan Principal and Interest Payment (Debt Service)	2,332,352	1,765,896	490,492
(9)	Constructed Properties and Progress	210,423,762	72,999,252	57,349,156
(10)	Total Liabilities	49,257,805	35,955,556	20,767,903
(11)	Self Revenue Ratio (2)/(1)	82%	84%	91%
(12)	Borrowing : Revenue Ratio (4)/(1)	18%	16%	9%
(13)	Current Exp.: Self Gen Revenue Ratio (3)/(2)	70%	71%	66%
(14)	Borrowing : Investment Ratio (4)/(6)	47%	43%	25%
(15)	Total Liability: Revenue Ratio (10)/(1)	63%	49%	33%
(16)	Total Liability: Self Generated Revenue (10)/(2)	77%	58%	36%
(17)	Debt Service: Self Generated Revenue (8)/(2)	4%	3%	1%

Source: City of Belgrade Official Gazette, JICA Study Team

8.8 Implementation Organization

It is recommended to set up a special task force with authority to issue notices for procurement, evaluate and select contractors, approve documents and physical deliverables and endorse payments to ensure timely implementation of the project. The taskforce appointed by the implementing agency, namely LDA, is normally termed as Project Implementation Unit (PIU). PIU is headed by Project Manager appointed by the implementation agency. It is envisaged that there will be three distinct areas of implementation. Since land acquisition is a prerequisite for any work at Veliko Selo WWTP. Given the number of the land owners in the area, there should be a dedicated section for this work to expedite the process. There are two totally distinguishable physical structures to be erected by the Project, i.e. a Veliko Selo Wastewater Treatment Plant and Interceptor/pumping stations. As the two subprojects need to proceed in tandem, there would be two sections each for WWTP and interceptor/pumping station. One documentation and contract manager may be effective to ensure the consistency between works and technical standard conformity.

The main functions of the PIU under main personnel will be:

(1) Organization Overall Responsibilities:

- To ensure coordination between Serbian government, city of Belgrade, LDA, BVK and other related government agencies, Consultant as well as all the hired contractors in the execution of the Project;
- To monitor progresses so that potential conflicts, delays or cost overrun are foreseen and their impacts are mitigated;
- To make and modify decisions to hire and allocate resources to ensure the progress and quality of the Project according to the plan;
- To amend the scope of contracts and other activities related to the Project in order to achieve the desired outputs and performance of the Project if some unforeseen issues and situations have come to effect the designed or planned activities;
- To involve the communities, NGOs and other stakeholders and communicate with them to receive feedback on the implementation or the effects caused by the implementation such as traffic congestions and new influx of migrated workers etc. and provide adequate mitigation measures;
- To undertake the acquisition of land, obtain permits and other licenses including location permits, construction permits, EIA approvals, and operation permits.
- To communicate frequently with the JICA on the progress and issues arising from implementation and discuss the appropriate actions for the Project implementation. Contract Manager
- To prepare the tender documents and supervise the procurement of Consultants;
- To supervise the preparation of the tender document preparation for the Contractors;
- To supervise the procurement of contractors and suppliers with the assistance of the Consultants;
- To supervise the compliance of the contractors in accordance to the contracts;
- To make modifications and other necessary means to rectify the problems surfaced during the implementation of the contracts.
- To coordinate the testing of the completed facilities, facilitate the training of the Operator of the facilities:

(2) Legal / Public Relation Section

- To develop the plan for land acquisition;
- To negotiate and conclude the contracts for the transfer of the land title;
- To supervise the establishment of the environmental management plan;
- To supervise the compliance of the contractors with the environmental management plan; and
- To communicate with the communities concerned, general public to promote good relationship on the execution of the Project

(3) WWTP Section / Interceptor / Pumping Station Section

- To prepare the tender documents for consultants contractors;
- To evaluate the bids by consultants and contractors on technical merits;
- To oversee the design work, specification development for facility tenders from technical perspective;
- To evaluate the cost estimates of tender documents;
- To oversee all the execution of contracts and ensure the delivery of targeted outputs by all the consultants and contractors;
- To assist Project Manager to negotiate contract;
- To maintain the up-to-date accounts of work in progress, inventories, backlogs, defects in records and financial accounts; and
- To suggest necessary modifications and amendments to the work concerned to ensure the delivery of the targeted outputs.

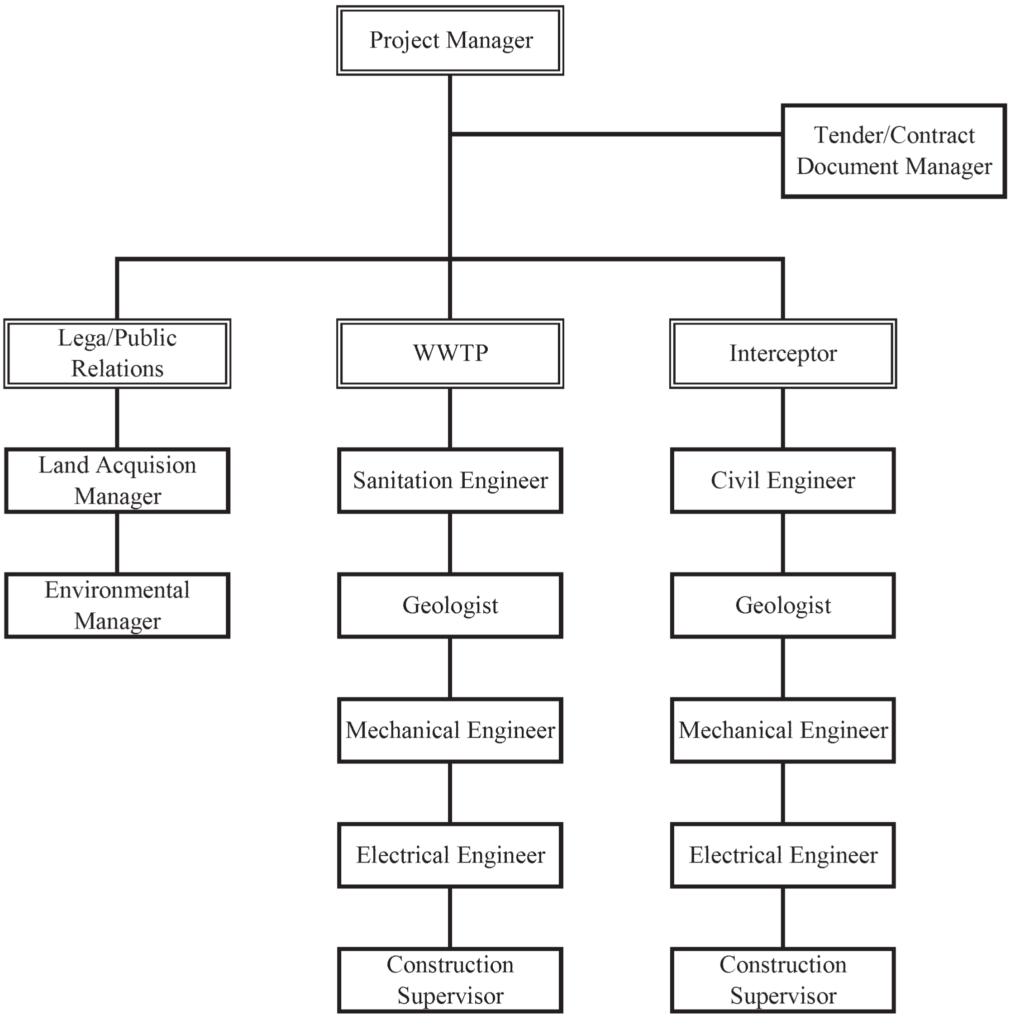


Figure 8.6 Implementation Organization

Operation Organization

The operation organization for this Project including both WWTP and pump stations is BVK. BVK currently operates several pump stations including UŠĆE and also maintains the entire network of sewers.

BVK lacks the experience of the operation of sewage treatment plants. However, the engineers and managers are quite capable with relevant educational background. Given a proper training by the contractor for the plant, the absorption of the technologies is not the issue. Also, there is a forerunner case of Subotica Sewage Treatment Plant which was commissioned in 2009. One young sanitation engineer was recruited to reinforce the manpower. It has an excellent track record in operation. Given well-established sewer and pumping station maintenance, BVK is well situated in operating the new facilities by adding a few cadre of sanitation engineers, technicians, workers with proper trainings. Given some redundant workforce, the first priority of BVK is to transfer the present employees from other sections to new positions required to run Veliko Selo WWTP and Mostar Pumping Station. However, the average age of BVK is 45 years old and the youngest staff is 27 years old. Even under restructuring pressures, the infusion of young recruits is indispensable to maintain the technological continuity of the institution. Figure 8.6 is the proposed organization of Sewerage System Department.

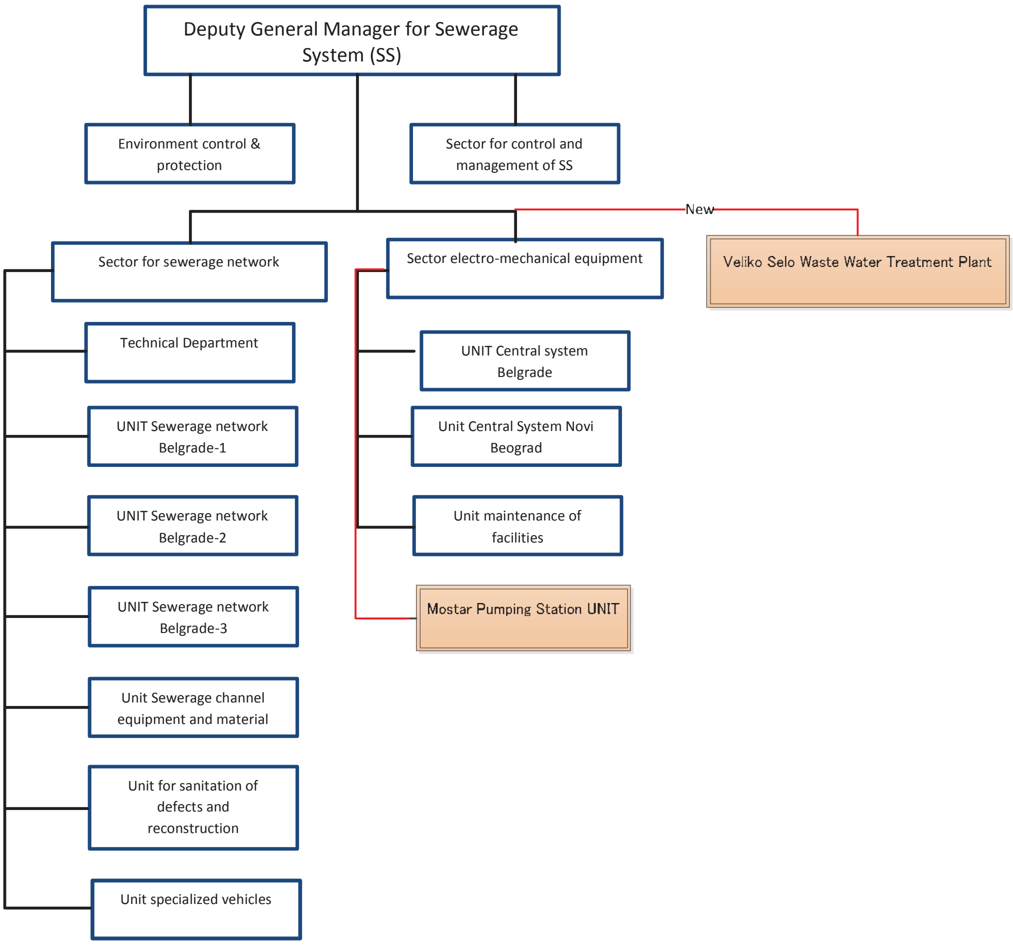


Figure 8.6 Proposed Organization of Sewerage System Department of BVK

8.9 Risk Analysis

Table 8.39 maps out the potential risks and provides the relevant preventive measures and mitigations for the Project from its construction through operation while evaluating the subjective probabilities of its occurrences and relative impacts. Most of the risks can be better managed by obtaining more room for maneuver through contingency measures and the damages may be minimized.

The most common risks are associated with the lack of capacities of the contractors. The most standard solution is to design and undertake tenders that enable the selection of qualified contractors with proper commitments. To realize effective tenders, it is critical to procure a qualified consultant who is capable of close coordination with the PIU. The contractor contract should be designed to provide appropriate incentives to induce higher performance and penalties to discourage underperformances.

For the Yen ODA loan arrangement, the ultimate determinant for the selection of the contractors is the price. In this arrangement it is probable that the Project may suffer from high operating costs while achieving lowest capital costs. More advanced system of the tender is to undertake the tender on the basis of life-cycle costs. In terms of wastewater treatment plant, the largest operating costs are power and coagulants apart from manpower costs. It is possible to include in the tender these two items as representative operation costs. In this case, during the indemnity period, some of the last payment may be linked to the results of the performance testing conducted.

There are some external risks such as the one arising from depreciation of yen. However, there are coping methods such as setting of prudent loan amount and furthermore there is an option to utilize the scheme of swapping the ODA loans, "Currency Conversion Scheme of Japanese ODA Loans."

Table 8. 39 Risk Analysis

Phase	Risks	Odds	Impacts	Measures
Construction	Location Permits, Construction Permits delays	L	M Delays in implementation schedule and cost increases	- Early start for application - Meticulous documentations - Close coordination with related authorities and PIU
	Delay in land acquisition	H	M Delays in implementation schedule and cost increases	- Allocation of sufficient budget - Concentrated and intensive negotiation - Community-wise commitment
	Procurement of unqualified contractor	M	H - Delay in schedule - Increase in cost - Underperformance in designed capacities	- Thorough qualification assessment at PQ - Sufficient qualification evaluation at tender
	Delay in implementation schedule	M	H - Increase in cost - Loss of opportunity for providing benefits of the Project	- Shortening of procurement schedule - Strategic construction packaging while retaining economy of scale - Inclusion of performance guarantee and bonus to the contract - Inclusion of penalty clause for delays
	Lack of finance due to depreciation of yen	M	H Delay in implementation	- Pragmatic cost estimation - Speeding up of implementation - Provision of counterpart funding - Use of dollar-based loan repayment program of JICA, "Currency Conversion Scheme of ODA Loans"
	Lack of local funding	M	H Delay in implementation	- Confirmation of loan conditions - Due evaluation of financial capacities of the city of Belgrade

Phase	Risks	Odds	Impacts	Measures
	Negative impacts on neighboring residents	M	M Noise/air pollution by construction vehicles etc.	- Adoption and implementation of strict environmental management plan
	Unsuccessful tender	M	M (Causes)Gap between cost estimation and implementation cost	- Selection and procurement of reliable consultation - Effective and well-designed tender documentation - Use of detailed design based tender (FIDIC Redbook) for well-established technologies to encourage cost competition - Use of design-build based tender (FIDIC Yellow Book) for more technologically innovative fields to encourage more cost reduction
	Under-achievement of designed capacities	L	H - Increase in OM costs - Underperformance in service levels	- Clarification of contractor obligations for compensation and modification during indemnity period - Inclusion of performance guarantee and bonus to the contract - Reinforcement of training program
	Under-achievement by contractors	M	H - Delay in implementation - Increase in construction costs	- Strict qualification assessment of contracts - Use of performance bond - Inclusion of penalty clause for delays
Operation and Maintenance	Under-achievement in treatment capacities	M	M - Lack of revenue - High unit cost for treatment due to under-utilization level	- Planed connection program for the unconnected areas to the collectors - Consistent and effective sewer to collector switching program
	Under-achievement of designed effluent water quality	M	H - Increase in unit cost for treatment due to inefficient operations - Violation of effluent limit values due to deficiencies	- Control of rainwater filtration within separate sewer system areas - Supervision and control of industry effluents without proper treatment
	Under-achievement in operation and maintenance capacities	L	M - Operation accidents - Inefficient operations - Increase in OM costs	- Reinforcement of training program - Long-term institutional development (recruitment of young qualified engineers)
	Lack of access to sludge disposal	M	L Increase in OM costs	- Early start in planning for obtaining landfill areas - Investigation and development of alternative disposal technologies - Close coordination with landfill management bodies
	Error in sewer connection and illegal connections	L	L - Loss of revenue - Increase in OM costs	- Completion of GIS asset maps that are now suspended - Effective planning and implementation of sewer network development

Phase	Risks	Odds	Impacts	Measures
	Under-achievement in treatment efficiency	L	M Increase in OM costs	- Clarification of contractor obligations for compensation and modification during indemnity period - Use of life-cycle cost in tender price evaluation - Inclusion of performance guarantee and bonus to the contract - Inclusion of penalty clause for delays
	Below 100％ Bill Recovery	H	M Lack of revenue	- Tariff affordable by low income households - Improvement in customer service and information management
	Appropriate and timely tariff revision	M	H Lack of revenue	- Continuous revision - Transparency of tariff revision and accountability to customers - Close coordination with city government and council
Note: H: High, M: Medium, L: Low				

8.10 Operation and Effect Indicator

It is a mandatory exercise for the implementation of Japanese yen loan financed project to have a post evaluation of the Project. The project evaluation is based on the selected Operation and Effect Indicators suited for the objectives and goals of the project. Before the commencement of the Project, the project implementation agency has to determine the baseline performance of the Operation and Effect Indicators, and the same parameters are to be measured again during the post performance evaluation for comparison. Normally the post evaluation takes place two to three years after the completion of the Project. Normally the Operation Indicators are set to measure the fulfillment of the project capacities whereas the Effect Indicators are set to measure the anticipated impacts by the project. The proposed Operation and Effect Indicators are as follows;

Table 8. 40 Operation Indicators

Operation Indicators	Definition	Planning Parameters	Note
Sewerage Treatment Capacity	Achieved Treatment Capacity / Planned Capacity	100%	
Plant Utilization Ratio	Average treated volume / Planned Treatment Capacity	80%	
Pollutants Removal Ratios (BOD_5, COD, TSS, T-N, T-P)	Effluent Measurements / Influent Measurements	BOD_5: 90% COD: 75% TSS: 90% T-N: 70% T-P: 80% (Lowest reduction percentage)	
Population Coverage	Estimated Service Population / Planned Service Population	90%	The target requires improvements in service connections by BVK.
Bill Recovery		Minimum 90%	
Tariff Addition For Sewerage Treatment	Separate Tariff Increment for Sewerage Treatment	12% or RSD 11/ m^3	The increments are minimum level recommended

Table 8. 41 Effect Indicators

Effect Indicators	Definition	Baseline Measurements	Note
Effluent Conformity with Serbian Standards (equivalent to EU Standards)	Max allowable number of samples exceeding Effluent Limit Values 25 samples (sampling 350-365 per year) 9 samples (sampling 96 -110 per year)	Every discharge exceeding the ELV.	ELV for communal wastewater discharge BOD_5 <25 mg/l COD <125mg/l TSS <35 mg/l T-N <10 mg/l T-P < 1.0 mg/l
Ambient Pollution	Present and post-project smell at current discharge points and WWTP point	Interview survey needs to be conducted.	
Impact on Land Uses of Current Sewage Discharge Points	Land use classification of 500 meter radius of current discharge points	Identification of Current Uses Required.	Current discharge sites are located in the central part of the city near waterfront with economic values.
Internal Rates of Return on Investment	Financial Internal Rate of Return and Economic Return on Investments	FIRR: 2.3% EIRR: 9.5%	

9. Current Engagement with CDM

9.1 Institutional and Legislative Framework for Implementing CDM Project in Serbia

The Republic of Serbia has been Party to Kyoto Protocol since 17 January 2008. Taking into account its non-Annex I status within the Protocol, one of three flexible mechanisms of Kyoto Protocol is available to the Republic of Serbia - Clean Development Mechanism. Trend of the structure formulation of the climate change (CDM) in Serbia is as follows;

1992	UNFCCC Signing
1997	UNFCCC Ratification
2001/03	UNFCCC Accession
2007/10	Ratification of Kyoto Protocol
2009/09	State of the Cool Earth Partner

One of required conditions for host country in the implementation of CDM projects is the establishment of the Designated National Authority (DNA). DNA began to operate in the Republic of Serbia on 21 November 2008 on the basis of the Government Decision (05 no.: 02-2099/2008-1 dated 5 June 2008), while the Agreement on the Establishment of DNA was signed on 30 July 2008. As separate body, DNA was introduced into the national legislative framework. DNA extends into a multisectoral body in the Republic of Serbia, whose participants are representatives from the relevant ministries. Refer to the information related to the DNA on the website (URL) of the Ministry of Energy Development and Environmental Protection of the Republic of Serbia (Institution was changed in July 2011); http://www.MERZ.gov.rs/.

9.2 Structure of DNA

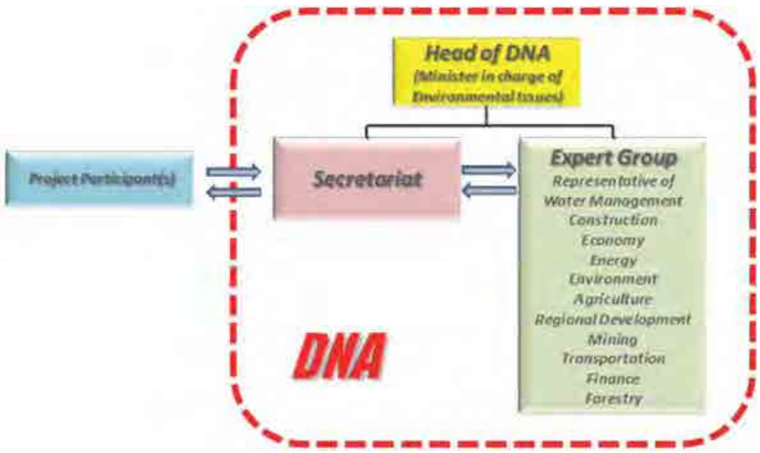


Figure 9.1 Structure of DNA in the Republic of Serbia

The head of Department for International Cooperation and Project Management, Sector of Climate Change in the same ministry serves as representative of the Secretariat of DNA.

9.3 Registered CDM Projects in Serbia

As of September 2012, the number of registered CDM project on CDM-EB (CDM Executive Board) of the Republic of Serbia is 4, all of which have been submitted in 2011. The projects (Wind Farm Projects) not involving Gas Distribution Network Project do not commence, of which the Crediting Periods are October 2012-September 2019 and January 2013-December 2019. Meanwhile, the Gas Distribution Network Project has already commenced, of which Crediting Period is January 2012-January 2022.

Table 9.1 Registered CDM Projects on CDM-EB in the Republic of Serbia

Project Name	Date	Methodology	Project Participants (Serbia)	Project Participants (Annex I Party)
Wind Farm Plandiste 1	2011/08	ACM0002	Wind Park Plandiste d.o.o	Energy Changes Projektentwicklung GmbH Plus Ultra Asset Management GmbH (Liechtenstein)
Wind Farm Kosava I+II	2011/08	ACM0002	MK-Fintel Wind AD	Ditto
Wind Farm Cibuk 1	2011/08	ACM0002	Vetroelektrane Balkana d.o.o	Ditto
Reduction of Methane Leakages in the Gas Distribution Network Operated by the Company PE Srbijagas	2011/03	AM0023	JP Serbiagas	Natsource Europe Limited (UK)

ACM0002 “Consolidated baseline methodology for grid-connected electricity generation from renewable sources” Ver.12.1.0

AM0023 “Leakage reduction from natural gas pipeline compressor or gate station” Ver.3

9.4 Baseline Setting (Planning of CDM Project)

9.4.1 Concrete Content of the Project

This Project, “Preparatory Survey on the Sewerage System Improvement Project for the City of Belgrade” has the content that the sewage of the city of Belgrade which currently is discharged untreated into the Danube River and the Sava River in untreated will be treated by the newly-built Veliko Selo Wastewater Treatment Plant (containing the advanced treatment) and treated water will be discharged into the Danube.

The sewage treatment method is the advanced treatment (having the function of phosphorus and nitrogen removal) attached to the normal secondary treatment and the outline of processing is as follows (refer to Pre-F/S with M/P);

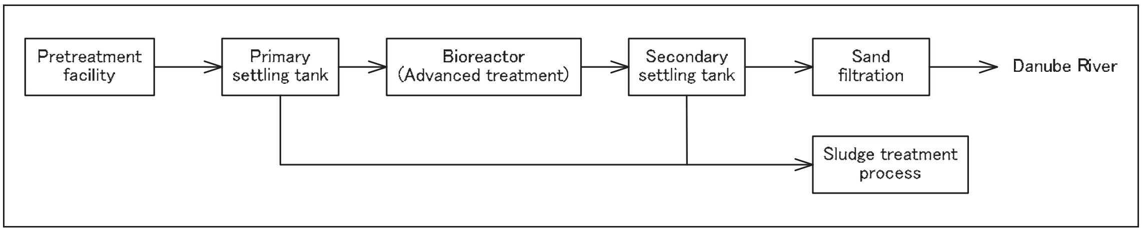


Figure 9.2 Sewage Treatment Process of Pre-F/S with M/P

Meanwhile, the original scheme of the sludge treatment process, which consists of the mechanical dehydration to obtain the dehydrated sludge cake with moisture content of approximately 80 % after gravity thickening and the subsequent disposal at the landfill site of urban waste for the last time, was introduced the anaerobic digestion, which produced biogas that is used for warming the sludge injected into digester and its surplus is combusted by flare facility in Pre-F/S with M/P. Also the digested sludge is dehydrated by the mechanical dehydration and disposed to the landfill site. The flow diagram of sewage treatment process and sludge treatment process in Pre-F/S with M/P is shown as flows:

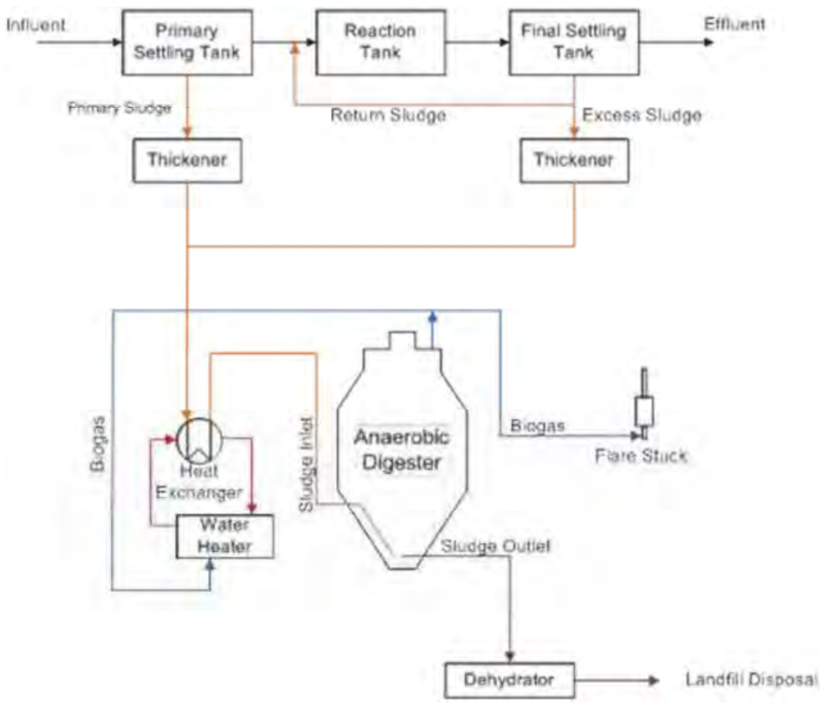


Figure 9.3 Sewage Treatment Process and Sludge Treatment Process of Pre-F/S with M/P

9.4.2 Review of Baseline Methodologies

(1) Selection of Approved Methodologies

The existing methodologies related to the wastewater treatment and the sludge treatment (introduction of anaerobic digestion for methane recovery) were first drawn (approx. 20), of which applicability (technology/measure) were studied on whether applicable to this project or not, and in consequence, the applicability was decided. CDM project is divided into the large scale CDM and the small scale CDM by its reduction of GHG emissions and the applicable approved methodologies is summarized as follows;

Large scale CDM approved methodologies

1) AM0080 “Mitigation of greenhouse gases emissions with treatment of wastewater in aerobic wastewater treatment plants” Version 01
2) ACM0014 “Treatment of wastewater” Version 05.0.0
3) ACM0022 “Alternative waste treatment” Version 01.0.0

Small scale CDM approved methodologies

1) AMS I-C “Thermal energy production with or without electricity” Version 19
2) AMS III-H “Methane recovery in wastewater treatment” Version 16

In accord with these approved methodologies, the study on the possibility of CDM formulation by this project is preceded. Wherein, the methodologies having the potential of applicability in the utilizable methodologies were listed and the result of the study on the applicability are shown below:

(B) Methodology 1

Methodology No.	AM0080
Methodology Title	*Mitigation of greenhouse gases emissions with treatment of wastewater in aerobic wastewater treatment plants* Version 01
Approval Period	February 2009
Project Title (Host Countries)	NM0250 Fés Waste Water Treatment Plant (WWTP) with sludge treatment and biogas recovery & utilization for electricity generation at Fés city, Morocco.
Content of Project Activity	The project activities are the introduction of sludge treatment consisting of wastewater treatment composed of aerobic treatment, anaerobic digester and co-generation system producing electricity and heat energy using biogas as a fuel. The most common wastewater and sludge treatment (in Morocco) are the wastewater treatment by open lagoons system and the sludge treatment of disposal after dried and stabilization. CH_4 emission from the lagoon treatment is totally reduced by the project activity. And the co-generation of electricity and heat coproduction using biogas as a fuel is substituted for fossil fuel and as a result, CO_2 emissions can be reduced.
Applicability	This methodology is applicable to project activities that implement a new aerobic wastewater treatment plant for the treatment of domestic and/or industrial wastewater. The sludge produced in the aerobic wastewater treatment plant in the project activity is either: (1) Treated in the same way as the sludge that would have been produced in the

	anaerobic open lagoon system in the baseline scenario would have been treated. This includes one of the following two options: (i) the sludge is dumped or left to decay; or (ii) the sludge is dried under controlled and aerobic conditions, and then disposed to a landfill with methane recovery or used in soil application; or (2) Treated in a new anaerobic digester, with the biogas extracted from the anaerobic digester being flared and/or used to generate electricity and/or heat. The residues from anaerobic digester are dehydrated, limed and stored before final disposal in a controlled landfill. ・ The project activity either replaces an existing anaerobic open lagoons system, with or without conversion of the sludge treatment system, or is an alternative to a new to be built anaerobic open lagoons system; ・ Loading in the wastewater streams has to be high enough to ensure that the existing or new to be built anaerobic open lagoons system develops an anaerobic bottom layer and that algal oxygen production can be ruled out; ・ The average depth of the existing or new to be built anaerobic open lagoons system is at least 1 meter. In case of an existing aerobic open lagoons system in the baseline scenario, the depth of the lagoons should be verified based on historical data available for one year before the implementation of the project activity. In case of a new to be built anaerobic open lagoons system, the depth of the lagoons should be determined following the guidance provided in Step 1 of the section "Procedure for the identification of the most plausible baseline scenario and assessment of additionality"; ・ The residence time of the organic matter in the anaerobic open lagoons system is at least 30 days. In case of an existing anaerobic open lagoons system in the baseline scenario, the residence time of the organic matter in the lagoon should be verified based on historical data available for one year before the implementation of the project activity. In case of a new to be built anaerobic open lagoons system, the residence time of organic matter in the lagoons should be determined following the guidance provided in Step 1 of the section "Procedure for the identification of the most plausible baseline scenario and assessment of additionality".
Advantage	・ Previously approved methodology
Issue	・ It isn't said that applicable to the project of sewage sludge. ・ Baseline scenario is formed the basis of an anaerobic open lagoons system.

(C) Methodology 2

Methodology No.	ACM0014
Methodology Title	*Treatment of wastewater* Version 05.0.0
Approval Period	July 2012
Project Title (Host Countries)	NM0038-rev Methane Gas Capture and Electricity Production at Chisinau Wastewater Treatment Plant project, Moldova NM0039 Bumibiopower Methane Extraction and Power Generation Project, Malaysia NM0085 Vinasse Anaerobic Treatment Project, Nicaragua NM0041-rev2 Korat Waste to Energy Project, Thailand AM0013 Avoided methane emissions from organic waste-water treatment – Version04 AM0022 Avoided Wastewater and On-site Energy Use Emissions in the Industrial Sector – Version04
Content of Project Activity	The project activities are the introduction of a new to be built anaerobic treatment facilities to the industrial organic wastewater treatment system based on the existing lagoon treatment. The wastewater partly treated by new anaerobic treatment facilities is released to the existing lagoons system. Herewith, CH_4 emissions from treatment system are totally reduced. The biogas recovered in the anaerobic treatment facility is used for the heat and/or electricity production. As a result, the fossil fuel required for heat and/or electricity will be substituted or the electrical energy purchased from grid can be reduced, which means that CO_2 emissions will be reduced. The surplus biogas from anaerobic treatment is treated by flare treatment.
Applicability	This methodology is applicable to project activities that reduce methane emissions from industrial wastewater treatment. The methodology is applicable to the scenarios described in Table.

Table Scenario applicable to the methodology

Scenario	Description of the baseline situation	Description of the project activity
1	The wastewater is not treated, but directed to open lagoons that have clearly anaerobic	The wastewater is treated in a new anaerobic digester or dewatered and directed to land application. The biogas is

	conditions.	extracted from the anaerobic digester and flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester, after treatment, is directed to open lagoons or is treated under clearly aerobic conditions.
2	The wastewater is treated in a wastewater treatment plant. Sludge is generated from primary and/or secondary settlers. The sludge is directed to sludge pit(s) that have clearly anaerobic conditions.	The wastewater is treated in the same wastewater treatment plant as in the baseline situation. The sludge from primary and/or secondary settler is treated in one or both of the following ways: (a) The sludge is treated in a new anaerobic digester. The biogas extracted from the anaerobic digester is flared and/or used to generate electricity and/or heat. The residual from the anaerobic digester after treatment is directed to open lagoons or is treated under clearly aerobic conditions. (b) The sludge is treated under clearly aerobic conditions.

Project participants should document in the CDM-PDD which scenario applies and clearly describe the situation before and after the start of implementation of the project activity, preferably by providing similar diagrams as contained in appendix 1, which provides an example for application of Scenario 2.
The following applicability conditions are for all scenarios:
- The average depth of the open lagoons or sludge pits in the baseline scenario is at least 1 m.
- In the baseline scenario and project activity, there is not great change in the requisite amount of electricity and/or heat per input unit in the wastewater treatment facilities.
- The data requirement indicated in the methodology is sufficient.

The following applicability conditions are for Scenario 1:
- The residence time of the organic matter in the open lagoon or sludge pit system should be at least 30days.
- Wastewater releasing to open lagoon is not prohibited by the local regulations.

The following applicability condition is for Scenario 2:
- The sludge produced during the implementation of the project activity is not stored onsite before land application to avoid any possible methane emissions from anaerobic degradation.

Advantage	・ Previously approved methodology
Issue	・ It isn't said that applicable to the project of sewage sludge. ・ The baseline scenarios are the lagoon treatment in case of wastewater and the sludge pit storage in case of sludge. ・ In many aspects, parameters endemic to the project are claimed to set, of which might be difficult to set out. ・ Applicability says that "Wastewater temperature in the anaerobic lagoons should always be at least 15ºC", though more than 15 ºC in case of sewage is hard to keep.

(D) Methodology 3

Methodology No.	ACM0022
Methodology Title	*Alternative waste treatment* Version 01.0.0
Approval Period	September 2012
Project Title (Host Countries)	NM0090 Organic waste composting at the Matuail landfill site Dhaka, Bangladesh NM0127 PT Navigat Organic Energy Indonesia Integrated Solid Waste Management project in Bali, Indonesia NM0032 Municipal solid waste treatment cum energy generation project, India NM0178 Aerobic thermal treatment of municipal solid waste (MSW) without incineration in Parobe – RS NM0174-rev MSW Incineration Project in Guanzhuang, Tianjin City AM0025 Alternative waste treatment processes AM0039 Methane emissions reduction from organic waste water and bioorganic solid waste using co-composting
Content of Project Activity	The project activity is avoiding methane emissions related on the organic wastes disposal including sludge at the SWDS.

<table>
<tr>
<td>Applicability</td>
<td>
This methodology applies to project activities where fresh waste, originally intended for disposal in a SWDS, is treated using any (combination) of the waste treatment options listed in Table 2 below. The project activity therefore avoids emissions of methane associated with disposing organic waste in a SWDS with or without a partial LFG capture system. In addition, the project activity may also potentially claim emission reductions for:

Avoiding methane emissions from degradation of wastewater in an anaerobic lagoon or sludge pit by treating the wastewater in combination with fresh waste by either co-composting or anaerobic digestion;
Displacing natural gas in a natural gas distribution system with upgraded biogas,
Displacing electricity in a grid or electricity generation by a fossil fuel fired captive power-only or cogeneration plant; and
Displacing heat generation by a fossil fuel fired cogeneration plant, boiler or air heater.

Table Applicability conditions for different waste treatment options
<table>
<tr><th>Waste treatment option under the project activity</th><th>Applicable types of wastes that may be treated</th><th>Applicable products and their use</th><th>Applicable waste by-products</th><th>Specific applicability conditions for the treatment option</th></tr>
<tr><td>Composting or co-composting</td><td>Types of waste specified in the scope and applicability section of the methodological tool ”Project and leakage emissions from composting”
Run-off wastewater
Excluding hospital and industrial waste</td><td>Compost: any use applicable</td><td>Glass, aluminium, ferrous metals and plastics from waste sorting stages.
Run-off wastewater</td><td>Any applicability conditions specified in the methodological tool "Project and leakage emissions from composting”</td></tr>
<tr><td>Anaerobic digestion</td><td>Wastewater, Freshwater, excluding hospital and industrial waste</td><td>Biogas which may be flared, used to generate electricity or heat, and/or is upgraded and distributed in a natural gas distribution grid</td><td>Glass, aluminium, ferrous metals and plastics from waste sorting stages.
Run-off wastewater
Digestate</td><td>Any applicability conditions specified in the methodological tool "Project and leakage emissions from anaerobic digestion”</td></tr>
<tr><td>Thermal treatment</td><td>Fresh waste, excluding hospital and industrial waste</td><td>RDF/SB: any use is applicable</td><td>Glass, aluminium, ferrous metals and plastics from waste sorting stages.</td><td>-</td></tr>
<tr><td>Mechanical treatment</td><td>Fresh waste, excluding hospital and industrial waste</td><td>RDF/SB: any use is applicable</td><td>Run-off wastewater
Glass, aluminium, ferrous metals and plastics from waste sorting stages.</td><td>-</td></tr>
<tr><td>Gasification</td><td>Fresh waste</td><td>Syngas which may be used to generate electricity and/or heat</td><td>Gasification by-products (e.g. inert materials);
Run-off wastewater
Glass,</td><td>-</td></tr>
</table>
</td>
</tr>
</table>

				aluminium, ferrous metals and plastics from waste sorting stages.	
	Incineration	Fresh waste	Electricity and/or heat	Incineration by-products (e.g. inert materials); Run-off wastewater Glass, aluminium, ferrous metals and plastics from waste sorting stages.	Incineration technology is rotary kiln, rotating fluidized bed, circulating fluidized bed, hearth or grate type: The fraction of energy generated by auxiliary fossil fuels is not more than 50% of the total energy generated in the incinerator
Advantage	• Previously approved methodology				
Issue	• It isn't said that applicable to the project of sewage sludge. Applicable to wastewater on paper. • Basically, the project activity is avoiding methane emissions from the organic wastes in SWDS.				

(2) Approach of New Methodology

A lot of projects on the subject of methane gas emission reductions from sludge treatment have been thrown up as one of climate change policies in the wastewater treatment field and the methane gas recovery projects which use the anaerobic digestion including covered lagoons have mainly been approved. Meanwhile, reviewing the main objectives adopting anaerobic digestion from a standpoint of sludge treatment; 1) sludge volume reduction, 2) sludge stabilization when disposal, 3) Produced methane gas reductions when disposal by landfill, etc. have been thought of. Especially, in Europe where many agricultural countries contained, (dehydrated) sewage sludge cake is mainly used for land application, and therefore, a number of anaerobic digestions aimed at sludge stabilization are adopted generally. Incidentally, it was explicitly stated in a current official document (issued by Union of the Baltic Cities Environment Commission) that "Anaerobic digestion is the main stabilization method in municipal sewage sludge treatment. The main benefits are the reduction of organic matter and the production of methane gas, which can be used to achieve the required treatment temperature (often 35-40°C)."[1]

At that stage of Pre-F/S with M/P, the introduction of an anaerobic digestion is also included in the original design, and in addition to the above-mentioned objectives, the methane gas avoidance was added on the climate change measures. However, the recovered methane gas will be used for warming sludge injected into the digester and disposed by flare facility (suppressing

[1] "GOOD PRACTICES IN SLUDGE MANAGEMENT"; p13, Published by and copyright 2012; Project on Urban Reduction of Eutrophication (PURE), c/o Union of the Baltic Cities Environment Commission, October 2012

new investments as much as possible and not implementing electric generation and/or heat production by boiler). Since this sludge warming and flare treatment is to combust the carbon-neutral methane gas, no CO_2 emissions is to be considered.

In the past existing approved methodologies related to the biogas recovery (including energy utilization), the baseline of wastewater treatment is anaerobic lagoons system, even if in case of wastewater treatment introduced the normal secondary treatment, the applicable conditions are sludge pits in the sludge treatment and/or the sludge left to decay (AM0080, ACM0014). In addition, concerning ACM0022, the applicable options contain the anaerobic digestion, though, the object does not clearly specify that wastewater, or sludge (wastewater as provided in description). Meanwhile, this methodology basically is to avoid methane emissions from the organic wastes in solid wastes disposal site (SWDS). In addition, in case of ACM0014, the wastewater treatment is viewed as the baseline conditions (secondary treatment) in the project activity options and in the sludge treatment, sludge pits are made of the baseline, however the introduction of anaerobic digester and the utilization of produced biogas include. Consequently, the above approved methodologies are inapplicable to the baseline dealt with the possibility in this project (Both the baseline and the project scenario are identical in the wastewater treatment and the methane gas recovery of sludge treatment is also identical).

Meanwhile, an opportunity of interview with the person in charge of the Serbian DNA was provided and the information of Serbian climate change policies was obtained. The main points are listed as follows;

- Serbia, along with other developing countries has no plan to develop CDM projects in a positive way in future, and has changed policies and shift to promote development and implementation of NAMAs (Nationally appropriate mitigation actions) projects.
- This project will probably be proceeded on track of the other climate change measures, not on the CDM procedure.
- Additionally, Japanese “Bilateral Offset Credit Mechanism (BOCM)” is also of great interest and its institutional establishment will be longed for.

With the view of approval of host country and circumstances, it reached a conclusion of no use for hanging up the approved methodologies. Since the current approved methodologies have repeated integrations and revisions and resulted in overly complex structures, it has been concluded that it would rather be advisable to build a new methodology for this Project.

(3) Proposed New Methodology

(A) Points to Build up New Methodology

- Simple and easily understandable
- Applicability in conformity to host countries
- Acquiring emission factors specific to the project by measured data (when difficult, adopt the default values)
- Not setting out unnecessary conditions

(B) Outline of New Methodology

Outline of proposed new methodology is as follows;

1) Setting of baseline scenario

Reckoning up the likely candidate scenarios, barrier analysis should be implemented. Investment analysis should be implemented out of the lowest barriers and the scenario which is the highest investment efficiency would be the baseline scenario.

2) Verification of additionality

Additionality should be verified by qualitatively-signifying that GHG emission of the project scenario is lesser than GHG emission of the baseline scenario.

3) Calculation of baseline emissions

GHG emissions of the baseline scenario can be obtained for the product of the heat energy required for warming sludge injected into digester and the emission factor of fuel for warming sludge. If the fuel is biogas from digester, though, no emission is to be considered since the biogas is carbon-neutral fuel.

4) Calculation of project emissions

Since electricity and heat produced by a newly-built co-generation are obtained by the biogas produced from anaerobic digester, GHG emissions of the project scenario is not to be considered.

5) Calculation of leakage emissions

Leakage (with consideration for only CO_2) in the baseline scenario is the emission by the grid which electricity has been substituted by co-generation in the Project. This can be obtained for the product of the (generated) electric energy and grid emission factor. Meanwhile, no leakage is considered in the project activity.

6) Calculation of emission reduction

The emission reduction is obtained by the deduction of GHG emissions in the project scenario from the sum of GHG emissions and leakage emissions in the baseline scenario.

(C) Applicability of New Methodology

The following applicability conditions are set in new methodology;

[Applicability-1]
In the existing WWTP, produced sludge is treated by the anaerobic digester and the biogas produced in digester is captured and/or stored, and then used for warming the sludge injected into digester, and its surplus gas is combusted by flare treatment. Some kind of sludge treatment would be no matter before injecting into the digester. The sludge discharged from digester is disposed to landfill after dehydrated or furthermore treated by composting and could be a case of land application. This methodology would be inapplicable in case where sludge is directly dehydrated and as-is disposed by landfill or where dehydrated cake is treated by composting and applied to farm land.

[Applicability-2]
In the project, the sludge produced from sewage treatment is treated by anaerobic digestion and the biogas produced from digester is totally collected and stored, and then used for fuels of co-generation or generator or boiler.

[Applicability-3]
Electricity obtained by co-generation or generator should be connected and supplied to WWTP and/or power grid. As a result, the electricity purchased from grid will be reduced in WWTP and the reduced emissions in the grid power station can be claimed. (If the emissions cannot be claimed, this methodology is applicable in the way of no reduction.)

[Applicability-4]
Exhaust heat obtained by co-generation or heat by boiler should be supplied to WWTP and/or neighborhood customers. The consumption of fossil fuel will be reduced by this alternative heat energy and as a result, the obtainable emission reduction can be claimed. (If the emissions cannot be claimed, this methodology is applicable in the way of no reduction.)

[Applicability-5]
By characteristics of the region, the sludge injected into anaerobic digester would be subject to be supplied to digester after warming to the most suitable temperature for digestion. In baseline, heat source for externally warming will be required and the additional emissions would arise.

On the other hand, in project scenario, the exhaust heat obtained by co-generation or boiler can be utilized and the emission by recovering exhaust heat can be reduced. (It can be claimed.)

(D) Applied Methodology for Provisional CDM-PDD

This project is classified into small scale CDM based on its emission reductions. (GHG emission reductions is less than 60,000 tCO_2/y) In CDM-PDD developing, it is necessary to take time and make a study on whether proposing and applying the above new methodology or dealing with revising of the most similar approved methodology. Development of the provisional PDD is applied to a similar approved methodology. However, as previously indicated, the methodology should be revised to be simple and easily understandable, in conformity to national conditions and without setting of unnecessary conditions. Meanwhile, the applied approved methodology for the provisional PDD is AMS-I.C "Thermal energy production with or without electricity" Version 19.

9.4.3 Study on Baseline Scenario and Verification of Additionality

(1) Indication of Baseline Scenario

The baseline of the project will be identified by the following procedures. First of all, scenarios legitimate and presumable in Serbia the Host country will all be enumerated. The project scenario should also be included in these scenarios. Any possible scenario is enumerated as given in the table below. Among the below scenarios, a reason will be suggested on the scenario thought of as improbable as baseline.

Conditions of Serbia

At present, sewage sludge (derived from sewage) is not accepted as biomass even if after dehydrated or after composting in Serbia. There is no disposal method other than disposal by landfill as (industrial) waste substances. Meanwhile, methane gas produced by anaerobic digestion of sludge is accepted as biogas, by which as fuel of co-generator and/or generator generated electricity is made possible to purchase by high price as biomass generated electricity.

Table 9.2 Legitimate and Presumable Scenarios in Serbia

Scenario No.	Contents of Scenario	Reason on the Scenario thought to be unlikely as Baseline, unnecessary to implement Barrier Analysis
Scenario 1	***Status quo***. i.e. Sewage in Belgrade is released as untreated into the Danube and the Sava.	Releasing untreated sewage progresses the contamination of (international) rivers, which means contradictory to the national environmental policy. Unlikely as baseline.

Scenario No.	Contents of Scenario	Reason on the Scenario thought to be unlikely as Baseline, unnecessary to implement Barrier Analysis
Scenario 2	***Pre-F/S with M/P scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	(presumable as baseline, it is necessary to examine in next step)
Scenario 3 (this project)	***Co-generation introduction scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas from digester produces electricity and heat by introduced co-generator and the electricity is connected to the existing grid and the exhaust heat is utilized for warming sludge injected into digester.	(presumable as baseline, it is necessary to examine in next step)
Scenario 4	***Composting introduction scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is dehydrated after thickening and dehydrated sludge cake is treated by composting. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	(presumable as baseline, it is necessary to examine in next step)
Scenario 5	***Drying process (sludge fuel conversion) introduction scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is dehydrated after thickening and dehydrated sludge cake is dried by newly-introduced sludge drying equipment. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	The product of dried sludge has no application as fuel. Unlikely as baseline by reason of no economic benefit even if dried.

Next, the barrier analysis of reckoned scenarios will be implemented. Investment analysis of ones having the least barrier will be implemented and the one of the highest investment efficiency will be baseline scenario. The result of barrier analysis is shown as follows:

Table 9.3 Barrier Analysis of Scenarios

Scenario No.	Contents of Scenario	Presumable Barrier
Scenario 2	***Pre-F/S with M/P scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	No technical barrier. Making a study of whether the project is formed economically or not is required.
Scenario 3 (this project)	***Co-generation introduction scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas from digester produces electricity and heat by introduced co-generator and the electricity is connected to the existing grid and the exhaust heat is utilized for warming sludge injected into digester.	No technical barrier. Making a study of whether the project is formed economically or not is required.
Scenario 4	***Composting introduction scheme***. i.e. Sewage is treated by secondary biological treatment	The barrier is existing. Sludge derived from sewage or wastewater

Scenario No.	Contents of Scenario	Presumable Barrier
	with advanced treatment and sludge is dehydrated after thickening and dehydrated sludge cake is treated by composting. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	treatment is not biomass in Serbia and no sludge composting is implemented. The reason is nonexistence of composting technology and social system.

The result of investment analysis on scenario 2 and 3 is shown as follows:

Table 9.4 Investment Analysis of Scenarios

Scenario No.	Contents of Scenario	Additional Expense	Additional Revenue	Post-tax IRR
Scenario 2	***Pre-F/S with M/P scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas produced from digester is utilized for warming sludge injected into digester and/or combusted by flare treatment.	Initial Construction Cost 300 million Euro	NA	IRR calculation is incapable.
Scenario 3 (this project)	***Co-generation introduction scheme***. i.e. Sewage is treated by secondary biological treatment with advanced treatment and sludge is treated by anaerobic digestion after thickening and disposed by landfill after dehydration. Biogas from digester produces electricity and heat by introduced co-generator and the electricity is connected to the existing grid and the exhaust heat is utilized for warming sludge injected into digester.	Initial Construction Cost 302 million Euro	Power purchase cost and cost of fuel for warming sludge are reduced by the efficient use of biogas. Revenue of electrical power selling; 1.212 million Euro/yr (0.067 Euro/kWh)	IRR calculation is incapable.

The study mentioned above concluded the baseline scenario was Pre-F/S with M/P scheme.

(2) Demonstration of Additionality

Secondly, the additionality will be demonstrated. The project is scenario 3. As it became clear that the scenario 3 was not the baseline scenario, it has already been confirmed that the project was additionality, however, "GHG emissions can be reduced additionally" will be demonstrated through the scenario 3. Mathematically, if the following formula becomes clear, the additionality can be verified.

$$\text{Baseline Emissions} + \text{Baseline Leakage} > \text{Project Emissions} + \text{Project Leakage} \quad (1)$$

Where,

$$\text{Baseline Emissions } (tCO_2/y)\ BE_{i,y} = EG_{i,y} * EF_{BL,i,FC} = 0 \quad (2)$$

$$\text{Baseline Leakage } (tCO_2/y)\ BL_y = P_y * EF_{grid,y} \quad (3)$$

Project Emissions (tCO_2/y) $PE_{i,y} = EG_{j,y} * EF_{BL,i,FC} = 0$ (4)
Project Leakage (tCO_2/y) $PL_y = 0$ (5)

As described above, it is obvious that $P_y * EF_{grid,y} > 0$ leads to the additionality

$BE_{i,y}$	=	Baseline emissions from electricity and thermal energy displaced by the project activity during the year y (tCO_2)
$EG_{i,y}$	=	Amount of fuel i of water heater used for warming sludge (mass or volume unit/y)
$EF_{BL,i,FC}$	=	Emission factor of fuel i (tCO_2/mass or volume unit/y) Emission factor of biogas fuel is 0
BL_y	=	Baseline leakage during the year y (tCO_2/y)
P_y	=	Net supplied power by the project co-generation system in the year y (MWh/y)
$EF_{grid,y}$	=	Emission factor of the baseline grid during the year y (tCO_2/MWh)
$PE_{i,y}$	=	Project emissions in the year y (tCO_2/y)
$EG_{j,y}$	=	Amount of exhaust heat energy j in the year y (mass or volume unit/y)
PL_y	=	Project leakage during the year y (tCO_2/y)

In the baseline, anaerobic digestion implemented with the purpose of sludge stabilization, the produced biogas is used for warming sludge injected into digester and its surplus is treated by flare combustion. On the other hand, in the project, the produced biogas is supplied to the co-generation system, and the power energy generated by biomass generation and the heat energy by recovered exhaust heat are obtained. Electricity is connected to the existing grid and sold, and exhaust heat is used for warming the sludge injected into digester. Herewith, a part of power consumption is substituted by co-generation. Consequently, the project is additionality.

9.4.4 Study on Leakage and Project Boundary

The project boundary is the area which includes the existing anaerobic digestion facilities (including flare combustion facility) and a newly-built co-generation system. Reckoning up the emission sources within the project boundary, each emission that would be included in the calculation or not is listed as below. In addition, Figure 9.4 shows the project boundary.

Table 9.5 Emission Source within the Project Boundary

Classification	Sources	GHG	Included/ Excluded	Justification/Explanation
Baseline	Anaerobic digester	CO_2	Excluded	CO_2 leakage from the digester is vanishingly so few. In addition, since this CO_2 originates in biomass, it is ignorable.
		CH_4	Excluded	CH_4 leakage from the digester is vanishingly so few.
	Water heater (warming sludge)	CO_2	Excluded	Since warming sludge injected into digester by water heater runs on the biogas from digester, no emission is to be considered.

Classification	Sources	GHG	Included/ Excluded	Justification/Explanation
Project Activity	Flare facility	CO_2	Excluded	Since this CO_2 originates in biomass, it is ignorable.
		CH_4	Excluded	CH_4 emission by fuel combustion is vanishingly so few compared to CO_2 emission.
	Anaerobic digester	CO_2	Excluded	CO_2 leakage from the digester is vanishingly so few. In addition, since this CO_2 originates in biomass, it is ignorable.
		CH_4	Excluded	CH_4 leakage from the digester is vanishingly so few.
	Water heater (warming sludge)	CO_2	Excluded	Since warming sludge injected into digester by water heater runs on the biogas from digester, no emission is to be considered.
	Co-generation system	CO_2	Excluded	Since this CO_2 originates in biomass, it is ignorable.
		CH_4	Excluded	CH_4 emission by fuel combustion is vanishingly so few compared to CO_2 emission.
		N_2O	Excluded	N_2O emission by fuel combustion is vanishingly so few compared to CO_2 emission.

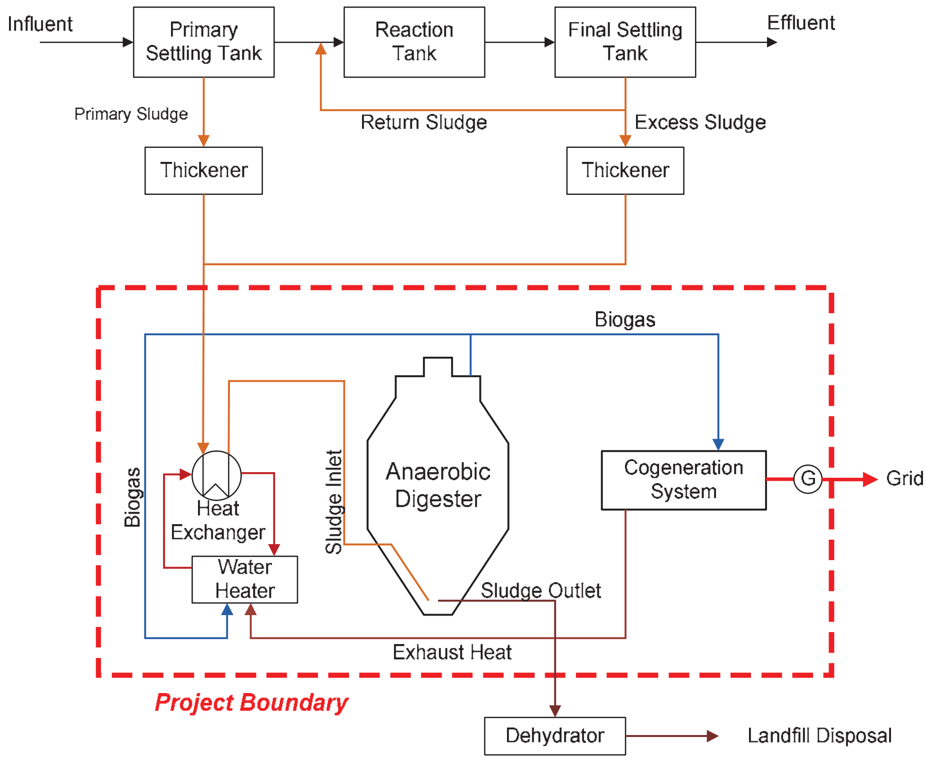


Figure 9.4 Project Boundary

Reckoning up the emission sources out of the project boundary, each emission that would be included in the calculation or not is listed below.

Table 9.6 Emission Sources out of Project Boundary

Classification	Sources	GHG	Included/ Excluded	Justification/Explanation
Baseline	Grid	CO_2	Included	This is the most important emission source
		CH_4	Excluded	CH_4 emission by fuel combustion is vanishingly so few compared to CO_2 emission.
		N_2O	Excluded	N_2O emission by fuel combustion is vanishingly so few compared to CO_2 emission.
Project Activity	Initial construction cost	CO_2	Excluded	When initial construction, there're some GHG emissions. This could be said the project leakage. However, this is vanishingly so few.

9.4.5 Calculation of Baseline Emission

(1) Baseline Emissions

Baseline emissions for heat produced using biomass fuel shall be calculated as follows:

$$\text{Baseline Emissions }(tCO_2/y)\ BE_{i,y} = EG_{i,y} * EF_{BL,i,FC} = 0 \qquad (2)$$

$BE_{i,y}$ = Baseline emissions from electricity and thermal energy displaced by the project activity during the year y (tCO_2)
$EG_{i,y}$ = Amount of fuel i of water heater used for warming sludge (mass or volume unit/y)
$EF_{BL,i,FC}$ = Emission factor of fuel i (tCO_2/mass or volume unit/y)
Emission factor of biogas fuel is 0

This shows that the fuel of hot water heater required for warming the sludge injected into anaerobic digester is covered by the biogas. Adopting the method of utilizing biogas for warming sludge into digester, no GHG emission is to be considered. Such condition setting is consistent with the simplification of this GHG reduction projects.

(2) Baseline Leakage

Baseline leakage shall be calculated as follows:

$$\text{Baseline Leakage }(tCO_2/y)\ BL_y = P_y * EF_{grid,y} \qquad (3)$$

BL_y = Baseline leakage during the year y (tCO_2/y)
P_y = Net supplied power by the project co-generation system in the year y (MWh/y)
$EF_{grid,y}$ = Emission factor of the baseline grid during the year y (tCO_2/MWh)

Regarding P_y, the capacity of co-generation system planned in the main project (Veliko Selo

WWTP Project) is as follows:

1,000 kW x 4 units total 4,000 kW (at peak time)

When assuming the generation capacity is 2,500 kW in normal operation, the annual operating time is 8,040 hrs (335-day running) and the self-consumption ratio is 10 %;

2,500 kW x 8,040 hrs x (1-0.1) = 18,090 MWh/y

And the emission factor of Serbian power grid $EF_{grid,y}$ is 0.945 tCO_2/MWh[2].

Thus, BL_y = 17,095 tCO_2/y

9.4.6 Calculation of Project Emission

(1) Project Emissions

Project emissions shall be calculated as follows:

Project Emissions (tCO_2/y) $PE_{i,y} = EG_{j,y} * EF_{BL,i,FC} = 0$ (4)

Thus no project emission is to be considered.

(2) Project Leakage

Project leakage shall be calculated as follows:

Project Leakage (tCO_2/y) $PL_y = 0$ (5)

Thus no project leakage is to be considered.

(3) Project of Emission Reduction

GHG emission reduction shall be calculated as follows:

Emission reduction = (Baseline emissions + Baseline leakage) – (Project emissions + Project leakage)

2 Technical Assistance of the Revision of Project Design Documents (PDDs), Calculation of the Carbon Emission Factor for the Serbian Power Grid; Rev.0 – JUNE 2011, Serbian Ministry of Environment, Mining and Spatial Planning Belgrade, Serbia

Thus, GHG emission reduction $ERCO^2$ = 17,095 tCO_2/y

9.5 Monitoring Plan

9.5.1 Study on Monitoring Methodology

From the view point of considering consistency with the baseline methodology, a new methodology will be developed for the monitoring methodology. Applicability is the same as the baseline methodology.

9.5.2 Study on Monitoring Item

Since both baseline emissions and project emissions, furthermore, project leakage are not to be considered, the monitoring items are solely the baseline leakage and as follows; the scheme drawing is shown in Figure 9.5.

Table 9.7 Monitoring Items Required for Calculation of Leakage

ID No.	Data/Parameter	Monitoring procedure	Data unit	Monitoring/ Calculation	Monitoring frequency	Percentage of data monitored	Method of custody	Any comment
1	P_y Net supply capacity by co-generation	Electric energy meter	MWh	Calculation	Once a year	100 %	Stored as electronic data. Data is filed for two years after crediting period	This net supply capacity will be obtained by the indicator of power meter.
2	$EF_{grid,y}$ Grid emission factor in the baseline	Calculation based on the baseline methodology	tCO_2/ MWh	Calculation	Once a year	100 %	Stored as electronic data. Data is filed for two years after crediting period	This item will be determined by using the procedures described in the baseline methodology.

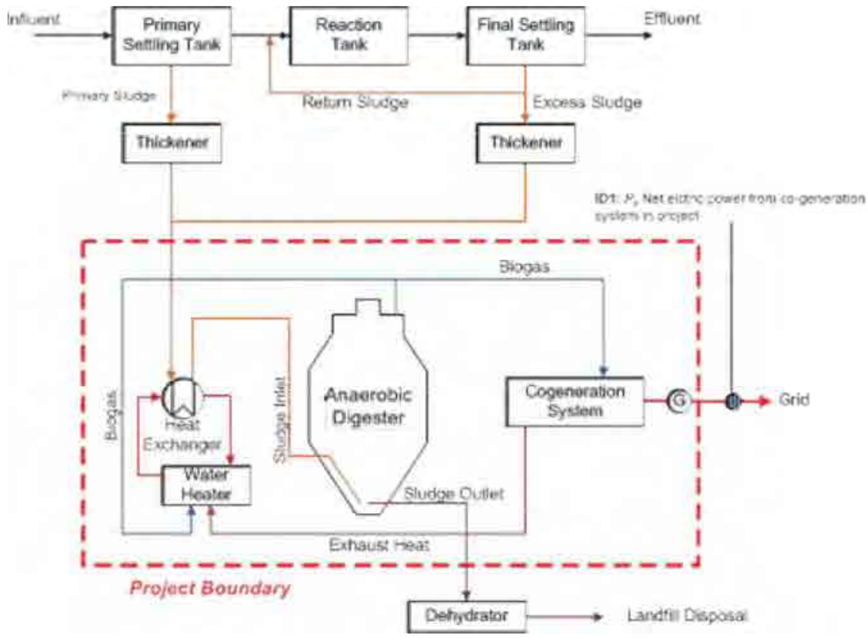


Figure 9.5 Monitoring Scheme Drawing

9.5.3 Calculation of Emission Reduction by Monitoring Outcome

In the GHG emitted outside project boundary, "the emissions of grid generating electricity substituted by co-generation" exists. These are positioned as leakage in the baseline. On the other hand, no leakage exists in the project activity. Calculation of the baseline and project leakage is summarized as follows;

Baseline Leakage (tCO_2/y) $BL_y = P_y * EF_{grid,y}$ (3)

Project Leakage (tCO_2/y) $PL_y = 0$ (5)

BL_y	=	Baseline leakage during the year y (tCO_2/y)
P_y	=	Net supplied power by the project co-generation system in the year y (MWh/y)
$EF_{grid,y}$	=	Emission factor of the baseline grid during the year y (tCO_2/MWh)

Regarding $EF_{grid,y}$, the value described in "Calculation of the Carbon Emission Factor for the Serbian Power Grid" issued by the Ministry of Energy Development and Environmental Protection (relevant government of CDM) will be adopted, and if the entries are updated, the value will be adopted.

9.5.4 Quality Control / Assurance in Monitoring

The frame of quality control/assurance in monitoring is shown below in Table 9.8.

Table 9.8 Quality Control / Assurances in Monitoring

ID No.	Degree of uncertainty	Frame of quality control/assurance
1	Low	Instrument should be periodically proofread.
2	Low	Calculation based on the baseline methodology.

The framework of quality control and quality assurance on the monitoring are as follows, where "Administrator" means the administration division of Belgrade Waterworks and Sewerage (BVK) and "Operator" means operators of Veliko Selo WWTP those who implement the monitoring under the directions of the administration division of BVK.

- Project implement bodies consist of the operator and the administrator.
- Administrator develops a procedure for facility operation.
- In the procedure, daily work contents, maintenance methods and various types of criteria for judgment are described and formatted appropriately.
- The operator should be assured of chances for receiving training and education periodically to take every available step to work in accordance with the above procedure.
- Operator should carry out the daily works and report the results to the administrator in accordance with the procedure.
- Administrator should check the report from the operator and make judgments whether having problems with or not in accordance with the procedure, and as a result of checking, develop an appropriate response at an appropriate time in the event of problems.
- Administrator should file the report from the operator daily and store them in accordance with the procedure.
- Administrator should take a tour of the sites, visit the site at an appropriate time and audit whether the operator's works properly in accordance with the procedure. As a result of auditing, the administrator should develop an appropriate response at an appropriate time in the event of problems.
- When an accident occurs (including unexpected GHG discharge), administrator should find out the cause and give the operator the direction of countermeasure and implementation.
- If an emergency arises (including unexpected GHG discharge), operator should take emergency measures and implement the countermeasures under the administrator's direction.
- Instrument should properly be corrected proofs periodically in accordance with the procedure. A period and a method of the proofreading should be in accordance with the monitoring plan.

10. Environmental and Social Consideration

The environmental and social considerations were carried out following the relevant Serbian legislation and Japan Bank for International Cooperation Guidelines for Confirmation of Environmental and Social Considerations (April 2002) (hereinafter referred as “JBIC Guidelines”).

10.1 Legal Framework related to EIA

10.1.1 Laws and Regulations on EIA

Environmental protection in Serbia is regulated by many republic and municipal laws and by-laws. The main laws and regulations currently in force which are relevant to the EIA are as follows.

(1) Law on Environmental Protection (“Official Gazette of RS” No. 66/91, 83, 92, 67/93, 48/94, 53/95, 135/04)

The Law of Environmental Protection is the fundamental law for environmental protection, and has served as the basis for three other laws. The items regulated by this law include not only measures for prevention of air, water, soil, noise and vibration pollution, but also provisions for waste control, radiation protection and chemical materials management. The law is also used to promote sustainable development of natural resources, maintain biodiversity, protect the ozone layer, and provide for a public participation system. The independent management and voluntary control are expressed as a method of risk management, and minimizing impacts on the environment by adopting BAT (Best Available Technology) is clear. The regulatory values are not clearly defined in the provision, but the law does specify that the government provide the environmental standards and emission norms. The regulatory values are set in individual laws and regulations.

(2) Law on Strategic Environmental Impact Assessment (“Official Gazette of RS” No. 135/2004)

The Law on Strategic Environmental Impact Assessment provides that the adverse effects etc., which a project has on the environment, are forecast beforehand and are evaluated, are prevented and are controlled, to makes compatible with Sustainable Development and the Environmental Protection (including the protection of natural resources, the spectacle and cultural asset, and biodiversity, etc.). At the same time it is to maintain the consistency with another field. The projects, plans and sector master plans that should execute the Strategic Environmental Impact Assessment are in the field of the spatial plan, the town planning or the land use planning, planning in the fields of agriculture, forestry, fishing industry, hunting, energy, industry, transport, the waste management, the water management, telecommunications, tourism, preservation of natural habitats and wildlife (flora and fauna).

The person to actually execute the Strategic Environmental Impact Assessment and to describe its report is prescribed clearly that the legal person or the natural person is registered in the registry book, and forms the specialist group composed of experts who have the qualification of the analysis concerning each strategy assessment element. The person in charge of the report author is a specialist with an appropriate university degree, who has the work experience of five years or more in the particular field, and who has already participated in two environmental impact assessment services. Then, it is necessary to consign it to third party's registered agency even in case of the competent authorities. The SEA procedure and the content of the SEA report and the criteria for the evaluation of the SEA reports are provided for in detail. Also, in this law it is clearly provided to adopt the public participation system.

(3) Law on Environmental Impact Assessment (“Official Gazette of RS” No. 135/2004)

Law on Environmental Impact Assessment provides regulations concerning the environmental assessment procedure related to the project that exerts a heavy influence on the environment. That is, it provides for the content of the EIA study report, monitoring procedures, the participation of the public, and the exchange of information on the project with the possibility of the border transgression contamination to the neighbor countries, etc. The execution of Environmental Impact Assessment is obligated to all projects that are planned in the natural resources protection area and in the cultural asset protection area. Also, the projects in the fields of industry, mining, energy production, transport, tourism, agriculture, forestry, the water management, waste management, and utility service are obligated. It is executed at each stage (at the time when the project is planned and executed, in the case of the exchange of the technology, reconstruction, the ability enhancing, the end of operation, and the abolishment of the project that has heavy influence on the environment).

The Ministry in charge of the environmental protection is able to specify the project that the Ministry admits the necessity for the object of EIA besides the above-mentioned obligated objects. The project developer will submit to the Ministry the application of the decision of the necessity of EIA according to this law. So, there is a problem that the project developer cannot judge if the project needs the EIA procedure or not.

A technical committee that includes an outside specialist is supposed to be set up and may undertake evaluations of EIA reports and take the approval procedure of the EIA. In this law it is provided that the public concerned and the local government may submit their opinion.

(4) Law on Integrated Environmental Pollution Prevention and Control－IPPC

The Law on Integrated Pollution Prevention and Control is called IPPC in the EC countries. In the IPPC process, enterprises and organizations regulated by this law submit to the inspective organization the application with data, how to treat the materials that might cause harmful effects on the environment, and the number and amounts of substances that are discharged into the environment. If, after an application is examined and approved by the inspecting organization, the enterprise or organization receives approval, it can begin operations. It is supposed that an actual emission limit values are decided under the inspective organization examinations. A permit with time limit may be authorized, and it will be reviewed twice during the time it is in effect. Moreover, the approved information and conditions are a matter of public record. A concrete emission standard is like the character that undertakes the examination and is decided.

Other related environmental regulations and rules are as follows.

- Regulations on permitted noise level in the environment (“Official Gazette of RS” No. 54/92)
- Decree on establishing the List of Projects for which the Environmental Impact Assessment is mandatory and the list of projects for which the Environmental Impact Assessment can be requested (“Official Gazette of RS” No. 84/05)
- Rulebook on the contents of requests for the necessity of impact assessment and on the contents of requests for specification of scope and contents of the Environmental Impact Assessment Study (“Official Gazette of RS” No. 69/05)
- Rulebook on the contents of the Environmental Impact Assessment Study (“Official Gazette of RS” No. 69/05)
- Rulebook on the procedure of public inspection, presentation and public consultation about the Environmental Impact Assessment Study (“Official Gazette of RS” No. 69/05)
- Rulebook on the work of the Technical Committee for the Environmental Impact Assessment Study (“Official Gazette of RS” No. 69/05)

10.1.2 EIA Process in Serbia

The procedures for EIA approval in Serbia is as follows.

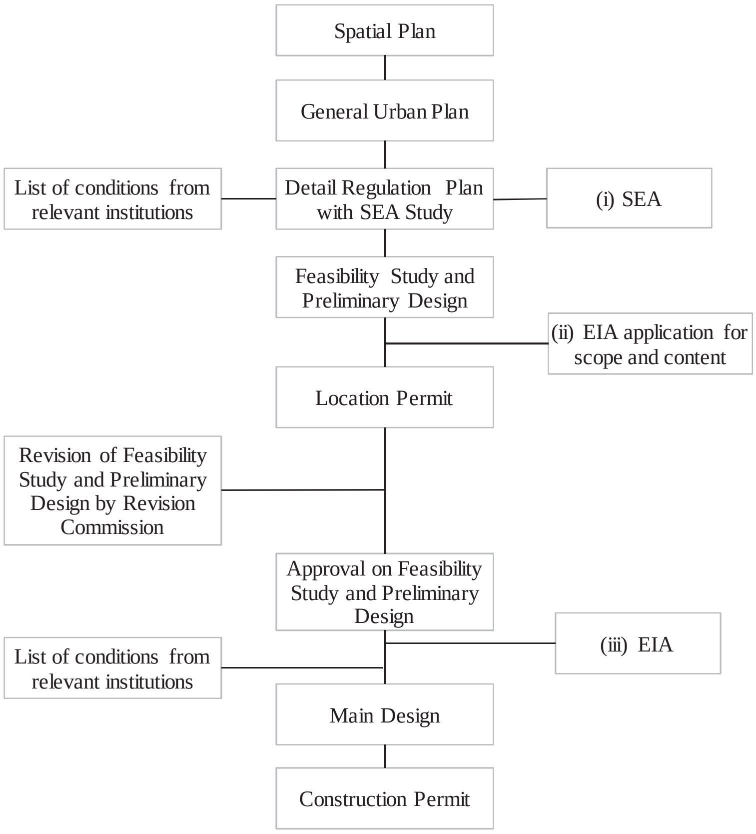


Figure 10.1 EIA Process in Serbia

(1) SEA (strategic environmental assessment)

SEA is done during the preparation of detail regulation plan (this is correspondent to master plan) which has to be in accordance with the Law on Planning and Construction and Law on Strategic Environmental Assessment. The competent planning authority shall provide for public participation in the strategic assessment report consideration prior to submission of application for granting the approval for strategic assessment report.

(2) Application for a decision on the scope and content of the EIA Study

The projects for which the EIA is obligatory and for which the EIA can be required are stipulated by Regulation on determination of a list of projects for which the impact assessments is obligatory (List I) and list of projects for which the impact assessment can be required (List II) (“Official Gazette of RS” No. 114/2008). According to the Regulation, for the wastewater treatment facilities in settlements with more than 100,000 of citizens, environmental impact assessment is mandatory. For the wastewater transport pipeline over 10 km length falls in the List II, however the interceptor which is included in the Preparatory Survey is around 7 km and

EIA may not be required.

According to the Law on EIA, the Ministry of Energy, Development and Environmental Protection decides on the required scope and contents of the EIA study for WWTP and City of Belgrade for other facilities (pumping stations and interceptors). The request for determination of scope and contents should be submitted with preliminary design after the approval of F/S. The requirement of EIA for the interceptor will be decided after this procedure.

(3) EIA

Based on the decision on the scope and content of the EIA Study, the investor prepares EIA report. EIA report shall be prepared after the approval of F/S and preliminary design by Revision Committee and during the detail design preparation. The EIA report shall contain the following mandatory data, information and documents:

- The data on project developer,
- The description of the planned project site,
- The description of the project,
- The outline of the main alternatives studied by the project developer,
- The outline of the environmental status at the site and its close vicinity (micro-location and macro-location),
- The description of likely significant effects of the project on the environment,
- The environmental impact assessment in cases of accidents,
- The description of measures envisaged to prevent, reduce and, if possible, eliminate any significant adverse effects on the environment,
- The program of monitoring of impact on the environment,
- The short non-technical summary of data,
- The data on technical shortcomings, absence of the appropriate expertise and skills or, impossibility of obtaining the appropriate data.

The Ministry of Environment and Spatial Planning shall make the EIA study available to public and arrange for a public presentation and debate on the study. Within seven days from the date of receipt of the application for the EIA study approval, the notification of public debate shall be done and public debate may not be held sooner than 20 days from the date when the public was informed. The evaluation is done by the technical commission together with the systematized report on the consultations of the authorities, organizations and the public. The Ministry of Environment and Spatial Planning shall adopt the decision granting the approval of the EIA study or the refusal of the application for approval of the EIA study based on the completed EIA procedure and the report of the technical commission.

10.1.3 Main differences between JBIC Guidelines and Serbian Legislation

There are differences between JBIC Guidelines for Confirmation of Environmental and Social Considerations and Serbian legislation as summarized below.

Table 10.1 Main Differences between JBIC Guidelines and Serbian Legislation

Item	JBIC (JICA) Guidelines	Serbian Legislation	Policy for this Project
Alternative study	Alternative studies including with/without project scenario	Alternative studies in terms with location, method, site and others but with/without is not included.	With/Without project scenario will be studied.
Environmental and social items to be studied	Broader social and environmental items	Limited items compared with JBIC (JICA), especially social items.	Cover the all items which are included in JBIC guidelines and Serbian legislation.
Public consultation	Broader participation of various stakeholders including affected persons and NGOs.	Public consultation is organized by Min. of Environment during the review process of EIA report	When the preliminary EIA report is ready, LDA will organize the workshop inviting broader participants from various stakeholders.

According to the Serbian legislation, the preparation of EIA report is not required during F/S stage. EIA report should be submitted together with preliminary design after the approval of F/S and the approval on EIA report should be obtained before the completion of detail design. However, as the environmental and social considerations are required by JBIC Guidelines and EIA will be required after F/S by the Serbian legislation, the preliminary EIA report shall be prepared during the Project which fulfills the requirements of Serbian legislation and JBIC Guidelines, and this will be utilized when LDA will implement the EIA study during detail design.

10.2 Legal Framework for Land Acquisition in Republic of Serbia

10.2.1 Related Regulations

Serbian law has the following instruments which provide instruction on matters relating land, land acquisition and compensation for other property losses:

- Law on Expropriation (passed in 1995 and enacted on January 1, 1996, amended in March 2001, amended on March 19, 2009) –"Official Gazette of the Republic of Serbia No. 53/95, 23/2001 and 20/09) "
- Law on Fundamentals of Property relations (1980, applicable from 1st September 1980, amended 1990 and 1996) –"Official Gazette of the Socialist Federal Republic of

Yugoslavia (SFRY)", No. 6 dated February 8, 1980; No. 36 dated June 29, 1990; and –"Official Gazette of Federal Republic of Yugoslavia (FRY)", No. 29 dated June 26, 1996.)

- Administrative Code (passed in 1996, amended June 26, 1997) –"Official Gazette of Federal Republic of Yugoslavia" No. 33/1997 and No. 31/2001 and "Official Gazette of the Republic of Serbia'' No. 30/2010.
- Law on Planning and Construction (passed on May 5, 2003, enacted on May 13, 2003) –"Official Gazette of the Republic of Serbia" No. 72/09, No. 81/09 and No. 24/11
- Law of Agricultural Land (passed on July 19, 2006, enacted July 27, 2006) – "Official Gazette of the Republic of Serbia'', No. 62/06, No. 65/08 and No. 41/09

10.2.2 Law on Expropriation

The Law on Expropriation (passed in 1995 and enacted on January 1, 1996, amended in March 2001, amended again on March 19, 2009) guides land acquisition and serves as a general framework for expropriation in the Republic of Serbia. The Law on Expropriation does not use the term "involuntary resettlement" but instead uses the term "expropriation". This law enables government institutions to acquire private property for projects that are deemed to be of national and/or local interest, while protecting the interests of all project affected persons with legal title, whose assets are to be expropriated. The law also enshrines the principle of fair compensation.
The important features of Law on Expropriation are:

- It is intended to ensure simple, efficient process, reducing as far as possible the need for a lengthy judicial process to facilitate necessary expropriation. Under normal circumstances, the entire process of acquisition can be completed within six months.
- The fair value of the land affected by a particular schema, or project, is determined by the Tax Administration, on behalf of the beneficiary of expropriation. The value is assessed on the basis of comparable sales transactions in the area in the recent past.
- As a condition to start expropriation, the beneficiary of expropriation must arrange a Bank Guarantee with a Commercial Bank, in the assessed total sum for payment.
- In the case of expropriating privately owned agricultural land, if land owner demands comparable land of the same type and quality instead of payment of the appropriate value, the project affected person with formal title can be offered such a land in the same area or vicinity, but only if the City of Belgrade possesses such a land in its public ownership.
- The comparability of land is determined on the basis of an assessment made by Tax Administration upon request by LDA as the beneficiary of expropriation.
- In case of disagreement on the comparability of the land offered, a different accredited expert would be hired by the local municipality to determine the comparability of the land offered.

- Further disagreement would result in the PAPs resorting to the judicial process, where a decision would be made on the comparability of the land, or the payment of the assessed fair value in monetary terms.
- Where comparable land cannot be identified, the PAPs with legal title are offered the assessed fair value determined by the Tax Administration. If the PAPs wish to challenge the assessment of fair value, they can resort to the judicial process.
- For the PAPs, without formal title, there is no provision to pay compensation currently under the Law on Expropriation.

The assessment of fair value takes into account the value of land, the cost of structures and installations, crops, woods, trees, fruit bearing trees, age of crops, vineyards, and the time needed to reproduce them. The impact of the scheme on the value of land will not be considered in the fair value of the immovable property.

The Law on Expropriation requires the beneficiary of expropriation to justify the need for expropriation and to demonstrate that the scheme cannot occur without the proposed expropriation. The Decision on public interest is reached by the Government of the Republic of Serbia and it precedes and enables any property acquisition and expropriation. When the scheme is declared to be “of public interest”, a concrete expropriation proposal by the beneficiary of expropriation is prepared and then submitted to the relevant municipality where immovable assets subject to expropriation are located. A concrete expropriation proposal is prepared for each PAP that contains the amount of land involved, the assessment of fair value for any immovable property, the justification of the need for the specific expropriation, together with the confirmation that the scheme is included in the relevant regional and/or spatial plan. The concrete expropriation proposal also involves the beneficiary of expropriation arranging a Bank Guarantee with a Commercial Bank for the assessed fair value. This assessment is prepared by referring to the Cadaster Register, which provides details on the title holder, the immovable property, the type of land, and the area of the affected land. The concrete expropriation proposal also obliges the beneficiary of expropriation to submit a request to the Cadaster Office, Land Registry, or other public register, to prevent any transaction on the land to be expropriated.

Under the Law, expropriation must be completed and all PAPs are compensated in comparable land or in monetary terms, before the Building Permit (or Construction License) is issued to the contractor to mobilize and start the civil works. In the event that a PAP (s) disagrees with the offered compensation in either form, they can resort to the judicial process, and the beneficiary of expropriation can request the Ministry of Finance, on an exceptional basis, for the permission to access the said plot(s).

The Beneficiary of Expropriation is not required to prepare a social assessment (socioeconomic study) or a baseline census with regard to project affected persons.

10.2.3 JBIC Guidelines related to Land Acquisition

JBIC Guidelines have its own policies on land acquisition and involuntary resettlement and is summarized below.

I. Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.

II. When, population displacement is unavoidable, effective measures to minimize the impact and to compensate for losses should be taken.

III. People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.

IV. Compensation must be based on the full replacement cost[3] as much as possible.

V. Compensation and other kinds of assistance must be provided prior to displacement.

VI. For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public. It is desirable that the resettlement action plan include elements laid out in the World Bank Safeguard Policy, OP 4.12, Annex A.

VII. In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance. When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.

VIII. Appropriate participation by affected people must be promoted in the planning, implementation, and monitoring of resettlement action plans.

IX. Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.

Above principles are complemented by World Bank OP 4.12. Additional key principle based on World Bank OP 4.12 is as follows.

[3] Description of "replacement cost" is as follows.

Land	Agricultural land	The pre-project or pre-displacement, whichever is higher, market value of land of equal productive potential or use located in the vicinity of the affected land, plus the cost of preparing the land to levels similar to those of the affected land, plus the cost of any registration and transfer taxes.
	Land in Urban Areas	The pre-displacement market value of land of equal size and use, with similar or improved public infrastructure facilities and services and located in the vicinity of the affected land, plus the cost of any registration and transfer taxes.
Structure	Houses and other structure	The market cost of the materials to build a replacement structure with an area and quality similar or better than those of the affected structure, or to repair a partially affected structure, plus the cost of transporting building materials to the construction site, plus the cost of any labor and contractors' fees, plus the cost of any registration and transfer taxes.

X. Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferable at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advantage of such benefits.

XI. Eligibility of benefits include, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying.

XII. Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based.

XIII. Provide support for the transition period (between displacement and livelihood restoration).

XIV. Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc.

XV. For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared.

In addition to the above core principles on the JBIC, it also laid emphasis on a detailed resettlement policy inclusive of all the above points; project specific resettlement plan; institutional framework for implementation; monitoring and evaluation mechanism; time schedule for implementation; and, detailed financial plan etc.

10.2.4 Gaps between Serbian's Legal Framework and JBIC Guidelines

In general, the institutional framework for expropriation in Serbia is strong and broadly compatible with the World Bank OP 4.12, which is also JBIC's requirement. Table below shows the analysis of and means to fill the gaps.

Table 10.2 Summary of Gap Analysis on Resettlement Policy

No.	JBIC Guidelines	Laws of Serbia	Gaps	Resettlement policy for the Project
1.	Involuntary resettlement and loss of means of livelihood are to be avoided when feasible by exploring all viable alternatives.	Not clearly mentioned. However, when the Urban Plan of Belgrade was prepared, the location for WWTP was selected considering not to cause resettlement nor huge loss of livelihood means.	JICA GL's policy is not clearly mentioned in the laws of Serbia;	The location for WWTP was already carefully selected not to cause involuntary resettlement and loss of means of livelihood. The policy was already applied to the Project.
2.	When population displacement is unavoidable, effective measures to minimize impact and to compensate for losses should be taken.	Article 1, 3, 15 and 16 of the Law on Expropriation said properties including land, building and other building should be compensated by a fee which cannot be lower than the market.	No significant gap	Population displacement is not occurred by the Project. Effective measures to compensate for losses will be taken.
3.	People who must be resettled involuntarily and people whose means of livelihood will be hindered or lost must be sufficiently compensated and supported, so that they can improve or at least restore their standard of living, income opportunities and production levels to pre-project levels.	Article 15 and 16 of the Law on Expropriation provide the fair compensation for the lost assets. Article 51 stipulates that the compensation should be determined taking into account the financial and other personal and family conditions, if these circumstances are essential to its financial existence (household size, number of household members who are capable of earning, or who are employed, health conditions, monthly income of the household, etc.).	There is no clear description about the support to improve or restore their standard of living to pre-project level.	There is no resettlement by the Project. The land which will be expropriated by the Project is not used for agriculture and the land is not PAP's primary income source, so the income restoration program is not required.
4.	Compensation must be based on the full replacement cost as much as possible.	Article 41 of Law on Expropriation stipulates that the value of the facility is determined on the market value of these objects. Article 45 stipulates the compensation for vineyard or orchard that bears fruits considering its age and fertility and investment made. Article 46 describes about compensation for nursery garden, Article 47 for mature or nearly mature forest, and Article 52 for crops.	Serbian laws stipulate the compensation not lower than the current market price, and the other assets considering the value of the installations and time needed to reproduce them. The compensation under the Serbian law can be almost comparable to the replacement	Compensation must be based on the full replacement cost as much as possible.

No.	JBIC Guidelines	Laws of Serbia	Gaps	Resettlement policy for the Project
			cost.	
5.	Compensation and other kinds of assistance must be provided prior to displacement.	Article 16 of Law on Expropriation said that the compensation should be provided before the demolition of the expropriated property.	No gap	There is no displacement. Compensation must be provided prior to demolition of the expropriated property.
6.	For projects that entail large-scale involuntary resettlement, resettlement action plans must be prepared and made available to the public.	Article 29 of Law on Expropriation said that to establish the decision of expropriation for public interest, the proposal which contains information on the project, type of structure, land to be expropriated, expropriated properties, etc. should be prepared.	Some contents which should be included in the resettlement action plan are not included in the documents required by Serbian laws.	Large scale involuntary resettlement will not occur due to the Project so resettlement action plan is not required.
7.	In preparing a resettlement action plan, consultations must be held with the affected people and their communities based on sufficient information made available to them in advance.	Article 41, 42, 43 and 50 of the Law on Planning and Construction stipulated that every plan, General Plan of the city and Detailed plan for certain part of the city, has to be opened to the public including the affected people and suggestions and remarks have to be incorporated to the plan. When the decision on public interest was issued, the public debates to explain the project, compensation policy and entitlement were organized. When the decision on expropriation will be issued, more detail public debates will be organized.	During the establishment of the expropriation for public interest, the consultations with the affected people are not required.	Resettlement action plan is not required for the Project. As there is no significant gap between Serbian legislation and JBIC Guidelines, the past public debates were considered in accordance with JBIC Guidelines. When the budget is secured, the detail public debates will be organized by LDA.
8.	When consultations are held, explanations must be given in a form, manner, and language that are understandable to the affected people.	Article 16 of the Law on General Legal Procedures stipulates the usage of Serbian language, language of minority and interpreter, if necessary.	No gap	Serbian language will be used when the consultation will be held. If minority is included, minority language or interpreter will be prepared.
9.	Appropriate participation of affected people must be promoted in planning, implementation, and monitoring of resettlement action plans.	Article 56 of Law on Expropriation stipulates that after the final decision on expropriation, the public hearing/discussion shall be held for mutually agreement of the compensation amount. All PAPs by the Project can be involved in the planning stage of the Project (Article 50 & 52 of Law on Planning and Construction).	During preparation of expropriation proposal, PAPs are not involved.	PAPs will be involved as much as possible in implementation and monitoring of LARAP.

No.	JBIC Guidelines	Laws of Serbia	Gaps	Resettlement policy for the Project
10.	Appropriate and accessible grievance mechanisms must be established for the affected people and their communities.	Complaint/grievance is established by the Article 213 to 238 of Law on General Administrative Procedures. Landowner may file an appeal against the Decision on expropriation, which is forwarded to the Ministry of Finance and Economy, and if the landowner is not satisfied with the decision of the Ministry of Finance and Economy, the next appeal level is complaint to the Administrative Court. Article 20 of Law on Expropriation stipulates that an appeal against the Decision on public interest reached by Serbian Government can be submitted to the Administrative Court.. Article 29 stipulates that the appeals against the decision on expropriation are solved by the ministry responsible for finance and economy. If the land owner has the objections about the value of the properties except land, he can employ another evaluator.	Serbia has its own grievance mechanisms There is no significant gap.	Present grievance mechanism can be available for the Project.
11.	Affected people are to be identified and recorded as early as possible in order to establish their eligibility through an initial baseline survey (including population census that serves as an eligibility cut-off date, asset inventory, and socioeconomic survey), preferable at the project identification stage, to prevent a subsequent influx of encroachers of others who wish to take advance of such benefits. (WB OP 4.12 Para.6)	After adoption of detail urban plan, separation of parcels is performed in cadaster in accordance to the plan, after that preparation of geodetic study on the basis which are all property relations are determined (during this, the experts are investigating the terrain and survey the property and the persons using the property) and by listing the property register evidence on the persons and objects are determined on the site for the future construction. Article 50 of Law on Expropriation stipulates that the investments made after the date when proposal for expropriation is notified to the owner in writing form are not compensated.	The law does not clearly mention about the baseline survey, however, such survey is conducted by LDA when LDA expropriates the private land. So no significance gap.	During preparation of LARAP in the Project, census survey and socio-economic survey were implemented.

No.	JBIC Guidelines	Laws of Serbia	Gaps	Resettlement policy for the Project
12.	Eligibility of benefits includes, the PAPs who have formal legal rights to land (including customary and traditional land rights recognized under law), the PAPs who don't have formal legal rights to land at the time of census but have a claim to such land or assets and the PAPs who have no recognizable legal right to the land they are occupying. (WB OP 4.12 Para.14)	Art 15 & 16 of Law on Expropriation describe the legal owner of property. Art 43a describes the user of the state or public ownership land. Art 53, 54 & 55 describe the easement and lease. For informal settlement, Law on Social Welfare and Ensuring Social Security of Citizens stipulates to provide assistance for employment and accommodation.	No significant gap.	In the proposed expropriated land of the Project, PAPs are land owners with formal legal rights, inheritance of the land where the registered land owner passed away (and land users authorized by the land owner to cultivate it). Eligibility of those PAPs should be covered.
13.	Preference should be given to land-based resettlement strategies for displaced persons whose livelihoods are land-based. (WB OP 4.12 Para.11)	Article 15 of Law on Expropriation said that for expropriated arable land from the person whom land is primary source of income, compensation is determined giving the title to other appropriate land of the same class and bioculture or corresponding values in the same area or in the vicinity.	No gap.	As the appropriate land of the same class cannot be available in the surrounding area and the land is not the primary source of income, the compensation will be paid by cash.
14.	Provide support for the transition period (between displacement and livelihood restoration). (WB OP 4.12 Para.6)	No description.	No description about the support for the transition period.	There is no resettlement in the Project so that the support for the transition period is not required.
15.	Particular attention must be paid to the needs of the vulnerable groups among those displaced, especially those below the poverty line, landless, elderly, women and children, ethnic minorities etc. (WB OP 4.12 Para.8)	Law on Social Welfare and Ensuring Social Security of Citizens stipulates that the vulnerable groups can be assisted to improve their living standards (health, education, employment, etc.). Art 16 of the Law on Expropriation, during the process of apartment allocation, the consideration is taken for elderly people and the location of the apartment in the building.	No significant gap.	There is no displacement by the Project. The vulnerable groups are not included in the Project area.

No.	JBIC Guidelines	Laws of Serbia	Gaps	Resettlement policy for the Project
16.	For projects that entail land acquisition or involuntary resettlement of fewer than 200 people, abbreviated resettlement plan is to be prepared. (WB OP 4.12 Para.25)	Laws of Serbia do not require the "resettlement action plan". Art 29 of Law on Expropriation said that to establish the expropriation for public interest, the proposal which contains information on the project, type of structure, land, expropriated properties, etc. should be prepared.	Some contents which should be included in the abbreviated resettlement action plan are not included in the documents required by Serbian laws.	The Land Acquisition and Resettlement Action Plan (LARAP) is prepared in the Project.

10.2.5 Policy of Land Acquisition and Resettlement of the Project

(1) The relevant Republic of Serbia laws and JICA Policy (same as WB OP 4.12) will be followed. Where there are gaps between the Serbian legal framework for resettlement and JICA Guidelines mutually agreeable approaches will be identified consistent with Serbian legislation and JICA Guidelines.
(2) Project affected peoples (PAPs) are registered landowners or their legal successors if the registered land owner is deceased, and persons authorized by the land owner to cultivate the land.
(3) Compensation for temporally or permanently acquired land will be paid to the registered landowners or legal successors if the landowner is deceased. Compensation for the assets eventually could be found on the acquired land will be paid to the PAPs.
(4) All PAPs will be eligible for compensation without any discrimination.
(5) If during the partial expropriation of a property, determined that owner does not have commercial interest to use the remaining property, or if because of the expropriation, the rest of the property is impossible to use or because of expropriation his financial existence is significantly impeded, at his request, the rest of the property will be expropriated.
(6) The Land Acquisition and Resettlement Plan (LARAP) will be designed in accordance with Serbia’s Law on Expropriation and JBIC Guidelines.
(7) 1^{st} cut-off date is the date of decision on public interest which determines the land plot to be expropriated. After this date, any transaction on identified plot is prohibited. 2^{nd} cut-off date is the date of decision on expropriation, by which landowner is informed his land has been expropriated for the public interest and eligibility for compensation. Once the agreement is signed by both parties, 3^{rd} cut-off date is the data compensation is paid to PAPs and ownership is to be transferred to the City of Belgrade. The 2^{nd} and 3^{rd} cut-off data are individually set for each land plot.
(8) Principle for compensation is market price for the land and assets that could possibly be found on the acquired land. The relevant date to determine the compensation is the date of decision on expropriation (2^{nd} cut-off date determined under item (7)).

10.3 Baseline Environmental and Social Data

The detail information of baseline environmental and social data is described in the Preliminary EIA reports and LARAP in Appendix-II. Here the summary of the baseline data is shown in the following sections.

10.3.1 Geography and Geology

See Section 3.2.1.

10.3.2 Climate Conditions

See Section 3.2.1.

10.3.3 Air Quality

The quality of ambient air originating from motor vehicles exhaust gasses in 16 most frequently used traffic arteries in Belgrade is measured by City of Belgrade according to the Regulation on Air Monitoring Conditions and Air Quality Requirement (2010). In addition, air quality originating from stationary sources (industrial facilities, heating stations, small trade facilities) is monitored at 27 measuring spots.

Indicative sampling of air pollutants is during a 24-hour period once a week, distributed evenly throughout the year. The following air pollution parameters are measured: CO, NOX, Pb, volatile organic compounds (VOCs), SO2, benzene, xylene and toluene. The sampling locations are shown in the map below. Sampling locations marked in the red on the map below are of interest as they are positioned near the planned Project works. These locations are:

1. "Mostar", very near the Mostar PS and the beginning of Interceptor No. 10;
2. "Cvijiceva" (Cvijićeva in Serbian), at the intersections of Despot Stefan Boulevard and Cvijiceva Streets, right by the area where Interceptors Nos. 3, 4 and 10 will meet;
3. "Pancevo Bridge" (Pančevački most in Serbian), close to Interceptor No. 6.

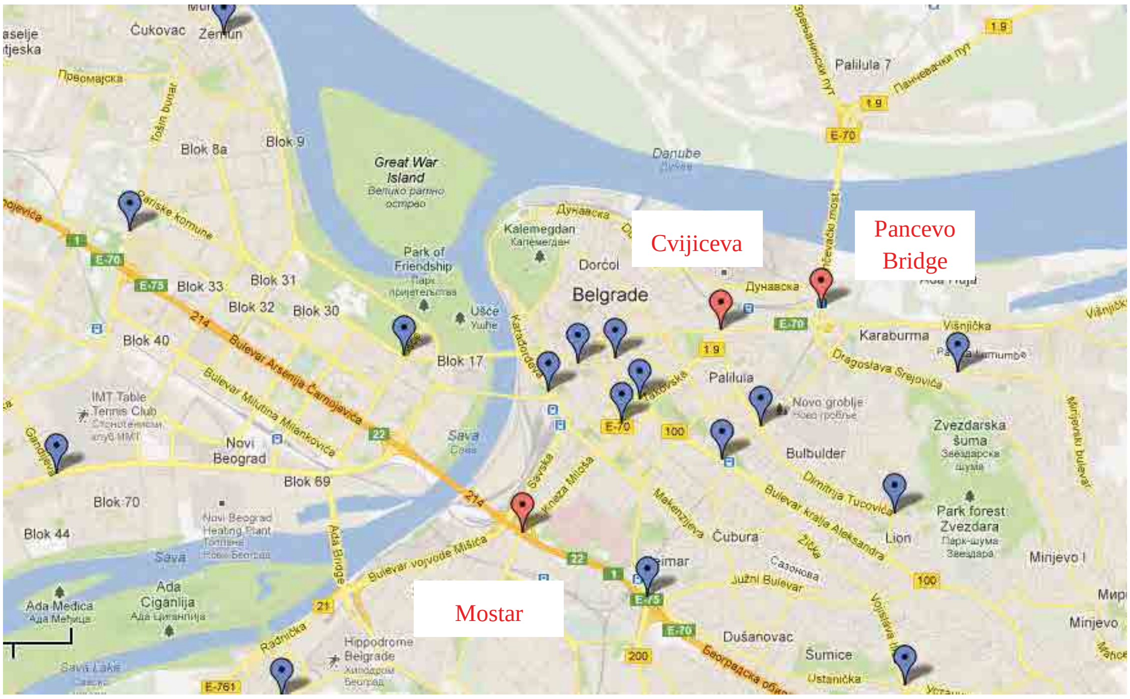


Figure 10.2 Location of Monitoring Stations of Air

Table 10.3 Average Hourly Measurement Results for the Months of 2012

	Pollutant (LV_h=hourly limit value)											
	CO LV_h=10 mg/m^3			NO_X LV_h=150 µg/m^3			Pb LV_h=1 µg/m^3			SO_2 LV_h=350 µg/m^3		
Location / Month	Cvijiceva	Mostar	Pancevo Bridge	Cvijiceva	Mostar	Pancevo Bridge	Cvijiceva	Mostar	Pancevo Bridge	Cvijiceva	Mostar	Pancevo Bridge
Jan.	6.4	3.5	3.5	96	109	116	0.4	**3**	**1.7**	68	35	30
Feb.	4.1	2.9	3.0	**130**	118	94	0.4	0.3	0.3	43	25	20
Mar.	9.5	5.6	5.0	124	**151**	140	0.8	**1.4**	**2**	145	46	45
Apr.	8.6	6.9	4.1	**260**	**151**	**154**	0.5	0.3	0.3	74	49	29
May	8.2	5.1	3.9	136	**190**	**154**	0.4	0.4	0.4	54	33	28
Jun.	4.2	3.6	4.2	**211**	**164**	136	0.4	0.4	0.5	56	35	39
Jul.	**10.2**	5.1	6.0	**168**	**176**	**170**	0.6	0.5	0.5	88	33	35
Aug.	4.8	5.5	7.0	**169**	**187**	**169**	0.3	0.3	0.3	41	35	49
Sep.	4.1	3.1	5.0	**171**	**157**	**173**	0.3	0.3	0.4	60	41	79
Oct.	6.37	4.7	7.94	**218**	**211**	**214**	0.3	0.3	0.4	46	35	69
Nov.	4.48	3.66	4.39	**188**	**152**	**161**	0.3	0.3	0.3	36	29	40
Dec.	4.98	4.39	3.85	127	121	145	0.4	0.4	0.3	40	33	29

Note: Bolded values indicate exceedance of the permitted hourly limit values

Limit values are stipulated by Regulation on Air Monitoring Conditions and Air Quality Requirement (2010)

10.3.4 Ambient Noise

The Belgrade Institute of Public Health monitors noise levels in Belgrade and reports the finding to the Secretarial for Environmental Protection. Noise measurements are conducted for a 24-hour period twice a year, in the spring and in the autumn, at 35 measuring points. The measuring locations are chosen as representative of different urban zones of the city and along major crossroads. The measurements are conducted according to the:

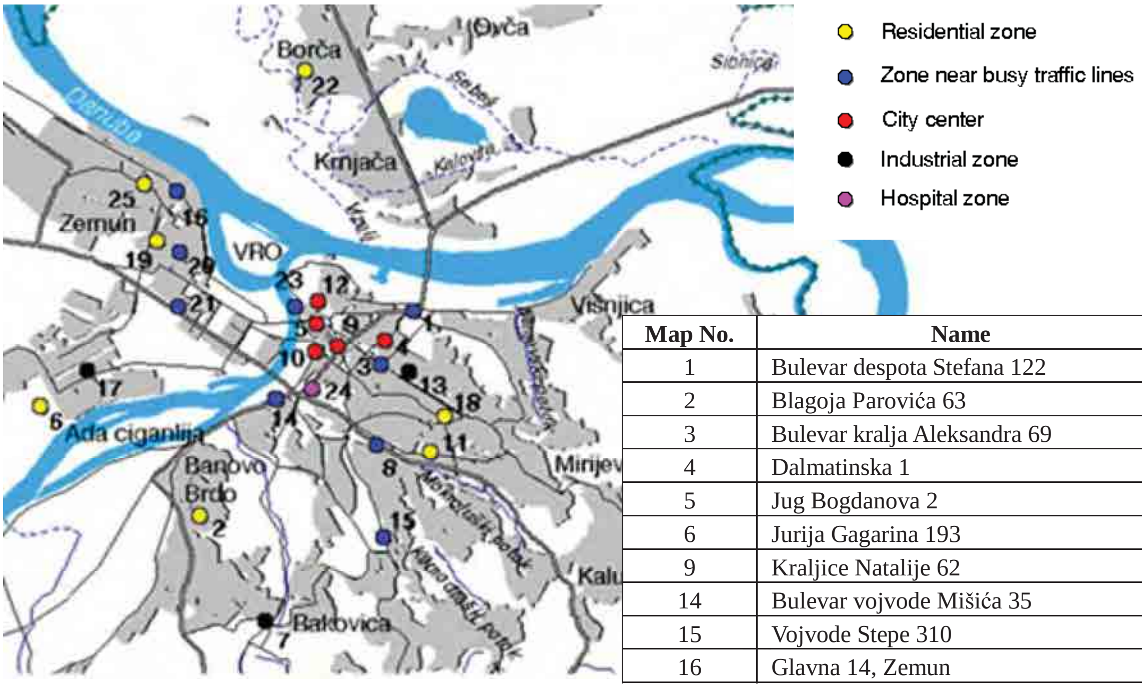
- Law on Protection against Noise in the Environment (2009 & 2010);
- Regulation of Noise Indicators, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Noise in the Environment (2010);
- Rulebook on Noise Measuring Methods, the Content and Scope of the Noise Measurement Report (2010).

The Regulation of Noise Indicators, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Environmental Noise (2010) stipulates the limit values for outdoor noise levels, as shown in the table below.

Table 10.4 Limited Values for Noise

Zone	Land Use	Noise level in dB (A)	
		Daytime	Nighttime 10 PM – 6 AM
1	Areas for recreation, hospital zones and rehabilitation, cultural and historical sites, large parks	50	40
2	Tourist areas, camps and school zones	50	45
3	Purely residential areas	55	45
4	Business-residential areas, commercial-residential areas and playgrounds	60	50
5	City center, commercial, trade, administrative areas with apartments, areas along highways and city roads	65	55
6	Industrial, warehouse and service areas and transportation terminals without residential buildings	At the border of this zone the noise level must not exceed the allowable levels of the boundary zone	

Regulation of Noise Indicators, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Environmental Noise (2010)



Map No.	Name
1	Bulevar despota Stefana 122
2	Blagoja Parovića 63
3	Bulevar kralja Aleksandra 69
4	Dalmatinska 1
5	Jug Bogdanova 2
6	Jurija Gagarina 193
9	Kraljice Natalije 62
14	Bulevar vojvode Mišića 35
15	Vojvode Stepe 310
16	Glavna 14, Zemun

Figure 10.3 Measurement Locations of Noise

Table 10.5 Level of Communal Noise, 2010

Measuring point	Average		Measuring point	Average	
	Day	Night		Day	Night
1. Bulevar despota Stefana 122	82	76	6. Jurija Gagarina 193	60	55
2. Blagoja Parovića 63	66	62	9. Kraljice Natalije 62	66	64
3. Bulevar kralja Aleksandra 69	69	66	14. Bulevar vojvode Mišića 35	75	71
4. Dalmatinska 1	65	59	15. Vojvode Stepe 310	67	65
5. Jug Bogdanova 2	72	61	16. Glavna 14, Zemun	73	68

Note: permitted level: day 65 dB (A), night 40 dB (A)
Source: Belgrade in Figures, 2012

10.3.5 River Water Quality

See Section 3.2.2.

10.3.6 Population

See Section 3.2.1.

10.3.7 Land Use

See Section 3.3.1.

10.3.8 Cultural Heritage

The cultural heritage within City of Belgrade is shown in the figure below.

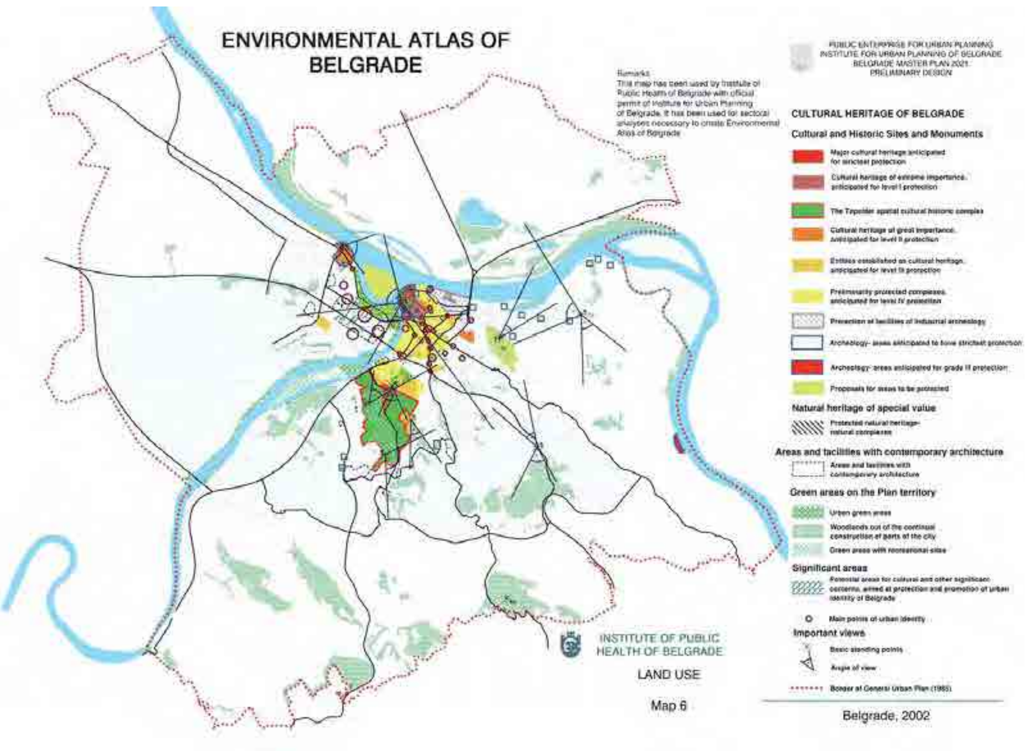


Figure 10.4 Map of Cultural Heritage

The part of interceptor No. 2 will be installed under the Bulevar Vojvode Bojovića, which passes along Belgrade Fortress Area named Kalemegdan. The Belgrade Fortress Area falls in the archeology areas anticipated for grade II protection. When the construction near the protected site is planned, the conditions for construction should be requested to Belgrade City Institute for the Protection of Cultural Monuments, and they provide the information and conditions that should be followed to construct the objects. The request was made for the construction of interceptor No. 2 and the route was already approved by the Institute and the condition that the architect shall attend at the time of open-cut the road and supervise the construction is followed by the conditions and the historical objects.

The existing and proposed Ušće pumping stations are located in the urban green areas and within the inner protection zone of the Belgrade wellhead. To construct the pumping station within this zone, during the review period by the Revision committee, the requests for the condition of the construction will be made to the related authorities. The construction should be followed by the provided conditions.

There is no cultural heritage near around the proposed WWTP site.

10.4 Preliminary EIA Study

The preliminary EIA study was conducted to prepare the preliminary EIA report (PEIA report) which fulfills the requirements of Serbian legislation and JBIC Guidelines. The PEIA reports are prepared for (i) WWTP and (ii) pumping stations and interceptors separately as the level of the review and approval for the EIA reports for each facility is different. The EIA report of WWTP shall be submitted to the central government, and EIA report of pumping stations and interceptors might be submitted to the City of Belgrade upon the decision on the necessity of EIA by City of Belgrade. The PEIA reports are attached as Appendix-II and the summary of study results are described in the following section.

10.4.1 Alternative Studies

The environmental and social aspects are considered during the identification of optimum plan (see Chapter 5.2 and 6.2).

10.4.2 Scoping, Evaluation of the Impacts and Mitigation Measures

Table 10.6 Scoping, Evaluation and Mitigation Measures

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
Social environment	1	Involuntary resettlement and land acquisition	A-	D	A-	D	Land acquisition is required for WWTP site only. The area for Ušće PS belongs to the City of Belgrade and Mostar PS is rehabilitated within the existing boundary which belongs to BVK. There is no involuntary resettlement as there are no residents within the area and the land is not the primary source of income. 75 ha of land need to be acquired for WWTP and 280 landowners are identified. Among them 251 landowners were surveyed by census survey and 1,250 project affected peoples are identified.	To mitigate the impacts by land acquisition, the gaps between Serbian legislation and JBIC Guidelines are analyzed and the policy of land acquisition for the Project is set. The detail is described in the Chapter 10.5 and LARAP in the Appendix-II.	LDA PIU which will be established at the beginning of the Project
	2	Local economies, such as employment, livelihood, etc.	B+	D	B+	D	Six owners (2.3 % of the landowners) will lose more than 50 % of land they own by the land acquisition. Among six, three do not earn any income from the land, two will lose some part of the income but the income from the land is not primary source of their income. The negative impact on economy by land acquisition is negligible and measures to restore livelihood is not required. Construction works provide positive impacts on local economy such as increase of employment and commercial services. The proposed WWTP land is not used for agriculture and impacts on livelihood is not expected.	-	-
	3	Land use and utilization of local resources	B-	D	B-	D	As the interceptor will be installed under the road, no impact is expected on land use and utilization of local resources. The construction of WWTP may change the land use and cause loss of properties such as crops and	The mitigation measures are described in the Chapter 10.5 and LARAP in the Appendix-II.	LDA PIU which will be established at the beginning

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
							forest.		of the Project
	4	Social institutions	D	D	D	D	The impact on social institution and local decision-making institutions is not expected.	-	-
	5	Existing social infrastructures and services	B-	D	B-	D	Some parts of the interceptors will be constructed by open cut method and the traffic disturbance will be expected.	The traffic authorities should be notified of the planned works in a timely manner so that alternative traffic routes can be formed and the public alerted. Traffic accidents can be avoided by collaborating with the traffic police and posting warning signs and directions to alternative routes.	LDA Traffic policy Department of Road in City of Belgrade
	6	The poor, indigenous & ethnic people, gender and children's right	C	D	D	D	No indigenous and ethnic people exist in and around the project site. Seven (7) % of the respondents answered their socio-economic situation is as poor and most of them are over 60 years old and does not earn any income from the land to be acquired.	-	-
	7	Misdistribution of benefits and damages	D	D	D	D	The construction and operation of sewerage system may not cause any misdistribution of benefits and damages.	-	-
	8	Cultural heritage	B-	D	B-	D	The interceptor No. 2 will be installed near around the Belgrade Fortress which is the important cultural heritage. The conditions for construction was once provided by the Belgrade City Institute for Protection of Cultural Monuments but need to be obtained again as it is expired.	The request should be made to obtain the conditions to construct the interceptor No. 2 by the Belgrade City Institute for Protection of Cultural Monuments. The architect should be present during construction.	LDA
	9	Local conflicts of interest	D	D	D	D	The construction and operation of sewerage facilities may not cause the local conflicts of interest.	-	-
	10	Water usage or	C-	B+	D	B+	The construction of sewerage system may not cause		

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
		water rights and rights of common					any impact on water usage, water rights and rights of common. The river water quality improvement by the operation of sewerage system may provide positive impacts on water usage of river in downstream.	-	-
	11	Hazards (Risk) infectious diseases	B-	D	B-	D	Influx of construction worker may affect the inhabitants during construction.	The plan to reduce the risk of infectious diseases should be prepared by the contract based on the Law on Occupational Health and Safety.	Contractor LDA
	12	Accidents	B-	D	B-	D	The construction may cause the accidents. Especially the construction of interceptor No. 2, 3 and 4 are open-cut method and traffic disturbance may raise the risk of accidents.	The plan to reduce the accidents during construction should be prepared based on the Law on Occupational Safety and regulation on Occupational Safety for Construction Works. The general public safety should be secured by the measures mentioned in the 5. Existing social infrastructures and services	Contractor LDA Traffic policy Department of Road in City of Belgrade
Natural Environment	13	Topography and geographical features	D	D	D	D	The scale of facility is not large and no impact is expected.	-	-
	14	Soil erosion	D	D	B-	D	The proposed WWTP area was flooded area frequently. To construct the interceptor No. 9, partially the bank stabilization has already been conducted. The bank stabilization is required for the other parts to protect WWTP from the bank erosion due to the flood.	The bank stabilization is already considered in the F/S. The contractor should follow the design which will be finalized in the detail design stage.	Design consultant LDA Contractor
	15	Groundwater	C-	D	D	D	Ušće PS is in the inner protection zone of the Belgrade wellhead, RB-2 well is located at the distance of 550 m RB-4 well is 750 m. The upper level of the aquifer is 25 m below the ground and the deepest point of Ušće PS is 10 m so	-	-

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
							that the facility will not cause any disturbance on the flow of the groundwater but on the water quality. Groundwater is found at 0.5 - 2.0 m below the terrain surface, and it is under dominant influence of Danube River water level. Due to significant discharge of the Danube River, there are no reasonable potential impacts on flow regimes by the WWTP.		
	16	Hydrological situation	C-	C-	D	D	The flow of the Danube River is huge and the current discharged wastewater into the river and future effluent from the WWTP into the river do not provide the significant impacts on the hydrological situation.	-	-
	17	Coastal zone	D	D	D	D	No coastal zone exists.		
	18	Protected area	B-	D	B-	D	Ušće PS is in the inner protection zone of the Belgrade wellhead and also in the urban green area.	During the review period by the Revision committee, the requests for the condition of the construction will be made to the Ministry of Agriculture, Forestry and Water Management. The construction should be followed by the provided conditions.	LDA BVK Revision Committee Ministry of Agriculture, Forestry and Water Management
	19	Flora, fauna and biodiversity	C-	C-	D	D	The protected plants or species are not found in and around the Project area. The profile of the Marine Neogene Sandbank is away from the location where Interceptor No. 1 will cross the Sava River and away from the Interceptor No. 2 route, and therefore will not be influenced by the planned works. Interceptor No. 1 will be constructed below the Sava River bed and the	-	-

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
							works will not influence the Great War Island protected zones.		
	20	Meteorology	D	D	D	D	No impact is expected as the scale of facility is not large.	-	-
	21	Landscape	B-	C-	D	D	Visually unaesthetic conditions may be expected due to cluttering of waste, spoil and dug up roads and pavements during construction. The construction of WWTP may disturb the landscape.	Visually unaesthetic conditions may be expected due to cluttering of waste, spoil and dug up roads and pavements during construction but the impacts are negligible. The trees will be planted in surrounding of WWTP so that the impact by WWTP is also negligible.	Contractor
Pollution	22	Air pollution	B-	D	B-	D	The operation of construction machines and other equipment will cause dust to rise and spread throughout the surrounding area during construction. The impact is temporary.	It can be minimized with the application of best practice construction methods (modern technologies) and site management, as should be defined in the Main Design Project Report and in the Project EMP. Construction vehicles, machinery and equipment should be in good working condition and well maintained. Dust emissions from piles of soil or any other material during earthwork, excavation and transportation should be controlled by wetting surfaces, using temporary wind breaks and covering truck loads.	Contractor PIU
	23	Water pollution	B-	A+	B-	A+ B-	Ušće PS is in the inner protection zone of the Belgrade wellhead, RB-2 well is located at the distance of 550 m RB-4 well is 750 m. The upper level of the aquifer is 25 m below the ground and the deepest point of Ušće PS is 10 m so that the facility will not cause any pollution on the groundwater quality, if it is operated property.	An appropriate monitoring program has to be established that includes monitoring of groundwater quality at monitoring piezometers. Monitoring piezometers should be adequately located in order to provide forehand information for mitigation measures.	Contractor BVK

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
							If some source of pollution is present in this area, there is a real risk that the contamination would reach the wells. The collection and treatment of wastewater will improve the river water quality where the wastewater is currently discharged directly.	The effluent will be discharged into the Danube River and the effluent quality will be met by the effluent standards set by the Serbian legislation. Thus the impacts on Danube River is not expected. In addition, the effluent quality shall be monitored daily.	
	24	Soil pollution	B-	B-	B-	B-	Due to excavation and earthwork, soil erosion, loss of top soil and silting might be expected. The compaction of soil due to vehicle movement, and ground contamination from the spillage of materials such as vehicle fuel, sewage sludge, chemicals might be expected. The soil might be contaminated if the sludge is not properly treated and disposed.	A silt fence and/or staked hay bales can be installed at the limit of work before construction begins to prevent sediment and debris being transported to down gradient areas. The silt fence/hay bale barrier should be inspected weekly and after all larger storm events, and repaired as needed. Sludge might be reused for agriculture or disposed at the disposal site, but if the sludge quality does not meet the standards, the sludge should be disposed at the hazardous waste disposal site to prevent the soil contamination. The sludge treatment and storage facilities should be provided the prevention measures for soil contamination and the details will be considered during the detail design.	Design consultant Contractor
	25	Waste	B-	A-	B-	A-	The spoil will be generated during installation of pipelines and construction of WWTP. The sludge will be generated from WWTP during operation.	The sludge can be utilized on agriculture if the quality meets the certain standards stipulated by the law. Waste Management Plan is obligation as per Waste Management Law in Serbia.	Contractor BVK

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
								The plan should be prepared by the contractor during the construction and by BVK during operation of the WWTP.	
	26	Noise and vibrations	B-	B-	B-	B-	Construction machines will cause noise and vibration during construction. Additionally, the operation of sewerage system such as pump stations with generators will cause noise and vibration during operation.	Temporary noise pollution due to construction works should be controlled by proper maintenance of equipment and vehicles, and tuning of engines and mufflers to keep the ELV set by the regulations. During operation, the pump stations will generate noise, but this should be confined within the buildings that house the pumps. Noise problems should be reduced to normally acceptable levels by incorporating low-noise equipment in the design and/or locating such mechanical equipment in properly acoustically lined buildings or enclosures. The necessary facility should be considered in the detail design.	Design consultant Contractor LDA BVK
	27	Ground subsidence	C-	D	B-	D	The proposed location of WWTP is often affected by the flood.	The WWTP area has a terrain elevation between 71.5 and 73 m a.s.l. The Danube River water level duration curve between 1991 and 2002, reveals that 25% of time the water level is above 71.5 m a.s.l. Therefore, significant filling will be required before construction.	Design consultant
	28	Offensive odors	D	B-	D	B-	Odors emitted at wastewater treatment works may be potential nuisance to the general public. Inlet works, grit channels, screening and grit handling,	The process equipment for these operations is usually housed in buildings that are ventilated and sometimes have	Design consultant BVK

Area	No.	Item	Evaluation of Scoping		Evaluation after study		Reason	Mitigation Measures	Responsible organization
			P/C	O	P/C	O			
							and sludge holding and dewatering units are the main sources of odor at the wastewater treatment facility.	exhaust air odor treatment. In many instances, odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures (incorporated into the Project Design Reports). When kept clean, sludge transfer systems, such as conveyors, screw pumps, and conduits, will not generate odors	
	29	Bottom sediment	D	B+	D	B+	The quality of bottom sediment will be improved by collection and treatment of wastewater which are currently discharged directly into the Sava and Danube Rivers.	-	-
	30	Global warming	D	D	D	D	No impact is expected as the scale of facility is not large.	-	-

P: Planning, C: Construction, O: Operation
A+/-: Significant positive/negative impact is expected.
B+/-: Positive/Negative impact is expected to some extent.
C+/-: Extent of positive/negative impact is unknown (a further examination is needed, and the impact could be clarified as the study progresses).
D: No impact is expected.

10.4.3 Monitoring Plan

The proper construction and operation of the Project facilities will not contribute to environmental pollution. All impacts can be avoided with the application of best practice construction methods (modern technologies) and site management, as defined in the PEIA reports and should be defined in the Main Design Project Report and in the Project EMP.

The monitoring plan is presented in the tables below. The associated costs covered by BVK are included in the cost estimation as operation and maintenance cost and other costs covered by the contractor shall be determined at the Preliminary Design Phase and included in the Contract. Monitoring should be conducted by relevant accredited expert institutions. The results of environmental monitoring must be submitted to the Belgrade Secretariat for Environmental Protection.

Table 10.7 Monitoring Plan

Environmental Item	Standard	Item / standards	Location	Frequency	Responsibility
Construction Phase					
Noise	Regulation of Noise Indicators, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Noise in the Environment (2010)	Daytime 65 dB (A) Nighttime 55 dB (A)	Near construction site	Once/month	Contractor
Vibrations	DIN 4150-3: Effects of vibration on structures (there is no regulation in Serbia)	10-50 Hz: 20-40 mm/s	Structures sUšćeptible to ground-borne vibration in areas above tunnel works where earth layer is shallow	Daily	Contractor
Sava River Water Quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012)	pH (6.5-8.5), SS (25 mg/l), DO (7 mg O_2/l), BOD5 (4-5 mg O_2/l), COD (15 mg O_2/l), TOC (5-6 mg/l), T-N (2 mg N/l), and others	Two locations: upstream and downstream from Ušće PS	During construction of Ušće PS and Interceptor No. 1, in case of accidental pollution	Contractor
Danube River arm (Dunavac) Water Quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012)	pH (6.5-8.5), SS (25 mg/l), DO (7 mg O_2/l), BOD5 (4-5 mg O_2/l), COD (15 mg O_2/l), TOC (5-6 mg/l), T-N (2 mg N/l), and others	Danube river arm (Dunavac), right downstream of the construction site	Weekly	Contractor
Groundwater Quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012) Regulation on Drinking Water Quality (98 & 99)	pH, SS, BOD5, COD, DO, T-N, T-P, MPN of Coliform and others	Piezometers located on streamlines from Ušće PS to the RB2 and RB4 wells, around the construction site	Twice/month	Contractor
Cultural Heritage	As set in the Decision on Technical Protection Measures for the Belgrade Fortress (to be obtained during Project Preliminary Design)	-	Along the Interceptor No. 2 route	As set in the Decision	Contractor
Operation Phase					

Environmental Item	Standard	Item / standards	Location	Frequency	Responsibility
Groundwater Quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012) Regulation on Drinking Water Quality (98 & 99)	pH, SS, BOD/COD, DO, T-N, T-P, MPN of Coliform and others	Piezometers located on streamlines from Ušće PS to the RB2 and RB4 wells, and around the construction site.	Once/month, for at least 2 years	BVK
Danube River arm (Dunavac) Water Quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012)	pH (6.5-8.5), SS (25 mg/l), DO (7 mg O_2/l), BOD5 (4-5 mg O_2/l), COD (15 mg O_2/l), TOC (5-6 mg/l), T-N (2 mg N/l), and others	Danube river arm (Dunavac), right downstream of the construction site	Once / Month	BVK
Noise and vibration	Regulation of Noise Indicators, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Noise in the Environment (2010) DIN 4150-3: Effects of vibration on structures (there is no regulation in Serbia)	Daytime 65 dB (A) Nighttime 55 dB (A) 10-50 Hz: 20-40 mm/s	WWTP Ušće and Mostar PS	Once / Month	BVK
WWTP process control parameters	Operation monitoring procedures		WWTP process train and sludge management	As set in the design reports	BVK
Flow and wastewater quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012)	BOD (25 mg/l), COD (125 mg/l), TSS (35 mg/l), T-P (1 mg/l), T-N (10 mg/l)	Inflow and outflow of the WWTP	Daily	BVK
Sludge quality	Regulation on the Limit Values of Pollutants in Surface Waters and Groundwater and Sediments and the Deadlines for Compliance with the Limit Values (2012)	Pb (0.1 mg/l)、Cd (10-100 mg/l)、Ni (1-2.5 mg/l)、Hg (0.1-5 mg/l)、Cu (1 mg/l)、Zn (0.08-10 mg/l) and others	WWTP	Once / Month	BVK

10.4.4 Stakeholder Meetings

(1) First Meeting

The first stakeholder meeting was held on 4 October 2012 using the forum of the workshop. Thirty-two (32) participants attended the workshop.

- Ministries concerned – 2
- City of Belgrade – 4
- LDA – 5
- BVK – 8
- Others (water company and university) – 2
- JICA and JICA Study Team – 11

In the workshop, the findings during the survey were presented, project outline, the results of the alternative studies, and the further activities which will be implemented in the feasibility study including the environmental and social considerations were explained to the participants.

(2) Second Meeting

The second stakeholder meeting was held on 7 March 2013 at the workshop. The results of F/S (facility planning, results of preliminary EIA and entitlement and compensation policy related to land acquisition) were presented. Around fifty persons participated in this meeting. As the representative of the citizens, the professors of universities and nature protection institute also participated.

- Ministries concerned – 2
- City of Belgrade – 7
- LDA – 5
- BVK – 12
- Knowledgeable person (professors, nature protection institute) –10
- JICA and JICA Study Team – 10

The participant gave the comments that all aspects were analyzed during the study and same approach should be taken in the future project in Serbia.

10.4.5 Check List

The check list for wastewater treatment is filled in the table below.

Table 10.8 Check List

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
1 Permits and Explanation	(1) EIA and Environmental Permits	(a) Have EIA reports been already prepared in official process? (b) Have EIA reports been approved by authorities of the host country's government? (c) Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied? (d) In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?	(a) N (b) - (c) - (d) -	(a) According to the Serbian legislation, the EIA report is not submitted during feasibility study. The scope of EIA study will be requested to Ministry of Energy, Development and Environmental Protection for WWTP and City of Belgrade for PS and interceptors after the feasibility study and preliminary design (i.e. JICA Survey) is completed. EIA report should be prepared after the approval on feasibility study and preliminary design and before detail design. In the JICA Survey, the preliminary EIA (PEIA) reports were prepared and they can be utilized for EIA study if the design is not significantly changed and submission time is not too far. The approval of EIA report should be obtained before completion of detail design.
	(2) Explanation to the Local Stakeholders	(a) Have contents of the project and the potential impacts been adequately explained to the Local stakeholders based on appropriate procedures, including information disclosure? Is understanding obtained from the Local stakeholders? (b) Have the comment from the stakeholders (such as local residents) been reflected to the project design?	(a) Y (b) -	(a) The workshop to explain the project, alternatives, potential impacts and mitigation measures will be organized in the 1st week of March 2013. (b) After workshop is held, the comments will be incorporated to the project design.
	(3) Examination of Alternatives	(a) Have alternative plans of the project been examined with social and environmental considerations?	(a) Y	(a) The environmental and social considerations are made for the alternatives of the Interceptor No.1 (1 line or 2 lines in casing pipe / pipe gallery), sewage treatment process, filtration process, aeration process, and sludge treatment process. The optimum plan is selected in a comprehensive manner, from the view point of technic, O&M, initial investment, O&M cost and environmental and social considerations (the environmental risk of the accidents, sludge generation, energy consumption and GHG generation, etc.)
2 Pollution Control	(1) Water Quality	(a) Do pollutants, such as SS, BOD, COD, pH contained in treated effluent from a sewage treatment plant comply with the country's effluent standards? (b) Does untreated water contain heavy metals?	(a) Y (b) N	(a) The quality of the effluent is followed by Law on Water, Regulation on Emission Limit Values of Pollutants in water and deadlines to reach the ELV. The treatment process to meet the effluent standards is selected and the effluent will meet the standards. The daily monitoring of the effluent is proposed in the monitoring plan.
	(2) Wastes	(a) Are wastes, such as sludge generated by the facility operations properly treated and disposed of in accordance with the country's standards?	(a) Y	(a) Law on Waste requires the waste management plan should be prepared by the pollutants. In addition, the sludge can be utilized for agriculture if the certain conditions are met by regulation. All the wastes including sludge shall be properly disposed of based on the waste management plan.
	(3) Soil Contamination	(a) If wastes, such as sludge are suspected to contain heavy metals, are adequate measures taken to prevent contamination of soil and groundwater by leachates from the wastes?	(a) -	(a) The wastewater does not contain heavy metals so that the measures are not required. The sludge also does not contain heavy metals as well. The sludge treatment and storage facilities should be provided the prevention measures for soil contamination and the details will be considered during the detail design.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
2 Pollution Control	(4) Noise and Vibration	(a) Do noise and vibrations generated from the facilities, such as sludge treatment facilities and pumping stations comply with the country's standards?	(a) Y	(a) Limit value for the noise is determined by the Regulation of Noise Indicator, Limits, Methods for Evaluating Noise Indicators, Disturbances and Harmful Effects of Environmental Noise (2010) and the noise generated should be followed by this regulation. To keep under the ELV, control is necessary such as proper maintenance of equipment and vehicles, turning off the engines and mufflers. The equipment which create noise and vibration should be installed in the properly acoustically lined building and low-noise equipment should be adopted. There is no regulation for vibrations in Serbia and it is proposed to follow the international standards, DIN 4150-3: Effects of vibration on structures. The equipment which cause the vibration should be carefully selected to keep the vibration level under DIA 4150-3.
	(5) Odor	(a) Are adequate control measures taken for odor sources, such as sludge treatment facilities?	(a) Y	(a) The process equipment for these operations is usually housed in buildings that are ventilated and sometimes have exhaust air odor treatment. Odors can be reduced or prevented through normal housekeeping and improved operation and maintenance design procedures.
3 Natural Environment	(1) Protected Areas	(a) Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	(a) Y	(a) Usce PS is located within the Belgrade wellhead area. Usce PS will not disturb the groundwater as the aquifer is deeper than the facility, but there is the risk of contamination of groundwater if the facility is not operated properly. To construct the facility within the protected area, the requests for the condition of the construction will be made to Min. of Agriculture, Forestry and Water Management during the review period by the Revision Committee. The construction should follow the provided conditions.
	(2) Ecosystem	(a) Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? (b) Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? (c) If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? (d) Is there a possibility that the project will adversely affect aquatic environments, such as rivers? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?	(a) N (b) N (c) - (d) N	(a) (b) (c) (d)

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(1) Resettlement	(a) Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? (b) Is adequate explanation on compensation and resettlement given to affected people prior to resettlement? (c) Is the resettlement plan, including compensation with full replacement costs, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? (d) Is the compensations going to be paid prior to the resettlement? (e) Is the compensation policies prepared in document? (f) Does the resettlement plan pay particular attention to vulnerable groups or people, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? (g) Are agreements with the affected people obtained prior to resettlement? (h) Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? (i) Are any plans developed to monitor the impacts of resettlement? (j) Is the grievance redress mechanism established?	(a) N (b) Y (c) Y (d) Y (e) Y (f) - (g) - (h) Y (i) Y (j) Y	(a) There is no resettlement occurred due to the land acquisition, as there is no residents in the area and the land is not the primary source of income. (b) LDA organizes the public debates in two stages and compensation policy and entitlement is explained. The first public debates were organized when the decision on public interest issued. The second stages will be implemented by LDA when the budget for compensation is secured. (c) In the Project, LARAP (land acquisition and resettlement action plan) was prepared including compensation with replacement cost. The restoration of livelihoods is not required from the results of socio-economic survey (d) Yes, Law on Expropriation stipulates so. (e) Compensation policies are prepared based on Serbian legislation and JBIC Guidelines in the LARAP. (f) Vulnerable groups are not identified through socio-economic survey (g) There is no resettlement. The agreement on compensation and transfer of ownership will be implemented before construction. (h) Each organization roles and responsibility and cost for expropriation are described in the LARAP. (i) Monitoring plan by PIU (Project Implementation Unit) and supervision consultant is proposed in LARAP. (j) Law on Expropriation set the mechanism and the third party is involved in that mechanism.
4 Social Environment	(2) Living and Livelihood	(a) Is there a possibility that changes in land uses and water uses due to the project will adversely affect the living conditions of inhabitants? (b) Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary?	(a) N (b) N	(a) The proposed land is often flooded area and is not used for agriculture. (b) It is not expected as the land is not the primary source of income.
4 Social Environment	(3) Heritage	(a) Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage? Are adequate measures considered to protect these sites in accordance with the country's laws?	(a)	(a) Interceptor No. 2 will be installed around the Belgrade Fortress, cultural heritage. The conditions for construction was obtained once from the Belgrade City Institute for the Protection of Cultural Monuments and construction is allowed if the conditions are followed. This conditions should be renewed before construction as the previous one is expired.
	(4) Landscape	(a) Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	(a) N	(a) Pumping stations are already exist and interceptor will be installed under ground. The measure to plant the trees around WWTP to reduce the impact on landscape is proposed.
	(5) Ethnic Minorities and Indigenous Peoples	(a) Are considerations given to reduce impacts on the culture and lifestyle of ethnic minorities and indigenous peoples? (b) Are all of the rights of ethnic minorities and indigenous peoples in relation to lands and resources respected?	(a) - (b) -	(a) No ethnic minorities and indigenous people are found. (b) No ethnic minorities and indigenous people are found.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
4 Social Environment	(6) Working Conditions	(a) Is the project proponent not violating any laws and ordinances associated with the working conditions of the country which the project proponent should observe in the project? (b) Are tangible safety considerations in place for individuals involved in the project, such as the installation of safety equipment which prevents industrial accidents, and management of hazardous materials? (c) Are intangible measures being planned and implemented for individuals involved in the project, such as the establishment of a safety and health program, and safety training (including traffic safety and public health) for workers etc.? (d) Are appropriate measures taken to ensure that security guards involved in the project not to violate safety of other individuals involved, or local residents?	(a) Y (b) Y (c) Y (d) Y	(a) Law on Occupational Safety and Regulation on Occupational Safety for Construction Works should be complied. (b) Detail measures should be established in the Detail Design Report based on Law on Occupational Safety and regulation on Occupational Safety for Construction Works and reviewed / modified by the contractor. (c) The detail measures should be established in the Detail Design Report and reviewed / modified by the contractor. (d) The detail measures should be established in the Detail Design Report and reviewed / modified by the contractor.
5 Others	(1) Impacts during Construction	(a) Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? (b) If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? (c) If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? (d) If the construction activities might cause traffic congestion, are adequate measures considered to reduce such impacts?	(a) Y (b) Y (c) Y (d) Y	(a) To limit the noise and vibrations under the limited values, the construction machinery and vehicles should be maintained properly and turned of the engines and mufflers should be installed. The low-noise equipment should be applied and mechanical equipment should be located in the acoustically lined buildings or enclosures. Waste should be properly handled based on the waste management plan which shall be prepared by the contractor and operator of the facilities. (b) Usce PS will be constructed within the protected area for water source. The request for the construction will be made to Ministry of Agriculture, Forestry and Water Management and conditions will be provided. The construction should follow the provided conditions. (c) For land acquisition, the policy for compensation and entitlement are set in the LARAP. LDA should follow the LARAP for the expropriation of the WWTP area. (d) During construction, the traffic disturbance may be expected and the proper notice and alternative routes may mitigate the impacts. The cooperation with traffic police is important.
	(2) Monitoring	(a) Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? (b) What are the items, methods and frequencies of the monitoring program? (c) Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? (d) Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	(a) Y (b) - (c) Y (d) Y	(a) (c) (d) The monitoring on noise, vibration, water quality (river and groundwater, sewage and effluent) are proposed and the responsible organization is stipulated. When EIA report is prepared, the monitoring plan will be reviewed and modified if necessary. (b) The organizational responsibilities and the budget such as monitoring of sewage and effluent are proposed. The details will be reviewed and discussed during preparation of EIA report.

Category	Environmental Item	Main Check Items	Yes: Y No: N	Confirmation of Environmental Considerations (Reasons, Mitigation Measures)
6 Note	Note on Using Environmental Checklist	(a) If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	(a) -	(a) This is not expected.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are required to be made.
In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan's experience).
2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which the project is located.

10.4.6 Monitoring Form

Based on the requirements of JBIC, the monitoring form is prepared.

MONITORING FORM

-If environmental reviews indicate the need of monitoring by JICA, JICA undertakes monitoring for necessary items that are decided by environmental reviews. JICA undertakes monitoring based on regular reports including measured data submitted by the project proponent. When necessary, the project proponent should refer to the following monitoring form for submitting reports.

-When monitoring plans including monitoring items, frequencies and methods are decided, project phase or project life cycle (such as construction phase and operation phase) should be considered.

<Construction Phase>

1. Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from City agencies	

2. Pollution

- Water Quality of Danube River

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
MPN of Coliform						
Ammonium ion						

- Water Quality of Sava River

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
MPN of Coliform						
Ammonium ion						

- Water Quality of Groundwater

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total Nitrogen						
Total Phosphorus						
MPN of Coliform						
Ammonium ion						
Turbidity						

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level at WWTP						
Noise level at Interceptor No.						
Vibration level at WWTP						
Vibration level at Interceptor No.						

3. Natural Environment

- Ecosystem

Monitoring Item	Monitoring Results during Report Period	Measures to be taken
Protected area (protection zone of the Belgrade wellhead)	Details of the groundwater quality results	

4. Social Environment

- Cultural Heritage

Monitoring Item	Monitoring Results during Report Period	Measures to be taken
Belgrade Fortress	Findings during open-cut	

- LARAP

Monitoring Item	Monitoring Results during Report Period	Measures to be taken
LARAP Implementation schedule		
Received grievance contents		

＜Operation Phase>

１． Responses/Actions to Comments and Guidance from Government Authorities and the Public

Monitoring Item	Monitoring Results during Report Period
Number and contents of formal comments made by the public	
Number and contents of responses from City agencies	

２． Pollution

- Water Quality of Danube River

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total N						
Total P						
MPN of Coliform						
Ammonium ion						

- Water Quality of Sava River

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total N						
Total P						
MPN of Coliform						
Ammonium ion						

- Water Quality of Groundwater

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
pH						
SS						
BOD/COD						
DO						
Total N						
Total P						
MPN of Coliform						
Ammonium ion						
Turbidity						

- Water Quality of Influent

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
BOD						
COD						
TSS						
Total N						
Total P						

- Water Quality of Effluent

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
BOD						
COD						
TSS						
Total N						
Total P						

- Noise / Vibration

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Noise level at WWTP						
Noise level Usce PS						
Noise level Mostar PS						
Vibration level at WWTP						

Vibration level Usce PS						
Vibration level Mostar PS						

- Sludge for agriculture use

Item	Unit	Measured Value (Mean)	Measured Value (Max.)	Country's Standards	Referred International Standards	Remarks (Measurement Point, Frequency, Method, etc.)
Pb						
Cd						
Cr						
Ni						
Hg						
Cu						
Zn						
As						
Adsorbing organic halogens						
PCB						
PCCD/F						
Salmonella						
Enterovirus						

10.5 LARAP Study

By the Project components, around 114 ha of the land is necessary for the proposed WWTP site. For other facilities such as pumping stations and interceptor, the land acquisition is not required. The decision on public interest was issued in 2010 and LDA has been proceeding the expropriation procedures since then. Among the 110 ha, the expropriation for around 39 ha is completed.

As more than 75 ha of land is acquired in future, the impacts by land acquisition is expected as large so that the LARAP (land acquisition and resettlement action plan) is prepared to avoid, minimize and mitigate the impacts as much as possible.

The Serbian legislative framework, the gap analysis between Serbian legislation and JBIC Guidelines and the compensation policy for the Project are described in Section 10.1.2.

In the following section, the main results are described and the detail information is included in the LARAP in Appendix-II.

10.5.1 Area to be Expropriated

The area of proposed WWTP is located along the tributary of the Danube River and lies in frequently flooded area. In 2006 whole area was fully flooded and the land was not used for any purpose despite the land is categorized as agriculture land. After the decision of public interest made, some peoples started to cultivate the land for crops and trees for the compensation purpose.

There are no residents in this area and involuntary resettlement will not happen.

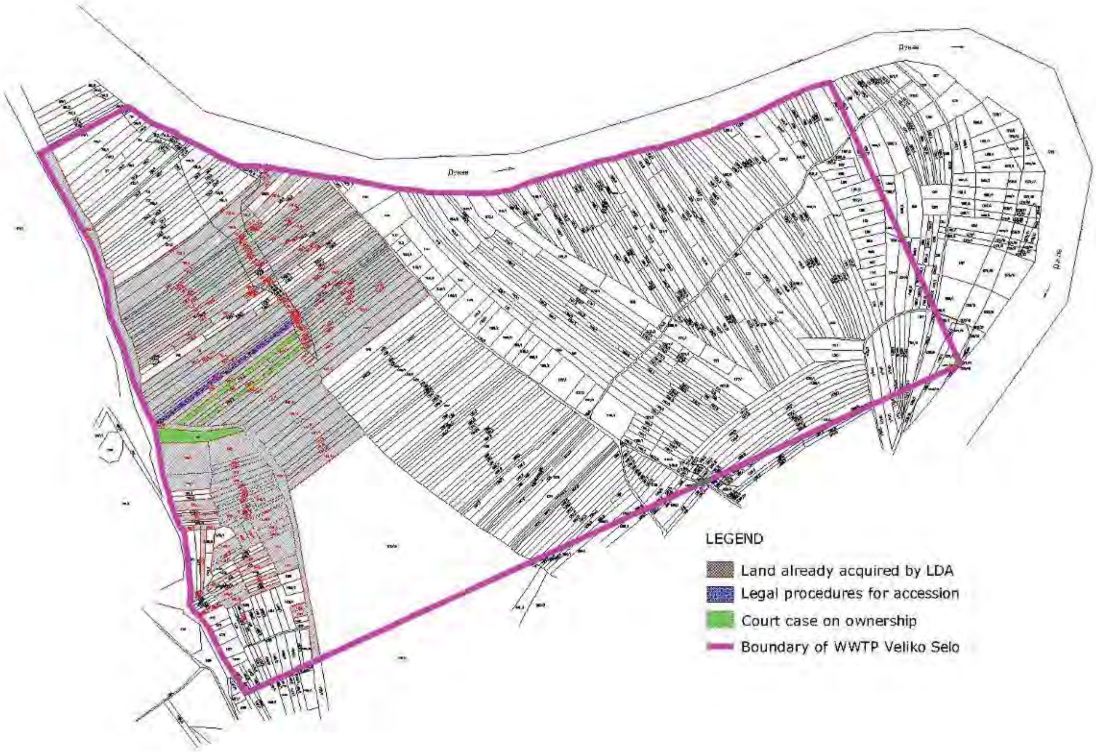


Figure 10.5 Cadaster Map of Proposed WWTP Site

10.5.2 Past Expropriation by LDA

LDA submitted the request to Ministry of Finance to declare the proposed WWTP area to be used for WWTP and approve the expropriation and the decision on public interest was issued by the Government in 2010. Since then, the budget for expropriation was requested to City of Belgrade and once it was allocated, LDA took the expropriation procedures.

There are 741 parcels within the whole WWTP site and among them, the expropriation of 137 parcels was completed, and the negotiation of compensation for 30 parcels was completed.

During the expropriation procedures of 167 parcels, the involuntary resettlement did not occur by the land acquisition so that LDA did not prepare livelihood restore program for PAPs.

By the hearing from Department for Legal and Property Affairs of LDA, responsible department for expropriation, there were not official complaints received in the past expropriation. During the negotiation of compensation amount, the PAPs often requested LDA to raise the price of the land but these were not formal complaints and they agreed to the compensation amount after explanation and negotiation.

There is one case so far and recently happened that goes to the judicial process and the appeal is about the value of the land and crops. Before judicial process, the possible measures are all taken to settle the complaint; i.e. re-evaluation by the evaluator, evaluation by another independent evaluator who is hired by the PAP by the cost of LDA, and involvement of municipality and the councilor of that area. However, the issue cannot be settled and court case is in progress.

10.5.3 Scale of Land Acquisition

(1) Number of PAPs

The results revealed that the involuntary resettlement will not occur as there are no houses in the affected area nor the agricultural land to be acquired is the primary source of income.

The PAPs are identified through census survey and the summary is shown in the following table.

Table 10.9 Summary of Affected Peoples

No. of affected parcels	Affected area (ha)	No. of affected ownership	No. of surveyed ownership	No. of affected owner in the surveyed ownership (person)	No. of surveyed owner* (person)	No. of affected household member (person)
511	75,90	1,228	1,140	280	251	1,250

Note: * No. of surveyed owner by census and socio-economic surveys are different.

There are 1,228 ownerships in the 511 parcels and 1,140 ownership data are obtained from Republic Geodesic Institute. The reason that the number of ownership is more than the number of parcel is that the land is divided to several inheritors when the landowner is passed away.

280 landowners have the ownership right of 1,140 ownerships. Among 280 owners, 251 owners are covered by the census survey as the reasons below:

- The owner is alive but is not in Belgrade - 3 cases
- The owner is not alive and the beneficiaries, that is, heirs, could not be found even after multiple attempts – 10 cases
- The owner had not willingness to cooperate the census survey – 16 cases

The total number of PAPs in surveyed area is 1,250.

(2) Affected Assets

The affected land use is as follows.

-	Gardens- vegetables	471,430 m^2	(62.1 %)
-	Pastures (meadows)...	42,375 m^2	(5.6 %)
-	Wood	65,000 m^2	(8.6 %)
-	State road (road)..	750 m^2	(0.1 %)
-	Local temporary road for owner needs	59,250 m^2	(7.8 %)
-	Not in use	120,242 m^2	(15.8 %)
	Total:	759.047 m^2	(100.0 %)

The percentage of the land which will be expropriated to the whole owned land is shown in the table below.

Table 10.10 Percentage of Area to be Expropriated

Less than 25 %	25 – 50 %	50 – 75 %	More than 75 %	No answer
79.4%	1.4 %	0.2 %	0.3 %	18.7 %

Six respondents (0.5 %) will lose more than 50 % of the owned land by the expropriation. By the results of the socio-economic survey, two respondents among six will lose the part of income from the expropriated land, 19 % and 0.2 % respectively. Three respondents do not earn any income from the land to be expropriated and one respondent did not give any data about income.

The area of 271,430 m2 (62.1 %) of the land is used for cultivating the crops such as cauliflower, cabbage, onion, leeks, tomato, spinach, green beans, etc. The table blow shows the fruit trees, wood and pasture.

Table 10.11 Trees and Pastures

Category	Kind	Unit	No.
Fruit	Walnut	Tree	45
	Sweet cherry	Tree	30
	Plum	Tree	160
Wood	Poplar, willow,	Tree	6,929
Pasture		m^2	42,375

The physical structures such as green house, irrigation such as sprinkler and wells are found in the area.

Table 10.12 Physical Structure

Structure		Unit	Quantity
Land		m^2	758,297.00
Greenhouses	Mobile	m^2	23,216.00
	Immovable	m^2	4799.00
Irrigation	Mobile	m^2	168,704.00
	Immovable	m^2	313,035.00
Wells		m	896.00

10.5.4 Socio-Economic Survey

The socio-economic survey covers 264 landowners. The results of the survey is described in the Chapter 4 of LARAP (see Appendix-II).

10.5.5 Entitlement

The project entitlements developed and presented in the entitlement matrix shown in table below correspond to the potential impacts identified.

(1) Entitlement Matrix

Table 10.13 Entitlement Matrix

Category of impacts/losses	Entitled persons	Project Entitlements	Notes/implementation issues
CATEGORY-A: IMPACT ON LAND			
A-1 Permanent loss of construction or agricultural land	Registered landowner, or legal successors	Cash compensation at current market price and free from transaction costs (e.g. taxes, certification, registration, administration costs)	If during the partial expropriation of a property, determined that owner does not have commercial interest to use the remaining property, or if because of the expropriation, the rest of the property is impossible to use or because of expropriation his financial existence is significantly impeded, at his request, the rest of the property will be expropriated.
	Persons authorized by the landowner to cultivate the land	No compensation for land.	If the crops / productive trees / wells exist in the land plot, those will be compensated as mentioned in C-2 of this table.
A-2 Permanent loss of public land	City of Belgrade	No compensation is required.	
	Republic of Serbia	No compensation is required.	Administrative cost to transfer the land to City of Belgrade should be covered by the City of Belgrade
A-3 Temporary loss of construction or agricultural land, or temporary loss of land use	Registered landowner, legal successors, persons authorized by the landowner to cultivate the land	Compensation is determined based on the rental price of the nearest similar plot by cash. After the expiry date of the temporary acquisition, land should be reinstated to pre-project condition.	Contractor will be responsible for returning land to pre-project / better condition after end of use.
CATEGORY-B: RELOCATION OF AFFECTED HOUSEHOLDS (NOT OBSERVED IN THE PROJECT AFFECTED AREA)			
CATEGORY-C: MOVABLE AND IMMOVABLE ASSETS ON THE LAND			
C-1 Public property (infrastructures / facilities)	City of Belgrade	Repairment/reconstruction or displacement of the property based on conditions by concerned authority shall be carried out.	Responsible person for repairment/reconstruction costs shall depend on the type of construction contract.
C-2 Loss of crops, productive trees and wells	Registered landowner, legal successors, persons authorized by the landowner to cultivate the land	The compensation will be done based on Law on expropriation (according to the evaluation by authorized evaluator)	
Category-D Social Assistance (NOT OBSERVED IN THE PROJECT AFFECTED AREA)			

(2) Cut-off Date

According to the Serbian legislation, there are two dates that determine the entitlements. The 1st cut-off date is the date that the decision of public interest was issued by the Government, i.e. 19 August 2010 in case of this Project. After this date, any transaction on identified plot is prohibited.

The expropriation is started after the Decision on public interest for expropriation of total land subject that procedure is reached by the Government of the Republic of Serbia. When the Decision on Expropriation is issued for each land to be expropriated, the negotiation will start. This date is the 2nd cut-off date. It often happens that there are several years between the decision on public interest and decision on expropriation, so that the owners can use the land till the decision on expropriation is issued. The assets to be lost due to the expropriation are determined on the date of the decision on expropriation.

(3) Livelihood and Other Assistance

As stated in section 10.5.3, there are six (6) owners among 251 owners who lose more than 50 % of owned land due to the expropriation. Among six, three respondents do not earn any income from the agriculture land and two respondents will lose some part of the income (19 % and 0.2 % respectively) due to the expropriation. The respondent who will lose 19 % of income has the permanent job as trader and the agriculture is not his primary source of income. It can be concluded by the impacts by expropriation on their lives are not significant and any livelihood or other assistance are not required for the Project.

10.5.6 Implementation Arrangement

(1) Roles and Responsibilities of Institutions

The institutions involved in the land acquisition process are LDA, as the beneficiary of expropriation, City of Belgrade, Municipality of Palilula as an administrative institution through which the expropriations being completed, Ministry of Finance, Ministry of Construction and Urban planning, Land Cadaster Office, Tax Administration Office. The beneficiary of expropriation LDA is determined to be beneficiary according to the Law on Expropriation. The detail roles and responsibilities of each organizations are described in the Chapter 6.1 of LARAP (see Appendix-II).

(2) Monitoring

To ensure that the Project is implemented in accordance with the Serbian legislation, JBIC

Guidelines and this LARAP, the monitoring should be undertaken to assess the progress and results of LARAP implementation.
The internal monitoring for LARAP implementation will be carried out by PIU (Project Implementation Unit) which will be set up for the implementation of the Project within LDA. PIU with the consultants who is in charge of the supervision and project management of the Project will carry out internal monitoring to assess and promote the progress of LARAP implementation.

Responsibilities of the PIU will include: (i) consultation and informal interviews with PAPs, (ii) regular visits to project affected areas and scheduled meetings with PAP, (iii) review of grievances received through grievance redress mechanism, (iv) preparation of monitoring reports that summarize results of LARAP implementation, investigations of grievances and solutions taken to solve the grievances. The consultants will support PIU in (i) ensuring the LARAP is implemented based on the principle mentioned in the LARAP, (ii) reviewing the grievance screening and redress procedure and providing advice based on the best international experience, (iii) assessing grievances received and finding measures to redress them, and other aspects of LARAP implementation, as needed.

(3) Grievance Mechanism

By the Law on Expropriation, the grievance mechanism is stipulated. When PAPs have the grievance against the decision on expropriation such as against the expropriation of his land, the appeals are solved by the Ministry of Finance, as the public interest and expropriation is the decision of the Government. If PAPs cannot accept the decision of Ministry of Finance, within 30 days from the decision, they can resort to the judicial process.

When PAPs disagree with the assessed fair value for lost assets (except land), they can demand the reevaluation of the assets by evaluator hired by LDA. The PAPs can hire an accredited expert, at the expense of LDA to review and determine the assessed fair value for the lost assets. The mediation by all possible measures is taken, involving the municipality, councilors of the concerned area, and evaluator. If after mediation, the PAP disputes the assessment of fair value, they are free to enter the judicial process in a manner consistent with the Law on Expropriation.

(4) Estimated Cost

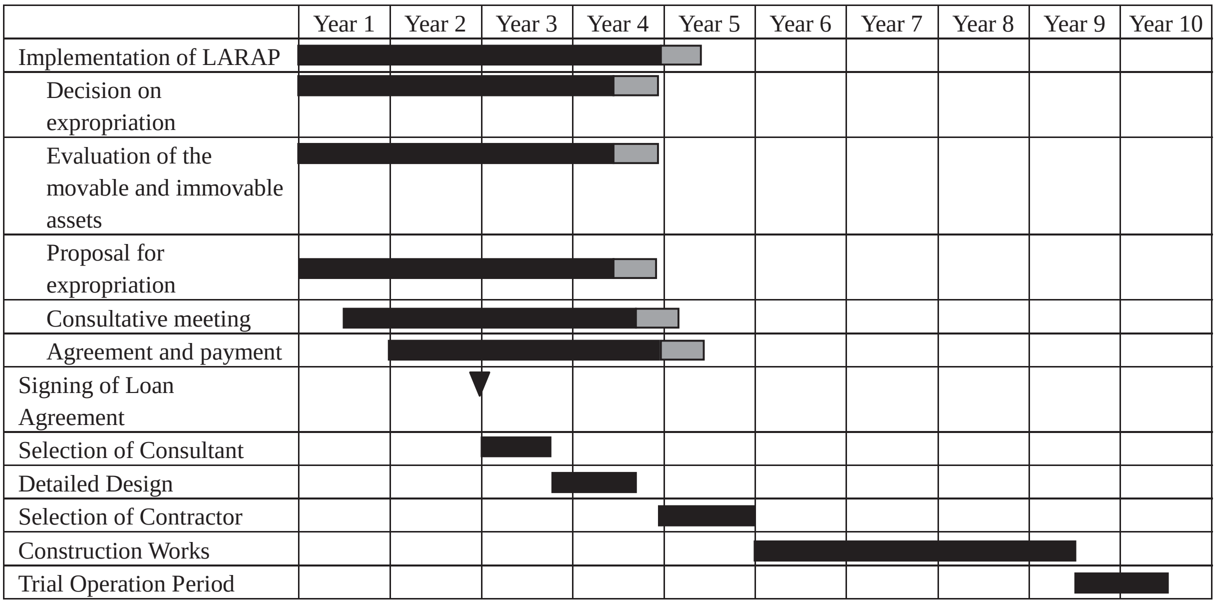
The table blow shows the estimated cost for the expropriation.

Structure		Unit	Quantity	Rate (RSD)	Amount (RSD)
Land		m^2	758,297.00	949.50	720,003,001.50
Greenhouses	Mobile	m^2	23,216.00	100.00	2,321,600.00
	Immovable	m^2	4799.00	5,000.00	23,995,000.00
Irrigation	Mobile	m^2	168,704.00	10.00	1,687,042.74
	Immovable	m^2	313,035.00	30.00	9,399,238.18
Wells		m	896.00	3,000.00	2,688,000.00
Wood	Forest	m^2	6,770	3,500.00	23,295,000.00
	Walnut trees	m^2	20	20,000.00	400,000.00
TOTAL:		-	-	-	783,788,882.42

(5) Implementation Schedule

The payment of compensation should be completed before the contractor obtains the building permit. As the expropriation cannot be started without the arrangement of the budget for expropriation, the schedule of LARAP implementation is different by the plot. The whole WWTP site (75 ha) is not necessarily acquired but the 35 ha for the area of WWTP should be completed by the project implementation. The schedule shows the earliest possible case of the Project implementation.

Table 10.14 LARAP Implementation Schedule



10.5.7 Public Consultation

The expropriation of proposed WWTP site has started from 2010 based on the Serbian legislations. Since then, the several public debates were organized to explain the project, need of expropriation, expropriation procedures and entitlement for compensation. All the PAPs are already familiar with the procedures and entitlement. The next procedures will go into individual and detailed consultation with PAPs upon the arrangement of the budget for expropriation.

The gap analysis between Serbian legislation and JBIC Guidelines shows no significant gaps and the policy and entitlement of the compensation explained in the public debates almost accord with the JBIC Guidelines. It means that the past debates are considered to be carried out practically in conformity with JBIC Guidelines. In addition, if the public consultation is held at this moment, PAPs consider this as detailed consultation and expect the immediate payment of compensation. To avoid these misunderstanding occurred, the public consultation will be organized in accordance with the Serbian legislations as well as JBIC Guidelines upon the budget arrangement for compensation becoming ready and the results of such public consultation will be recorded.

In the past public debates that LDA organized several times, the following topics were explained and the main comments from PAPs (landowners and their legal successors) are summarized below.

Subject of public debates was to inform landowners that LDA submitted request to the Municipal Palilula that their parcels will be expropriated for the construction of WWTP. Landowners are also informed of the policy for compensation, expropriation procedures, their rights on compensation for land, as well as for crops, trees and wells which can be found on the land, evaluation method and grievance redress mechanism.

PAPs concerned that the schedule of the compensation payment and the amount of the compensation and legal successors rights.

11. Conclusion and Recommendations

The survey prepared the facilities planning of the sewerage facilities for the Sewerage System Improvement Project for the City of Belgrade. The facilities planning covers interceptors, pumping stations and Veliko Selo WWTP, which conveys all the wastewater from the Central system currently discharged untreated to the rivers to the WWTP and treat it to the level complying with Standards of EU directive.

As a result of the project cost estimation, it was revealed that the estimated project cost is higher than the fund availability currently considered being possible. To overcome, the Survey introduced the phased implementation of the project to make the project sizable compared to the fund availability. Phase-1 Project, which conveys all the wastewater from Central system on the right bank of the Suva river except the Mokrolung catchment area, corresponding 52% of the total wastewater from the entire Central system, and treat it in Veliko Selo WWTP, was concluded to be sizable compared to the expected fund availability, financially and economically viable and feasible from environmental and social consideration viewpoints.

The Sewerage Improvement Project for the City of Belgrade started in 1990 when the construction started for No. 5 and No.7 interceptors, and is currently constructing No. 8 and No. 9 interceptors. Without the Phase-1 project, facilities constructed more than 20 years ago and to be constructed will be further left in nonperforming status. Therefore, the early realization of the Phase-I project is desperately required.

Towards the realization of the projects, concerned organizations, such as the State Government, the Belgrade City, LDA and BVK are required to take necessary actions in accordance with each organization's competence.

The project belongs to the Belgrade City. Therefore, the City Hall should take full responsibility for the implementation of the project and operation of the project facilities. However, considering the objectives of the project, that is to contribute to the improvement of the environment and to fulfill the prerequisite of the accession to the EU, which is the highly prioritized national credo, the State Government should take the initiative to promote the project by expeditious approval and license proceedings related to the project preparation and implementation and arrangement with foreign and international funding agencies. Also the State Government should take an appropriate responsibility for the project financing through subsidy because the project would contribute to the national policies, such as the environmental protection and the accession to the EU.

Even in the case of the Belgrade City or the State Government, a borrower of a loan is possible to be responsible for financing of the non-eligible portion of the project cost. In the case that the

Belgrade City would be a borrower of the loan, as the foreign loan requires a sovereign guarantee, the close coordination with the State Government is required in the application of and negotiation for the loan. In the project implementation and operation stages, it would carry out its responsibility through its subordinate organizations, namely LDA for the project implementation and BVK for the operation of the sewerage system. It is not only expected to take the lead by these organizations but also take initiatives in coordination with the State Government, related governmental organizations and related other Belgrade City organizations. Furthermore, the City is responsible for decision on water supply/sewerage tariff which ensures BVK's sound operation after the project.

LDA would be the main player of the project preparation and implementation. In the preparation stage, many required actions are beyond the competence of LDA. Many actions, such as some approval and license procedures, financing arrangements, negotiation with financing organizations, etc., would proceed out of LDA's control. Even tough, LDA must be an initiator of those actions. In the implementation stage, LDA literally plays the main role. All the activities in the project implementation will come under LDA's responsibilities and those responsibilities are presently scattered among various sections of LDA. Therefore it is highly recommended to organize a unit to implement the project (PIU) by gathering functions and responsibilities required for the project implementation.

BVK is responsible for the operation and maintenance of the facilities constructed by the project. Presently BVK is operating and maintaining the sewerage facilities except WWTP. WWTP is a new facility and is required to be equipped with technology and human resources for the WWTP operation and maintenance. BVK should create a new section responsible for the WWTP operation by organizing proper human resource and providing proper technical training. Probably, it is required to expand the present sections for the operation and maintenance of the interceptors and pumping stations. BVK is responsible for its sound financial operation as a self-supporting organization. The Survey concluded that the project is financially viable by increasing sewerage tariff by 23% of the present. Therefore, BVK should be prepared to initiate the tariff increase procedures. The adoption of the progressive tariff structure may be one of the options to ease the impact of the tariff increase on lower income users.