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JAPAN INTERNATIONAL COOPERATION AGENCY

CAPITAL DEVELOPMENT CORPORATION
THE CITY OF ASTANA

THE FEASIBILITY STUDY ON WATER SUPPLY AND SEWERAGE IN THE CITY OF ASTANA IN THE REPUBLIC OF KAZAKHSTAN

FINAL REPORT

VOL. III SUPPORTING REPORT

MARCH 2001

KISHO KUROKAWA ARCHITECT & ASSOCIATES
NIPPON KOEI CO., LTD.
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A. WATER SUPPLY

A.1 Water Consumption

A.1.1 Assumptions on Actual Water Consumption

(1) Estimation of Water Consumption based on Wastewater

Based on the flow meter installed on the inlet pipe of the WWTP, average wastewater volume during 7th to 14th of September 2000 was 95,000 m^3/day. While distribution volume of drinking water in September was around 153,000 m^3/day. The incoming wastewater volume corresponds to 62 % (95,000/153,000) of supply water volume. Therefore, average wastewater volume in 1999 is assumed as; 131,063 m^3/day x 0.62 = 81,000 m^3/day

(2) Assumptions upon Examination of Table 3.2.3

1) Total drinking water supply volume is 131,063 m^3/day
2) 131,063 m^3/day – (Total Consumption) = "Leakage and Unknown"
3) Incoming wastewater volume is 81,000 m^3/day
4) Leakage from water supply pipes is assumed to intrude into sewer pipe with the 30% of "Leakage and Unknown Water Volume".
5) "Industry and Commercial" water use, 20,049 m^3/day shown in Table 3.2.1, includes the water consumption in Thermal Plant No.1 and 2. According to ASA data, their actual water consumption in 1999 was 18,188 m^3/day. So, subtracting this amount, industry and commercial water use comes;

   20,049 – 18,188 = 3,861 m^3/day

However, it seems too small compared with "Public" water use, 4,814 m^3/day shown in Table 3.2.1, because the number of employee in the public sector was 36,100. While that in industrial and commercial sector is 111,200 in 1999. Per capita water consumption in public sector is:

4,814,000 / 36,100 = 133 l/c/d

Assuming that per capita water consumption in industrial and commercial sector is equal, water consumption in this sector will be;

111,200 person x 133 l/c/d = 14,790 m^3/day

This figure is adopted in "Modified Case".

6) "Leakage and Unknown Rate" will be ranging from 20 to 30 %.

A.1.2 Flow Measurement

Flow measurement of raw water and distribution water volume were conducted in this study using Ultra-sonic Flow-meter, Fuji Porta-flow, FLCS1011. Measurement sites are shown in Figure A.1.2.1. Out of nine measurement sites, two sites (M1 and M2) were not able to measure successfully due to extensive pipe deterioration. M1 and M2 are set on the transmission line near the intake pumping station.

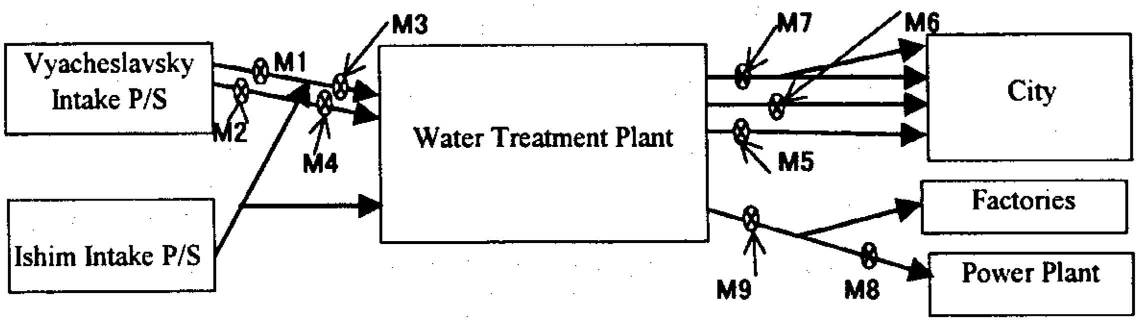


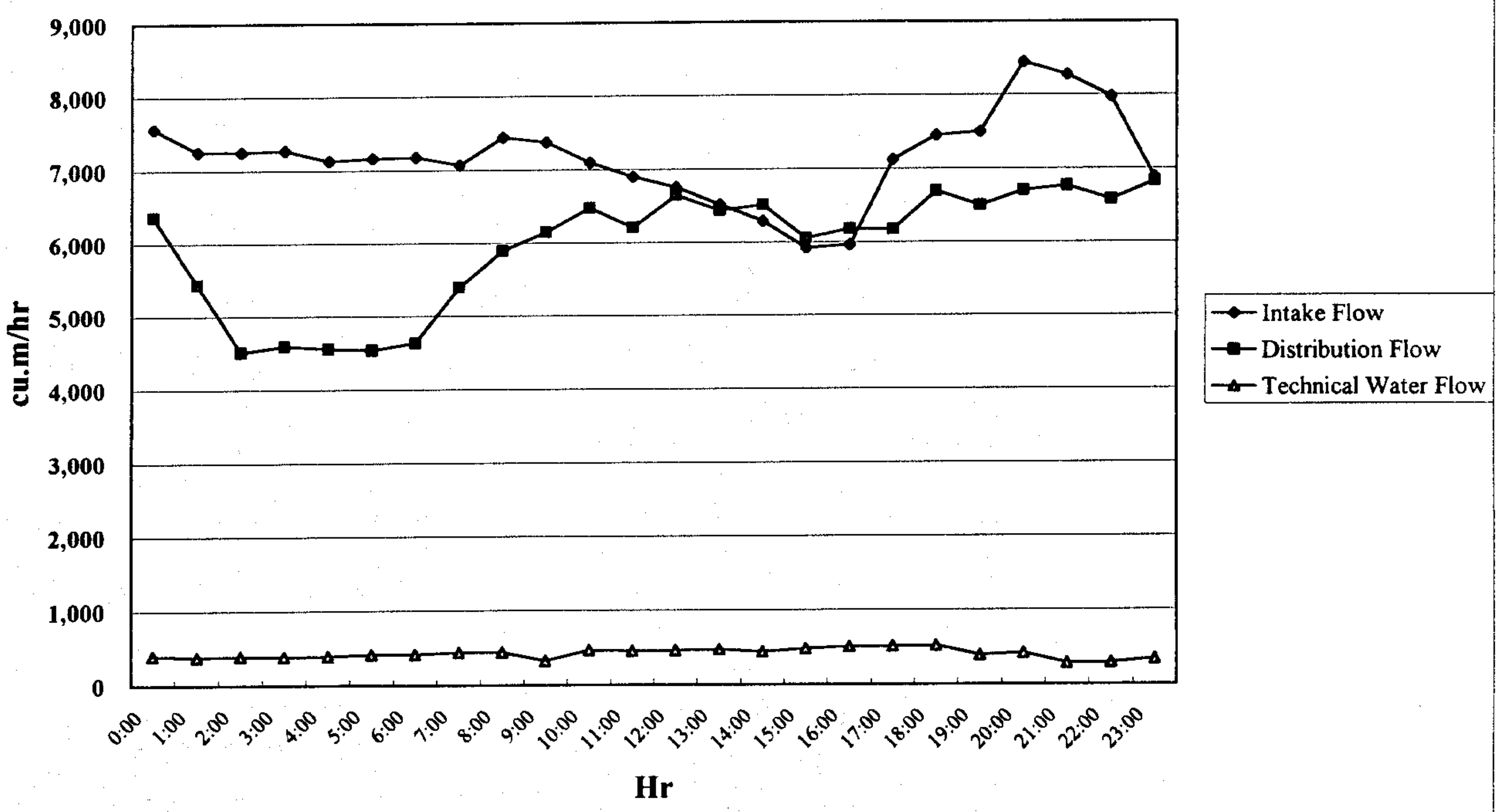
Figure A.1.2.1 Flow Measurement Sites

Results of flow measurement are summarized in Table A.1.2.1 and flow pattern of "Raw Water", "Treated Water" and "Technical Water" is shown in Figure A.1.2.2. Water demand in nighttime corresponds almost 80% of daily average demand.

Table A.1.2.1 Flow Measurement Results

Time \ Pipe No.	No.3 Sep.5	No.4 Sep.6	Intake Total(1)	No.5 Sep.4	No.6 Sep.1	No.7 Aug.31	Distribution Total(2)	No.8 Aug.11	No.9 Sep.2
0:00	4,175	3,392	7,567	2,340	1,153	2,870	6,363	400	438
1:00	4,133	3,121	7,254	2,200	1,150	2,080	5,430	382	404
2:00	4,144	3,110	7,254	1,800	961	1,750	4,511	390	385
3:00	4,150	3,124	7,274	1,800	1,071	1,718	4,589	387	372
4:00	4,079	3,050	7,129	1,800	1,108	1,648	4,556	392	402
5:00	4,074	3,093	7,167	1,800	1,023	1,714	4,537	416	401
6:00	4,068	3,112	7,180	1,800	1,048	1,787	4,635	413	405
7:00	4,099	2,968	7,067	2,000	1,170	2,222	5,392	440	380
8:00	4,175	3,265	7,440	2,100	1,150	2,642	5,892	437	377
9:00	4,096	3,279	7,375	2,200	1,167	2,780	6,147	325	364
10:00	3,900	3,200	7,100	2,200	1,515	2,768	6,483	464	450
11:00	3,700	3,200	6,900	2,236	1,277	2,695	6,208	452	411
12:00	3,556	3,200	6,756	2,423	1,433	2,792	6,648	461	333
13:00	3,319	3,200	6,519	2,363	1,408	2,666	6,437	476	384
14:00	3,093	3,200	6,293	2,442	1,119	2,951	6,512	442	382
15:00	2,717	3,200	5,917	2,041	1,399	2,613	6,053	483	382
16:00	2,762	3,200	5,962	2,100	1,501	2,585	6,186	507	380
17:00	3,924	3,200	7,124	2,222	1,433	2,520	6,175	513	358
18:00	4,249	3,200	7,449	2,406	1,399	2,890	6,695	520	446
19:00	4,297	3,200	7,497	2,309	1,464	2,727	6,500	396	370
20:00	5,244	3,200	8,444	2,290	1,588	2,825	6,703	420	380
21:00	5,069	3,200	8,269	2,357	1,475	2,931	6,763	284	385
22:00	5,301	2,670	7,971	2,340	1,314	2,927	6,581	291	467
23:00	3,672	3,209	6,881	2,340	1,475	3,008	6,823	339	368
Total	95,996	75,793	171,789	51,909	30,801	60,109	142,819	10,030	9,424

Figure A.1.2.2 Flow Patern in WTP



A.1.3 Analysis on Leakage and Wastage

The Study Team carried out the flow measurement for 24 hours at WTP using ultrasonic flow-meter. Based on this result and water distribution record of ASA, hourly flow fluctuation was estimated as shown in Figure A.1.3.1. Calculation details are given hereinafter;

a) Line (1): For the "Distribution Volume from WTP", the annual average volume of 131,063 m^3/day as shown in Table 3.2.2 was used.

b) Line (2): For the "Actual Distribution Volume", the modified total water consumption of 96,783 m^3/day in 1999 as shown in Table 3.2.3 was adopted. "Actual Distribution Volume" is the water amount deducting pipeline leakage from "Distribution Volume from WTP".

c) Line (3): For the "Actual Consumption". The total consumption becomes 70,400 m^3/day multiplying 300,800 people to 234 l/c/d, the target drinking water demand in 2010, when the most of all the water meter installation is completed and "water consumption reduction effect" is supposed to be generated.

Using these figures, the following wastage and leakage rates were calculated;

- Wastage and Leakage Rate = (131,063 – 70,400)/131,063 = 46.3%
- Leakage in Pipeline = (131,063 – 96,783)/131,063 = 26.2%
- Leakage and Wastage by Consumer = (96,783 – 70,400)/131,063 = 20.1%

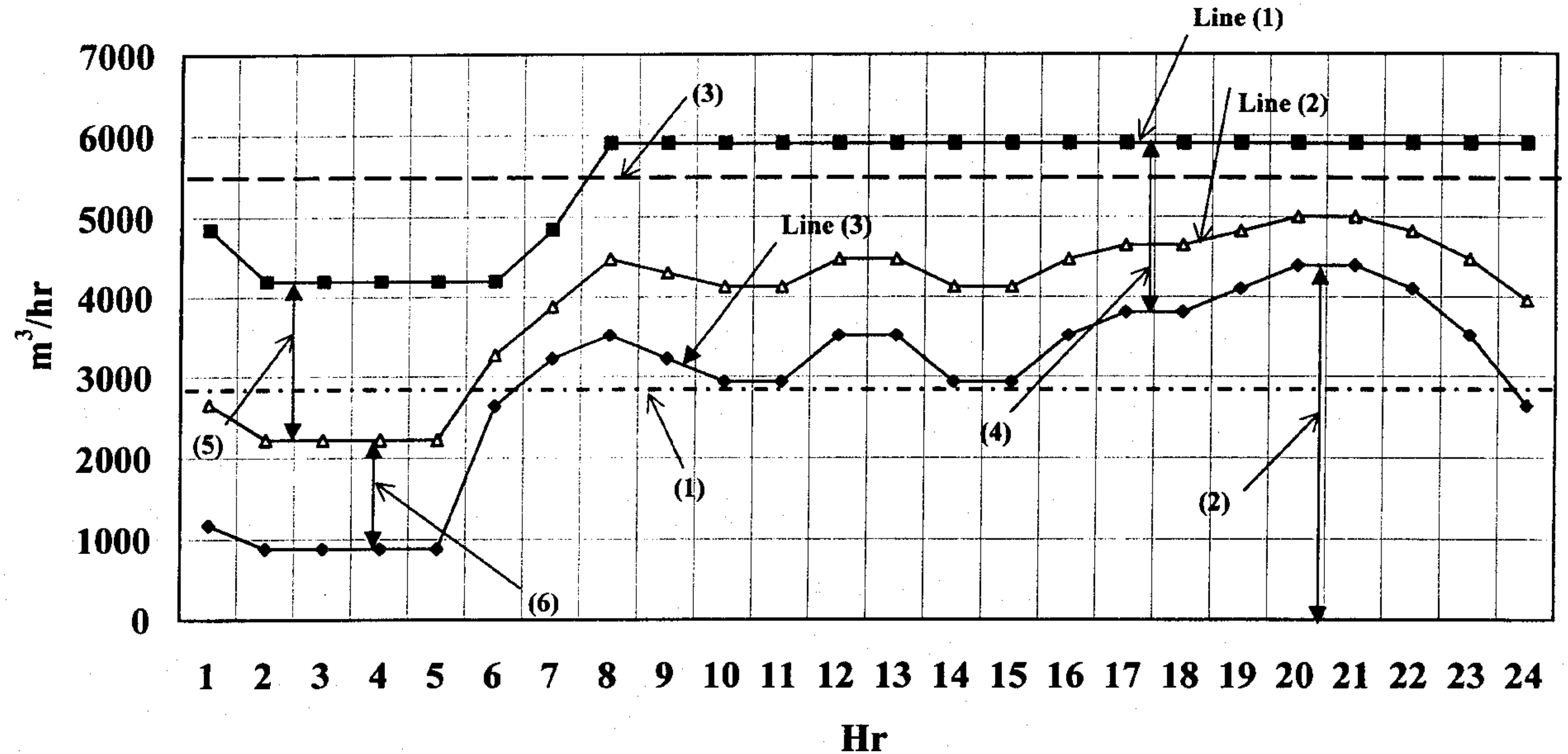


Figure A.1.3.1 Hourly Flow Fluctuation

1) Actual Consumption = 234Lpcd x 300,800 people = 70.400 m^3/d
2) Hourly Consumption Flactuation Rate=Maximum/Average=1.4
3) Average Drinking Water Distribution Volume in 1999 = 131,063 m^3/d
4) Water Wastage and Leakage Rate=(131,063-70,400)/131,063=46.3%
5) Leakage in the Pipeline=(131,063-96,783)/131,063=26.2%
6) Leakage and Wastage by Consumer=(96,783-70,400)/131,063=20.1%

A.2 Water Sources

A.2.1 Well List

Name	Well No. or Name	Year of Construction	Abstruction Capacity (m^3/hr)	Remarks
North Western 20th	No.1	1965	12.5	
	No.2	1965	0.41	
	No.3	1965	1.8	
	No.4	1965	0.86	
	No.5	1965	1.38	
	No.6	1965	0.53	
	No.7	1965	5.6	
	No.8	1965	6.8	
	No.9	1965	2.68	
39th Crossing	No.1	1960	4.0	
	No.2	1960	4.0	
Aqmolasky Wells	Omskaya	1943	50.0	Currently Operated
	No.4	1941	40.0	
	No.5	1956	40.0	
	No.6	1957	4.0	
	No.10	1965	25.0	
	K.Marksa	1943	50.0	
Alluvial Water Intake	No.1	1964	3.7	
	No.2	1964	2.0	
	No.3	1964	5.15	
	No.4	1964	2.0	
	No.5	1964	2.3	
	No.6	1964	8.4	
	No.7	1964	5.5	
	No.10	1964	8.1	
	No.11	1964	2.1	
	No.12	1964	7.1	
	No.15	1964	3.6	
	No.16	1964	3.24	
	No.17	1964	2.88	
Total	30		305.63 m^3/hr (7,355 m^3/day)	

Source : Well List, ASA, 1999

A.2.2 Drinking Water Quality Standards.

Item		WHO		Kazakstan	
		Unit	Value	Unit	Value
1	Odour	-	-	-	2.0
2	Taste	-	-	-	2.0
3	pH	-	< 8.0	-	6.0 - 9.0
4	Colour	TCU	15.0	-	20.0
5	Turbidity	NTU	5.0	mg/l	1.5
6	Hardness	-	-	mg/l	7.0
7	General Radio Activity	Beckerel/l	0.1	Beckerel/l	0.1
8	General B-Radio Activity	Beckerel/l	1.0	Beckerel/l	1.0
9	Beryllium (Be)	mg/l	-	mg/l	0.0002
10	Barium (Ba)	mg/l	-	mg/l	0.1
11	Boron (B)	mg/l	0.3	mg/l	0.5
12	Bromine (Br)	mg/l	-	mg/l	NIS
13	Cadmium (Cd)	mg/l	0.03	mg/l	0.001
14	Sodium (Na)	mg/l	-	mg/l	200
15	Molybdenum (Mo)	mg/l	0.07	mg/l	0.25
16	Arsenic (As)	mg/l	0.01	mg/l	0.05
17	Nitrate (NO3-)	mg/l	50.0	mg/l	45.0
18	Res. Acrylamide Polymer	mg/l	-	mg/l	2.0
19	Lead (Pb)	mg/l	0.01	mg/l	0.03
20	Selenium (Se)	mg/l	0.01	mg/l	0.001
21	Silver (Ag)	mg/l	-	mg/l	0.05
22	Silicate	mg/l	-	mg/l	NA
23	Fluoride (F)	mg/l	1.5	mg/l	1.5
24	Chromium (Cr)	mg/l	0.1	mg/l	0.05
25	Cyanide	mg/l	0.07	mg/l	0.035
26	Iron (Fe)	mg/l	0.3	mg/l	0.3
27	Manganese (Mn)	mg/l	0.5	mg/l	0.1
28	Copper (Cu)	mg/l	1.0	mg/l	1.0
29	Sulfate (SO4)	mg/l	250.0	mg/l	500.0
30	Solid Redisue	mg/l	1000.0	mg/l	1000.0
31	Chloride (Cl)	mg/l	250.0	mg/l	350.0
32	Zinc (Zn)	mg/l	3.0	mg/l	5.0
33	Oil Products	mg/l	-	mg/l	0.1
34	Volatile Phenols	mg/l	.0001 - 0.2	mg/l	0.25
35	Microorganisms	pc/100ml	-	pc/mm^3	50
36	Bacterias	pc/100ml	-	pc/l	0

* The standards values are determined by several types of phenols.
Source : SanPiN 3.01.067.97

A.3 Raw Water Transmission Facilities

A.3.1 Structures of Intake Pump Station

Table A.3.1.1 Vyacheslavsky Reservoir Intake Pumping Station

Facility	Power Receiving Building	Pump Room	Operation & Electric Room	Pump Loading Room	Administrative Room	Stair Room
Type	Prefabricated Concrete	Concrete Structure	Concrete Structure	Brick Structure	Brick Structure	Brick Structure
Number	1	1	1	1	1	1
Dimension	W6m x L30m x H5m	W12m x L34 m x H9.4m	W12m x L34 m x H7.3m	W8m x L18m x H9m	W12m xL9.3m x H4m	W3.3m x L12.2m x H3m
Location	Ground Structure*	2nd Basement	1st Basement	1st Floor	1st and 2nd Basement : Included in Electric Room and Pump Room	

Note : * Power Receiving Building does not belong to P/S, but a independent structure.

Table A.3.1.2 Ishim Intake Pumping Station

Facility	Power Receiving Building	Pump Room	Ground Building	Screen Loading Room	Electric Room
Type	Brick structure	Concrete Structure	Brick structure	Brick structure	Brick structure
Number	1	1	1	1	1
Dimension	W6m x L19m x H4.5m	W10.5m x L19.5m x H7.7m	W12.5m x L27.8m x H8m	W8.8m x L14m x H6m	W4m x14.5m x H5m
Others	Independent Structure				

A.3.2 Specifications of Mechanical and Electrical Facilities in Intake P/S

Table A.3.2.1 Vyacheslavsky Reservoir Intake Pumping Station

Item	Intake Pumps		Drainage Pump	Sand Drain Pump	Ventilation Fan
Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Turbo
Number	2	(1)	1+(1)	2	2
Dimension	Q: 4,095 m^3/hr H: 95 m Dia. 800 mm kW: 1,250	Q: 6,300 m^3/hr H: 95 m Dia. 800 mm kW: 2,000	Q: - H: 20 m Dia. 150 mm kW: -	Q: - H: 20 m Dia. 150 mm kW: -	Q: - H: - Dia. 1.0x1.0 m KW:
Item	Electrical Facility			Intake Screen	Pipe & Valves
Type	Power Receiving Facilities (U.H. Voltage)	Power Receiving Facilities (U.H. Voltage)	Control Panel Central + Side	Vertical Bar screen	Steel Pipe
Number	1	1	1+3	2 units /2 line	1
Dimension	50 KV	10KV	Central: 1unit Side: 3 unit	W2.5m x h5.5m	Dia.600-1000mm. Auto Valve 6 unit
Item	Ceiling Crane	Ceiling Crane	Transmission Pipe No.1	Transmission Pipe No.2	Flow meter
Type	Mobile (longitudinal, horizontal and vertical direction)	Mobile (longitudinal, horizontal and vertical direction)	Steel pipe, Installed in 1968	Steel pipe and Ductile iron pipe, Installed in 1988	Ultra-sonic Meter, Installed on March 2000
Number	1	1	1	1	2
Dimension	W8m, 2 Loading equipment 20t+3.2t	Basement W12m x 20t	Diameter 800-1,000mm x 51km	1,000mm x 51km	Transmission pipe

Note : U.H. Voltage = Ultra High Voltage, ( ) Stand-by

Table A.3.2.2 Ishim Intake Pumping Station

Item	Intake Pumps			Drainage Pump	Intake Screen
Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Vertical Bar screen
Number	(2) (Stand-By)	(1)	1	2	2 units /3 line ,
Dimension	Q: 2,400 m^3/hr H:55 m Dia.600x800mm kW: 500	Q:2.200 m^3/hr H: 55 m Dia.600x800mm kW: 500	Q:1,600 m^3/hr H: 55 m Dia.400x400mm kW: 350	Q: - H: - Dia.100x100mm kW: -	Coarse and fine screens W3.5m
Item	Electrical Facility			Pipe & Valves	
Type	Electric Receive Facilities (U.H. Voltage)	Steel Pipe	Steel Pipe	Steel Pipe	
Number	1	1	1	1	
Dimension	50 KV	Dia.600-1000mm. Auto Valve 6 unit	Dia.400-800mm. Auto Valve 6 unit	Dia.400-800mm. Auto Valve 6 unit	
Item	Pump Ceiling Crane	Screen Ceiling Crane	Flow meter	Flow meter	
Type	Mobile (length, side and vertical direction)	Mobile (length, side and vertical direction)	Ultra-sonic	Ultra-sonic	
Number	1	1	2	2	
Dimension	W11m x 20t	W8m x 3.2t	Installed in Transmission pipe	Installed in Transmission pipe	

A.3.3 Evaluation on C-value of existing Raw Water Transmission Pipes from Vyacheslavsky Reservoir Intake P/S to WTP

$$V = Q/A = 0.8495 \times C \times R^{0.63} \times I^{0.54} \Rightarrow I = (1.1774Q/(A \times C \times R^{0.63}))^{1/0.54}$$

where; V : Velocity (m/sec)
Q : Flow (m^3/sec)
A : Cross Sectional Area (m^2)
C : Velocity Coefficient (New pipe = 130)
R : Hydraulic Radius (m)
I : Hydraulic Gradient

Maximum flow based on the flow record of 0.889 m^3/sec (=3,200 m^3/hr) for No.1 pipe 1.00 m^3/sec (=3,600 m^3/day) for No.2 pipe was applied for calculation.

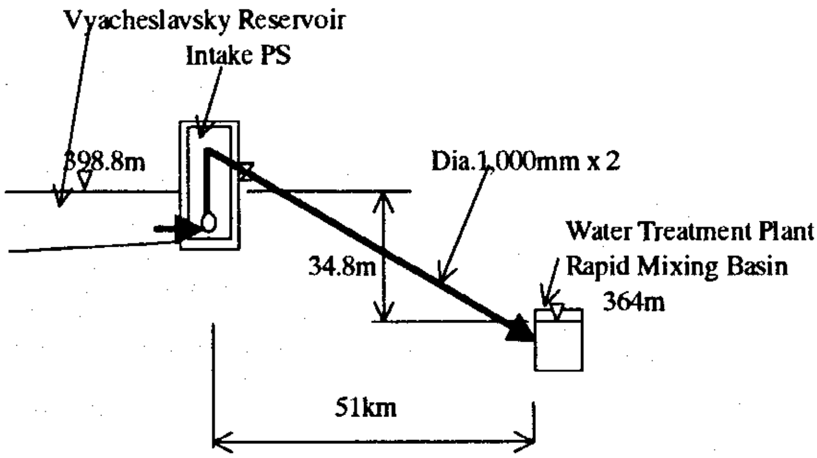


Figure A.3.3.1 Schematic Diagram for Vvacheslavsky Intake PS to WTP

Table A.3.3.1 Calculation of Pipe Head Loss

	C	110	100	90	80
No.2 Pipe (New)	I	0.001769	0.00211	0.002565	0.00319
	R (m)	0.250			
	Q (m^3/s)	1.000			
	A (m^2)	0.7854			
	Loss for 51km (m)	90.2	107.6	130.8	162.7
	Pump H (m)	55.4	72.8	96.0	127.9
No.1 Pipe (Old)	I	0.001422	0.001697	0.002063	0.002565
	R	0.250			
	Q (m^3/s)	0.889			
	A (m^2)	0.7854			
	Loss for 51km (m)	72.5	86.5	105.2	130.8
	Pump H (m)	37.7	51.7	70.4	96.0

The nominal pump head is 95m. Based on this calculation, the velocity coefficient of No.2 pipe is assumed to be higher than 100. Whereas, that of No.1 pipe is assumed to be 90.

A.3.4 Evaluation on C-value of existing Raw Water Transmission Pipes from Ishim Intake P/S to WTP

Figure A.3.4.1 shows the schematic diagram from the Ishim intake P/S to WTP. The transmission pipe with diameter of 1,000 mm and 9 km length connects these two facilities.

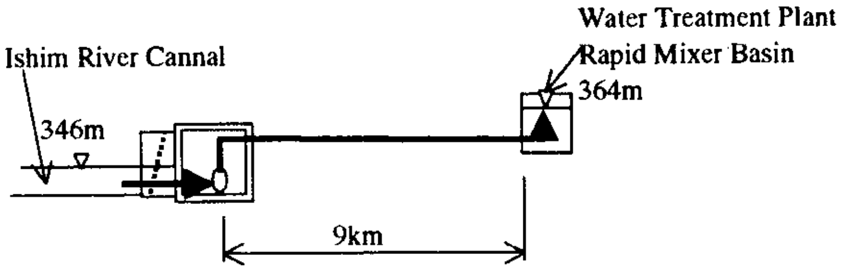


Figure A.3.4.1 Schematic Diagram for Ishim Intake P/S and WTP

Applying Hazen-Williams Formula, the head loss is calculated by several operational options;

1) Actual Measurement : Measured flow by the existing flow meter =0.255 m^3/sec, pressure gauge reading at distribution pipe = 2.0 kgf/cm^2
2) Usual Operation : Operation of smaller pump with a capacity of 1,600 m^3/hr
3) Main Pump (1) : Operation of main pump with a capacity of 2,400 m^3/hr x 1 unit.
4) Main Pump (2) : Operation of main pump with a capacity of 2,400 m^3/hr x 2 units.

$$V = Q/A = 0.8495 \times C \times R^{0.63} \times I^{0.54} \Rightarrow I = (1.1774Q/(A \times C \times R^{0.63}))^{1/0.54}$$

where; V : Velocity (m/sec)
Q : Flow (m^3/sec)
A : Cross Sectional Area (m^2)
C : Velocity Coefficient (New pipe = 130)
R : Hydraulic Radius (m)
I : Hydraulic Gradient

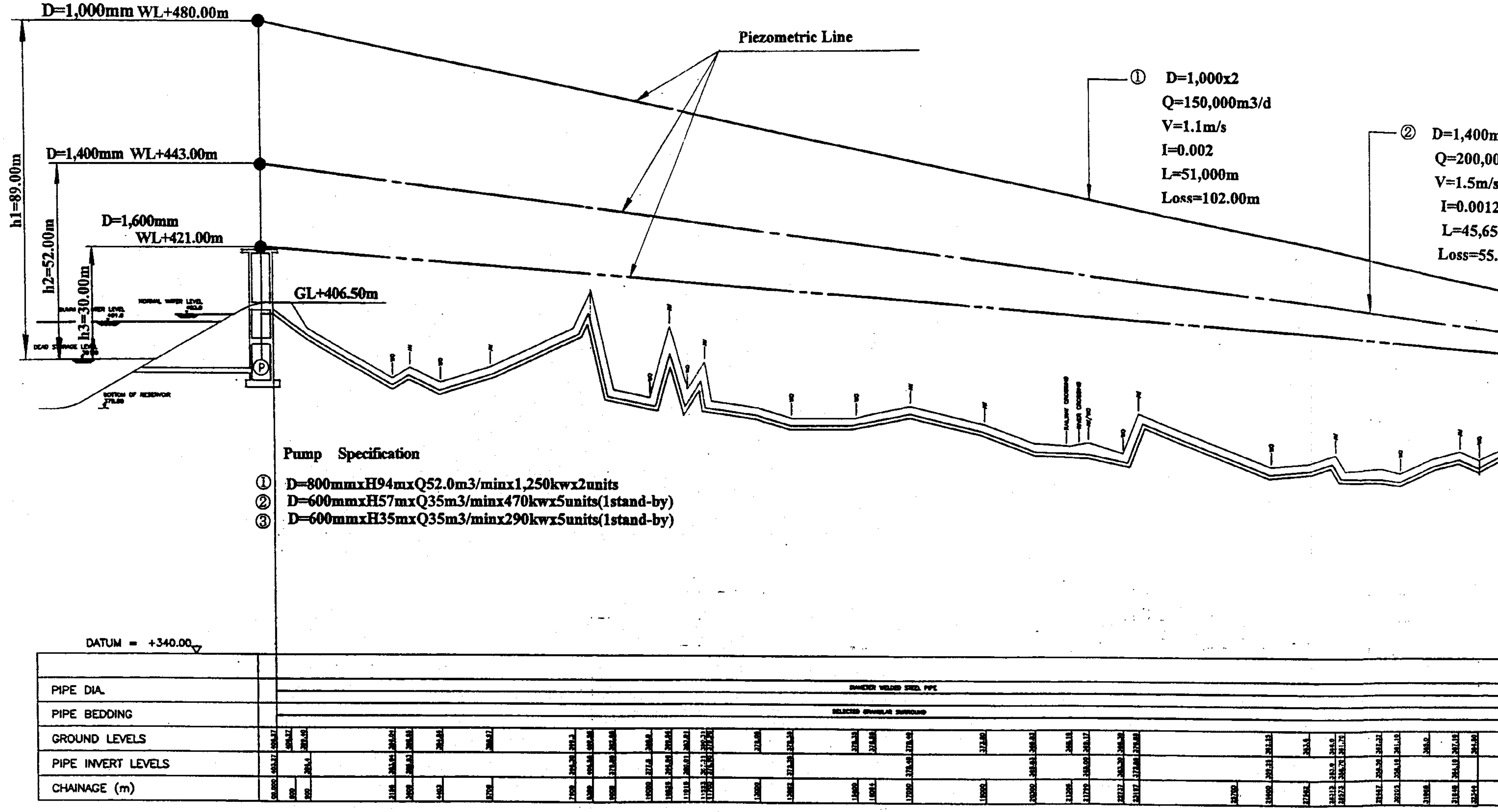
110 was adopted for C value, since the calculation based on "Usual Operation Option" with 110 most corresponds to the "Actual Measurement". Calculation results are shown below:

Table A.3.4.1 Calculation of Pipe Loss

Item	Actual Measurement	Usual Operation	Main Pump (1)	Main Pump (2)
Q (m^3/s)	0.255	0.444	0.667	1.333
I	0.000141	0.000393	0.000836	0.003012
C	110	110	110	110
R (m)	0.250			
A (m^2)	0.7854			
Loss for 9 km (m)	1.3	3.5	7.5	27.1
Head	19.0	19.0	19.0	19.0
Pump H (m)	20.3	22.5	26.5	46.1

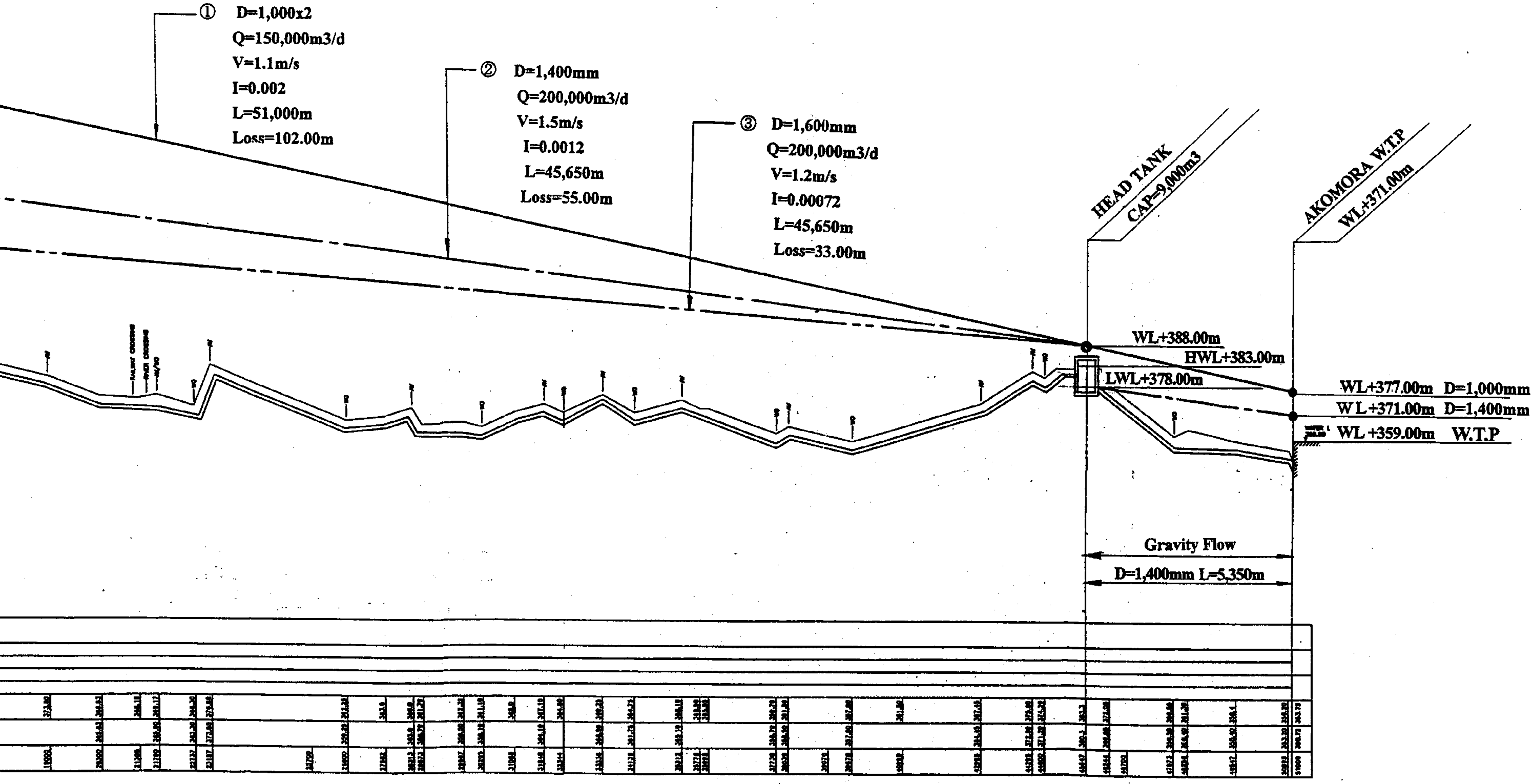
A.3.5 Head Loss Calculation for New Transmission Pipeline

Items Cases	Case 1	Case 2	Case 3
Pipe Diameter (mm)	1,000 x 2 lines	1,400 x 1 line	1,600 x 1 line
C Value	90	130	130
Q (m^3/day)	150,000	200,000	200,000
V (m/sec)	1.1	1.5	1.2
I	0.00198	0.00120	0.00072
L_1 (m, pressured)	51,000	45,650	45,650
L_2 (m, gravity)	-	5,350	5,350
Actual Head (m)	89.0	52.0	30.0
Friction Loss (m)	-	7.0	7.0
Pump Head (m)	89+5 = 94	52+5 = 57	30+5 = 35
Power (kW)	1,250 kW	470 kW	290 kW
Units (stand-by)	3 (1)	5 (1)	5 (1)



Raw Water Transmission Profile, Vyacheslavsky to WTP

Scale Horiz 1 : 50,000. Vert 1:500



Transmission Profile, Vyacheslavsky to WTP

Scale Horiz 1 : 50,000. Vert 1:500

A.4 Water Treatment Facilities

A.4.1 Facilities in Water Treatment Plant

Table A.4.1.1 Sedimentation and Coagulation Facilities

Item	Rapid Mixing Tank	Coagulant Dissolution Tank	Dissolved Coagulant Storage Tank	Coagulant Injection Tank	Powder Activated Carbon Injection Facilities	Polymer Injection Facilities
Type	Vertical Flow Mixing, Reinforced Concrete	Reinforced Concrete	Reinforced Concrete	Gravity Injection, Reinforced Concrete	Dissolved Tank and Injection Pump	Dissolved Tank and Injection Pump
Number	2	8	3	6	1	1
Dimension	V=368 m^3	W 5.8 x 5.8 x H 2.5, V=84 m^3 x 7 = 588 m^3 Mixer: Air Bubbling, Blower 6 units	W 11.7m x L 5.7m x H 3m, V=200 m^3 x3 = 600 m^3 Transportation Pump: Chemical Pump	3 m^3 x 6 + Injection Pipes and Valves	Dissolve tank: 3 m^3 with agitator, Injection Pump: Centrifugal type	Dissolve tank: 3m^3 with agitator, Injection Pump: Centrifugal type
Status			Used occasionally	Used occasionally	Used occasionally	Used occasionally
Item	Inlet Valve	Rapid Mixing Tank Outlet Valve	Flocculation Basin Inlet Valve	Flocculation Basin	Sedimentation Basin	
Type	Motor Valve	Motor Valve	Motor Valve	Up-flow Reinforced Concrete	Horizontal Reinforced Concrete	
Number	4	3	3	20	20	
Dimension	D-1000	D-1000	D-600	V:2,290 m^3 T:16.5min	V:23,200 m^3 DT:2.8hr Average Horizontal Speed: 0.3m/min	
Status	By-Pass Valve is installed			Drain Pipe is installed	Drain Pipe is installed	

Table A.4.1.2 Filtration Facilities

Item	Filter	Filter Layer and Trough	Filter Washing Pump	Pipes and Vaives	Electric Facilities
Type	Rapid	Quartz Sand Gravel	Centrifugal	Steel Pipe and Motor valve	Control Panel
Number	10	10	1(1)	10	10
Dimension	(1)w5.1xL10.5mx2 Area:107.1m^2 Filtration rate: 186.7m/d (no stand-by) Back-Wash: 0.6m/min, Washing Time:10min, Water consumption of washing: 6,000 m^3/d	A:107.1 m^2 Filter Bed : t= 0.26m Installed steel perforated Pipe Gravel Bed : t=0.6m (4th Layer), Quartz-sand (0.5-1.2mm): t=1.0m Trough : W0.8m x L5.4 x 6 unit x2 line	Q:5,000 m^3/hr (83.3/min) D: 800mm H: 30m kw: 500	Inlet:d-600mm Out-let:d-600mm Drain: d-1.000mm Back-wash: d-800mm	Manual operation for valve & washing facilities
Status			Motor Valve is installed		

A.4.2 Facility Loadings

Facility Name	Specification	Facility Loading	Japanese Criteria	Kazakhstan Criteria
Rapid Mixing Tank	737 m^3 x 1 unit	Retention time : 6.4 min	1 to 5	6 to 10
Inlet Pipe	Diameter 1,000 mm x 2 units	Velocity : 1.22 m/sec	----	0.7 to 1.2
Floculation Basin	114.5 m^3 x 20 units	Retention time :20.0 min	20 to 40	<20
Sedimentation Basin	1,160 m^3 x 20 units	Retention time : 3.4 hr	---	1 to 3
Surface Area	A = 5,928 m^2 (total)	Surface load : 19.3 m/min	15 to 30	---
Section Area	A = 468 m^2 (total)	Surface load : 0.24 m/min	0.4>	---
Water Collecting Weir	None	None	500	---
Rapid Filter	105 m^2 x 10 units	Filtration speed : 157.1 m/day	120-150*[1]	96-288
Back-wash Pump	5,000 m^3/hr	Washing speed : 0.78 m/min	0.6-0.9	0.72-0.84
Surface or Air Wash	None	None	0.15-0.2	(Air Wash)
Reservoir	20,000 m^3 x 2 units	Retention time : 5.8 hr	12>	2-11

*[1]: 1 supplemental basin is needed

A.5 Water Distribution Facilities in WTP

Table A.5.1.1 Facilities of Drinking Water Distribution System

Item	Distribution Pumps				Electric Facilities	Power Supply Facilities	Hoist Crane
Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Standing Panel	Standing Panel	Hoist type
No. of Unit	(1)	2(1)	1	2(1)	6	1	1
Specification	Q:6,300 m^3/hr H:50m D:1000,800mm kW:1000	Q:3,600 m^3/hr H:55m D:800,600mm kW:630	Q:2,500m^3/hr H:60m D:600,500mm kW:500	Q:1,500.m^3/hr H:65m D:600,400mm kW:315	Renewed in 2,000	Renewed in 2,000	W : 12m Loading Weight: 20t
Status	Motor Valve included	Motor Valve included	Motor Valve included	Motor Valve included			

Note : ( ) shows stand-by

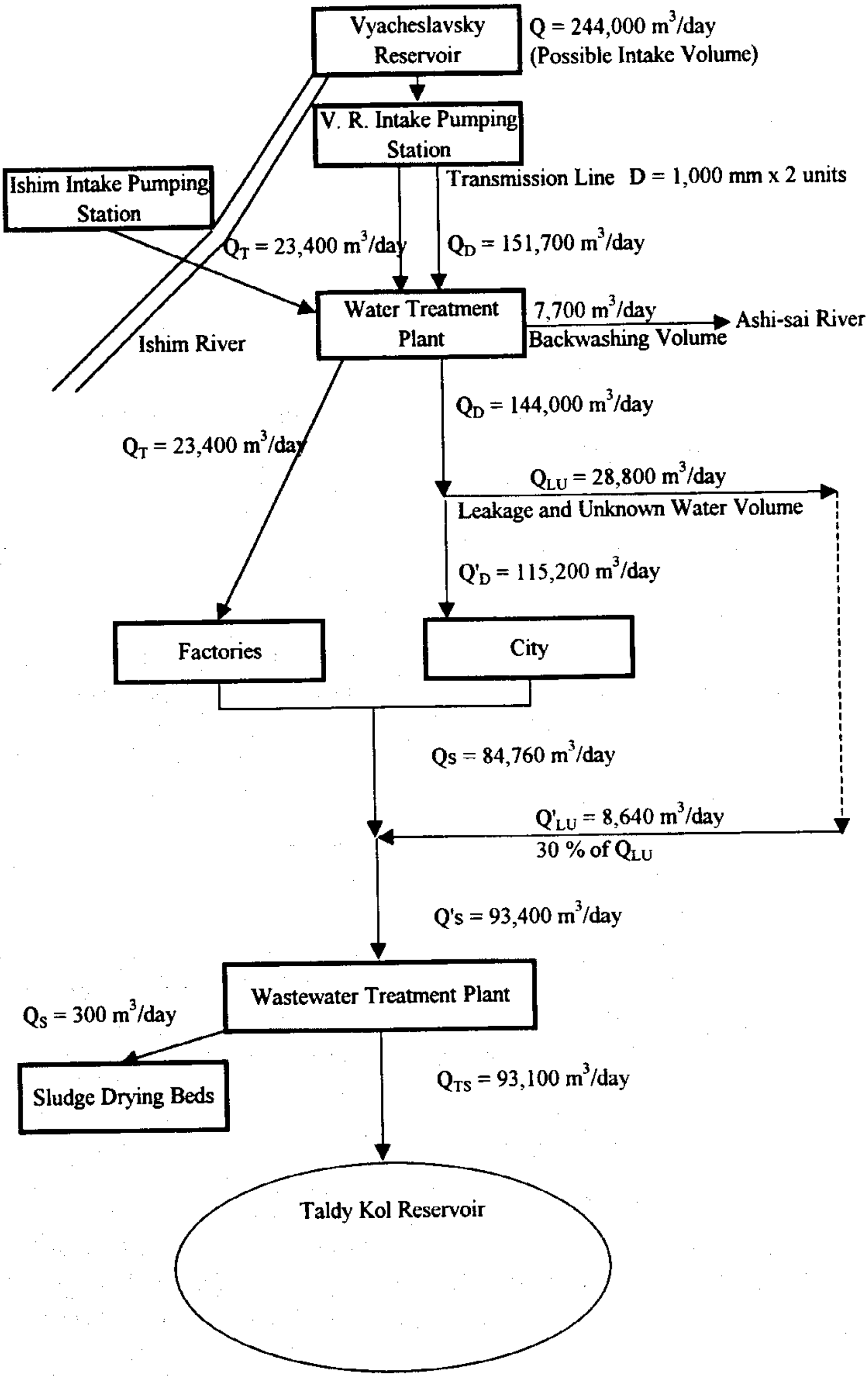
Table A.5.1.2 Facility List of Technical Water Distribution System

Item	Distribution Pumps			Electric Facilities	Power Supply Facilities
Type	Centrifugal	Centrifugal	Centrifugal	Standing Panel	Standing Panel
No. of Unit	(1)	(1)	3(1)	1	1
Specification	Q:3,600 m^3/hr H:55m D:800,600mm kW:630	Q:3,200 m^3/hr H:55m D:800,600mm kW:630	Q:500 m^3/hr H:70m D:400,300mm kW:320	----	Renewed 2,000
Status	Motor Valve included	Motor Valve included	Motor Valve included		

Note : ( ) shows stand-by

A.6 Water Demand Projection

A.6.1 Overall Water Balance in Astana City in 2010



A.7 Water Supply Facility Plan

A.7.1 Examination on Types of Treatment Facilities

(1) General Description

- For flow measurement and water quality analysis on incoming raw water, Raw Water Receiving Well will be installed.
- Agitator will be installed in Rapid Mixing Tank for efficient coagulant dissolution.
- In Flocculation Tank, instead of mechanical mixer, gravity flow will be utilized for moderate mixing to grow floc.
- Sedimentation Basin will segregate floc by sedimentation. Effluent trough will be installed to prevent carry over of floc. Sludge will be gathered by sludge collector and be withdrawn by sludge pump.

(2) Detailed Examination

1) Rapid Mixing Tank

Rapid Mixing Tank has two types, namely a) Gravity Mixing Type and b) Mechanical Mixing Type. However, mixing intensity of gravity mixing type will be largely affected by incoming flow and thus mixing effect is not stable. While, mixing effect of mechanical type is stable and power consumption of mixer is relatively small. Malfunction of this type of mixer seldom occurs.

Therefore, <u>Mechanical Mixing Type</u> will be adopted.

2) Flocculation Tank

Flocculation Tank also has two types, namely a) Mechanical Mixing Type and b) Gravity Mixing Type. Mechanical type is large-scaled and repair of worn-out parts is complicated. Also, power consumption in not small. Though gravity type has defect that mixing intensity is largely affected by incoming flow, flow can be adjusted by operation number of the tank.

Therefore, <u>Gravity Mixing Type</u> will be adopted.

3) Sedimentation Basin

Major types of Sedimentation Basin is a) Horizontal Flow Type (Rectangular Tank), b) Radial Flow Type (Circular Tank) and c) Sludge Blanket Type. However, sludge blanket type is not suitable for raw water with turbidity less than 5 degree and radial flow type is not applicable considering the limited site area.

Therefore, Horizontal Flow Type, same as the existing one, will be adopted.

As for sludge collector, the simplest "Submerged Wire Traction Type" will be employed.

4) Rapid Sand Filter

Rapid Sand Filter is classified by washing methods of filter layer. Major washing methods are as follows;

- Back-washing only
- Back-washing and Surface-washing
- Washing by air and water

Back-washing is applied in the existing WTP but if chemicals are applied in water treatment, sand surface is mainly clogged. So, surface-washing shall also be adopted. System and operation of air-water washing is complicated.

Therefore, Back-washing and Surface-washing shall be applied.

Surface-washing needs pump since pressure of 2.0 kg/cm^2 will be necessary for washing. Back-washing in the existing filters is conducted by pump operation but filter can be back-washed by other filter's filtration water. This method is called "Self Back-washing Method". Compared with back-washing by pump, system of self back-washing method is quite simple and also economical.

Therefore, Self Back-washing Method will be applied as back-washing method.

A.7.2 Capacity Calculation for Proposed Water Treatment Plant

I Design Criteria

1) Design Flow

Table 7.2.1 Design Treatment Flow

	m^3/day	m^3/hour	m^3/min	m^3/sec
Daily Maximum Flow	173,000	7,208	120.1	2.00
Existing Plant	73,000	3,042	50.7	0.84
New Plant	100,000	4,167	69.4	1.16

Table 7.2.2 Design Distribution Flow

	m^3/day	m^3/hour	m^3/min	m^3/sec
Hourly Maximum Flow	242,000	10,083	168.1	2.80
Daily Maximum Flow	173,000	7,208	120.1	2.00
Daily Average Flow	144,000	6,000	100.0	1.67

2) Design Flow by Treatment Facilities

Table 7.2.3 Design Treatment Flow by Unit of Facilities

	Units in the Existing Plant	Units in the New Plant	Design Flow by Unit
Receiving Well	0	2	52,500 m^3/day/unit
Rapid Mixing Tank	2	2	52,500 m^3/day/unit
Flocculation Basin	20	6	17,500 m^3/day/unit
Sedimentation Basin	20	6	17,500 m^3/day/unit
Rapid Sand Filter	10	12	8,750 m^3/day/unit
Chlorine Mixing Tank	0	1	100,000 m^3/day/unit

3) Solid Loadings of Treatment Facilities for Sludge and Back-washing Water

Table 7.2.4 Solid Loadings by Facilities

	No. of Unit	Solid Loading	Remarks
Back-washing Water Receiving Tank	2	1,200 m^3/unit	Equivalent to the back-washing water volume of 2 units
Sludge Thickener Tank	2	7.037 t-DS/day	In high turbidity (173,000 m^3/day)
Sludge Drying Bed	9	1.633 t-DS/day	In ave. turbidity (144,000 m^3/day)
Dry Cake Yard	1	1.633 t-DS/day	ditto
Discharge Pool	2	1,500 m^3/unit	Supernatant from sludge thickening tank and sludge drying bed

II. Water Treatment Plant

Item	Total System
Planned Flow	Q= 100,000 m^3/day
Plant Capacity (Daily Max)	Q= 105,000 m^3/day 100,000 m^3/day = 4,375 m^3/hour 4,167 m^3/hour = 72.9 m^3/min 69.4 m^3/min = 1.215 m^3/sec 1.157 m^3/sec
(1) Receiving Well Criteria	Retention Time T = 2.0 min
Dimension	Rectangular 2 units L m x W m x D m x units 6.0 4.2 5.0 2 V= 252.0 m^3 T= 3.5 min
(2) Mixing Chamber Criteria	Mechanical Mixing Retention Time T= 1 - 5 min
Dimension	Rectangular 2 units L m x W m x D m x units 4.2 4.2 5.00 2
Unit Volume Total Volume Retention Time	UV = 88.2 m^3/unit V = 176.4 m^3 t = 2.0 min
(3) Flocculator Criteria	Retention Time T = 20 - 40 min Required Volume V = 1,458 m^3 to 2,917 m^3
Unit Flow	q = 12.2 m^3/min/basin
Dimension	6 units
Step 1	W m x L m x D m m x No.of Channel 1.3 10.0 3.7 2
Step 2	W m x L m x D m m x No.of Channel 1.8 10.0 3.7 2
Step 3	W m x L m x D m m x No.of Channel 2.4 10.0 3.7 2
Volume	Step 1 96.2 m^3/unit Step 2 133.2 m^3/unit Step 3 177.6 m^3/unit Volume / Unit 407.0 m^3/unit
Totol Volume	V= 2,442 m^3

Item	Total System
Retention Time	33.5 minutes
(4) Sedimentation Basin	
Type	Rectangular, Horizontal Flow
Unit Flow	q = 729 cu m/hr/basin
Criteria	Retention Time T = 2.5 hours Surface Load a = 15 - 30 mm/min Hor. Flow Velocity v < 0.40 m/min L/W Ratio L/W = 3 - 8 times Depth D = 3 - 4 m Depth of 30 cm or more is provided for sludge settlement.
Dimension	No. 6 basins W m x L m x D 9 50 4.0
Volume	V = 1,800 m^3/basin
Retention Time	T = 2.5 hours
L/W Ratio	L/W = 5.6
Surface Load	a = 27.0 mm/min
Hor. Flow Velocity	v = 0.338 m/min
Overflow Weir	Load = 350 m^3/m/day
Trough Length	L = 50 m or longer No. 6 troughs L m x N 4.2 6 L = 50.4 m
Sludge Removal	Cable-operated underwater bogie sludge collector
(5) Rapid Sand Filter	
Type	Down Flow, Single Media
No.	12 units (wash 2 unit)
Unit Flow	q = 8,750 m^3/day/unit
Criteria	Filtration Rate Fr = 120 - 150 m/day Filter Area per Unit A < 73.1 m^2
Dimension	W m x L m x N units 5.8 12.6 12 (10 filters/group) A = 73.1 m^2/unit
Filtration Rate	Fr = 120 m/day (12units)

Item	Total System		
Filtration Rate during washing	Fr'= 144 m/day (10units) 2 units out of 12 are washing		
Filter Washing Frequency	Once a day for each filter		
Rate	Surface Washing	rate = duration =	0.20 $m^3/m^2/min$ 5 min
	Backwashing	rate = duration =	0.80 $m^3/m^2/min$ 7 min
Water Amount for washing	Surface Washing	Vs =	73.1 m^3/unit
	Backwashing	Vb =	409.2 m^3/unit
		Vs + Vb =	482.3 m^3/unit
for Total Units	Total Amount for Washing		5,787.9 m^3/day
	Percentage for Planned Flow		5.5 %
(6) Chlorination Channel			
Location	at the Inlet of the Clear Water Reservoir		
Criteria	Contact Time	T >	5 minutes
Required Volume	V = 347 m^3		
Dimension	No. 1 units L m x W m x D m x N units 56.5 2.4 3.4 1		
Total Volume	v = 461 m^3		
Retention Time	t = 6.3 min		
(7) Distrbution Reservoi	(existing reservoirs)		
Criteria	Retention Time	T >	8.0 hours
Required Volume	V = 57,667 m^3		
Dimension	No. 3 units L m x W m x D m x N units 64.0 64.0 5.0 3		
Total Volume	V = 61,440 m^3		
Retention Time	T = 8.52 hours		
(8) Distribution Pumps			
Required Total Capacity	V = 140,000 m^3 (Hourly Maximum)		
Pump Capacity	Capacity of Large Pump/Small Pump = 2/1		
Large Pump	V_L = 140,000/24 hr/(2+1/2x2)=1,944 m^3/day = 33 m^3/min		
Small Pump	V_S = 33/2 = 16.5 m^3/min		

III Treatment Facilities for Sludge and Back-washing Water

(1) Design Criteria upon Capacity Calculation

1) Design Turbidity

As design turbidity upon capacity calculation, four times of annual average turbidity will be applied. Since annual average turbidity in 1999 was 7.5 degree, 30 degree will be adopted as design turbidity.

2) Design Solid Volume and Sludge Volume

Design solid volume and sludge volume is tabulated in Table 1.1.

Table 1.1 Design Solid Volume and Sludge Volume

	Treated Water Volume (m^3/day)	Turbidity (deg)	Alum Injection Rate (mg/L)	Solid Volume s(t-Ds/day)	Generated Sludge	Sludge Concentration (%)	Sludge Volume (m^3/day)
Annual Average Turbidity	144,000	7.5	10.0	1.633	S.B. Sludge	0.2	816.5
					S.T.T. Sludge	2.0	81.7
In case of High Turbidity	173,000	30	20.0	7.037	S.B. Sludge	0.2	3,518.5
					S.T.T. Sludge	4.0	175.9
In case of Low Turbidity	144,000	1	2.5	0.257	S.B. Sludge	0.2	128.5
					S.T.T. Sludge	2.0	12.9

Note) S.B. : Sedimentation Basin, S.T.T. : Sludge Thickener Tank

a) $So = Q \times [k \times (T_1 - T_2) + B \times 156/666] \times 10^{-6}$

Q : Treated Water Volume

k : Conversion rate of Turbidity and SS = 1.2(0.8~1.5)

T_1 : Turbidity of Raw Water

T_2 : Turbidity after sedimentation = 0

B : Alum Injection Rate

b) Withdrawal Sludge Volume

Total number of sludge withdrawal hopper is 48 units and sludge will be withdrawn 24 times in a day. Sludge withdrawal duration is 60 sec/time.

According to the withdrawal pipe capacity, sludge withdrawal volume is q=0.05 m^3/sec. (ϕ 250mm, I=4.5/1,000, Q=3,700 m^3/day)

Daily sludge withdrawal volume = 0.05 m^3/sec x 60 min x 48 units x 24 times/day = 3,456 m^3/day

c) Withdrawal Sludge Concentration

Based on the aforementioned calculation results, concentration of sludge in Sedimentation Basin was calculated as follows;

W = 7.404 t-DS/d x 1/3,518.5 m^3/day x 100 = 0.2%

(2) Capacity Calculation

1) Back-wash Drainage Receiving Tank

This tank will receive the back-washing drainage from Rapid Sand Filter and return the treated water to Raw Water Receiving Well. Necessary tank capacity shall be 120 % of back-washing water volume per filter, accounting 20 % of allowance.

Back-washing drainage volume per filter (Existing WTP)

Back-washing 0.8 m^3/m^2/min x 105 m^2/filter x 7 min x 1unit = 588 m^3⇒600m^3

Back-washing drainage volume per filter (New WTP)

Surface washing 0.2 m^3/m^2/min x 70.7 m^2/filter x 5 min x 1unit = 71 m^3

Back-washing 0.7 m^3/m^2/min x 70.7 m^2/filter x 7min x 1unit = 346 m^3

Sub Total =417m^3

Total 600+417=1,017 m^3

Accounting 20% of allowance, 1,200 m^3 shall be adopted.

Dimension : W 14.0 m x L 29.0 m x H 3.0 m

No. of Units : 2 units (1 unit stand-by)

Capacity : 1,200 m^3/tank x 2 = 2,400 m^3

2) Return Pump (Back-wash Drainage Receiving Tank to Raw Water Receiving Tank)

Type : Sludge Pump with suction screw

Capacity : Pump capacity shall be sufficient to return the back-wash drainage per 1 unit of filter up to raw water receiving tank in 2 hours.

Q=1,200 m^3/2hr x 60min = 10.0m^3/min x 2 units(1 unit stand by)

P=0.163 x 10.0 m^3/min x 20 m/0.75 x 1.2=55 kW

3) Sludge Thickener Tank

This tank will store the sludge from Sedimentation Basin. Thickened sludge will be sent to Sludge Drying Bed.

Necessary Area : Adopting the solid loading of 20 kgDS/m^2/day;

A=7.037 kgDS/day x 1/20 kgDS/d=352 m^2/tank

Necessary Capacity : 2 units of thickener tank will be needed. According to the following capacity calculation methods, larger capacity will be adopted.

a) Capacity equivalent to 7 days' storage volume against high turbidity sludge, concentration is 4 % ;

7.037 t-DS/day x 1/0.04 x 7 day = 1,231 m^3/tank

b) Capacity equivalent to 3 months' storage volume against low turbidity sludge, concentration is 2 % ;

0.257 t-DS/day x 1/0.02 x 90 day = 1,157 m^3/tank

Therefore, tank capacity shall be 1,231 m^3/tank.

Dimension : Inner diameter 21.6 m x effective depth 3.5 m

(Surface Area 356 m^2/tank)

Capacity : 1,300 m^3 x 2 tanks = 2,600 m^3

Check : In case of low turbidity sludge (concentration is 2 %)

t = 2,600 m^3/12.9 m^3/day = 201 day>180 day OK

In case of low turbidity sludge (concentration is 4 %)

t = 2,600 m^3/175.9 m^3/day = 14 day>7day OK

Surface Area : A = 356 m^2/tank x 2 tanks = 712 m^2

Check (Solid Loading) :

In case of low turbidity sludge

t = 257 kgDS/day/356 m^2/tank = 0.7 kgDS/m^2/day

In case of high turbidity sludge

t = 7.037 kgDS/day/356 m^2/tank = 19.8 kgDS/m^2/day

<20 kgDS/m^2/day

4) Return Pump (Sludge Thickener Tank to Sludge Drying Bed)

Type : Horizontal Shaft Non-clog Type Sludge Pump

Design Sludge Volume : Pump capacity shall be sufficient to send the thickened sludge with volume equivalent to the capacity of 1 unit of sludge drying bed in 12 hours.

Q = 890 m^2 x 1.0 m/12 hrs+60 min = 1.24 m^3/min x 2 units (1 unit stand by)
P = 0.163 x 1.24 m^3/min x 15 m/0.4 x 1.2 = 6.3 = 7.5kW

5) Sludge Drying Bed

Solid loading of 35 kgDS/m^2/time is applied on Sludge Drying Bed. All beds are operated 2 times a year.

Necessary Area : 596,045 kgDS/year x 1/35 kgDS/m^2/time x 1/2 times = 8,500m^2
Dimension : 21.5 m x 44.0 m x 1.0 m (Effective Area 944 m^2)
Number of Beds : 9 beds
Capacity : 944 m^2/bed x 9 beds = 8,500 m^2

6) Sludge Cake Yard

This yard will store the dried sludge cake removed from sludge drying bed temporally before transportation by truck.

Dimension : 20 m x 35 m = 700 m^2
Number of Yard : 1 unit
Capacity : 700 m^2 x 1 m = 700 m^3 > 460 m^3/year
(1.633 t-DS/day/1.3t/m^3 = 1.26 m^3/day x 365days = 460 m^3/year)

7) Discharge Pool

Discharge pool will store the supernatant of sludge thickener tank and sludge drying bed.

Necessary Capacity : Water Quality Sampling Drainage 260 m^3 + Sludge Thickener Tank 817 m^3 + Sludge Drying Bed 445 m^3 = 1,500 m^3
Dimension : 9.0 m x 42.0 m x 4.0 m (Effective capacity 1,500 m^3)
No. of Tank : 2 tanks (1 unit stand by)
Capacity : 1,500 m^3/tank x 2 tanks = 3,000 m^3

8) Discharge Pump Facility

Pump Type : Horizontal Shaft Non-clog Type Sludge Pump

Design Capacity : Pump capacity shall be sufficient to pump stored supernatant of 1,500 m^3 in one day.

Q = 1,500 m^3/24 hr x 60 min = 1.0 m^3/min x 2units (1 unit stand-by)

P = 0.163 x 1.0 m^3/min x 15m/0.6 x 1.2 = 3.4kW = 3.7kW

(3) Design of Chemical Dosing Facilities

1) Alum Injection Rate

Based on the actual plant operation from January 1999 to August 2000, design alum injection rate was determined as follows;

Table 3.1 Design Alum Injection Rate

	Turbidity in Raw Water (degree)	Alum Injection Rate (ml/L)	Remarks
Maximum	30 (7.5 x 4)	**20** (19.5)	
Average	7.5	**10** (8.69)	
Minimum	1.0	**2.5** (1.09)	

Note : ( ) actual operational rate

2) Alum Injection Facility

Design Flow 173,000 m^3/day = 120.1 m^3/min

Injection Rate Max. 20 mg/L
Average 10 mg/L
Minimum 2.5 mg/L

Solution Concentration Al_2O_3 15 %

Dissolve Tank Capacity

Q = 173,000 m^3/day x 15 mg/L/1,000 = 2,595 kgAlum/day

2,595 kgAlum/day/(15/100) x 1/1,000=20.0 m^3/day

Dimension 2.2 m x 2.2 m x 1.5 m

No. of tanks 4 tanks (1 tank stand by)

Capacity 7.0 m^3/tank x 3 tanks = 21 m^3

3) Chlorination Facility

Table 3.2 Chlorination Rates

	Pre-Cl Rate	Post Cl Rate	Remarks
Maximum	10.0	**5.0** (4.93)	
Average	5.0	**3.0** (2.91)	
Minimum	3.0	**1.5** (1.39)	

Note : ( ) actual operational rate

a) Pre-Chlorination Facility

Design Flow	173,000 m^3/day = 7,208 m^3/hr
Chlorination Rate	Maximum 10.0 mg/L
	Average 5.0mg/L
	Minimum 3.0mg/L
Cylinder	1 ton cylinder (Actual capacity 900 kg)

<u>Chlorinator</u>

Injection Volume	Q_{Ave} = 7,208 m^3/hr x 5.0 mg/L/1,000 = 36.0 kg/hr
	Q_{Max} = 7,208 m^3/hr x 10.0 mg/L/1,000 = 72.1 kg/h
	Q_{Mim} = 7,208 m^3/hr x 3.0mg/L/1,000 = 21.6 kg/h
Injection Range	Max 72.1 kg/hr
	Min 21.6 kg/hr
Specification	20 kg/hr
No. of Chlorinator	5 units (1 unit stand by)

b) Post Chlorination Facility

Design Flow	173,000 m^3/day = 7,208 m^3/hr
Chlorination Rate	Maximum5.0mg/L (4.93)
	Average 3.0mg/L (2.91)
	Minimum 1.5mg/L (1.39)
Cylinder	1 ton cylinder (Actual capacity is 900 kg)

<u>Chlorinator</u>

Injection Volume	Q_{Ave} = 7,208 m^3/hr x 3.0 mg/L/1,000 = 21.6 kg/hr
	Q_{Max} = 7,208 m^3/hr x 5.0 mg/L/1,000 = 36.0 kg/hr
	Q_{Min} = 7,208 m^3/hr x 1.5 mg/L/1,000 = 10.8 kg/hr
Injection Range	Max 36.0 kg/hr
	Min 10.8 kg/hr
Specification	20 kg/hr
No. of Chlorinator	3 units (1 unit stand by)

c) Chlorine Cylinder

As calculated, average chlorine injection volume is 57.6 kg/hr (= 21.6+36.0), by pre and post chlorination. Assuming possible chlorine gas withdrawal rate from 1 ton cylinder is 20 kg/hr, 3 cylinder is necessary to cope with the said total hourly injection volume. 3 units of measures shall also be installed. Daily cylinder consumption in case of average injection is;

57.6 kg/hr x 24 hrs = 1,382 kg/900 kg = 1.54 cylinder/day

Necessary storage day is 15 days. Therefore, necessary number of cylinder is;

1.54 cylinder/day x 15 days = 23 cylinder

Storage day is;

T = 900 kg x 23 cylinder/57.6 kg/hr x 24 hr = 15.0 days

d) Injection Pumps

Specification	Horizontal Type centrifugal Pump
Pre Chlorination	Q = 36.0 kg/hr x 10^6/1,500 mg/L = 24,000 L/hr = 400 L/min x 2 units (1 unit stand by) P = 0.163 x 0.400 m^3/min x 40 m/0.83 x 1.2 = 2.6 kW = 3.7kW
Post Chlorination	Q = 21.6 kg/hr x 10^6/1,500 mg/L = 14,400 L/hr = 240 L/min x 2 units (1 unit stand by) P = 0.163 x 0.24 m^3/min x 40 m/0.83 x 1.2 = 1.6 kW = 2.2 kW

A.8 Operation and Maintenance Plans

A.8.1 Staffing Arrangements

(1) Vyacheslavsky Reservoir Intake P/S

Breakdown of current and proposed staff arrangement in Vyacheslavsky reservoir Intake P/S is shown in Table A.8.1.1.

Table A.8.1.1 Staff Arrangement of Vyacheslavsky Intake P/S

Assignment	Present	Proposal
Manager	1	1
Electric Engineer		1
Electric Worker	1	
Mechanic	1	1
Driver	1	1
Auxiliary Workers	2	-
Shift Workers	2 men x 4 shifts	2 men x 4 shifts
Total	14	12

Proposed staff will maintain both of the existing P/S and the new one. In new intake P/S, all equipment excluding motor will be installed in B1 floor and daily O&M works will be much easier. Operation safety and stability will also increased because transmission pressure will be lessen to almost half on the current pressure. However, shift workers are absolutely needed and as daytime worker, manager, electric engineer, mechanical engineer and driver are necessary.

(2) Ishim Intake P/S

The present staff arrangement will be adopted in future operation.

Table A.8.1.2 Staff Arrangement of Ishim Intake P/S

Assignment	Present	Proposal
Manager	1	1
Shift Workers	2 men x 4 shifts	2 men x 4 shifts
Total	9	9

(3) Water Treatment Plant

Table A.8.1.3 shows the current and proposed staff arrangement in the existing WTP, including distribution P/S. Although all facilities of the existing WTP will remain, treatment capacity will be largely decreased and its liability will also be lowered. Since the new WTP will introduce the automatic operation and monitoring system, less O&M staff will be needed. Therefore, some O&M staff assigned in the existing WTP shall be allocated for the new WTP and/or their number shall be reduced.

Table A.8.1.3 Staff Arrangement of WTP

Assignment	Present	Proposal
Manager	1	1
Section Chief	4	4
Electric Engineer	1	2
Mechanic Engineer	1	2
Operator (Existing)	23	11
Operator (New)	—	12
Operator (Sludge)	—	4
Repair and Others	26	13
Laboratory	18	18
Auxiliary Workers	10	5
Shift Workers	4 men x 4 shifts	4 men x 4 shifts
Total	100	88

Transportation of dried sludge cake shall be "contract-out".

(4) No.7 Booster P/S

No.7 Booster P/S will serve the whole Western Area and its role will be quite important. Current and proposed staff arrangement is shown in Table A.8.1.4. Considering the significant of this P/S, one additional electric worker shall be assigned to cope with emergency cases.

Table A.8.1.4 Staff Arrangement of No.7 Booster PS

Assignment	Present	Proposal
Electric Worker	0	1
Shift Workers	2 men x 4 shifts	2 men x 4 shifts
Total	8	9

(5) Alyuviy Booster P/S

Current staff arrangement will be maintained through the future.

Table A.8.1.5 Staff Arrangement of Alyuviy Booster PS

Assignment	Present	Proposal
Shift Workers	1 men x 4 shifts	4
Total	4	4

(6) ASA

As shown in Table A.8.1.6, about 310 staffs are allocated in water supply sector of ASA currently. Since water supply service area will be expanded, staff of "Water Network Section" shall be increased as well as "Electrical Section" to secure appropriate O&M of the system. 50% of additional staff assignment is proposed. Especially, electric section will bear important role in future system operation and thus, additional staff shall be engineers familiar with advanced technology. Proposed staff assignment will be as shown in Table A.8.1.6.

Table A.8.1.6 Staff Arrangement of ASA

Sections	Present	Proposal
Emergency Dispatch Service	24	24
Water Network Section (Zone 1)	15	23
Water Network Section (Zone 2)	15	23
Work Shop Section	10	10
Mechanical Section	150	150
Repair/Construction	60	60
Electric Section	34	51
Total	308	341

A.8.2 Power Consumption in 1999 and 2010

(1) Vacheslavsky Reservoir Intake P/S

1) In 1999

Specifications of the existing pumps are as follows;

- 4,095 m^3/hr x 1,250 kW x 95 mH x 2 units
- 6,300 m^3/hr x 2,000 kW x 95 mH x 1 unit (stand-by)

As of now, the upper 2 units of pumps are mainly operated, so the power consumption will be as follows;

E_{1999} = 1,250 kW x 24 Hrs x 2 units x 365 days = <u>21.9 million kWH/Year</u>

2) In 2010

Specification of the newly installed pumps in the New Vyacheslavsky Intake P/S will be as follows;

2,100 m^3/hr x 470 kW x 57 mH x 5 units (1 unit : stand-by)

In actual operation, 4 units of pumps will be operated, so the power consumption will be as follows;

E_{2010} = 470 kW x 24 Hrs x 4 units x 365 days x 0.67 = <u>11.0 million kWH/Year</u>

where : 0.67 = power saving ratio by introduction of "Automatic Operation System"

(2) Distribution P/S in Water Treatment Plant

1) In 1999

a) Drinking Water System

Specifications of the existing pumps are as follows;

- 6,300 m^3/hr x 1,000 kW x 50 mH x 1 unit
- 3,600 m^3/hr x 630 kW x 55 mH x 2 units (1 unit is operated)
- 2,500 m^3/hr x 500 kW x 60 mH x 1 unit (operated)
- 1,500 m^3/hr x 315 kW x 70 mH x 2 units (1 unit is operated)

As of now, some of these pumps are mainly operated, so the power consumption will be as follows;

E_{1999D} = (630 kW + 500 kW + 315 kW) x 24 Hrs x 1 unit x 365 days
= <u>12.7 million kWH/Year</u>

b) Technical Water System

Specifications of the existing pumps are as follows;

- 3,600 m^3/hr x 630 kW x 55 mH x 1 unit
- 3,200 m^3/hr x 630 kW x 55 mH x 1 unit
- 500 m^3/hr x 320 kW x 70 mH x 3 unit (2 units are operated)

As of now, some of these pumps are mainly operated, so the power consumption will be as follows;

E_{1999T} = 320 kW x 24 Hrs x 2 unit2 x 365 days = <u>5.6 million kWH/Year</u>

2) In 2010

a) Drinking Water System

(Existing Pumps)

As aforementioned in Main Report, existing plant will only produce necessary volume of water and its estimated be production volume in 2010 is 82,000 m^3/day

Out of the existing pumps, capacity equivalent to the abovementioned plant capacity will be operated. Since 3,600 m^3/hr x 24 Hrs = 86,400 m^3/day> 82,000 m^3/day, the following pump will be operated;

- 3,600 m^3/hr x 630 kW x 55 mH x 1 unit

(New Pump)

Specifications of newly installed distribution pumps will be as follows;

- 1,944 m^3/hr x 200 kW x 55 mH x 3 units (1 unit stand-by)
- 972 m^3/hr x 160 kW x 55 mH x 2 units

Since the projected water demand in 2010 is 173,000 m^3/day, total pump capacity of new pumps shall be more than, 173,000 – 86,400 (existing pump) = 86,600 m^3/day

1,944 m^3/hr x 24 Hrs x 2 units = 93,312 m^3/day > 86,600 m^3/day

Therefore, 2 units of pumps with capacity of 1,944 m^3/hr will be operated.

So the total power consumption will be as follows;

E_{2010D}=(630kW + 200kW x 2units) x 24Hrs x 365days x 0.67= <u>6.0 million kWH/Year</u>

b) Technical Water System

Pump operation will be the same but power consumption will be reduced by introduction of "Automatic Operation System".

E_{2010T} = 320 kW x 24 Hrs x 2 units x 365 days x 0.67 = 3.8 million kWH/Year

(3) Ishim Intake P/S

1) In 1999

Specifications of the existing pumps are as follows;

- 2,400 m^3/hr x 1,000 kW x 50 mH x 1 unit (stand-by)
- 2,200 m^3/hr x 630 kW x 55 mH x 1 unit (stand-by)
- 1,600 m^3/hr x 800 kW x 20 mH x 1 units (operated)

As of now one pump is operated mainly. So the power consumption will be as follows;

E_{1999} = 800 kW x 24 Hr x 1 unit x 365 days = 7.0 million kWH/Year

2) In 2010

Pump operation is supposed as the same of that in 1999 but power consumption will be reduced by introduction of "Automatic Operation System".

E_{2010} = 800 kW x 24 Hr x 1 unit x 365 days x 0.67 = 4.7 million kWH/Year

(4) No.7 Booster P/S

1) In 1999

Specifications of the existing pumps are as follows;

- 2,400 m^3/hr x 1,000 kW x 50 mH x 1 unit (stand-by)
- 2,200 m^3/hr x 630 kW x 55 mH x 1 unit (stand-by)
- 1,500 m^3/hr x 500 kW x 70 mH x 1 units (operated)

As of now one pump is operated mainly. So the power consumption will be as follows;

E_{1999} = 500 kW x 24 Hr x 1 unit x 365 days = 4.4 million kWH/Year

2) In 2010

Pump operation is supposed as the same of that in 1999 but power consumption will be reduced by introduction of "Automatic Operation System".

E_{2010} = 500 kW x 24 Hr x 1 unit x 365 days x 0.67 = <u>2.9 million kWH/Year</u>

B. WASTEWATER

B.1 Wastewater Collection System

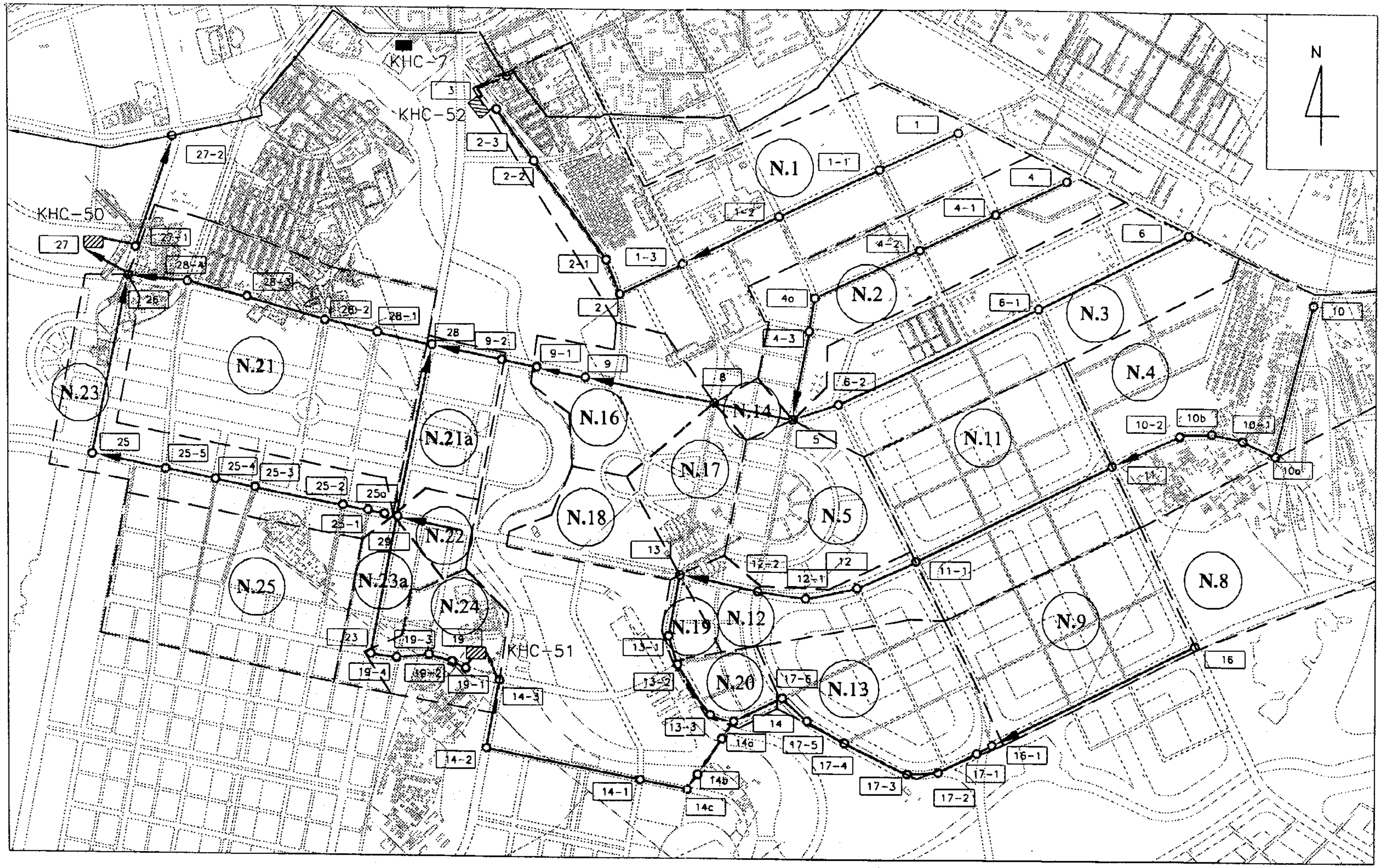
B.1.1 Proposed Sewage Pipeline Design - 2010

The study areas for extension of the system is presented on Figure B.1.1.
A schematic of the wastewater collection system in year 2010 is shown on Figure B.1.1.2.
Hydraulic calculation for proposed sewage pipeline carried out in accordance with SNiP is shown on Table B.1.1.1 and detailed explanation of captions is presented below;

Sewer Line No. : collectors reference number
Manhole No. : manhole reference number – upstream and downstream
Service Area Ref. No. : The Study areas for extension of the wastewater collection system are presented on B.1.1.
Sewage Flow : PCWD x 0.9 x service population
Other Flow : infiltration (sewage flow x 0.1)
Average Flow : Sewage Flow + Other Flow
Peak Flow : Average Flow x 2
Full Flow Q : pipe full capacity
Full Flow V : pipe full velocity
Ratio q/Q : ratio of Peak Flow to pipe full flow
Ratio v/V : ratio of Peak Flow to pipe full velocity
Peak Flow vp : velocity at Peak Flow
Pipe E.L. : top elevation of proposed sewer
G.L. : ground level, upstream and downstream
D : earth covering depth, upstream and downstream

A logical check is carried out of the design capacity and velocity in the proposed sewer. The logical value "TRUE" is indicated if the design satisfy all of the following logical statements :

1. $q < Q$
2. $vp > 0.6$
3. $vp < 3.0$



Legend

- - - Sector Boundary

N.25 Reference Number of Service Area

KHC-51 Proposed Pump Station

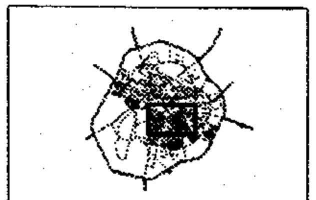
Existing Collectors

Proposed Primary Collectors

Proposed Secondary Collectors

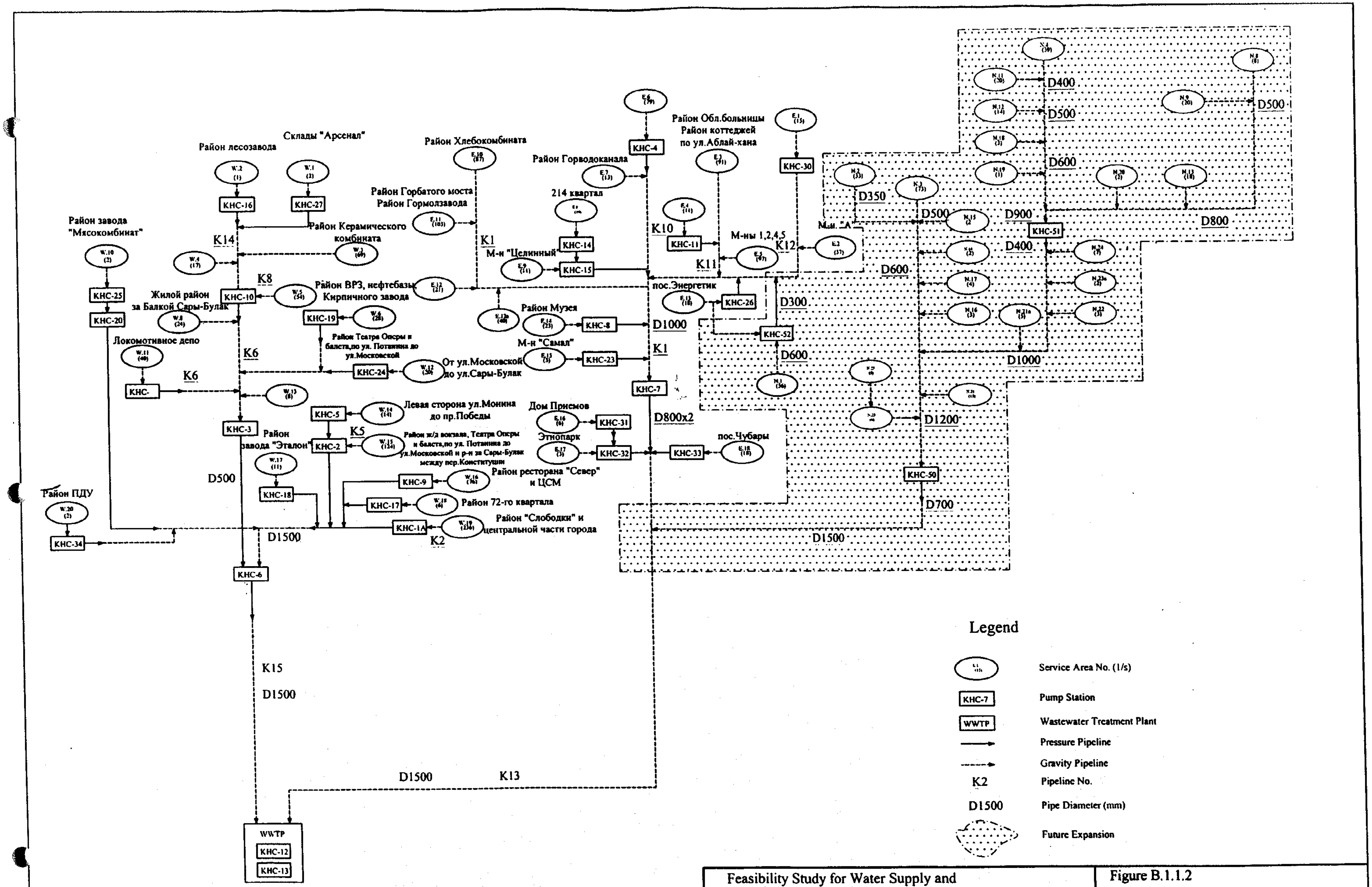
14-2 Monhole Number

0 0.5 km 1km



Key Map

The Feasibility Study on Water Supply and Sewerage in the City of Astana	Figure B.1.1.1 Study Areas for Extension of Wastewater Collection System
JAPAN INTERNATIONAL COOPERATION AGENCY	



Note : KHC-26 will be abandoned upon completion of KHC-52

Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure B.1.1.2 Schematic of Proposed Wastewater Collection System in 2010 including Existing Network
JAPAN INTERNATIONAL COOPERATION AGENCY	

Table B.1.1.1 Proposed Sewage Discharge Table (1 of 8 sheets)

YEAR 2010

Peak Factor: 2.0
Domestic 0.13 m3/cap./d

Sewer Line No.	Manhole No. Up stream	Manhole No. Down stream	Service Area Ref. No.	Service Area ha	Sewer Line Length m	Sewer Line Number line	Pop/D P/ha	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow l/s	Other Flow Sec. l/s	Other Flow Accum. l/s	Average Flow qa (l/s)	Peak Flow q (l/s)	Proposed Sewer Dia. mm	Slope 0/00	Full Flow Q (l/s)	Full Flow V (m/s)	Ratio q/Q	Ratio v/V	Peak Flow vp (m/s)	Pipe E.L. m	G.L. m	D m	Check
A1	1	1-1	N.1	183	600	1		30,504		51	5		56	113	***500***	***3.0***	192	0.978	0.587	1.020	0.998	358.5 356.7	360.0 359.0	1.5 2.3	TRUE
	1-1	1-2	N.1	183	800	1		30,504		51	5		56	113	***500***	***3.0***	192	0.978	0.587	1.020	0.998	353.9 351.5	359.0 353.0	5.1 1.5	TRUE
	1-2	1-3	N.1	183	800	1		30,504		51	5		56	113	***500***	***3.0***	192	0.978	0.587	1.020	0.998	349.9 347.5	353.0 349.0	3.1 1.5	TRUE
A2	1-3	2	N.1	183	500	1		30,504		51	5		56	113	***600***	***2.5***	285	1.008	0.395	0.895	0.902	347.5 346.2	349.0 348.0	1.5 1.8	TRUE
	2	2-1	N.1	183	320	1		30,504		51	5		56	113	***600***	***2.5***	285	1.008	0.395	0.895	0.902	346.2 345.4	348.0 347.5	1.8 2.1	TRUE
	2-1	2-2	N.1	183	760	1		30,504		51	5		56	113	***600***	***2.5***	285	1.008	0.395	0.895	0.902	345.4 343.5	347.5 347.5	2.1 4.0	TRUE
	2-2	2-3	N.1	183	500	1		30,504		51	5		56	113	***600***	***2.5***	285	1.008	0.395	0.895	0.902	343.5 342.2	347.5 347.5	4.0 5.3	TRUE
	2-3	3	N.1	183	100	1		30,504		51	5		56	113	***600***	***2.5***	285	1.008	0.395	0.895	0.902	342.2 341.9	347.5 347.5	5.3 5.6	TRUE
B1	4	4-1	N.2	204	600	1		17,952		30	3		33	66	***350***	***3.5***	80	0.833	0.828	1.120	0.933	361.0 358.9	363.0 360.5	2.0 1.6	TRUE
	4-1	4-2	N.2	204	600	1		17,952		30	3		33	66	***350***	***3.5***	80	0.833	0.828	1.120	0.933	358.9 356.8	360.5 360.0	1.6 3.2	TRUE
	4-2	4a	N.2	204	800	1		17,952		30	3		33	66	***350***	***3.5***	80	0.833	0.828	1.120	0.933	356.8 354.0	360.0 356.5	3.2 2.5	TRUE
	4a	4-3	N.2	204	220	1		17,952		30	3		33	66	***350***	***3.5***	80	0.833	0.828	1.120	0.933	354.0 353.2	356.5 355.0	2.5 1.8	TRUE
	4-3	5	N.2	204	600	1		17,952		30	3		33	66	***350***	***3.5***	80	0.833	0.828	1.120	0.933	353.2 351.1	355.0 353.0	1.8 1.9	TRUE
B2	6	6-1	N.3	175	1,200	1		39,300		66	7		72	145	***500***	***3.0***	192	0.978	0.755	1.105	1.081	361.5 357.9	363.0 361.0	1.5 3.1	TRUE
	6-1	6-2	N.3	175	1,580	1		39,300		66	7		72	145	***500***	***3.0***	192	0.978	0.755	1.105	1.081	357.9 353.2	361.0 359.0	3.1 5.8	TRUE
	6-2	5	N.3	175	350	1		39,300		66	7		72	145	***500***	***3.0***	192	0.978	0.755	1.105	1.081	352.6 351.5	359.0 353.0	6.4 1.5	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (2 of 8 sheets)

Sewer Line No.	Manhole No.		Service Area		Sewer Line		Sewage Flow				Other Flow		Average Flow	Peak Flow	Proposed Sewer										Check
	Up stream	Down stream			Length	Number	Pop/D	Population		Flow	Sec.	Accum.			Dia.	Slope	Full Flow		Ratio		Peak Flow	Pipe E.L.	G.L.	D	
			Ref. No.	ha	m	line	P/ha	Sec.	Accum.	l/s	l/s	l/s	qa (l/s)	q (l/s)	mm	0/00	Q (l/s)	V (m/s)	q/Q	v/V	vp (m/s)	m	m	m	
	5		N.2	204				17,952		30	3		33	66											
			N.3	175				39,300		66	7		72	145											
			N.14	20				880		2	0		2	3											
			N.15	28				1,232		2	0		2	5											
B3		8			550	1						*Subtotal*	110	219	*600*	*2.5*	285	1.008	0.769	1.105	1.114	350.9 349.5	353.0 351.0	2.1 1.5	TRUE
	8		B1, B2										110	219											
			N.17	44				1,936		3	0		4	7											
			N.16	42				1,848		3	0		3	7											
		9			940	1						*Subtotal*	116	233	*600*	*2.5*	285	1.008	0.817	1.120	1.129	348.9 346.5	351.0 348.0	2.1 1.5	TRUE
B4-1	9	9-1	B3		420	1							116	233	*600*	*2.5*	285	1.008	0.817	1.120	1.129	346.5 345.4	348.0 347.9	1.5 2.5	TRUE
RC No.1	9-1	9-2	9 - 9-1		200	1							116	233	*600*	*2.5*	285	1.008	0.817	1.120	1.129	345.4 344.4	347.9 347.9	2.5 3.5	TRUE
B4-2	9-2	28	9-2 - 28		530	1							116	233	*600*	*2.5*	285	1.008	0.817	1.120	1.129	344.4 343.1	347.9 347.9	3.5 4.8	TRUE
	10	10a	N.4	198	1,200	1		21,324		34	3		36	73	*400*	*4.0*	122	0.973	0.596	1.020	0.992	367.5 362.7	369.0 365.0	1.5 2.3	TRUE
	10a	10-1	N.4	198	250	1		21,324		34	3		36	73	*400*	*4.0*	122	0.973	0.596	1.020	0.992	362.7 361.7	365.0 364.0	2.3 2.3	TRUE
C1	10-1	10b	N.4	198	200	1		21,324		34	3		36	73	*400*	*4.0*	122	0.973	0.596	1.020	0.992	361.7 360.9	364.0 363.5	2.3 2.6	TRUE
	10b	10-2	N.4	198	300	1		21,324		34	3		36	73	*400*	*4.0*	122	0.973	0.596	1.020	0.992	360.9 359.7	363.5 362.0	2.6 2.3	TRUE
	10-2	11	N.4	198	500	1		21,324		34	3		36	73	*400*	*4.0*	122	0.973	0.596	1.020	0.992	359.7 357.7	362.0 361.0	2.3 3.3	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (3 of 8 sheets)

Sewer Line No.	Manhole No.		Service Area		Sewer Line		Sewage Flow				Other Flow		Average Flow	Peak Flow	Proposed Sewer										Check
	Up stream	Down stream			Length	Number	Pop/D	Population		Flow	Sec.	Accum.	Flow	Flow	Dia.	Slope	Full Flow		Ratio		Peak Flow	Pipe E.L.	G.L.	D	
			Ref. No.	ha	m	line	P/ha	Sec.	Accum.	l/s	l/s	l/s	qa (l/s)	q (l/s)	mm	0/00	Q (l/s)	V (m/s)	q/Q	v/V	vp (m/s)	m	m	m	
C2	11		11 - 11-1										36	73											
			N.11	66				10,956		18	2		20	40											
		11-1			1,550	1						*Subtotal*	57	113	***500***	***3.0***	192	0.978	0.590	1.020	0.998	357.7 353.0	361.0 360.0	3.3 7.0	TRUE
	11-1		C1										57	113											
			N.11	66				10,956		18	2		20	40											
			N.12	46				7,636		13	1		14	28											
		12			450	1						*Subtotal*	91	182	***500***	***3.0***	192	0.978	0.947	1.150	1.125	353.0 351.6	360.0 355.0	7.0 3.4	TRUE
	12	12-1	11-1 - 12		250	1							91	182	***500***	***3.0***	192	0.978	0.947	1.150	1.125	351.6 350.8	355.0 354.0	3.4 3.2	TRUE
	12-1	12-2	12 - 12-1		450	1							91	182	***500***	***3.0***	192	0.978	0.947	1.150	1.125	350.8 349.4	354.0 353.0	3.2 3.6	TRUE
	12-2	13	12-1 - 12-2		600	1							91	182	***500***	***3.0***	192	0.978	0.947	1.150	1.125	349.4 347.6	353.0 351.0	3.6 3.4	TRUE
C3	13		C2										91	182											
			N.18	34				1,496		3	0		3	6											
			N.19	13				572		1	0		1	2											
		13-1			460	1						*Subtotal*	95	190	***600***	***2.0***	255	0.902	0.743	1.090	0.983	347.6 346.7	351.0 350.0	3.4 3.3	TRUE
	13-1	13-2	13 - 13-1		200	1							95	190	***600***	***2.0***	255	0.902	0.743	1.090	0.983	346.7 346.3	350.0 350.0	3.3 3.7	TRUE
	13-2		13-1 - 13-2										95	190											
			N.20	9				396		1	0		1	2											
		13-3			400	1						*Subtotal*	96	191	***600***	***2.0***	255	0.902	0.749	1.090	0.983	346.3 345.5	350.0 351.0	3.7 5.5	TRUE
	13-3	14	13-2 - 13-3		200	1							96	191	***600***	***2.0***	255	0.902	0.749	1.090	0.983	345.5 345.1	351.0 350.0	5.5 4.9	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (4 of 8 sheets)

Sewer Line No.	Manhole No. Up stream	Manhole No. Down stream	Service Area Ref. No.	Service Area ha	Sewer Line Length m	Sewer Line Number line	Sewage Flow Pop/D P/ha	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow l/s	Other Flow Sec. l/s	Other Flow Accum. l/s	Average Flow qa (l/s)	Peak Flow q (l/s)	Proposed Sewer Dia. mm	Slope 0/00	Full Flow Q (l/s)	Full Flow V (m/s)	Ratio q/Q	Ratio v/V	Peak Flow vp (m/s)	Pipe E.L. m	G.L. m	D m	Check
D1	16		J										0	0											
			N.8	61				4,514		8	1		8	17											
			N.9	76				10,776		18	2		20	40											
			N.10	0				0		0	0		0	0											
		16-1			1,550	1						***Subtotal***	28	57	***500***	***3.0***	192	0.978	0.294	0.820	0.802	353.5 348.8	355.0 352.0	1.5 3.2	TRUE
C4	16-1												0	0											
			D1										39	79											
		17-1			100	1						***Subtotal***	39	79	***800***	***2.0***	549	1.092	0.143	0.690	0.753	348.8 348.6	352.0 352.0	3.2 3.4	TRUE
	17-1		17 - 17-1										39	79											
			N.13	58				9,628					18	35											
		17-2			400	1						***Subtotal***	57	114	***800***	***2.0***	549	1.092	0.208	0.760	0.830	348.6 347.8	352.0 352.0	3.4 4.2	TRUE
	17-2	17-3	17-1 - 17-2		250	1							57	114	***800***	***2.0***	549	1.092	0.208	0.760	0.830	347.8 347.3	352.0 352.0	4.2 4.7	TRUE
	17-3	17-4	17-2 - 17-3		450	1							57	114	***800***	***2.0***	549	1.092	0.208	0.760	0.830	347.3 346.4	352.0 352.0	4.7 5.6	TRUE
	17-4	17-5	17-3 - 17-4		280	1							57	114	***800***	***2.0***	549	1.092	0.208	0.760	0.830	346.4 345.8	352.0 352.0	5.6 6.2	TRUE
	17-5	17-6	17-4 - 17-5		240	1							57	114	***800***	***2.0***	549	1.092	0.208	0.760	0.830	345.8 345.3	352.0 352.0	6.2 6.7	TRUE
	17-6		17-5 - 17-6										57	114											
			N.20	9				396					1	2											
		14			370	1						***Subtotal***	58	116	***800***	***2.0***	549	1.092	0.210	0.760	0.830	345.3 344.6	352.0 351.0	6.7 6.4	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (5 of 8 sheets)

Sewer Line No.	Manhole No.		Service Area		Sewer Line		Sewage Flow				Other Flow		Average Flow	Peak Flow	Proposed Sewer										Check
	Up stream	Down stream			Length	Number	Pop/D	Population		Flow	Sec.	Accum.	Flow	Flow	Dia.	Slope	Full Flow		Ratio		Peak Flow	Pipe E.L.	G.L.	D	
			Ref. No.	ha	m	line	P/ha	Sec.	Accum.	l/s	l/s	l/s	qa (l/s)	q (l/s)	mm	0/00	Q (l/s)	V (m/s)	q/Q	v/V	vp (m/s)	m	m	m	
C5-1	14		C4										58	116											
			C3										4	8											
		14a			110	1						*Subtotal*	62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	344.6 344.4	351.0 351.0	6.4 6.6	TRUE
RC No.2	14a	14b	14 - 14a		200	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	344.4 342.0	351.0 350.0	6.6 8.0	TRUE
C5-2	14b	14c	14a - 14b		200	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	342.0 341.7	350.0 350.0	8.0 8.3	TRUE
	14c	14-1	14b - 14 -1		500	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	341.7 340.9	350.0 350.0	8.3 9.1	TRUE
	14-1	14-2	14 -1 - 14 -2		1,100	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	340.9 339.2	350.0 350.0	9.1 10.8	TRUE
	14-2	14-3	14c - 14d		500	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	339.2 338.4	350.0 350.0	10.8 11.6	TRUE
	14-3		14d - 14 -3										62	123											
			M2										0	0											
		19			200	1							62	123	***900***	***1.5***	651	1.023	0.189	0.730	0.747	338.4 338.1	350.0 349.5	11.6 11.4	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (6 of 8 sheets)

Sewer Line No.	Manhole No. Up stream	Manhole No. Down stream	Service Area Ref. No.	Service Area ha	Sewer Line Length m	Sewer Line Number line	Sewage Flow Pop/D P/ha	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow l/s	Other Flow Sec. l/s	Other Flow Accum. l/s	Average Flow qa (l/s)	Peak Flow q (l/s)	Proposed Sewer Dia. mm	Slope 0/00	Full Flow Q (l/s)	Full Flow V (m/s)	Ratio q/Q	Ratio v/V	Peak Flow vp (m/s)	Pipe E.L. m	G.L. m	D m	Check
E1	19	19-1	C5		100	1							62	123	***1000***	***1.5***	862	1.098	0.143	0.690	0.758	348.0 347.8	349.5 350.0	1.5 2.2	TRUE
	19-1		19 - 19-1										62	123											
			N.24	65				3,640		6	1		7	13											
		19-2			200	1						***Subtotal***	68	137	***1000***	***1.5***	862	1.098	0.158	0.700	0.769	347.8 347.5	350.0 350.0	2.2 2.5	TRUE
	19-2	19-3	19-1 - 19-2		240	1							68	137	***1000***	***1.5***	862	1.098	0.158	0.700	0.769	347.0 346.6	350.0 349.5	3.0 2.9	TRUE
	19-3	19-4	19-2 - 19-3		140	1							68	137	***1000***	***1.5***	862	1.098	0.158	0.700	0.769	346.6 346.4	349.5 349.0	2.9 2.6	TRUE
	19-4	23	19-3 - 19-4		200	1							68	137	***1000***	***1.5***	862	1.098	0.158	0.700	0.769	346.4 346.1	349.0 348.5	2.6 2.4	TRUE
	23		19-4 - 23										68	137											
			N.23a	22				1,232		2	0		2	5											
		29			1,000	1						***Subtotal***	71	141	***1000***	***1.5***	862	1.098	0.164	0.700	0.769	346.1 344.6	348.5 348.1	2.4 3.5	TRUE
	29		23 - 29										71	141											
			N.22	31				1,472		3	0		3	6											
			N.21a	62				2,728		5	0		5	10											
		28			1,240	1						***Subtotal***	78	157	***1000***	***1.5***	862	1.098	0.182	0.730	0.802	344.6 342.7	348.1 347.9	3.5 5.2	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (7 of 8 sheets)

Sewer Line No.	Manhole No. Up stream	Manhole No. Down stream	Service Area Ref. No.	Service Area ha	Sewer Line Length m	Sewer Line Number line	Sewage Flow Pop/D P/ha	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow l/s	Other Flow Sec. l/s	Other Flow Accum. l/s	Average Flow qa (l/s)	Peak Flow q (l/s)	Proposed Sewer Dia. mm	Slope 0/00	Full Flow Q (l/s)	Full Flow V (m/s)	Ratio q/Q	Ratio v/V	Peak Flow vp (m/s)	Pipe E.L. m	G.L. m	D m	Check
E2	28		E1										78	157											
			B4										116	233											
			N.21	180				8,120		14	1		15	30											
		28-1			250	1						*Subtotal*	210	420	***1200***	***1.0***	1145	1.012	0.367	0.895	0.906	342.7 / 342.4	347.9 / 347.8	5.2 / 5.4	TRUE
	28-1	28-2	28 - 28-1		500	1							210	420	***1200***	***1.0***	1145	1.012	0.367	0.895	0.906	342.4 / 341.9	347.8 / 347.7	5.4 / 5.8	TRUE
	28-2	28-3	28-1 - 28-2		500	1							210	420	***1200***	***1.0***	1145	1.012	0.367	0.895	0.906	341.9 / 341.4	347.7 / 347.5	5.8 / 6.1	TRUE
	28-3	28-4	28-2 - 28-3		500	1							210	420	***1200***	***1.0***	1145	1.012	0.367	0.895	0.906	341.4 / 340.9	347.5 / 347.2	6.1 / 6.3	TRUE
	28-4	26	28-3 - 28-4		450	1							210	420	***1200***	***1.0***	1145	1.012	0.367	0.895	0.906	340.9 / 340.4	347.2 / 347.2	6.3 / 6.8	TRUE
E5	25a	25-1	N.23	58	200	1		3,248		10	1		10	20	***500***	***3.0***	192	0.978	0.105	0.625	0.611	346.6 / 346.0	348.1 / 348.0	1.5 / 2.0	TRUE
	25-1		25a - 25-1										10	20											
			N.25	43				2,408		9	1		11	21											
		25-2			200	1						*Subtotal*	21	41	***500***	***3.0***	192	0.978	0.214	0.760	0.743	346.0 / 345.4	348.0 / 347.9	2.0 / 2.5	TRUE
	25-2	25-3	25-1 - 25-1		650	1							21	41	***500***	***3.0***	192	0.978	0.214	0.760	0.743	345.4 / 343.4	347.9 / 347.7	2.5 / 4.3	TRUE
	25-3	25-4	25-2 - 25-3		300	1							21	41	***500***	***3.0***	192	0.978	0.214	0.760	0.743	343.4 / 342.5	347.7 / 347.7	4.3 / 5.2	TRUE
	25-4	25-5	25-4 - 25-5		380	1							21	41	***500***	***3.0***	192	0.978	0.214	0.760	0.743	342.5 / 341.4	347.7 / 347.2	5.2 / 5.8	TRUE
	25-5	25	25-5 - 25		520	1							21	41	***500***	***3.0***	192	0.978	0.214	0.760	0.743	341.4 / 339.8	347.2 / 347.2	5.8 / 7.4	TRUE
E4	25		E5										21	41											
			P6										0	0											
		26			1,250	1						*Subtotal*	21	41	***800***	***2.0***	549	1.092	0.075	0.560	0.612	339.8 / 337.3	347.2 / 347.2	7.4 / 9.9	TRUE

Table B.1.1.1 Proposed Sewage Discharge Table (8 of 8 sheets)

Sewer Line No.	Manhole No. Up stream	Manhole No. Down stream	Service Area Ref. No.	Service Area ha	Sewer Line Length m	Sewer Line Number line	Sewage Flow Pop/D P/ha	Sewage Flow Population Sec.	Sewage Flow Population Accum.	Sewage Flow Flow l/s	Other Flow Sec. l/s	Other Flow Accum. l/s	Average Flow qa (l/s)	Peak Flow q (l/s)	Proposed Sewer Dia. mm	Slope 0/00	Full Flow Q (l/s)	Full Flow V (m/s)	Ratio q/Q	Ratio v/V	Peak Flow vp (m/s)	Pipe E.L. m	G.L. m	D m	Cleck
E3	26		E2										210	420											
			E4										21	41											
		27			200	1						*Subtotal*	230	461	***1500***	***0.8***	1857	1.051	0.248	0.785	0.825	337.3 337.1	347.2 347.0	9.9 9.9	TRUE
													230	461	***1500***	***0.8***	1857	1.051	0.248	0.785	0.825	345.0 344.8	347.0 347.2	2.0 2.4	TRUE
F1	27	27-1	E3		200	1							230	461	***1500***	***0.8***	1857	1.051	0.248	0.785	0.825	344.8 344.2	347.2 346.5	2.4 2.3	TRUE
	27-1	27-2	27 - 27-1		800	1																			

B.1.2 Calculation of Pump Capacity

(1) Development plan of pump station

Design of pump capacity in year 2010 is carried out in taking consideration of year 2030 and presented in B.1.2.1 new pumping station list and B.1.2.2 influent vs duty pump capacity for KHC-50 to KHC-52.

(2) Calculation of pump capacity

Calculation of pump capacity is carried out by using the following formula and shown on B.1.2.3.

$$P = 0.163 \times \frac{H \times Q}{\eta} \times (1 + \alpha)$$

where,

P : motor output (kW)
H : total head (static head + loss head) (m)
Q : discharge (m^3/min)
η : efficiency of pump/motor
α : safety factor for motor capacity (0.15)

Table B.1.2.1 Specification of Proposed Pump Station

(unit : m^3/min)

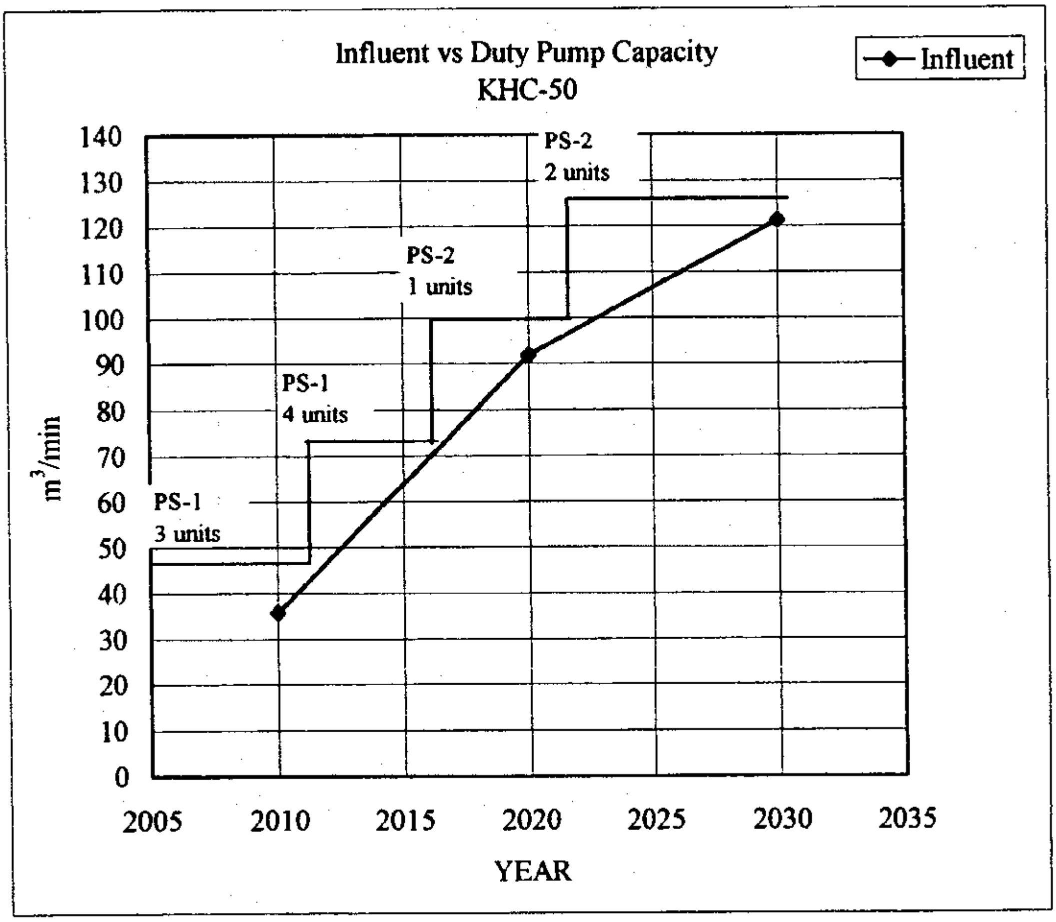
Pump Station		Y2010 Duty	Y2010 Standby	Y2015 Duty	Y2015 Standby	Y2020 Duty	Y2020 Standby	Y2025 Duty	Y2025 Standby	Y2030 Duty	Y2030 Standby
KHC-50	Influent	Q=35.8		Q=64.0		Q=91.9		Q=106.0		Q=121.2	
	Total Pump Capa.	QT=49.0		QT=73.5		QT=98.0		QT=122.5		QT=122.5	
	No. 1	Q1=49.0		Q1=73.5		Q1=73.5		Q1=73.5		Q1=73.5	
		Qp1=24.5 2 units	1 units	Qp1=24.5 3 units	1 units	Qp1=24.5 3 units	1 units	Qp1=24.5 3 units	1 units	Qp1=24.5 3 units	1 units
	No. 2					Q2=24.5		Q2=49.0		Q2=49.0	
						Qp2=24.5 1 units	0 units	Qp2=24.5 2 units	0 units	Qp2=24.5 2 units	0 units
KHC-51	Influent	Q=15.0		Q=30.0		Q=45.8		Q=54.0		Q=62.6	
	Total Pump Capa.	QT=25.0		QT=37.5		QT=50.0		QT=62.5		QT=75.0	
	No. 1	Q1=25.0		Q1=37.5		Q1=37.5		Q1=37.5		Q1=37.5	
		Qp1=12.5 2 units	1 units	Qp1=12.5 3 units	1 units	Qp1=12.5 3 units	1 units	Qp1=12.5 3 units	1 units	Qp1=12.5 3 units	1 units
	No. 2					Q2=12.5		Q2=25.0		Q2=37.5	
						Qp2=12.5 1 units	0 units	Qp2=12.5 2 units	0 units	Qp2=12.5 3 units	0 units
KHC-52	Influent	Q=8.3		Q=9.5		Q=10.9		Q=12.0		Q=13.3	
	Total Pump Capa.	QT=10.0		QT=15.0		QT=15.0		QT=15.0		QT=15.0	
		Q1=10.0		Q1=15.0		Q1=15.0		Q1=15.0		Q1=15.0	
		Qp1=5.0 2 units	1 units	Qp1=5.0 3 units	1 units	Qp1=5.0 3 units	1 units	Qp1=5.0 3 units	1 units	Qp1=5.0 3 units	1 units
KHC-53	Influent	Q=0.0		Q=0.0		Q=17.7		Q=24.0		Q=28.8	
	Total Pump Capa.					QT=20.0		QT=30.0		QT=30.0	
						Q2=20.0		Q2=30.0		Q2=30.0	
						Qp2=10.0 2 units	1 units	Qp2=10.0 3 units	1 units	Qp2=10.0 3 units	1 units

B.1.2.2 Development Plan of Pump Station

(1) KHC-50

(m^3/min)

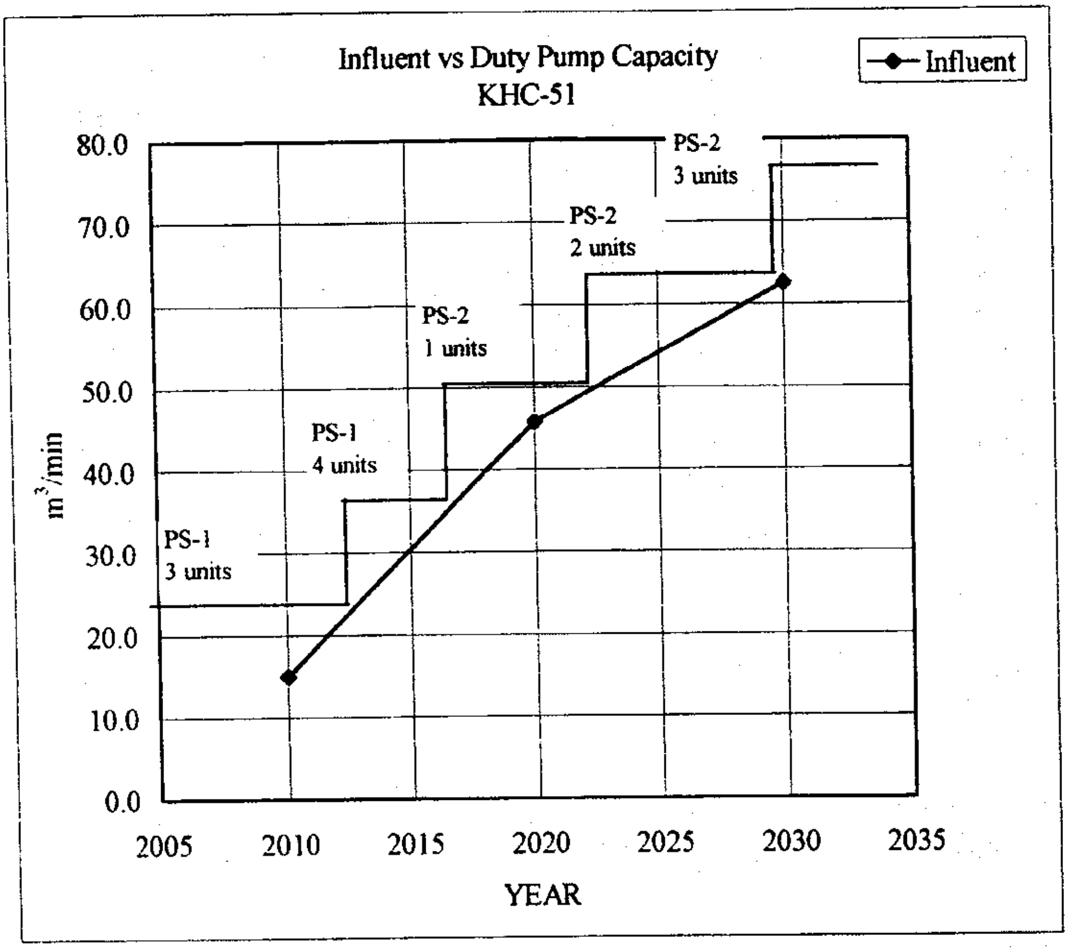
Year		2010	2020	2030
Influent		35.8	91.9	121.2
Duty Pump Capa		49.0	98.0	122.5
Installed Capa.		73.5	122.5	171.5
Pump No. Q=24.5	PS-1	3	4	
	PS-2		1	2



(2) KHC-51

(m3/min)

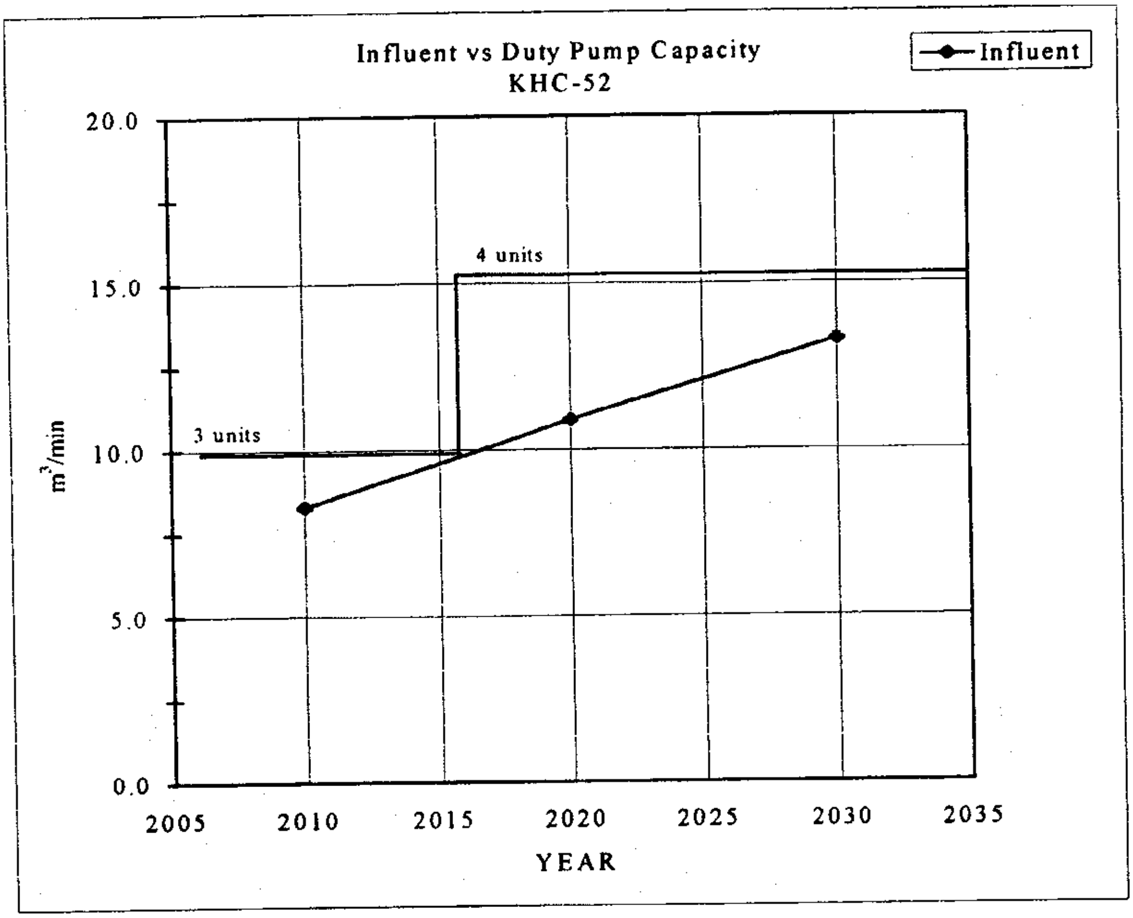
Year		2010	2020	2030
Influent		15.0	45.8	62.6
Duty Pump Capa.		25.0	50.0	75.0
Installed Capa		37.5	62.5	87.5
Pump No. Q=12.5	PS-1	3	4	
	PS-2		1	3



(3) KHC-52

(m3/min)

Year	2010	2020	2030
Influent	8.3	10.9	13.3
Duty Pump Capa.	10.0	15.0	15.0
Installed Capa	15.0	20.0	20.0
Pump No. Q=5	3	4	



B.1.2.3 Calculation of Pump Capacity

(1) Pump Station KHC-50

DESIGN CONDITION

1 INFLOW				
- Design flow	(m3/min)	73.5	(m3/s)	1.225
2 UNITS OF PUMP	(unit)	3		
3 MAX. DICHARGE PER UNIT	(m3/min)	24.5	(m3/s)	0.408
4 WATER LEVEL				
- WL in suction	(EL)	335.63		
- WL in delivery	(EL)	346.50		
5 STATIC HEAD : hs	(m)	10.87		
6 PRESSURE MAIN				
- Diameter : Dp	(mm)	700		
- Velocity : Vp	(m/s)	3.2		
- Velocity coefficient : C		130		
- Length : Lp	(m)	10		
- Pipe loss : hp_1	(m)	2.7		
straight pipe	(m)	0.1		
suluice valve	(Q'ty)	1		0.2 (f/pc)
bend	(Q'ty)	4		0.9 (f/pc)
outlet	(Q'ty)	1		1.0 (f/pc)
7 DISCHARGE PIPE				
- Diameter : d	(mm)	400		
- Velocity : v	(m/s)	3.2		
- Pipe loss : hp_2	(m)	3.2		
check valve	(Q'ty)	1		1.5 (f/pc)
sluice valve	(Q'ty)	1		0.2 (f/pc)
enlarge pipe	(m)	0		
bend	(Q'ty)	3		0.9 (f/pc)
tee	(Q'ty)	1		2.3 (f/pc)
8 TOTAL HEAD : $hs + hp_1 + hp_2$	(m)	16.77		
9 PUMP/MOTOR EFFICIENCY	(e)	60%		
10 MOTOR OUTPUT	(kw)	129		

Pump Type	Submersible Motor Pump
Motor Output	132 kw
Head	17 m
Discharge	24.5 m3/min
Pump Discharge Pipe	400 mm

(2) Pump Station KHC-51

DESIGN CONDITION

1 INFLOW					
- Design flow		(m3/min)	37.5	(m3/s)	0.625
2 UNITS OF PUMP		(unit)	3		
3 MAX. DICHARGE PER UNIT		(m3/min)	12.5	(m3/s)	0.208
4 WATER LEVEL					
- WL in suction		(EL)	337.12		
- WL in delivery		(EL)	349.50		
5 STATIC HEAD : hs		(m)	12.38		
6 PRESSURE MAIN					
- Diameter : Dp		(mm)	500		
- Velocity : Vp		(m/s)	3.2		
- Velocity coefficient : C			130		
- Length : Lp		(m)	10		
- Pipe loss : hp_1		(m)	2.8		
	straight pipe	(m)	0.2		
	suluice valve	(Q'ty)	1		0.2 (f/pc)
	bend	(Q'ty)	4		0.9 (f/pc)
	outlet	(Q'ty)	1		1.0 (f/pc)
7 DISCHARGE PIPE					
- Diameter : d		(mm)	300		
- Velocity : v		(m/s)	2.9		
- Pipe loss : hp_2		(m)	2.6		
	check valve	(Q'ty)	1		1.5 (f/pc)
	sluice valve	(Q'ty)	1		0.2 (f/pc)
	enlarge pipe	(m)	0.1		
	bend	(Q'ty)	3		0.9 (f/pc)
	tee	(Q'ty)	1		2.3 (f/pc)
8 TOTAL HEAD : hs + hp_1 + hp_2		(m)	17.78		
9 PUMP/MOTOR EFFICIENCY		(e)	60%		
10 MOTOR OUTPUT		(kw)	70		

Pump Type	Submersible Motor Pump
Motor Output	75 kw
Head	18 m
Discharge	12.5 m3/min
Pump Discharge Pipe	300 mm

(3) Pump Station KHC-52

DESIGN CONDITION

1 INFLOW					
- Design flow		(m3/min)	37.5	(m3/s)	0.625
2 UNITS OF PUMP		(unit)	3		
3 MAX. DICHARGE PER UNIT		(m3/min)	12.5	(m3/s)	0.208
4 WATER LEVEL					
- WL in suction		(EL)	337.12		
- WL in delivery		(EL)	349.50		
5 STATIC HEAD : hs		(m)	12.38		
6 PRESSURE MAIN					
- Diameter : Dp		(mm)	500		
- Velocity : Vp		(m/s)	3.2		
- Velocity coefficient : C			130		
- Length : Lp		(m)	10		
- Pipe loss : hp1		(m)	2.8		
	straight pipe	(m)	0.2		
	suluice valve	(Q'ty)	1		0.2 (f/pc)
	bend	(Q'ty)	4		0.9 (f/pc)
	outlet	(Q'ty)	1		1.0 (f/pc)
7 DISCHARGE PIPE					
- Diameter : d		(mm)	300		
- Velocity : v		(m/s)	2.9		
- Pipe loss : hp2		(m)	2.6		
	check valve	(Q'ty)	1		1.5 (f/pc)
	sluice valve	(Q'ty)	1		0.2 (f/pc)
	enlarge pipe	(m)	0.1		
	bend	(Q'ty)	3		0.9 (f/pc)
	tee	(Q'ty)	1		2.3 (f/pc)
8 TOTAL HEAD : hs + hp1 + hp2		(m)	17.78		
9 PUMP/MOTOR EFFICIENCY		(e)	60%		
10 MOTOR OUTPUT		(kw)	70		

Pump Type	Submersible Motor Pump
Motor Output	75 kw
Head	18 m
Discharge	12.5 m3/min
Pump Discharge Pipe	300 mm