CHAPTER 3
CURRENT STATUS OF WATER SUPPLY SYSTEM

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3.1 Introduction

In the 1950's, Astana City was served by the rural water supply system using groundwater, and it was replaced by the comprehensive water supply system, which was constructed in the 1960's. Figure 3.1.1 shows the existing water supply system, comprised of the Vyacheslavsky Reservoir, Intake Pump Station, raw water transmission pipe, Ishim Intake Pumping Station, Booster Pumping Station (not shown) and, the Water Treatment Plant.

Before the establishment of these facilities using surface water as water source, groundwater had been used as major water source. There were 30 wells within the city boundary, but due to the limitation of their water production capacity and water quality with high hardness, most of them were abandoned.

Astana City is served by these facilities and service ratio has become nearly 100%, including 26.8% of population served by "Stand-point Faucet". Two separate water supply systems are managed by ASA, a state enterprise for O & M and repair works. The main system is for drinking water purposes and the smaller system is for untreated technical water supplied to industries for uses such as cooling, washing etc. ASA is also managing water charge billing and collection.

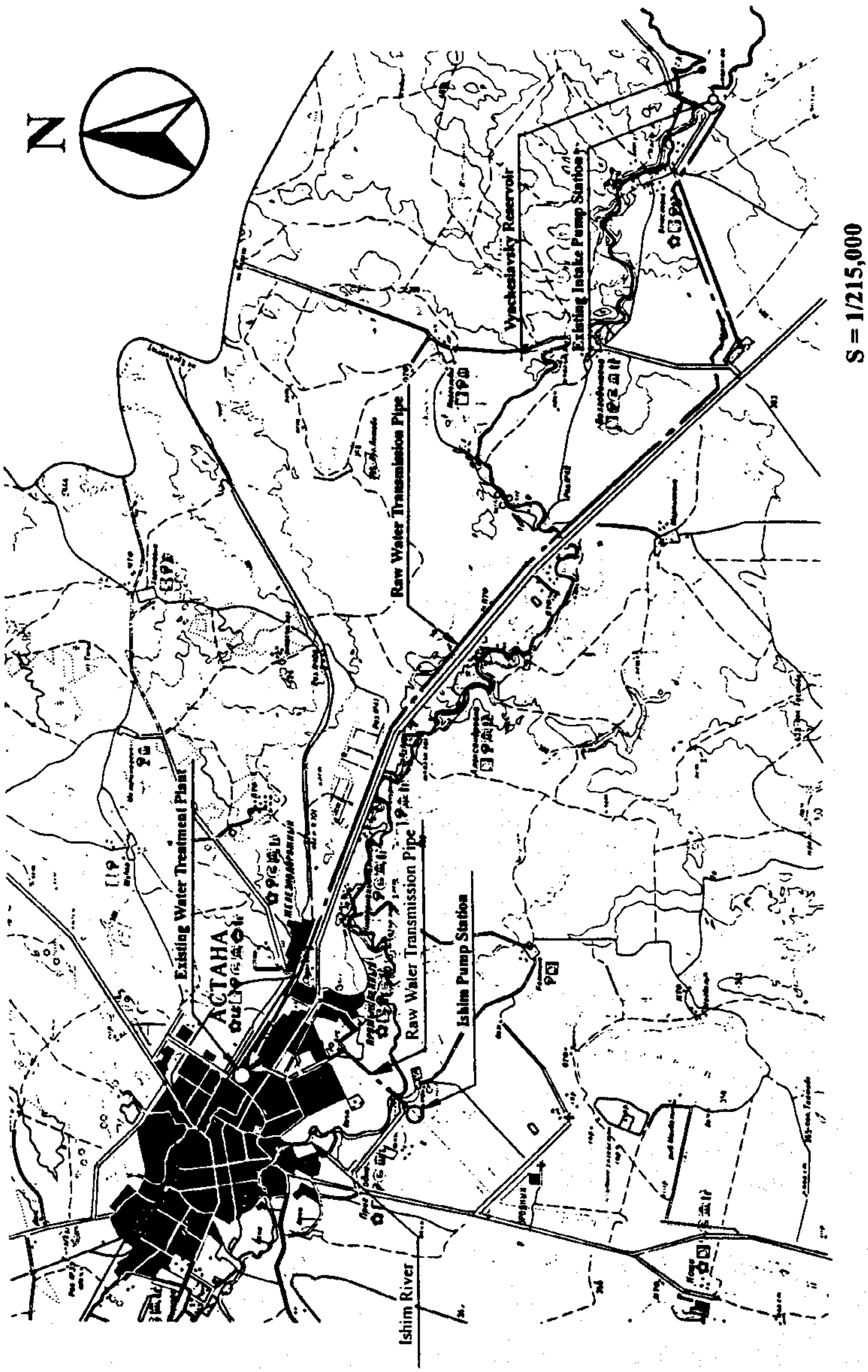
One of the serious managerial issues of ASA is "Leakage and Wastage". Rates of leakage from distribution pipeline and leakage and wastage by consumer are estimated at 26 % and 20 %, respectively. The former is mainly caused by deterioration of pipeline. While, the later can be attributed to the low numbers of individual water-meters installed, reported to be 26 %, and application of "flat rate" tariff.

Because of the limited availability of water resources and to provide a stable operating system in the future, these issues should be solved immediately.

3.2 Water Consumption

3.2.1 Current Water Consumption and Unaccounted for Water

There is very little water consumption data available because there are very few meters on the distribution system. To calculate the volume of water to be billed for each customer, ASA uses the official number of people registered at the address



Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 3.1.1 Location Map of the Existing Water Supply System in Astana City
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with the Department of Housing and a standard per capita consumption of 240 litres per capita. The number of people registered with the Department of Housing is only about 200,000 compared to the 300,000 population presently in Astana. This implies that about 50% of the presently billed water remains unbilled and is therefore a loss of revenue to ASA.

The only reliable flow measurement data available is the volume of water introduced into the distribution system at the WTP. During 1999 an average of 131,000 m^3/day is distributed. An analysis has been carried out to reconcile this data with billed data provided by ASA. Table 3.2.1 summarizes the analysis.

Table 3.2.1 Analysis of Drinking Water Consumption (1998 to 1999)

Item / Year	1998	1999
Water Consumption (m^3/day)		
Domestic – Billed	37,452	46,667
Domestic – Unbilled *	18,726	23,334
Public	6,222	4,814
Industry and Commercial	26,578	22,049
Sub-Total	88,978	96,864
Unaccounted-for-Water (m^3/day)		
UFW Rate	26.5%	26.1%
UFW Volume	32,146	34,199
Total	121,124	131,063

Source: "Water Intake and Distribution, ASA"

* Unbilled volume assumed to be 50% of billed amount for the purpose of this analysis

This analysis is based on an assumed per capita consumption of approximately 240 litres per capita which is high when compared to average water consumption in Europe of 150 litres per capita.

The volume of water introduced into the distribution system from the water treatment plant (WTP) as measured during 1999 is presented on Table 3.2.2.

In order to verify the above analysis another analysis was carried out by correlating the volume input into the distribution system with the volume of sewage reaching the WWTP in 1999, which was estimated at 81,000 m^3/day. Realistic assumptions regarding per capita consumption within the different class of housing and infiltration have been made, details of which are presented in Supporting Report A.1.1.

The facilities available within each housing class and their 1999 population are presented in Table 3.2.3.

Table 3.2.2 Distributed Drinking Water Volume from WTP

Year	Month	Distribution Volume (m^3/day)
1999	January	147,871
	February	147,714
	March	150,581
	April	148,500
	May	131,742
	June	129,800
	July	132,387
	August	123,387
	September	105,200
	October	101,323
	November	114,700
	December	139,548
Average		131,063

Source: Operation record of WTP, ASA

Table 3.2.3 Population by Housing Class

No	Class	Piped Water	Sewerage	Water Heater	District Heating	Population	%
1	Communal Faucet	×	×	×	×	80,700	26.8
2	Houses 1	O	×	×	×	25,600	8.5
3	Houses 2	O	O	O	×	22,500	7.5
4	Houses 3	O	O	×	O	172,000	57.2
	All Classes					300,800	100

The result of this correlation is presented on Table 3.2.4 and is comparable to the analysis shown in Table 3.2.1.

Recent surveys of metered consumption carried out by ASA showed that the per capita consumption assumed above are reasonable for the condition in Astana as can be seen in Table 3.2.5. It can be observed that households on bulk meters have a high per capita consumption, compared to households on individual meters. This implies that there is a high degree of wastage of water by households without individual meters.

Table 3.2.4 Correlation of Water Supply Input and Sewage Collected

No	Name	Per Capita l/c/d	Consumption, m³/day	%	% collected	Sewage Volume, m³/day	%
1	Communal Faucet	22	1,775	1.8	0	0	0
2	Houses 1	100	2,560	2.7	0	0	0
3	Houses 2	170	3,825	4.0	90	3,443	4
4	Houses 3	270	46,440	48.1	90	41,796	52
	Sub-total	182	54,600	56.6		45,239	56
	Public		4,814	5.0	90	4,333	5
	Commercial & Industry		14,790	15.3	80	11,832	15
	Thermal Plant		22,260	23.1	30	6,678	8
	Technical (20,000m³)				10	2,000	2
	Sub-total		41,864	43.4		24,843	31
	Sewer Infiltration % leakage				30	10,380	
	Total		96,464	100		80,461	
	Measured Sewage					81,000	
	Water Supply Input		131,063				
	UFW		34,599	26.4			

Table 3.2.5 Survey of Metered Per Capita Water Consumption

Type of Meter / Measured consumption	Bulk Water Meter (l/c/d)	Individual Water Meter (l/c/d)
Minimum	83.6	51.7
Maximum	742.4	750.0
Average (Ratio)	294.8 (2.22)	132.5 (1.00)

The calculations presented above are only the best estimated using the limited data available and should be reconfirmed when additional meters are installed on the distribution system.

The above analysis confirms that leakage from the distribution system is at least 26% but is probably more, because it is likely that real consumption is lower than the per capita consumption, conservatively assumed above.

3.3 Water Sources

There are two main sources of water which are presently in use by ASA, Vycheslavsky Reservoir and the Ishim River. Two other sources of water, groundwater and the Nura - Ishim Canal are available but their use have been mostly discontinued. The details of these sources are described below:

3.3.1 Vyacheslavsky Reservoir

Vyacheslavsky Reservoir has a catchment area of 5,310 km^2, and the gross and effective storage capacities are 390 million m^3 and 358.8 million m^3, respectively. The reservoir has the following dimensions 11.2 km in length, 9.8 km at maximum width, and 25 m at maximum depth and 54.3 km^2 of water surface area. It is a relatively shallow reservoir. Elevation of normal high water level is +403 m, but due to the decrease of precipitation over the last few years, the water level is dropping. As of March 1st, 2000, water level was +397.79 m, 5 m lower than the high water level and the stored capacity is now only 174.4 million m^3,about half of the effective capacity.

3.3.2 Ishim River

Water extraction from the Ishim River is mainly for use as technical water, however, under emergency situation ASA treats raw water from the Ishim River for potable use. According to records at Ishim River Basin Department, ASA extracts between 6 and 35 million cubic metres per year from the Ishim River during the last 10 years. This is equivalent to between 16,000 and 96,000 m^3/day.

3.3.3 Other Water Sources

(1) Groundwater

30 wells used to be operational but due to the limitation of capacity and poor water quality, most of them were abandoned. A detailed list of the wells is shown in the Supporting Report A.2.1. The poor water quality is due mainly to the presence of high hardness and high chloride, both of which are above the National Drinking Water Standard. as shown in the Supporting Report A.2.2.

Only one well is operational within the "Omskaya Wellfield" located within the Aqmolasky Aquifer to the north of the city. There used to be several wells at intervals of 500 m, but due to water demand decrease, the other wells were abandoned. A pump with a capacity of 6 m^3/hr is installed inside the well and the groundwater is stored in an elevated tank to supply water by gravity to the 10 families served by this system. It is proposed that this well be rehabilitated by ASA as soon as its financial position is improves.

(2) Nura Ishim Canal

The Nura Ishim Canal was used as a source of water until 1991, when it was discovered that the water in the Nura River was contaminated by mercury. Use of the water has been stopped since then.

3.4 Raw Water Transmission Facilities

There exist two raw water transmission systems to provide raw water to the water treatment plant in Astana. The main system is the Vyacheslavsky intake pump station and two pipelines each 51 km long. The other system pumps water from the Ishim River through 9km of pipeline to the WTP.

3.4.1 Vyacheslavsky Reservoir Intake Pumping Station

Table 3.4.1 presents details of the Vyacheslavsky Reservoir Intake P/S and its general layout plan is shown in Figure 3.4.1.

Table 3.4.1 Outline of Vyacheslavsky Reservoir Intake P/S

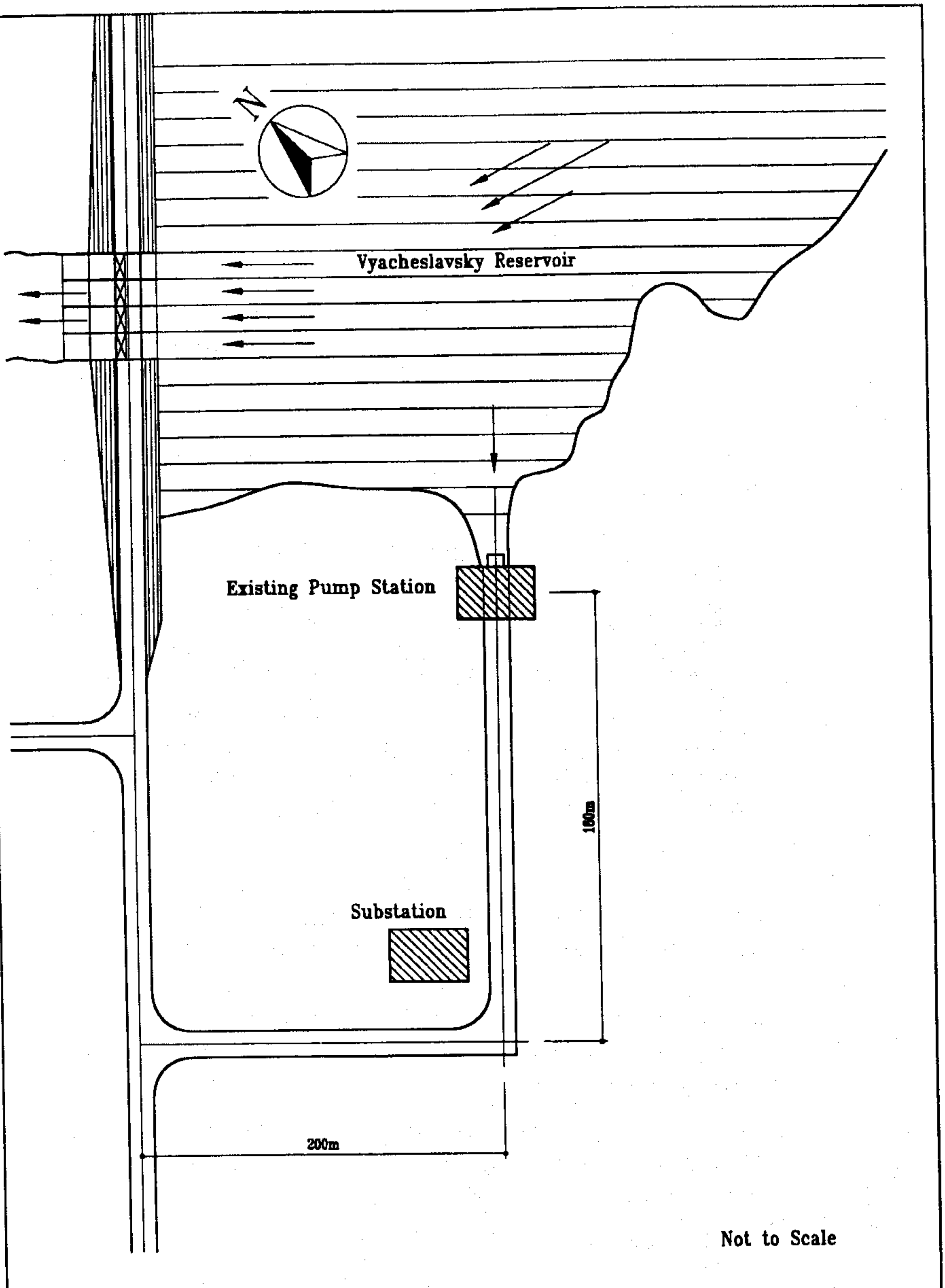
Facilities	Type	Dimension
Pump Loading Room	RC, 1st Floor	L 18m x W 8m x H 9m
Operation Room	RC, 1st Basement Floor	L 34m x W 12m x H 7.3m
Pump Room	RC, 2nd Basement Floor	L 34m x W 12m x H 9.4m
Pumps	Centrifugal Pump	4,095 m^3/hr x 95mH x 1,250 kW x 2 units 6,300 m^3/hr x 95mH x 2,000 kW x 1 unit (stand-by)

Further details of civil structures and the specification for mechanical and electrical facilities are given in the Supporting Report A.3.1 and A.3.2.

Three pumps including one stand-by pump are installed. Nominal pumping rate is 4,095 m^3/hr x 2 (= 8,190 m^3/hr = 196,560 m^3/day), while the flow rate measured by a flow meter installed in March 2000 was 140,000 to 150,000 m^3/day. The measurement result corresponds to about 76 % (150,000/196,560) of the nominal rate. The difference is the result of valve throttling operation carried out to reduce pressure in the transmission mains. This is necessary because the existing two lines of transmission pipes, especially the old one, are in poor structural condition and cannot sustain high pressures.

To improve the situation the installation of an additional transmission line called "Third Pipeline" was already approved by the Government and will be implemented under the governmental budget.

The following are the summary of system diagnosis:



Feasibility Study for Water Supply and Sewerage in the City of Astana

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Figure 3.4.1
General Plan of Vyacheslavsky Reservoir Intake Pumping Station

- The existing civil structure is still operational, but improvement work will be extremely difficult since a large part of it is underground.
- Main pumps are relatively new and can operate for more years, but electrical equipment is out of date and has deteriorated beyond repair. However the replacement of electrical equipment will be difficult since internal working space is quite limited.
- When the new transmission line is completed, the necessary pump head will be reduced to half of the current head and therefore operation of existing pumps with large pump head will be uneconomical. From economical viewpoint, pumps with adequate pump head shall be installed and relevant electric equipment shall also be replaced.
- A further complication is that the works have to be maintained during reconstruction work.

3.4.2 Ishim Intake Pumping Station

Table 3.4.2 shows the outline of the Ishim Intake P/S. Details of civil structures and the specification of mechanical and electrical facilities are shown in the Supporting Report A.3.1 and 3.2, respectively. Plan of this intake P/S is shown in Figure 3.4.2.

Table 3.4.2 Outline of Ishim Intake P/S

Facilities	Type	Dimension
Operation Room	RC, 1st Floor	L 27.8m x W 12.5m x H 8m
Pump Room	RC, Basement Floor	L 19.5m x W 10.5m x H 7.7m
Pumps	Centrifugal Pump	1,600 m^3/hr x 55mH x 350 kW x 1 unit 2,400 m^3/hr x 55mH x 500 kW x 2 units (stand-by) 2,200 m^3/hr x 55mH x 500 kW x 1 unit (stand-by)

The Ishim River water is transmitted from this P/S to WTP and then directly pumped to industrial consumers for technical use.

Of the four existing pumps, three large pumps (2,400 m^3/hr x 2 units and 2,200 m^3/hr x 1 unit) installed in 1975 are still operational but with the decline in the industrial sector, these large capacity pumps have become redundant. To cope with this reduced demand, another main pump with a smaller capacity of 1,600 m^3/hr was installed and operated instead of the large pumps.

The following a the summary of the system diagnosis:

- The civil structure and buildings are in reasonable condition and is not a cause for concern.
- All pumps are well maintained but safety circuit and auto relay of the control panel are malfunctioning.

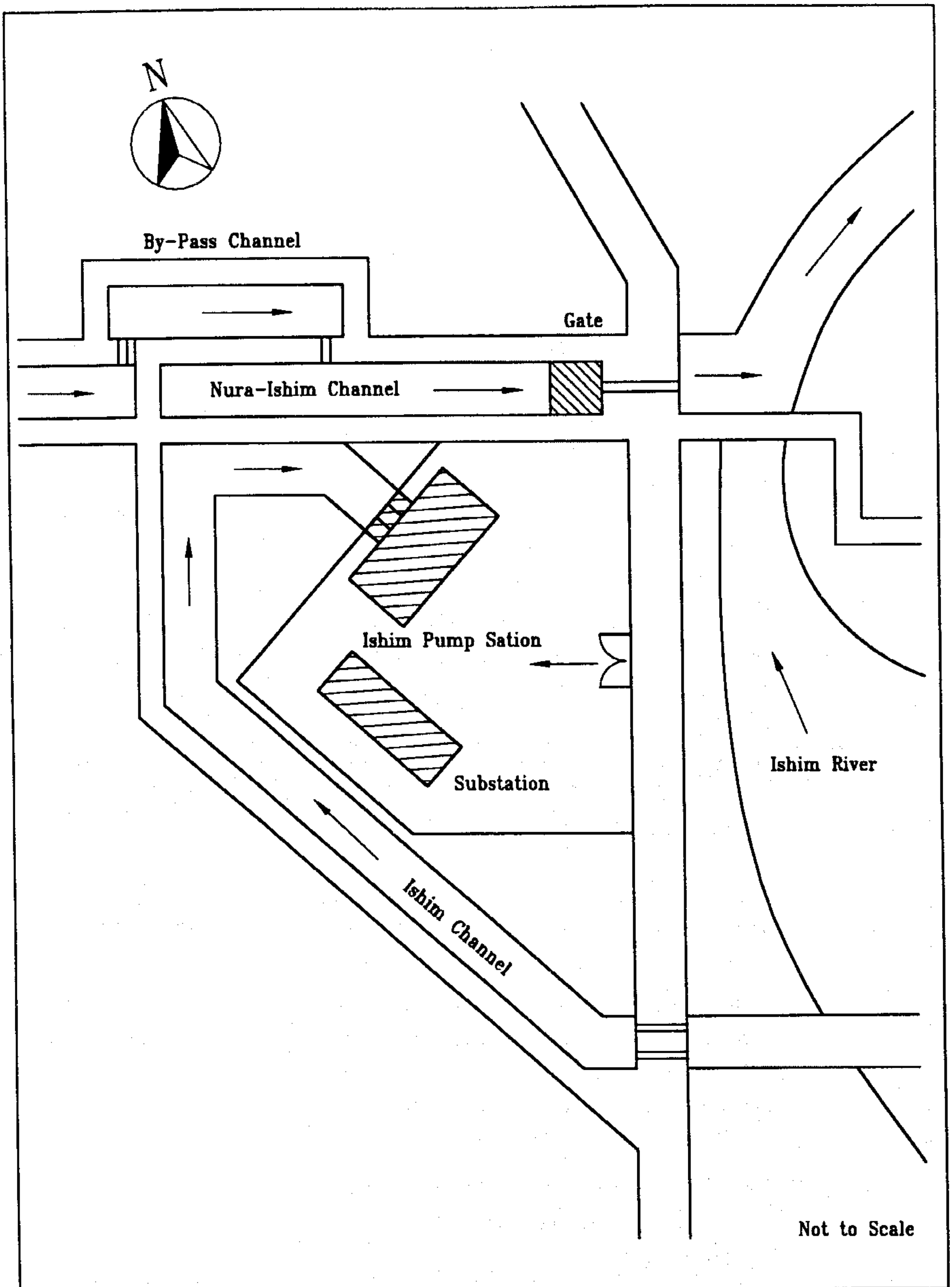

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Figure 3.4.2
General Plan of Ishim Intake Pumping Station

- Ishim Intake P/S can continue operation a the foreseeable future, provided that replacement of the control panel and proper maintenance is carried out.

3.4.3 Transmission Pipelines

There are two transmission pipelines to transfer water in Vyacheslavsky reservoir to the Water Treatment Plant. Both pipelines have diameters of 1,000 mm and a length of 51 km which were installed in 1967 and 1988 respectively. Since the capacity of intake pump, 4,095 m^3/hr x 2 units = 196,560 m^3/day, is larger than the necessary flow of around 150,000 m^3/day, flow and pressure are regulated by valve control to prevent pipe breakage. Such discrepancy between design capacity and actual capacity leads to inefficient operation. In fact, these transmission pipelines have encountered several breakage accidents.

Both transmission pipelines are in poor condition and suffer from corrosion as a result of poor corrosion protection. It is estimated that 13,000 m^3/d leaks from the pipelines or about 5.3 m^3/hr/km compared to a normally accepted 1 m^3/hr/km. Measures are already being taken to construct a new replacement pipeline.

The Ishim River transmission line was constructed between the Ishim Intake P/S and the WTP in 1975. The pipe diameter is 1,000 mm and the length is approximately 9 km. This pipeline is reported to be in reasonable condition.

The hydraulic systems were analysed and the roughness coefficient C-values of these transmission lines are evaluated as follows. Details of the calculations are shown in the Supporting Report A.3.3 and A.3.4.

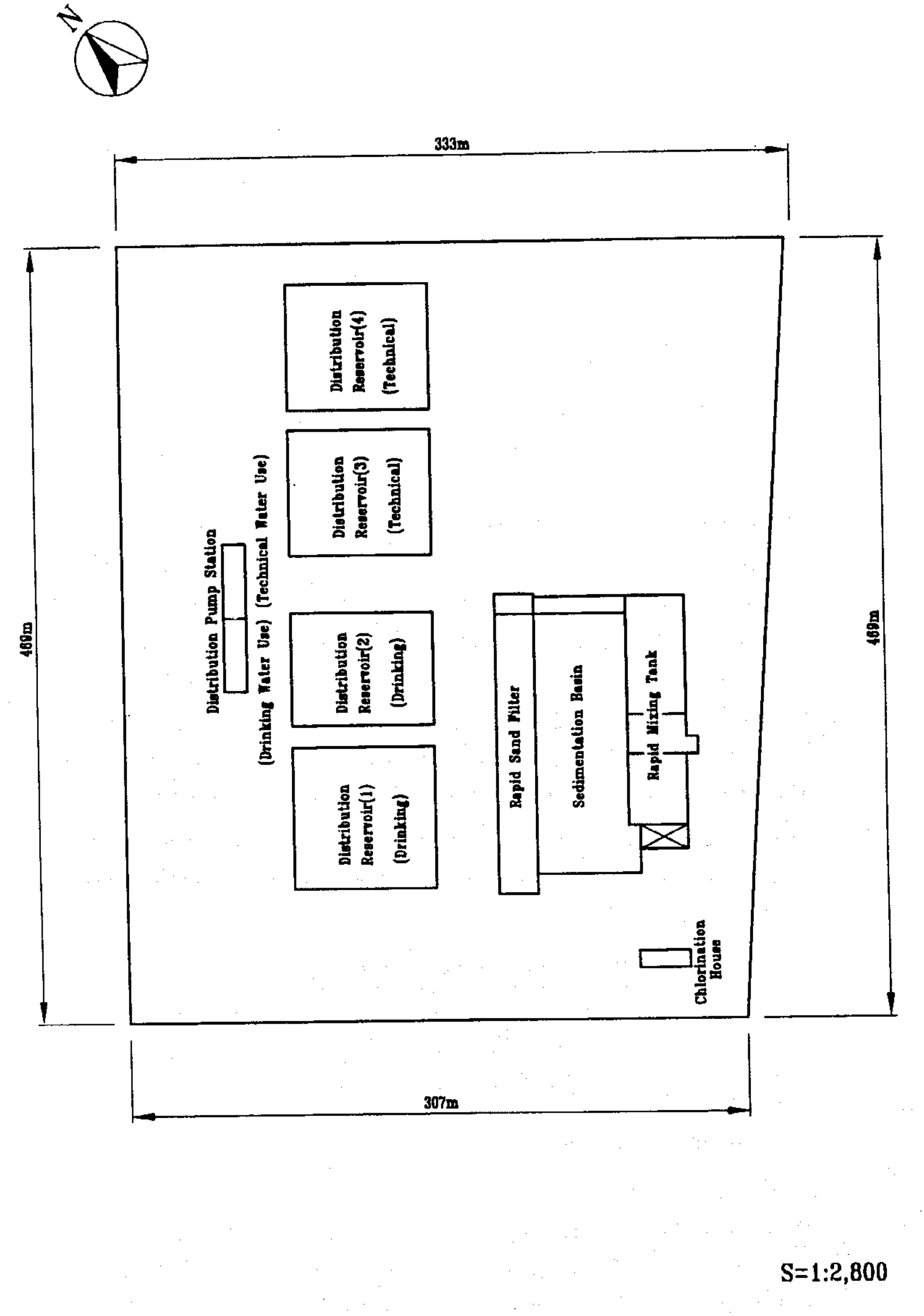
Hazen-Williams Coefficient for Transmission Line

	C-Value
Vyacheslavsky Transmission Line (No.1)	90
Vyacheslavsky Transmission Line (No.2)	100
Ishim Transmission Line	110

3.5 Water Treatment Facilities

3.5.1 Water Treatment Plant

The layout and the flowchart of the existing WTP are shown in Figures 3.5.1 and 3.5.2, respectively. The list of water treatment facilities and facility loading are shown in Table 3.5.1 and the Supporting Report A.4.1 and 4.2 provide more details. Structural drawings of major facilities are presented in the Drawings.



Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 3.5.1 Layout of the Existing Water Treatment Plant
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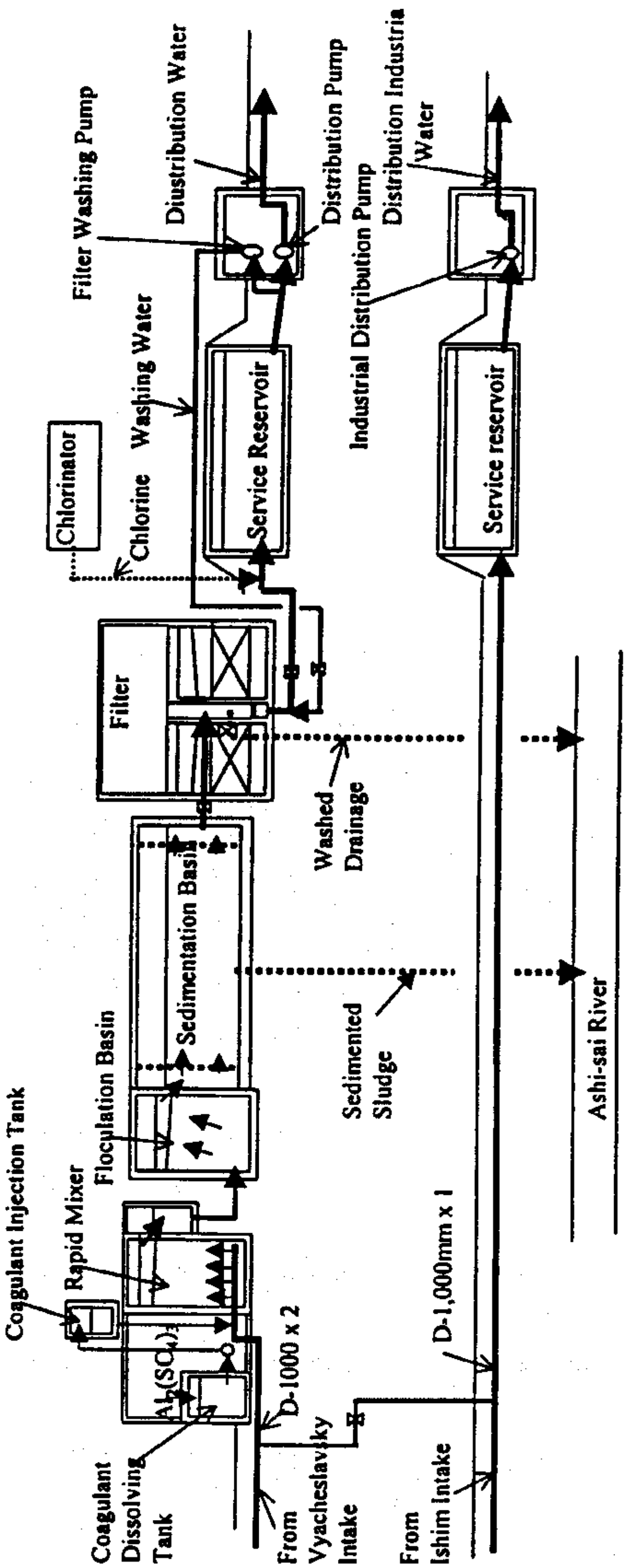

Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 3.5.2 Flow Chart of the Existing Water Treatment Plant
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Table 3.5.1 Outline of Water Treatment Plant

Facilities	Type	Dimension	Loading
Rapid Mixing Tank	RC Tank	L12.0mxW6.0xH3.2m (upper) L(12.0 to 1.25)mxW4.21mxH12.0m (below) x 1unit	6.4 min
Flocculation Basin	RC Tank	L 3.6m x W 6.0m x H 6.0m x 20units	20.0 min
Sedimentation Basin	RC Tank	L 49.6m x W 6.0m x H 4.2m x 20units	3.4 hr
Rapid Sand Filter	RC Tank	L 10.5m x W 5.1m x 2 x 10units	157.1 m/d
Chlorination	Chlorine gas	2 evaporators and injectors	
Treated Water Reservoir	RC Tank	20,000 m^3 x 2 units	5.8 hr
Technical Water Reservoir	RC Tank	20,000 m^3 x 2 units	
Administration Building	RC, 3 story	L 12m x W 16m x 3 story	
Distribution Pumps (Drinking Water)		6,300 m^3/hr x 50mH x 1,000 kW x (1 unit stand-by) 3,600 m^3/hr x 55mH x 630 kW x 2 units (1 stand-by) 3,200 m^3/hr x 55mH x 630 kW x (1 units stand-by) 2,500 m^3/hr x 60mH x 500 kW x 1 unit 1,500 m^3/hr x 65mH x 315 kW x 2 units (1 stand-by)	
Distribution Pumps (Technical Water)	Centrifugal Pump	3,600 m^3/hr x 55mH x 630 kW x (1 unit stand-by) 3,200 m^3/hr x 55mH x 630 kW x (1 unit stand-by) 500 m^3/hr x 70mH x 320 kW x 3 units (1 stand-by)500 m^3/hr x 70mH x 320 kW x 3 units (1 stand-by)	

Note) loadings are "retention time" except "filtration speed" of filter

The summary of system diagnosis is as follows:

- Concrete cover over flocculation tank and sedimentation basin is preventing visual inspection of the state of the floc blanket and of the clarification process.
- No mixing equipment is installed in flocculation tank and flocculation is not carried out properly.
- There is no effluent trough in sedimentation tank and settled sludge is swirled up by flow occurred at the end of tank.
- Serious deterioration of the more recently constructed filter stream, including building and tanks.
- Operation of distribution pumps in WTP is carried out manually according to the water level in clear water reservoirs.

3.5.2 Sludge Treatment and Disposal

No sludge treatment facility is installed and sludge in the sedimentation basin is directly discharged into the Ashi-sai River together with filter back-washing water. This practice is not acceptable in current practise because the discharged sludge will increase the turbidity in the receiving river.

3.6 Drinking Water Distribution Facilities

Figure 3.6.1 presents the general plan of the existing drinking water supply system in Astana City. The whole city is served by distribution P/S in the WTP and the No.7 Booster P/S. Details are described hereinafter.

3.6.1 Pumping Stations (P/S)

The major P/Ss within the city are the distribution P/S in the WTP and the booster P/Ss of No.7 and Alyuviy. Facility list of distribution P/S in WTP is shown in the Supporting Report A.5. Summary of system diagnosis is as follows:

P/S in WTP

- All pumps are maintained well but pump buildings are in poor condition.
- Electric panels and power supply equipment were replaced in August 2000 and are well maintained.

No.7 Booster P/S

- All pumps are maintained well but since pump capacity is larger than the actual demand, flow is regulated by valve control.
- Control panel is malfunctioning.

Alyuviy Booster P/S

- It was constructed in 1960 and all of civil structure and mechanical and electric equipment are in very poor condition, though the facility itself is in operation.

3.6.2 Distribution Network

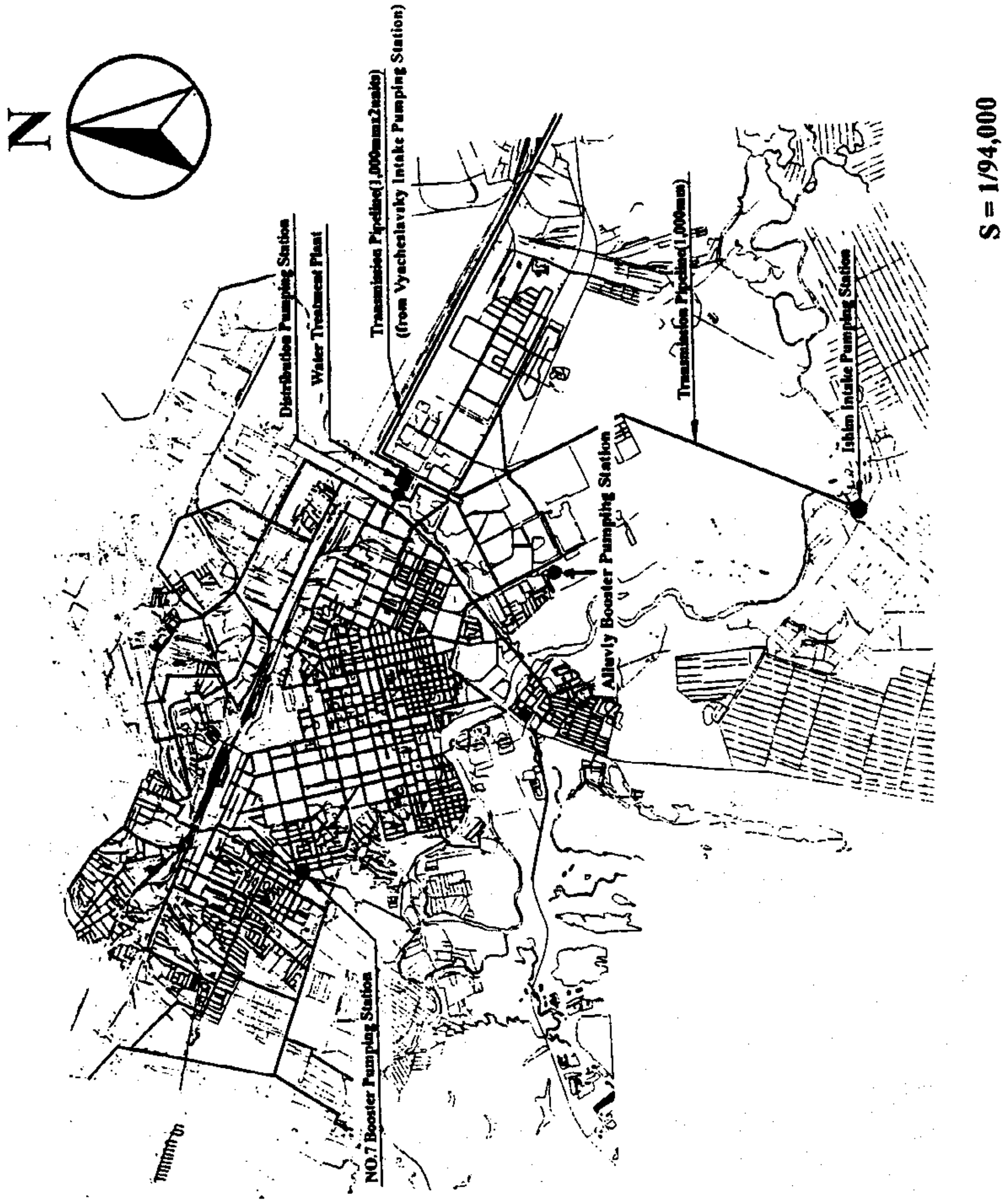
(1) Current Status

As shown in Figure 3.6.1, the whole city is served by distribution P/S in the WTP and the No.7 Booster P/S. The minimum residual water pressure that can serve five-storied building is calculated as follows:

5 stories x 3.2 m + 5 m (allowance) = 21 m = 0.21 MPa.

To maintain the minimum residual head at the marginal area in the network, water pressure in pipelines near the WTP has to be sufficiently high but not excessively high because high pressures increases leakage in the pipelines. An interview of operators in the WTP indicated that the current distribution pressure of 5.5 kg/cm^2 (= 0.56 MPa) is controlled by valve in current pump operations.

Layout plan of the existing pipeline is shown in Figure 3.6.2. The total length of the distribution system is 489 km and the lengths by material and diameter are presented in Table 3.6.1.



Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 3.6.1 General Plan of the Existing Water Supply System in the City of Astana
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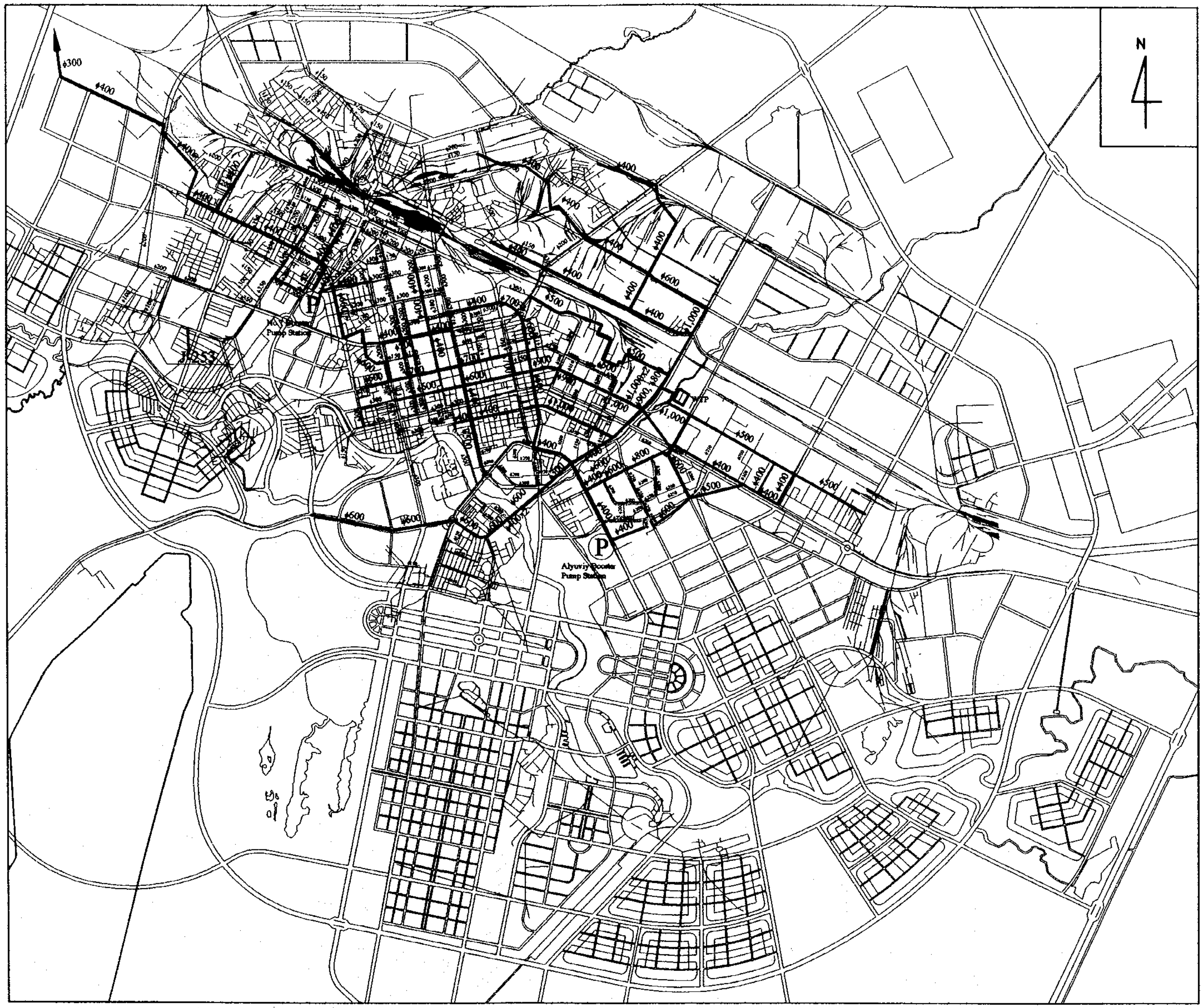

Legend

- □ Existing water treatment plant
- ━ Existing pipeline (greater than 400)
- ─ Existing pipeline (less than 300)

0 1km 2km 5km

The Feasibility Study on Water Supply and Sewerage in the City of Astana	Figure 3.6.2 Plan of the Existing Distribution Pipeline
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Table 3.6.1 Distribution Pipeline List

Materials	<100 mm	125-200 mm	225-400 mm	>500 mm	Total	Ratio
	m	m	M	m	M	%
Cast Iron Pipe	28,639	90,114	97,611	97,058	313,422	64.0
Steel Pipe	33,768	24,164	38,431	71,806	168,169	34.4
Asbestos Cement Pipe	0	3,835	237	0	4,072	0.8
Polyethylene Pipes	1,113	1,531	1,034	0	3,678	0.8
Total Length (m)	63,520	119,644	137,313	168,864	489,341	100.0
Ratio (%)	13.0	24.5	28.1	34.5	100.0	

Source: Pipeline Database, ASA

(2) Distribution Network Analysis

1) Analysis Basis

Based on the existing pipeline data and pipeline network, a hydraulic analysis was carried out. The following are the basic analysis data;

Basic Data for Network Analysis

Design Flow	155,000 m^3/day (Q_{DM}), 205,000 m^3/day (Q_{HM})
Pump on WTP	60 m^3/min x 65 mH x 2 units
	25 m^3/min x 65 mH x 2 units
Pump in No.7 Booster P/S	25 m^3/min x 70 mH x 1 unit
Velocity Coefficient of Pipes	C = 100

2) Analysis Results

- The average flow velocity is 0.44 m/sec which is low. In general, the economical diameter is usually produces a velocity of arround 1.0 m/sec. This means that the existing pipe diameter is excessively large and whole pipeline system is uneconomical . On the other hand, it can be argued that the existing network has sufficient capacity to handle the future water demand.
- In junction J-253 (see Figure 3.6.2) at the end of the network, its residual head of 0.17 MPa is less than the mininum residual head of 0.21 MPa. However, most of the residents within this service area live in private houses, mostly of the two-story type . Therefore, this low water pressure will not affect the water supply to these houses.

3.7 Technical Water Distribution Facilities

The technical water distribution facilities include the technical water pumps at the WTP and about 16.4 kms of pipelines with diameters varying between 300mm and

1,000mm. The details of the technical water pumps are provided in Table 3.5.1.

3.8 Operations and Maintenance

(1) Vyacheslavsky Reservoir Intake P/S

Breakdown of current staff in the Vyacheslavsky reservoir Intake P/S is shown below:

Breakdown of Staff at Vyacheslavsky Intake P/S

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

Although the total number of staff seem excessive as O&M staff for one pumping station, the following specific operational conditions shall be noted;

1) All pumps and electric equipment are installed in deep underground floor and it makes the daily O&M work relatively complicated.
2) Due to location of 51 km from city center, dispatching of maintenance staff from city takes a long time . Thus, O&M staff must stay in the P/S 24 hours through four shifts, to cope with accidents and repair works.
3) If the operation of this P/S has to be stopped because of an emergency, the Ishim Intake P/S can't cover the total demand and serious damage will be occur to the whole water supply system. Therefore, careful O&M is needed.

(2) Ishim Intake P/S

The present staff arrangement is shown below. The P/S is well-maintained.

Breakdown of Staff at Ishim Intake P/S

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

(3) Water Treatment Plant

Next table shows the current staff arrangement in the existing WTP, including the distribution P/S. Workers per shift comprises of two operators, one mechanic and one electrician. They mainly operate and maintain mechanical and electrical equipment during 24 hours of four shifts per day.

Breakdown of Staff at Water Treatment Plant

Assignment	Present
Manager	1
Section Chief	4
Electric Engineer	1
Mechanic Engineer	1
Operator	23
Repair and Others	26
Laboratory	18
Auxiliary Workers	10
Shift Workers	4 men x 4 shifts
Total	100

(4) No.7 Booster P/S

The No.7 Booster P/S serves the whole Western Area and its role is quite important. Current staff arrangement is shown below and the P/S is well maintained.

Breakdown of Staff at No. 7 Booster P/S

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

(5) Alyuviy Booster P/S

Staffing for this pump station is presented below:

Breakdown of Staff at Alyuviy Booster P/S

Assignment	Present
Shift Workers	1 men x 4 shifts
Total	4

(6) ASA

As shown in the table below, a staff of about 310 are allocated to the water supply sector of ASA currently.

Breakdown of Staff at ASA

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

3.9 Summary of Key Issues

(1) Leakage and Wastage

Current water consumption includes leakage from pipelines and wastage by consumers estimated as 26% and 20% of the total distribution amount, respectively. Because of the limited water resources, leakage from pipeline shall be eliminated by replacement of the existing deteriorated pipes, while wastage by consumer will be reduced by full-scale individual water meter installation and upgrading of residents' awareness toward water saving incurred by meter installation.

(2) Vyacheslavsky Reservoir Intake P/S

Since this P/S was built in 1968, all civil structures and electric panels are in very poor condition. The P/S supplies most of the raw water to the WTP so rehabilitation work has to be carried out whilst maintaining necessary pumping capacity. However, replacement work of electric panels will be extremely difficult due to quite limited internal working space, and there will be no remedial method for deteriorated civil structure except reconstruction. Pumps are still in good operational condition. However, their capacities are excessive compared with necessary demand water volume and pumping head, and this makes current pump operation uneconomical. Pumps with appropriate capacities should be installed. Therefore, construction of new P/S is necessary for a secure raw water transmission for the future.

(3) Ishim Intake P/S

This P/S is well maintained and if proper O&M works including replacement of electric panels is carried out by ASA, it will be operational for a considerable future.

(4) Water Treatment Plant

The existing WTP was constructed in 1970 and 1980 with nominal capacity of 100,000 m^3/day, respectively. All civil structures have deteriorated. Of particular concern is the settlement of half the size of sand filter for which there can be no improvement method except reconstruction. Further, since the WTP has structural deficits, treatment efficiency will not be drastically recovered even if rehabilitation work is conducted. However, the rehabilitation work itself will be quite difficult since the work has be carried out while maintaining necessary treatment capacity. To meet with the future water demand, construction of a new treatment plant is indispensable.

(5) No.7 Booster P/S

This P/S is well maintained and if proper O&M works including replacement of electric panels is carried out by ASA, it can be operational for many more years.

CHAPTER 4
PLAN OF FUTURE WATER SUPPLY SYSTEM

CHAPTER 4 PLAN OF FUTURE WATER SUPPLY SYSTEM

4.1 Planning Policy

Major planning policies adopted in this Feasibility Study are as follows:

- Importance of future development for water supply is placed on the improvement of existing facilities. Expansion plans shall be limited to a minimum on both the existing city and areas to the left and right side of the Ishim River.
- The establishment of an appropriate water supply facilities and expansion plan shall be based on water conservation policy requiring reduction of water leakage and wastage of water.
- Rational facility design of water supply system to establish easer operation and maintenance for sustainable operation.

4.2 Water Demand Projection

4.2.1 Set Up of Unit Water Demand

(1) Domestic Water Use

The JICA Master Plan Study prepared the following comparison table based on per capita water consumption of households with bulk and individual water meters, which were surveyed by ASA.

Table 4.2.1 Comparison of Per Capita Water Consumption

Type of Meter / Items	Bulk Water Meter (l/c/d)	Individual Water Meter (l/c/d)
Minimum	83.6	51.7
Maximum	742.4	750.0
Average (Ratio)	294.8 (2.22)	132.5 (1.00)

Water consumption observed at bulk water meter is larger than that of individual water meter, being more than double on the average. In the case of bulk waters meter, the water charge of each household is calculated dividing the total water consumption by the total number of family members, regardless of the actual individual water consumption. Whereas, in the case of individual water meters, the actualy consumed water volume is charged to the respective households. Through observation and evaluation of this situation, motivation of consumers toward "water conservation" at individual meter consumers can be seen to be greater than that of bulk meter consumers. In other words, consumers using bulk meters are less aware about wastage. In addition, leakage is considered as another reason for the large difference between them. When bulk water-meters are replaced by individual water-meters by ASA, per capita water consumption is expected to decrease drastically.

The consumption measured on individual meters is consistent with the 132.5 l/c/d average. The 1999 value of individual meter reading in water demand type of No.4 is shown in Table 3.2.4. No. 4 housing, "Houses with Bathtubs and District Hot Water Supply System" is the largest consumer group among the four water consumer types.

Target domestic unit water demand in 2010, the target year of the Feasibility Study, shall be the average value of the unit water demand for these four water demand types. However the effect of water conservation due to installation of water meters has to be taken into account. On the above basis the unit domestic per capita water demand in 2010 is as shown below.

Domestic Water Demand by Demand Type

No.	Water Consumer Type	Population	Unit Water Demand (l/c/d)	Water Demand (m^3/day)
1	Public Faucets	77,600	25	1,940
2	Houses with no Bathtubs	47,800	103	4,923
3	Houses with Bathtubs and Individual Water Heaters	42,100	137	5,768
4	Houses with Bathtubs and District Hot Water Supply Systems	322,500	159	51,278
Total		490,000		63,909
Average Unit Water Demand			130	

Total proportional average unit water demand is likewise established at 130 l/c/d and adopted as target domestic unit water demand in this Feasibility Study. The unit water demand in the said water consumer type No.4 is estimated to increase from 132.5 l/c/d in 1999 to 159 l/c/d in 2010.

It should be noted that review of water demand projection is inevitable by the year 2010, since there is considerable uncertainty in the progress of the urban development in the future, and thus future modification becomes duly necessary.

(2) Other Drinking Water Use

1) Public, Commercial and Industrial Water Use

According to the data of ASA, the relationship between the water consumption and number of employees in 1999 is summarized as follows:

Table 4.2.2 Water Consumption and Number of Employees by Water Use Category in 1999

Items / Water Use	Water Consumption (m^3/day)	No of Employees	Per Capita (l/empl./day)
Public	4,814	36,100	133
Industry & Commercial excl. thermal plant (13,053m^3/d)	8,996	111,200	81
Total	13,810	147,300	93.7

Analysis of the water consumption for public institutions, industries and commercial enterprises as presented in Table 4.2.2 show that the per capita consumption is about 93 litres per employee. It can also be noted that the consumption from the thermal plants have been excluded from the analysis. Considering that water efficiency of industries and wastage within public and commercial enterprises will improve, a value of 90 litres per employee has been adopted for future public, industrial and commercial consumption. The water consumption for the thermal plants have been estimated separately.

The per capita demand adopted for public, industrial and commercial sector as shown in Table 4.2.3.

Table 4.2.3 Per Employee Water Demand by Water Use Category

(Unit : l/Employee/day)

Year	1999	2010
Public	133	90
Industry	(81)⇒133	90
Commercial		90

For establishing the future demand beyond 2010, the following assumptions are established:

If water meter installation ratio increases along with the improvement projects, it is estimated that the water demand in each category will settle at around 80% of present water demand and stay constant in the future accounting, following the introduction of water saving devices.

2) Thermal Plants

Future demand is projected, based on the daily average water consumption of 22,260 m^3/day between 1994 and 1999 and an annual increase equivalent to the annual rate of increase of the design population.

(3) Technical Water

Based on the water consumption record of ASA, technical water consumption in 1999 was estimated to be 16,000 m^3/day, including the consumption of the two

Thermal Plants. An additional water demand of 5,880 m^3/day resulting from the expansion of Thermal Plant No.2 proposed in 2006 will have to be included to the estimates of 2010 water demand, thus taking the total technical water demand to 28,000 m^3/day.

4.2.2 Projection of Water Demand for 2010

Based on the unit water demand projection together with the population projection conducted by the JICA Master Plan, the future water demand in 2010 is estimated as shown in Table 4.2.4.

Table 4.2.4 Water Demand Projection

Items	Year	1999	2010	2020	2030
Drinking Water	Unit				
Population	(person)	300,800	490,000	690,000	800,000
Public		36,100	61,900	94,300	108,600
Industry		15,900	28,000	37,000	44,000
Commercial		95,300	164,900	247,800	287,500
Water Volume	(m^3/day)	96,783	115,180	164,970	201,090
Domestic		54,920	63,908	103,500	136,000
Public		4,814	5,520	8,016	8,688
Industry		14,790	2,550	3,145	3,520
Commercial			14,610	21,063	23,000
Thermal Plant		22,260	28,590	29,250	29,880
Leakage	(m^3/day)	34,599	28,800	41,240	50,280
Leakage Ratio		26%	20%	20%	20%
Total Drinking Water Demand		131,100	144,000	206,200	251,400
Per Capita Drinking Water Demand	(l/c/d)	436	294	299	314

Total water demand for the right bank and the left bank of the Ishim River in 2010 can be estimated as follows:

Demand for Right and Left Bank of Ishim River

Unit : m^3/day

	Ishim Right Bank	Ishim Left Bank	Total
Water Demand (Q_{DA})	131,650 m^3/day	12,350 m^3/day	144,000 m^3/day

4.2.3 Peak Factors

Peak factors adopted for the design of the drinking water system were based on daily maximum peak factor measured in other cities of same size in the world. The factors adopted are presented below.

Peak Factors for Drinking Water Supply System

Daily Maximum Peak Factor	1.2
Hourly Maximum Peak Factor	1.4

In case of technical water, the following peak factors are employed based on the water consumption data of Thermal Plants:

Peak Factors for Thermal Plants

Daily Maximum Peak Factor	1.9
Hourly Maximum Peak Factor	1.1

The water balance for demand and consumption for 2010 is given in the Supporting Report A.6.

4.2.4 Comparison with the Demand by SNiP

Table 4.2.5 shows the comparison of the water demand based on the standard proposed in SNiP and this Feasibility Study. As presented in the table, the water demand adopted for this Feasibility Study corresponds approximately to the average value of water demand presented in SNiP.

4.3 Future Water Sources

The availability of water resources for the City of Astana is covered in more detail in the JICA Master Plan and in Chapter 2. A short summary is provided below.

4.3.1 Surface Water

The normal source of water for Astana in the future will be Vyacheslavsky Reservoir supplemented by water from the Irtysh-Karaganda Canal system which will terminate upstream in the Ishim River. Vyacheslavsky Reservoir has a yield of 89.2 MCM which is insufficient for 2030. The IKC system can provide an additional 60MCM at Vyacheslavsky Reservoir. Those two sources are sufficient to guarantee the water resources for Astana. Technical water shall continue to be taken from the Ishim River.

4.3.2 Groundwater

Groundwater has been used in Astana since 1938, but has been gradually abandoned as Vyacheslavsky Reservoir was developed. Recent studies show that water of potable quality is still available in Astana. These reserves should be maintained and conserved for emergency purposes.

Table 4.2.5 Comparison of Water Demand (2010) between SNiP Norms and the Feasibility Study

No.	Types of Water Demand	SNiP Norms			F/S Proposals		
		Population	Rate (specific consumption)	Volume (m^3/day)	Population	Rate	Volume (m^3/day)
1.	Public Faucets	77,600	30 - 50	2,328 - 3,880	77,600	25	1,940
2.	Houses with no bathtub	47,800	125 - 160	5,975 - 7,648	47,800	103	4,923
3.	Houses with Bathtubs and Individual Water Heaters	42,100	160 - 230	6,736 - 9,683	42,100	137	5,768
4.	Houses with Bathtubs and District Hot water Supply System	322,500	230 - 350	74,175 - 112,875	322,500	159	51,278
	Domestic Use Subtotal	490,000		89,214 - 134,086	490,000		63,909
	Commercial Use			-			14,610
	Public Use			-			5,520
	UFW			8,921 - 13,409			28,800
	TOTAL			98,135 - 147,495			112,839

4.3.3 Nura River

The water from the Nura river can constitute another source of water for Astana, however, as mentioned in Chapter 2.1.3, before further consideration of usage can be made, the economic feasibility and technical viability of clean-up, of mercury from the river has to be clarified, based on the current World Bank project. The volume potentially available for Astana will depend on the level of irrigation requirements.

4.4 Water Supply Facility Plan

4.4.1 Intake Facilities

(1) Outline of Facility

The necessity of construction of new intake P/S was confirmed in Chapter 3.8 and a new Vyacheslavsky Reservoir Intake P/S is proposed about 100 m upstream of the existing P/S taking into account the sanitary protection zone. All civil structures and an access road should be constructed. Mechanical and electrical equipment should also be installed. The existing sub station, however, can be utilized for this new P/S. The proposed layout of the pump station is shown in Figures 4.4.1(1) to (3).

(2) Proposed Pump Capacity

Proposed total pump capacity should be equivalent to the original pump capacity of existing intake P/S,i.e. 200,000 m^3/day (= 8,333 m^3/day = 138.9 m^3/min).

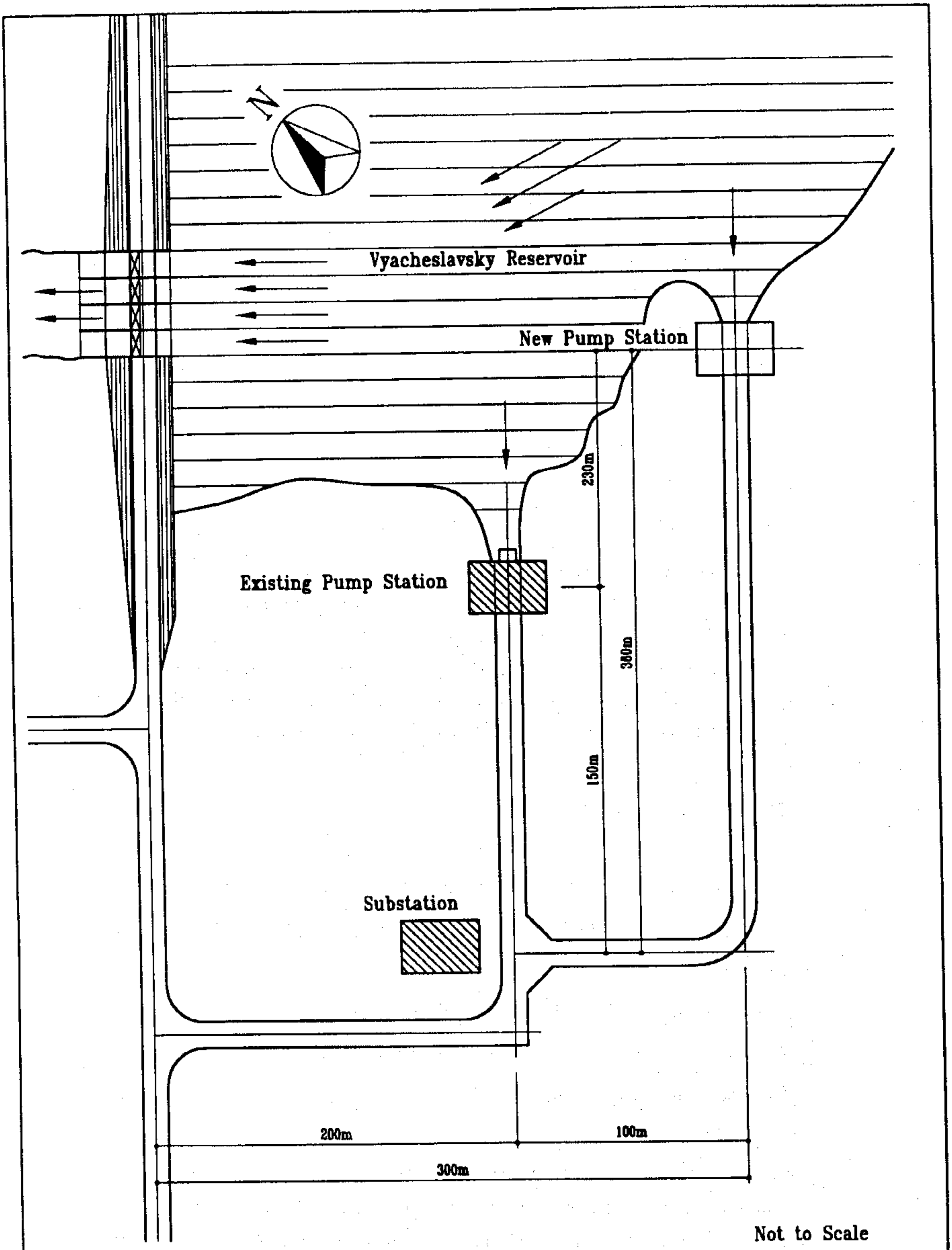
Including a stand-by pump, five pumps should be installed with the following specification:

35 m^3/min x 57 mH x 470 kW x 5 Units (1 Unit Stand-by)

(3) Design of Pump House and Equipment Installation

Pumps and electrical equipment should be located at ground floor for safety and ease of maintenance.

As shown in Figure 4.4.1(2), "vertical type" centrifugal pump is proposed and floor level of motor room should be above the HHWL. Four intake gates are planned for selective intake, considering seasonal water level and water quality fluctuation. The main body of the structure is proposed to be constructed by caisson in view of the reliability of implementation.



Feasibility Study for Water Supply and Sewerage in the City of Astana

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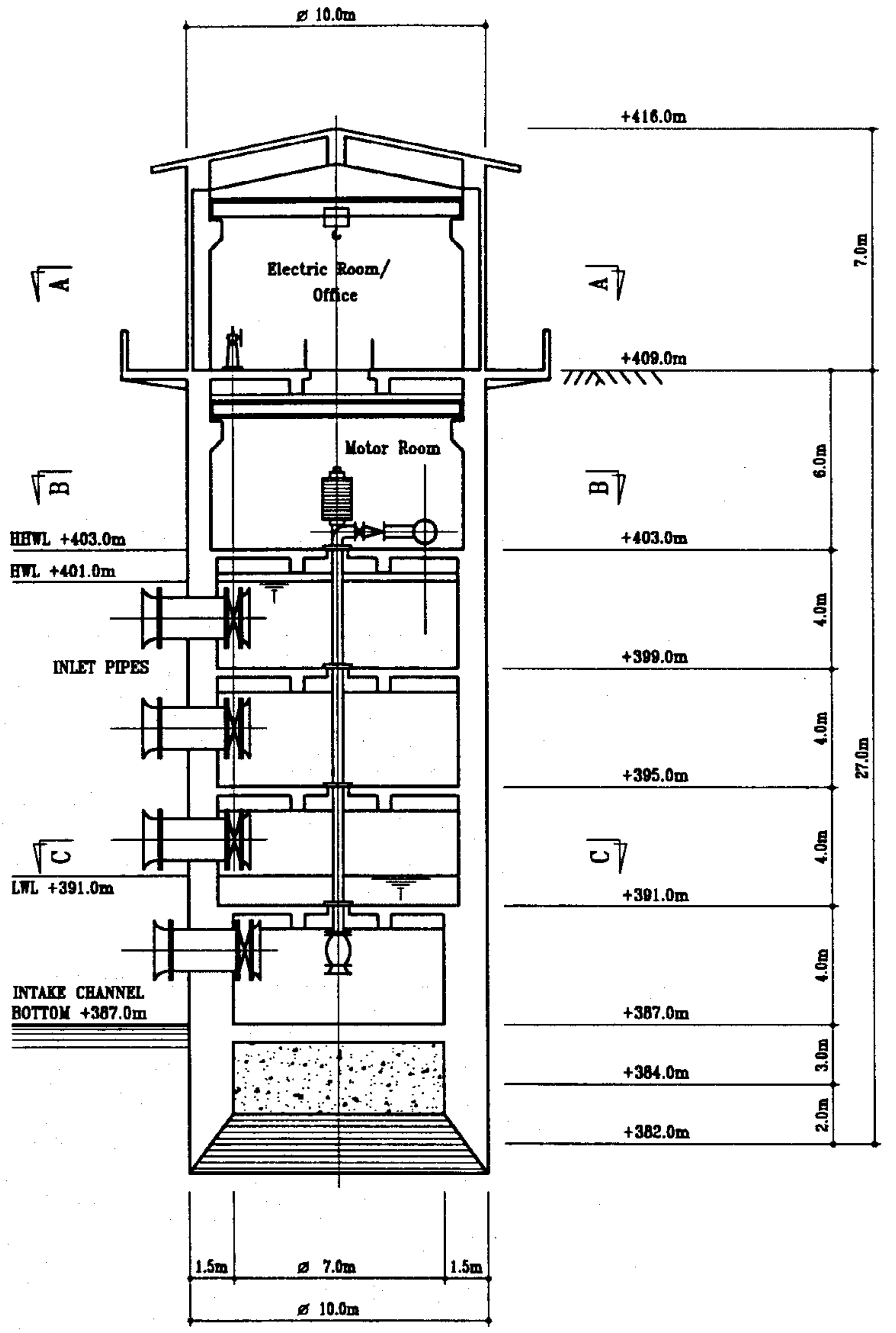
Figure 4.4.1 (1)
General Plan of New Vyacheslavsky Reservoir Intake Pumping Station



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Feasibility Study for Water Supply and Sewerage in the City of Astana

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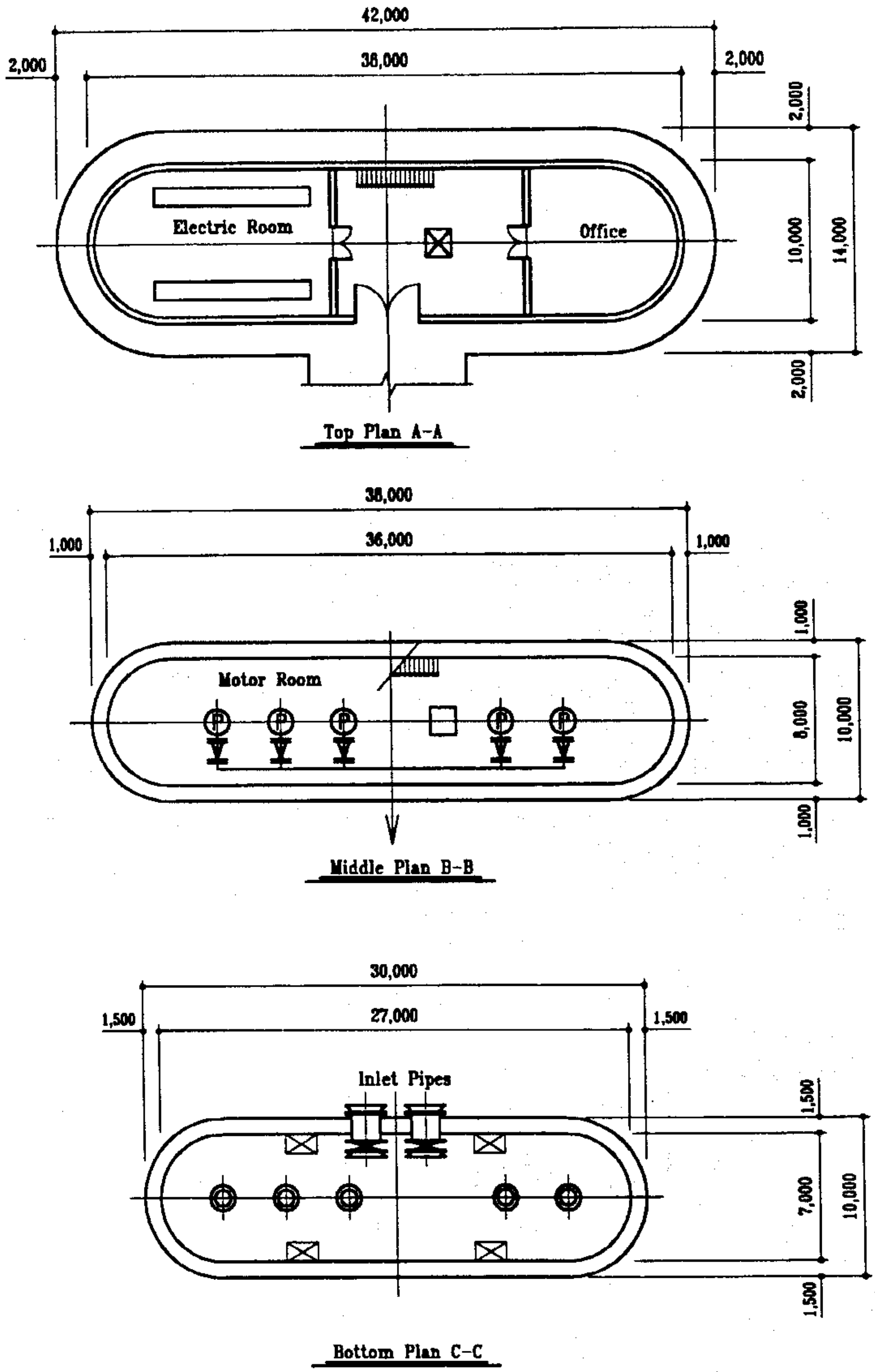
Figure 4.4.1(2)
Sectional Plan



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Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 4.4.1(3) Top to Bottom Plans
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(4) Buffer zones

Buffer zones for the existing water intake have not been implemented and and preventive sanitary measures have not been undertaken.

A survey of the water intake and adjacent areas indicated that setting out and construction of the first protective belt around the water intake can be carried out in accordance with and within the requirements of SNiP 2.04.84, item 10.8. The sanitary conditions of the area within a radius of 100 m, which has not being developed, and the water area of the intake channel are satisfactory. This plot of land should be acquired and enclosed with barbed wire fencing with a minimum height of 2 m

The measures required to implement the second and third protective belt can also be undertaken.

4.4.2 Transmission Facilities

The Kazakhstan Government has decided to install the new transmission pipeline, "Third Transmission Line" with a diameter of 1,400 mm for a length of 51 km, connecting the Vyacheslavsky Reservoir Intake P/S and the WTP. This pipeline is planned to be designed and constructed with local funding in the near future. Installation of additional transmission pipe from the Ishim Intake P/S was also planned, but implementation schedule has not been established yet.

4.4.3 Water Treatment Plant

(1) Treatment Plant Development Plan

The water treatment plant development plan for 2010 is summarized in Table 4.4.1.

Table 4.4.1 Water Demand and Necessary WTP Capacity

Items	Year	1999	2010
WTP Capacity (m^3/d)	Existing WTP	165,000	82,000
	New WTP (No.1)	—	100,000
	Total	165,000	182,000
Daily Maximum Demand		165,000	173,000

The capacity of the present WTP is assessed to be 165,000 m^3/day but only half of this capacity is expected to be operational by the year 2010, due to deterioration, especially in the more recently constructed half of the rapid gravity filters. In order to meet the water demand in 2010, a capacity of approximately 100,000 m^3/day of additional drinking water should be constructed to replace the capacity lost from the existing plant. This WTP (WTP No.1) is proposed on the same site as the existing

WTP. According to the water demand projection and WTP construction plan prepared by JICA Master Plan Team, a second new WTP is necessary to meet the demand of 2020. This WTP (WTP No.2) is proposed on the left bank of the Ishim River with a capacity of 120,000 m^3/day.

The existing WTP and WTP No. 1 cannot meet the demand for year 2030 and therefore a third water treatment plant (WTP No. 3) with a capacity of 100,000m^3/day on the same site as WTP No 1 will be necessary.

Location of these facilities is shown in Figure 4.4.2.

(2) The Existing Water Treatment Plant

The Existing WTP will continue operations until the commissioning of the New WTP (No.3) which is intended to replace WTP No1. Until the completion of the New WTP (No.1), this WTP is the only plant in the city, so it is therefore important that ASA properly maintains this facility.

(3) Proposed Water Treatment Facilities for New Water Treatment Plant (No.1)

Figure 4.4.3 shows the general plan of the existing and the proposed New WTP (No.1). The system diagram of WTP (No.1) is shown in Figure 4.4.4.

The following Table 4.4.2 summarizes the major facilities proposed for WTP No1:

Table 4.4.2 Major Facilities of WTP

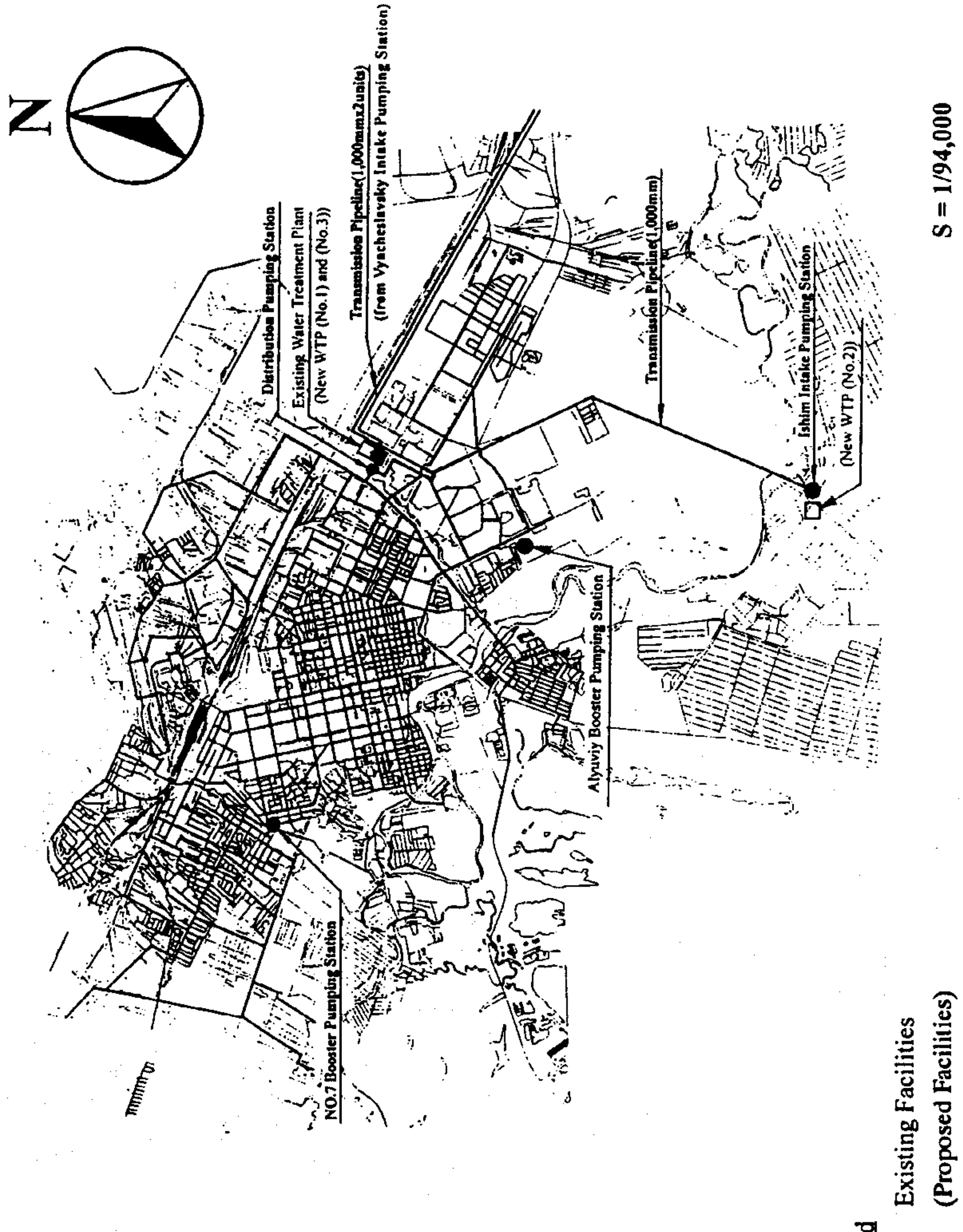
Facilities	Type	Dimension
Receiving Well	RC Rectangular Tank	L 6.0m x W 4.2m x D 5.0m x 2 units
Rapid Mixing Tank	Machine Mixing Type	L 4.2m x W 4.2m x D 5.0m x 2 units
Flocculation Tank	3 Step Horizontal Flow Type	W 1.3m x L 9.0m x D 3.7m x 6 channels W 1.8m x L 9.0m x D 3.7m x 6 channels W 2.4m x L 9.0m x D 3.7m x 6 channels
Sedimentation Basin	Horizontal Flow Type with Sludge Collector	W 9m x L 50m x D 4.0m x 6 units
Rapid Sand Filter	Down Flow Type	W 5.8m x L 12.6m x 12 units
Administration Bldg	RC, 3 story	W 15.0 m x L 60.0 m x H 12.5 m
Distribution Pump Building	RC, B1 and Ground Fl	W 12.0 m x L 66.0 m x H 8.0 m

Following is the summary of evaluation on types of treatment facilities:

a) Receiving well is proposed to enable incoming flow measurement and raw water quality analysis.

b) Proper agitation equipment is installed in the rapid mixing tank to assure appropriate coagulation.

c) Flocculation tank is designed to allow sound mixing by gravity flow. Three-step channels are installed. Their width is widened as it goes downstream to gradually lower the velocity.



Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 4.4.2 General Plan of the Existing and Proposed Water Supply Facilities in the City of Astana
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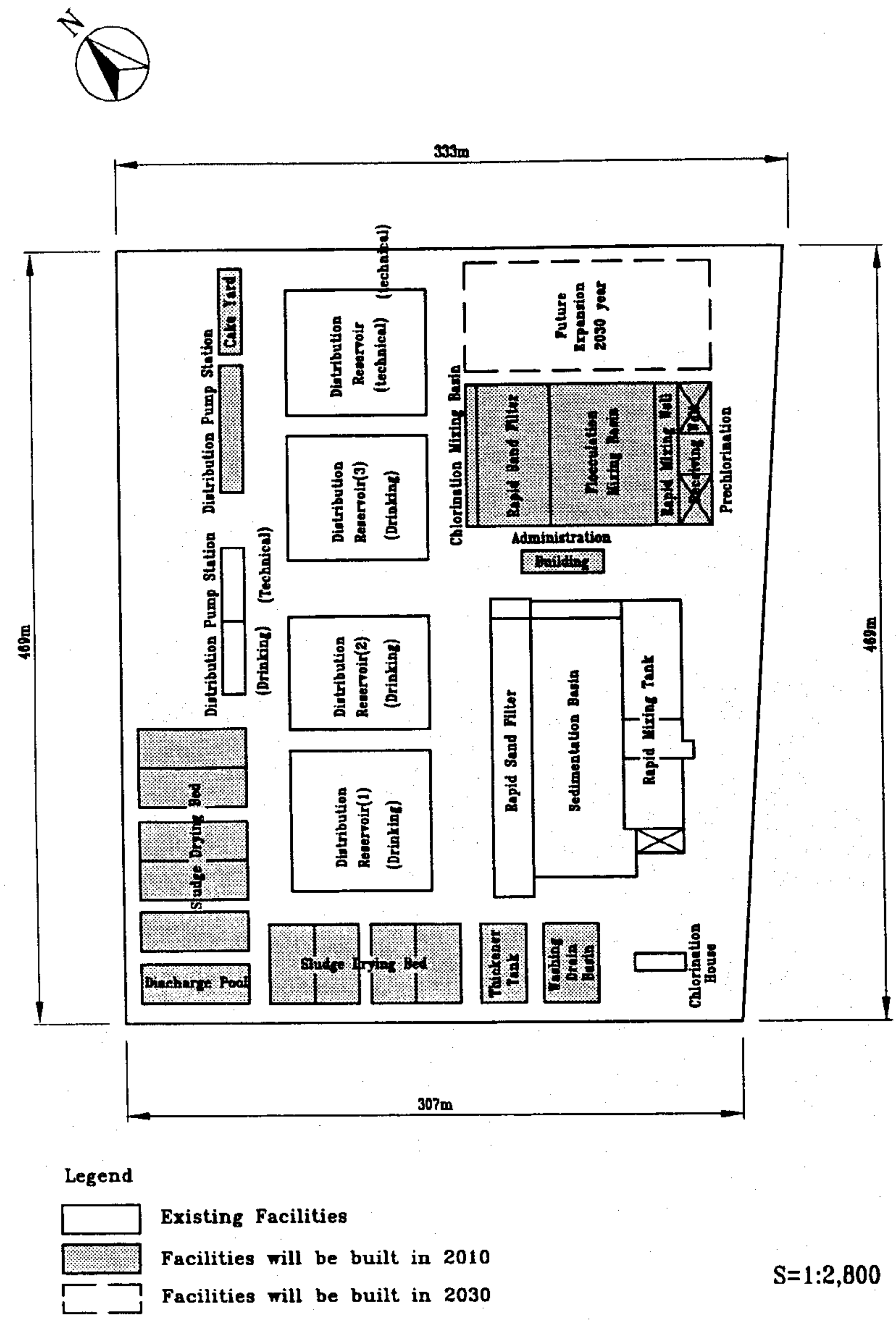

Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 4.4.3 General Plan of the Existing and Proposed Water Treatment Plant
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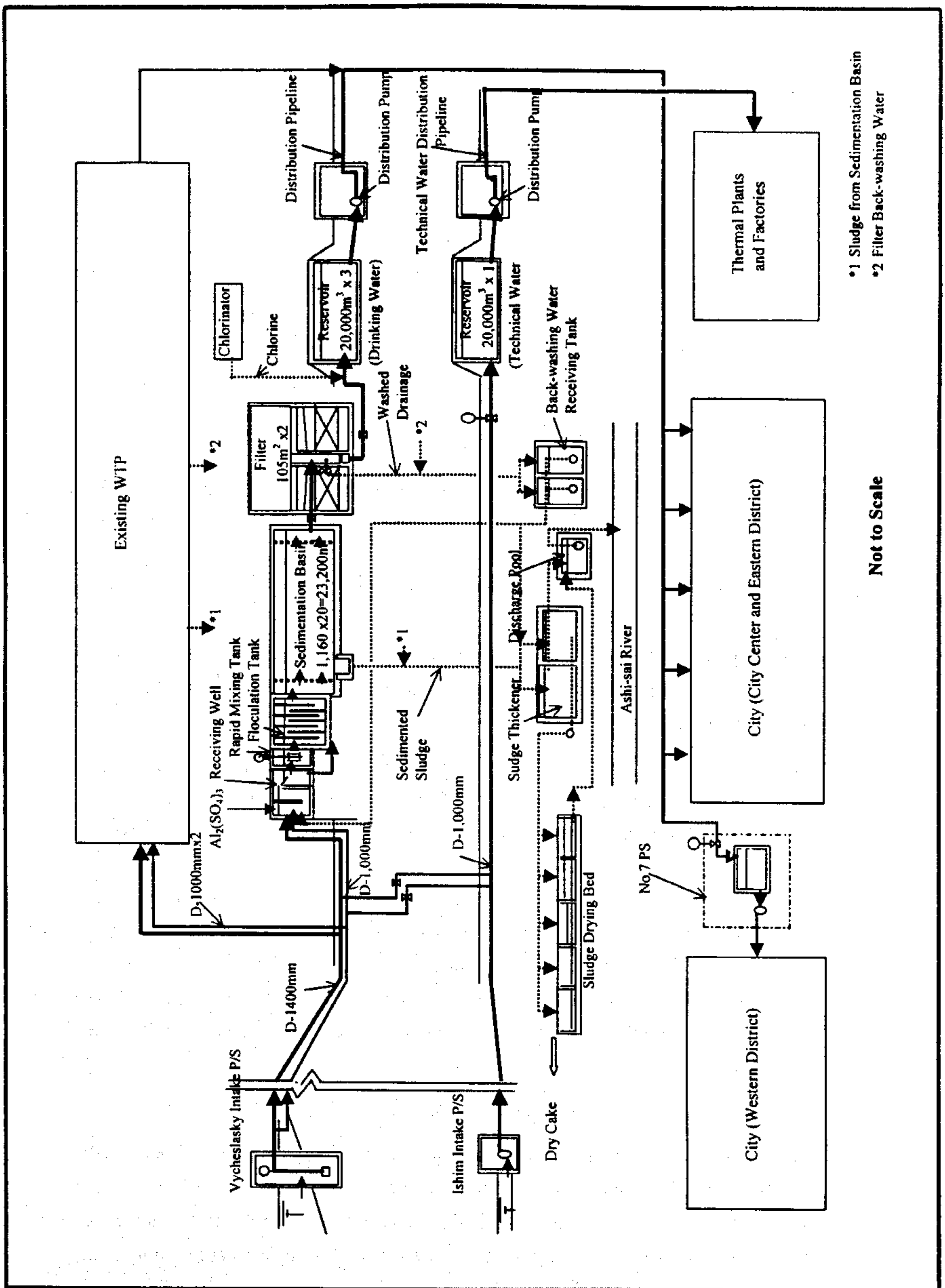

Feasibility Study for Water Supply and Sewerage in the City of Astana	Figure 4.4.4 System Diagram of a New WTP(No.1)
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d) At the end of sedimentation tank, effluent trough is installed to prevent overflow of floc.

e) For rapid sand filter, the following features are proposed;
   - Inlet weir is proposed instead of inlet pipe for stable inlet flow.
   - As for filter washing method, "back-washing + surface washing" is proposed for efficient filter washing when chemical aided sedimentation is practiced.
   - "Self-back washing type" using water from the filtered water channel is proposed for structural simplicity. Surface washing is an essential part of this type of rapid gravity filters

f) Although it is not necessary at the present moment, pre chlorination is proposed in the event that water quality in Vyacheslavsky Reservoir should deteriorate for reason such as eutrophication.

g) Activated carbon treatment should be considered if problems of taste and odours are to appear.

The Supporting Report A.7.1 provides further details and the calculation of capacities for these facilities. Detailed design drawings of WTP facilities are shown in the "Drawing Book".

It is proposed that one of the two technical water reservoirs be converted for drinking water use. This additional reservoir will increase the total drinking water reserve capacity to 60,000 m^3 (=20,000 m^3 x 3 units) The retention time for this arrangement can be calculated by dividing the total capacity by daily maximum water demand in 2010 (=144,000 x 1.2 = 173,000 m^3/day = 7,208 m^3/hr), which returns a retention time of 8.3 hrs (=60,000/7,208). As shown in the Supporting Report A.4.2, Japanese and Kazakhstan design criteria differently stipulated the retention time as 12 hrs and 5.6 hrs, respectively. This retention time will be sufficient for required peak-cut effect and thus, clear water reservoir will work efficiently.

(4) Proposed Automatic Operation and Monitoring System

Automatic operation will be adopted in the sand filter and monitoring system will be introduced for monitoring operating status of pumps, transmission/distribution flow and pressure. Pumps are controlled by timer set based on the past hourly flow fluctuation. Total monitoring system will be installed in the central monitor room in the administration building in WTP and panels will visually monitor the whole system.

(5) Buffer zones

The existing buffer zone complies with the requirements of SNiP. The maintenance of the buffer zones is an operational requirement and should be implemented by ASA. The details of the rehabilitation of the buffer zones will be prepared during detailed design stage.

4.4.4 Distribution Pumping Station

(1) Distribution P/S in WTP

Capacity of the New WTP (No.1) which corresponds to the daily maximum demand is 100,000 m^3/day. In order to design the pump capacities, hourly maximum is calculated to be 140,000 m^3/day (100,000 x 1.4). Two different pump capacities are adopted to cope with flow fluctuation. Of them, the smaller pump capacity is half of the larger pump. Three large pumps and two small pumps are proposed to be provided. Pump capacities are calculated as follows:

Table 4.4.3 Specifications of New Distribution Pumps

Large Pump	φ 450mm x 250mm x 33.0m^3/min x 200kW x 55 mH x 3 units (1 stand-by)
Small Pump	φ 400mm x 250mm x 16.5m^3/min x 160kW x 55 mH x 2 units (1 stand-by)

The flow rate can be controlled by the operation of a small pump that has a capacity of 990 m^3/hr to cope with the flow variation. System efficiency of the pumping station will be increased by this combination of pumps to match demand more closely and consequently, power consumption will be lowered.

(2) Booster P/S

No.7 P/S, one of the two existing booster P/Ss will be required for the foreseeable future. Replacement of control panels is proposed for secure operation.

As to the Alyuviy booster P/S, it shall be maintained by ASA as an emergency measure.

4.4.5 Distribution Pipelines

(1) Existing Pipelines

As described in Chapter 3.6.2, most of the existing pipelines are over-sized and therefore, they have sufficient capacity to cope with future water demand. However, deteriorated pipes should be replaced as soon as possible to eliminate the water leakage, This is one of the main project targets of ASA.

The following criteria have been adopted for selection of pipeline for renewal:

a) Steel pipe installed before 1970
b) Cast Iron Pipe installed before 1960
c) All Asbestos Cement Pipe, considering unstable joint and hygiene issues
d) Polyethylene Pipe installed before 1960

Table 4.4.4 shows the pipe length to be replaced based on the above criteria:

Table 4.4.4 Existing Pipeline List and Replacement Length

Materials	Diameter	<100mm (m)	125-200mm (m)	225-400mm (m)	>500mm (m)	Total (m)	Ratio (%)
Cast Iron Pipe	Total Length	28,639	90,114	97,611	97,058	313,422	64.0
	Replacement	1,195	38,093	2,342	0	41,630	42.7
Steel Pipe	Total Length	33,768	24,164	38,431	71,806	168,169	34.4
	Replacement	8,746	9,355	17,751	15,987	51,839	53.1
Asbestos Cement Pipe	Total Length	0	3,835	237	0	4,072	0.8
	Replacement	0	3,835	237	0	4,072	4.2
Polyethylene Pipe	Total Length	1,113	1,531	1,034	0	3,678	0.8
	Replacement	0	0	0	0	0	0.0
Total Length (m)		63,520	119,644	137,313	168,864	489,341	100.0
Ratio (%)		13.0	24.5	28.1	34.5	100.0	
Replacement Length (m)		9,941	51,283	20,330	15,987	97,541	100.0
Ratio (%)		10.2	52.6	20.8	16.4	100.0	

(2) Distribution Network Analysis

In 2010, New WTP No.1 will be completed at the site of the existing WTP. Treated water generated in the existing and the new WTP will be distributed by two distribution P/S in these two WTPs. Design flow and specifications of pumps in these P/Ss are listed below.

Design Flows for Pumping Stations

Design Flow	261,400 m^3/day (Q_{HM})
Pump in WTP (Existing P/S)	60 m^3/min x 65 mH x 2 units (1 stand-by)
	25 m^3/min x 65 mH x 2 units (1 stand-by)
Pump in WTP (New P/S)	33 m^3/min x 55 mH x 3 units (1 stand-by)
	16.5 m^3/min x 55 mH x 2 units (1 stand-by)
Pump in No.7 Booster P/S	25 m^3/min x 70 mH x 3 units (2 stand-by)

The results of hydraulic network analysis are as follows:

- Although in-pipe velocity in the existing pipelines is still low, ranging from 0.02 to 0.79 m/sec and average velocity is 0.28 m/sec, they have enough capacity for 2010.
- The Government City is planned in the new development areas on the left bank of the Ishim River. All of the new development area will be served by the new distribution P/S of New WTP No.1 and dedicated distribution trunk mains to be installed across the Ishim River, as shown in Figure 4.4.5. An average flow velocity is 0.78 m/sec. To relieve the low pressure and high flow velocity, two

existing pipelines should be replaced, as follows:

Recommended Pipes to be Replaced

Pipe No.	Existing Pipe Diameter	Proposed Pipe Diameter
P-63	600 mm	900 mm
P-221	200 mm	250 mm

4.4.6 Back-washing Water and Sludge Treatment and Disposal

(1) Proposed Facilities

Treatment facility is proposed for treatment of sludge and filter back-washing water. An outline of the proposed facilities is provided below:

a) Sludge thickening tank will be installed to treat sludge produced in the existing and new WTP.

b) Back-washing water receiving tank will receive back-washing water from filters and supernatant will be sent back to the raw water receiving well.

c) Generated sludge should be dewatered in sludge drying beds and the dried cake will be scraped by loading machine and transported to the dry cake yard.

d) The supernatant from the thickener and leachate from the sludge drying bed will be collected to the discharging pool, then the treated wastewater will be discharged into the Ashi-sai River.

Major treatment facilities are listed in Table 4.4.5 below.

Table 4.4.5 List of Treatment Facilities

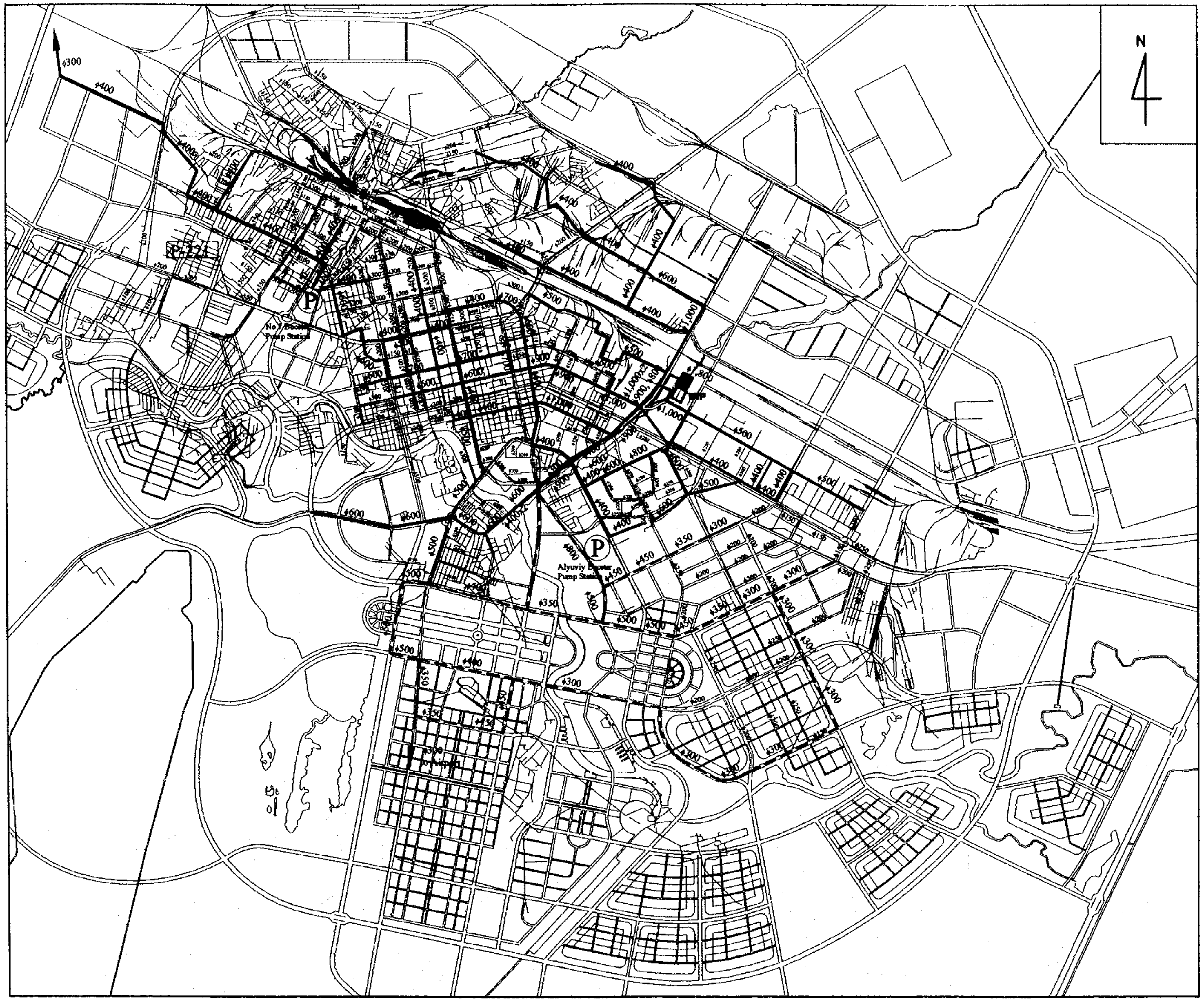
Facility	Type	Dimension
Sludge Thickener Tank	RC Circular Tank	ϕ 21.6 m (inner diameter) x D 3.5 m x 2 units
Back-washing Water Receiving Tank	RC Rectangular Tank	W 14.0 m x L 29.0 m x D 3.0 m X 2 units (1 stand-by)
Discharging Pool	RC Rectangular Tank	W 9.0 m x L 42.0 km x D 4.0 m X 2 units (1 stand-by)
Sludge Drying Bed	RC Rectangular Tank with Sand and Gravel Layer	W 21.0 m x L 39.0 m x D 1.0 m X 9 units
Dry Cake Yard	RC Rectangular Yard	W 20.0 m x L 35.0 m x 1 unit

(2) Sludge Volume

Based on the estimation of raw water turbidity, the volume of sludge and dry cake generated through the treatment process are summarized as follows:

Daily Sludge and Dry Cake Production

Thickened Sludge	81.7 m^3/day
Dry Cake	1.26 m^3/day



Legend

- Existing water treatment plant
- Existing pipeline (greater than 400)
- Existing pipeline (less than 300)
- Proposed water treatment plant
- Proposed pipeline (greater than 300)
- Proposed pipeline (less than 250)

0 1km 2km 5km

The Feasibility Study on Water Supply and Sewerage in the City of Astana	Figure 4.4.5 Plan of Distribution Pipeline Expansion in 2010
JAPAN INTERNATIONAL COOPERATION AGENCY	

Volume of dry cake is not huge, and it can be used as soil substitute, for instance in green zones, planting and gardening.

4.5 Operation and Maintenance Plan

4.5.1 Staff Arrangement

For smooth and efficient operation of water supply facilities, appropriate staff arrangement is essential. In order to improve the efficiency of ASA staff development through training is essential. Training seminars and "on the job" training are to be provided by ASA. Staff arrangement for water supply works is proposed based on the following policy:

- Reduction in the number of O&M staff of Vyacheslavsky Reservoir Intake P/S shall be minimized taking into consideration the location and existing O&M status of this facility.
- At the WTP, some of the staff presently engaged in the existing plant will be allocated to the new plant and the number of O&M staff shall be minimized in view of the introduction of automatic operation and monitoring systems in new plant.
- To cope with the future expansion in the area of water service , O&M staff of "Water Network Section" and "Electric Section" of ASA shall be strengthened.
- As for the other facilities, the present staff composition will be maintained.

Staff arrangement at every facility is proposed as follows:

- In case of the Vyacheslavsky Reservoir intake P/S, auxiliary workers are excluded.
- At the WTP, the number of repair and auxiliary workers is reduced.
- Some 50% of additional staff to be assigned in "Water Network Section" and "Electric Section" is proposed for ASA
- As to Ishim intake P/S, the present staff composition will be adopted in future operations and one Electrical Engineer is allocated to No.7 booster P/S.
- Alyuviy booster P/S will be maintained as an emergency measure.

Proposed staff arrangement is shown below.

Table 4.5.1 Total Staff Arrangement for Water Supply Works

Unit : person

Facility	Present	Proposal
Vyacheslavsky Reservoir Intake P/S	14	12
Ishim Intake PS	9	9
WTP	100	88
No.7 PS	8	9
Alyuviy Booster PS	4	4
ASA	308	341
Total	443	463

Further details are given in the Supporting Report A.8.1.

For efficient and smooth O&M works, small-scale workshops are proposed to be established within the City and staff and equipment shall be properly allocated.

4.5.2 Procurement of O&M Equipment, Power Saving and Chemical Consumption

(1) Equipment

Measurement results of flow, pressure and water level in the reservoirs are not carried out as part of normal operation. The following consideration should be included in the design of the future O&M works.

1) Sufficient spare parts shall be procured and stored in the warehouse in the existing WTP. Electrical Engineers who are knowledgeable with maintenance should be allocated for maintenance.

2) The laboratory in the existing WTP has not been provided with efficient water quality testing, particularly for pesticides and organic chlorides. Procurement of more advanced equipment, for instance atomic absorption spectro-photometer or gas chromatographic mass spectrometer is needed.

3) Necessary work tools shall be procured and allocated to the workshops in WTP and ASA for rapid repair works.

(2) Power Saving

Operation of each pumping station can be more efficient by introducing the following countermeasures:

1) Distribution pressure from WTP shall be lowered. Distribution flow shall be controlled by the number of pumps in operation and not by valve control.

2) Necessary pump head of the new Vyacheslavsky Reservoir intake P/S will be lowered upon completion of new raw water transmission line.

3) Valve control shall be minimized also in Ishim intake P/S and No.7 booster P/S.

As shown in Table 4.5.2, power consumption in 2010 will be decreased compared with that of 1999. Detailed calculations are provided in Supporting Report A.8.2.

Table 4.5.2 Power Consumption Unit : million kWH/Year

P/S Year	Vacheslavsky R. I. P/S	WTP P/S		Ishim Intake P/S	No.7 Booster P/S	Total
		Drinking W.	Technical W.			
In 1999	21.9	12.7	5.6	7.0	4.4	51.6
In 2010	11.0	6.0	3.8	4.7	2.9	28.4

(3) Chemical Consumption

Chemicals used in WTP are solid aluminum sulfate and liquid chlorine. Based on the design chemical dosage rate, annual chemical consumption in 2010 is calculated as shown in Table 4.5.3.

Table 4.5.3 Chemical Consumption

Item Chemicals	Coagulant	Chlorine
Unit Cost (Tg/ton)	11.000	80.000
Annual Water Volume (Million m^3)	55.367	
Injection Rate (mg/L)	10.0	5.5
Annual Consumption (ton)	553.7	304.5
Annual Expense (Million Tg)	6.090	24.360

4.5.3 Data Base Management

The followings aspects are proposed for future data base management:

1) Every P/S, WTP, WWTP shall prepare a "Monthly Audit Report" by means of electronic media and should be transmitted to ASA. This report shall include all the expenses namely, electricity, chemicals, fuel, labors, water quality results and pumped or treated water volume. Expense per unit of pumped or treated water volume will be a valuable O&M indicator. Major repair works shall also be reported. Analysis of the data collected should be carried out to obtain a water balance within the system. Any large discrepancy should be investigated.
2) Computer-aided-mapping system should be introduced to facilitate the data management and control system. The database shall include the following:
   - Pipe Materials

- Installation Year
- Diameter
- Length
- Valve Location
- Major Repair Record

The maps shall be revised from time to time.

3) The laboratory in WTP should be improved by the introduction of more advanced measuring equipment. Their audit report including all expenses and analysis results shall be transmitted to ASA periodically by electronic media. Periodic spot checks on water quality investigation shall also be carried out and monitored by laboratory staff.

4.5.4 Leakage Management

Leakage management is one of the major issues for ASA and leakage from the existing pipeline must be reduced as soon as possible to save on pumping and chemical costs and to extend the availability of existing resources. Along with the replacement of deteriorated pipelines, leakage detection shall be conducted. "Leakage Detection Team" shall be created in the "Water Network Section" in ASA together with the procurement of leakage detection equipment.

In order to target leakage detection it is usual to install district meters on the distribution system such that flows into districts can be monitored on a continuous basis. This permanent monitoring will permit the early discovery of increased flows to the district resulting from increased leakage flows. Such a system is proposed for Astana. However a detailed design of the distribution system is necessary to define in detail the locations of the district meters and the changes required within the system to enable the creation of closed districts.

4.6 Summary of Proposed Development Plan

1) Installation of Individual Water Meter

Individual water meter will be installed to reduce wastage by consumers and to preserve the limited water resource. Some 65,500 units of meters will be procured and installed.

2) New Vyacheslavsky Reservoir Intake P/S

Construction of new intake P/S is proposed as follows:

Specification of New Vyacheslavsky Reservoir Intake P/S

Facility	Type	Dimension
Pump Room	RC Cason	W 30m x L 10m x D 27m
Pump	Vertical Pump	35 m^3/min x 57 m x 470 kW x 5 units

3) New Water Treatment Plant (No.1)

New WTP is to be constructed within the confine of the existing one. Major facilities are shown below.

Outline of New Water Treatment Plant

Facility			
Name of Facility	Quantity	Name of Facility	Quantity
Receiving Well	2 units	Distribution Pump Building	1 unit
Rapid Mixing Tank	2 units	Sludge Thickener Tank	2 units
Flocculation Tank	6 channels	Back-washing Water Receiving Tank	2 units
Sedimentation Basin	6 units	Discharging Pool	2 units
Rapid Sand Filter	12 units	Sludge Drying Bed	9 units
Administration Building	1 unit	Dry Cake Yard	1 unit

4) Pipe Replacement

Deteriorated pipeline is proposed to be replaced for leakage reduction. Breakdown is shown below.

Outline of Replacement Pipe by Material

Types of Pipe	Dimension
CIP	Diameter 100 to 300 mm, L = 41,630 m
SP	Diameter 50 to 1,000 mm, L = 51,839 m
ACP	Diameter 150 to 300 mm, L = 4,072 m
Total	L = 97,541 m

5) New Pipe Installation

New pipes will be installed to serve in the new development areas. Breakdown is shown below.

Outline of Newly Installed Pipe

Types of Pipe	Dimension
DCIP	Diameter 150 to 800 mm, L = 70,876 m
SP	Diameter 900 to 1,800 mm, L = 2,252 m
Total	L = 73,128 m

It shall be noted that pipes for the replacement and new installation works must have watertight mechanical joints, instead of the existing primitive ones using yarn and concrete.

Priority for implementation will be as shown in the order below.

1. Installation of individual water meter
2. Pipe replacement
3. New Vyacheslavsky reservoir intake P/S,
4. New water treatment plant (No.1)
5. New pipe installation