Chapter 3 Current Issues of the Water Supply System

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3.1 Deteriorated and Inefficient Water Supply System

3.1.1 Major Technical Issues

(1) Deterioration of Facilities

Most of the water supply facilities were constructed before 1980 and proper investments for their maintenance and replacement have not been made. Some of the major facilities such as intake pumps and pipelines need to be urgently replaced.

(2) Decline of Well Capacity

There are six groundwater treatment plants in Tashkent City. The yields of the majority of the wells have been declining and well pumps have been breaking down frequently. In particular is declining yield of the deep wells located at the left bank in Kibray WTP as the groundwater level of some wells is lower than the level at which pumps have been installed.

(3) Inefficient Distribution Network

The major WTPs (Kadirya, Boz-su and Kibray) are located higher than the City, quite ideal for the gravity water supply. However, the difference in the height among these facilities and some parts of the City is too great that pipeline valves are used to lower the pressure to prevent pipe breakages. As a result, water pressure in the City is so low that over 100 booster pump stations have been constructed all around the City.

(4) Lack of Ability to Regulate Distribution Flow

The diurnal variation of distribution flow from each WTP is currently almost flat. In the future, flow fluctuations will occur when water demand decreases as a result of water meter installation and by pipe replacement. Currently, the retention time of reservoirs in the City is too short to cope with the future flow fluctuation.

(5) Inappropriate Operation and Maintenance Methods

In Tashkent City the staff members are working hard to carry out their responsibilities; however, Tashkent Vodokanal lacks sufficient budget, the correct manuals and appropriate trainings for staff, all of which are necessary for the proper operation and maintenance of the facilities.

3.1.2 Diagnosis Study of Facilities (Details are referred to S 3.1.2)

(1) Results of Function and Deterioration Diagnosis

The Study Team conducted functional diagnosis over what caused the deterioration of WTPs, booster PSs and the pipeline network. However, since the diagnosis of the pipeline network could not be conducted directly, the Team analyzed the hydraulic condition using information from Vodokanal. Specialists in the fields of civil structures/buildings, mechanical, electrical and pipeline carried out these diagnoses.

1) Surface water WTPs (Details are referred to S 3.1.2(2))

The results of diagnosis for Kadirya and Boz-su WTP are summarized in Table 3.1.1. At the Kadirya WTP many facilities need replacement or repair, especially the intake pumps. Civil structures and buildings may be in relatively good condition; however, some structures require additional repair and improvement works. The real operational capacity of the WTP exceeds its nominal design capacity; thus the plant does not operate efficiently. For example, when raw water turbidity is high, the coagulant dosing rate is insufficient to lower raw water turbidity to a level suitable for filtration. In spite of this, the plant can still distribute drinking water in most of the days, since the raw water meets the water quality standards only by the filtration.

In Boz-su WTP, the actual treatment capacity is rarely exceeded; and there are no serious problems for operation. But the facilities of Boz-su WTP including civil structures and buildings, are seriously deteriorated and so large-scale rehabilitation and replacement would be absolutely necessary.

Table 3.1.1 Summarized Diagnosis Results for WTP

Division	Name	Kadirya WTP	Boz-su WTP
Installation year	Structures	No.1 intake and old filter: 1969,	Circle filter 1961and the others: 1931,
	Facilities	No.2 intake and new filter: after 1985	Intake: 1982, Filters& others: 1960th to 1980th
Function diagnosis	Design capacity	1,375,000m^3/d	235,600m^3/d
	Intake capacity	2,250,000m^3/d	270,000m^3/d
	Distribution capacity	By gravity pipes:2,250,000m^3/d, By pumps: 121,000m^3/d	260,000m^3/d
	Actual distribution	2,150-2,250×1000m^3/d	240-260x1000m^3/d
	Sedimentation	No.1-1,000,000m^3 (RT=18hr), No.2-500,000m^3 (RT-12.5hr), Insufficient flocculation facilities	Volume 89,400m^3 (RT=8.6hr), Insufficient flocculation facilities
	Filter	A=6,720m^2, 320-335m/d	A=1,000m^2, 240-260m/d
	Coagulant	To be able to meet demand,	To be able to meet demand
	Disinfection	To be able to meet demand, 14kg/hrx16units	To be able to meet demand, 14kg/hrx6units
	Service reservoirs	30,000m^3(RT=0.3hr)	29,900m^3 (RT=3hr)
Deterioration diagnosis	Sedimentation basins	No serious deteriorations, attached equipment is needed to replace or repair	No serious deteriorations, needed to repair for some parts
	Other civil structures		Deteriorations is progressing, replacement or refurbishing are necessary
	Buildings	Fittings and steel product are needed to replace or repair	Deteriorations is progressing, Fittings and steel product are needed to replace or repair
	Intake channel facilities	Needed to replace or repair	Needed to replace or repair
	Intake pump facilities	Needed to replace for pumps and repair for accessories urgently	Needed to replace for pumps and repair for accessories urgently
	Filters	Some pipes and auto-valves are needed to repair	Needed to replace or reconstruct urgently
	Distribution pump facilities	Needed to replace for pumps and repair for pipes urgently	Needed to replace for pumps and repair for accessories urgently
	Washing pump facilities	Needed to repair for some parts	Needed to replace for pumps and repair for accessories urgently
	Coagulant dosing facilities	Needed to replace urgently	Needed to replace urgently
	Disinfection facilities	Needed to replace urgently	Needed to replace urgently
	Power receiving facilities	Needed to replace within 10 years	Needed to replace within 10 years
	Electric facilities	Needed to replace when machines will be replaced	Needed to replace when machines will be replaced
	Pipes and valves	Due to lack of painting maintenance, the deterioration was accelerated	Due to lack of painting maintenance, the deterioration was accelerated
	Laboratory	Old Equipment, no electron measurement device, which can analyze rapidly and precisely	Old Equipment, no electron measurement device, which can analyze rapidly and precisely

2) Groundwater WTPs (Details are referred to S 3.1.2(3))

The results of diagnosis for groundwater WTPs are summarized in Table 3.1.2. The table shows that many wells have been non-operational, including the relatively new wells with submerged pumps. Additionally, many well pumps have frequently broken down at an average breakdown frequency, which is about once or twice a year. The results of the pumping tests show that the well capacities have decreased by 40 - 70 % of their original capacities during construction. For cleaning well screens, the air-lifting washing method has been adopted which may not be suitable for the wells that contain high concentration of hardness.

Many of the wells have some water quality problems. High nitrate concentration has been observed at the right bank in Kibray WTP and high hardness at South WTP. But there are no problems with the quality and quantity of water being distributed because the water is mixed from other sources.

The WTPs' total intake capacity in Tashkent City has been decreasing yearly since all WTPs are already old and facilities have deteriorated. It will take large investments to maintain groundwater intake capacities.

3) Booster Pump Stations (Details are referred to S 3.1.2(4))

Table 3.1.3 shows diagnosis results of booster pump stations. Diagnosis was conducted for almost all PSs with capacity of over 600 m^3/hr. Pump stations are classified into four categories shown in Table 3.1.4. Based on the diagnosis, 70% of PS were either A or B rank, 9% - belonged to the C1 rank, and 21% to the - C2 rank.

Table 3.1.2 Summarized Diagnosis Results for WTPs

Division	Name	Kibray	South	Sergeli	Kara-su	Kuiluk	Bectemir
Installation year	Structures	1955	1961	1977	1946	1964	1973
	Facilities	No.1P/S: 1962, No.2 P/S: 1969	Wells:1959-1998, P/S:1970-2000	Wells:1966-1976, P/S:1978	Wells:1962-1964	Wells	Wells:1973-, P/S: 1986
Function diagnosis	Design cap. (1000m^3/d)	455.2	143.0	40.0	52.0	20.0	20.0
	Wells number (Operating)	95(66) Many left wells	41(24) Many left wells	9(7) Two left wells	11(6) Many left wells	9(6) Three left wells	11(5) Many left wells
	Test intake capacity (1000m^3/d)	912	246	42	----	43.6	----
	Actual maximum capacity (1000m^3/d)	70% operation x 70% capacity =447	24 operation x 100%capacity=144	7 operation x 50%capacity =21	From record: 35	7 operation x 80%capacity =27	From record: 15
	Yield capacity (1000m^3/d)	No.1:217, No.2: 247	156	46.8	----	----	24.5
	Actual yield (Average)(1000m^3/d)	310-479(353)	124-198(142)	15.5-31.1(22.9)	24.7-35.2(28.7)	13.3-26.2(19.9)	14-15
	Raw water quality	High nitrate in right bank	High hardness	Some bacteriological issues	High hardness+Some bacteriological issues	High hardness	Contamination from surface
	Disinfection (stand-by)	2.5kg/hr x 6(3)	2.5kg/hr x 2	2.5kg/hr x 2	2.5kg/hr	2.5kg/hr	2.5kg/hr
	Service reservoirs	10,000m^3(RT-0.5hr)	10,000m^3(RT-1.7hr)	4,000m^3(RT=2.5hr)	----	----	1,000m^3(RT=1.0)
Deterioration diagnosis	Filter ponds	Reduction of filtration function	----	----	----	----	----
	Wells	Progressing capacity reduction	Many non operation wells	Two non operation wells	Many non operation wells	Some non operation wells	Many non operation wells
	Well's pumps	Many of them frequently broke down and some submerged pump broken-down were left					
	Reservoir	Accessories need to replace			----	----	Accessories need to replace
	Pump buildings	Needed to replace	Fittings are needed to replace		----	----	Needed to replace
	Disinfection building	Needed to replace	Fittings are needed to replace		----	----	----
	Administration building	Fittings are needed to replace					
	Distribution P/S	Needed to replace for pumps and repair for pipes urgently		----	----	Needed to replace for pumps and repair for pipes urgently	
	Disinfection facilities	Needed to replace					
	Power receiving facilities	Needed to replace within 10 years					
	Electric facilities	Needed to replace when machine will be replaced					
	Laboratory	Old equipment, no electronic measurement device			----	----	----

Table 3.1.3 Diagnosis Results of Booster PS

Capacity: m^3/hr, (Average)	Number	Results of diagnosis					
		A	B	C1	C2	No execution	Total
30,000	1			1			1
7,200	1	1					1
3,000	5		4		1		4
1,000	43		25	4	13	1	44
800	3		3				3
600	11		8		2	1	11
500-300(402)	9		5	2		2	9
200-100(164)	10		4			6	10
Under100(38)	51	1	5		1	44	51
Total	134	2	54	7	17	54	134

Table 3.1.4 Classification of Diagnosis Rank and Evaluation

Class	Evaluation
A	Good
B	No serious problems, but replacement will be necessary in future
C1	Needed to be replaced because of deterioration
C2	Breakdowns frequently take place, so replace is needed urgently

The diagnosis was mainly carried out in pump facilities. Buildings of C1 and C2 ranks were so deteriorated that the fitting and roof need to be replaced or repaired when the pumps will be changed.

(2) Pipeline Network (Details are referred to D 5.2.3)

Fourteen percent of the pipelines of network are over 40 years old. Around 67% of the pipelines are steel pipes and 33% are cast iron pipes as shown in Table 2.3.16. Since most of the steel pipes were not properly protected by lining, these got rusty and sometimes had holes due to electric corrosion. Cast iron pipes are resistant to rust; but since yarn type of sealing connector is utilized, leakages easily take place at connection easily take place at the connection pointes. Around 8,000 leakage accidents have been reported annually, and the losses from distribution network are calculated to reach 40% to the total amount of water distributed. Vodokanal has already selected those frequently leaking pipes to be replaced.

The total length of selected pipes listed in Table 3.1.5(1) and (2) is 420 kms and there are selected sites. Thus the average distance between those sites is less than 1 km. It means that Vodokanal carried out very detailed investigation in locating these sites.

As shown in Table 3.1.5(2), 67.9% of the selected pipes have diameters less than 150 mm, and its average diameter is 209mm.

Table 3.1.5(1) Selected Pipes for Replacement

District name	Length (m)	Selected sites
Mirzo Ulugbek	67,265	46
Sabir Rahimov	28,242	4
Akmal Ikramov	52,700	94
Hamza	34,317	39
Yunusabad	30,162	24
Sergeli	51,520	39
Bektemir	8,420	54
Chilanzar	33,248	67
Shayhantahur	47,996	65
Yakkasaray	31,066	63
Mirabad	35,145	33
Total	420,081	528

Source: Vodokanal

Table 3.1.5(2) Selected Pipes for Replacement by District

District name	Total (m)	Pipe length for each diameter (m)														
		50	80	100	150	200	250	300	400	500	600	700	800	900	1,000	1,200
Mirzo Ulugbek	67,265		2,080	14,130	13,220	3,450		14,155	2,600	2,400	3,230	4,200		7,300	500	
Sabir Rahimov	28,242	1,340	750	8,175	3,987	3,780		2,060	960	750	6,440					
Akmal Ikramov	52,700			36,100	8,160	2,200		6,240								
Hamza	34,317	3,420	3,270	17,641	6,886	2,560	70	470								
Yunusabad	30,162	540		6,166	8,470	1,240		5,328	1,078		4,850		1,740			750
Sergeli	51,520	15,845	230	28,610	2,855	1,000		1,880			1,100					
Bektemir	8,420			2,123	3,173	824		2,300								
Chilanzar	33,248	230		28,458	370	460		1,030	2,700							
Shayhantahur	47,996	490		17,205	12,194	1,754	3,660	7,230	2,420		3,043					
Yakkasaray	31,066		622	7,116	6,138	1,200	1,460	7,200	980		6,350					
Mirabad	35,145	900	1,670	13,835	8,810	2,190	2,060	5,040			640					
Total	420,081	22,765	8,622	179,559	74,263	20,658	7,250	52,933	10,738	3,150	25,653	4,200	1,740	7,300	500	750

Source: Vodokanal

3.1.3 Declining Capacity of Wells

(1) Evaluation of Operation for Wells

The actual intake capacity for each groundwater WTP is shown in Table 3.1.6.

Table 3.1.6 Actual Intake Capacity of Groundwater WTPs

Name	Kibray	South	Sergeli	Kara-su	Kuiluk	Bectemir	Total
Design capacity (1000m^3/d)	455.2	143.0	40.0	52.0	20.0	20.0	730.2
Actual capacity (1000m^3/d)	300.0	160.0	30.0	35.0	35.0	15.0	575.0

As shown in the table, the intake capacity is lower than the nominal capacity and the reasons are as follows:

- Pumps break down frequently and repair work is difficult due to lack of spare parts, many of which are no longer in production;
- Distance between wells is so short that the draw-down of groundwater level is quite large, which also the cause of the frequent breakdown of pumps;
- Pumps' discharge capacity is not suitable for the water intake capacity specified by pumping test; and
- Wells require some rehabilitation works, which include cleaning of screens. The once-a year washing by air-lift carried out by Vodokanal may no longer be effective.

Additionally, there are some quality issues as follows:

- High nitrate in some of the wells at the right bank., although water distributed from the Kibray WTP meets the Drinking Water Standard of water quality; and
- High hardness of some wells at South WTP.

(2) Capacity Decline of Kibray WTP (Details are referred to S 3.1.3)

As shown in Table 3.1.6, the decline of the intake capacity at Kibray WTP is notable when compared with the design capacity of 455,200m^3/d. In Kibray WTP, as already mentioned, the right bank's wells have a high nitrate concentration; however, production of these wells is stable. Many of the left bank's wells are left idle as mentioned below. Pumps break down frequently, although water quality is excellent as shown in Table 2.3.12.

The other issues are described as follows:

- The distance between the wells is too short to secure a stable water production, especially along the river. As the result, the groundwater level falls because of the mutual interference of wells as shown in Figure 3.1.1;
- Because pumps with excessive capacities are installed for the majority of wells, there is a fall of the water level in the wells; together with harmful vibration of the pumps caused by excessive closing of discharge valves to prevent the fall of water level;

- Although wells are arranged at intervals of 350m in the left bank site far from the river, there is a huge drop in the water level. It means to say that water supply to groundwater layer, provided from the Chirchik River by penetration flow flux, is small in this area;
- Since the well pumps are operated manually, if water level drops to a certain level, the pumps are on dry operation, which causes serious breakdowns;
- Deterioration of old wells at the right bank is faster compared to the wells at the left bank, which are relatively newer;
- As a result of the above issues, well pumps frequently broken down or became out of order. This is the main reason of the capacity decline of Kibray WTP. In 2004, the operation ratio of wells at the right bank was 70-80%, and at the left bank only around 40%. For the whole area, it is around 50%, as shown in Figure 3.1.1;
- The nitrate concentration of some wells at the right bank exceeds the standard of 45mg/l. Average concentration of all wells at the right bank was from 36 to 47 mg/l for the years 2000 to 2003, and the concentration in the last decade has not decreased. Since the concentration of well water at the left bank was less than 10mg/l, the yield from the right bank should be mixed with the yield from the left bank;
- A total 28 hectares of infiltration (artificial groundwater recharge) ponds was constructed as shown in Figure 3.1.1, but since removal of the bottom mud has not been carried out, the recharge ability may be small; and
- At the left bank, where the gradient of the ground is large, the upstream and down stream transmission pipes are directly connected. This is harmful for the well pumps downstream in the site, thus most of the pumps located downstream have broken down as shown in Figure 3.1.1.

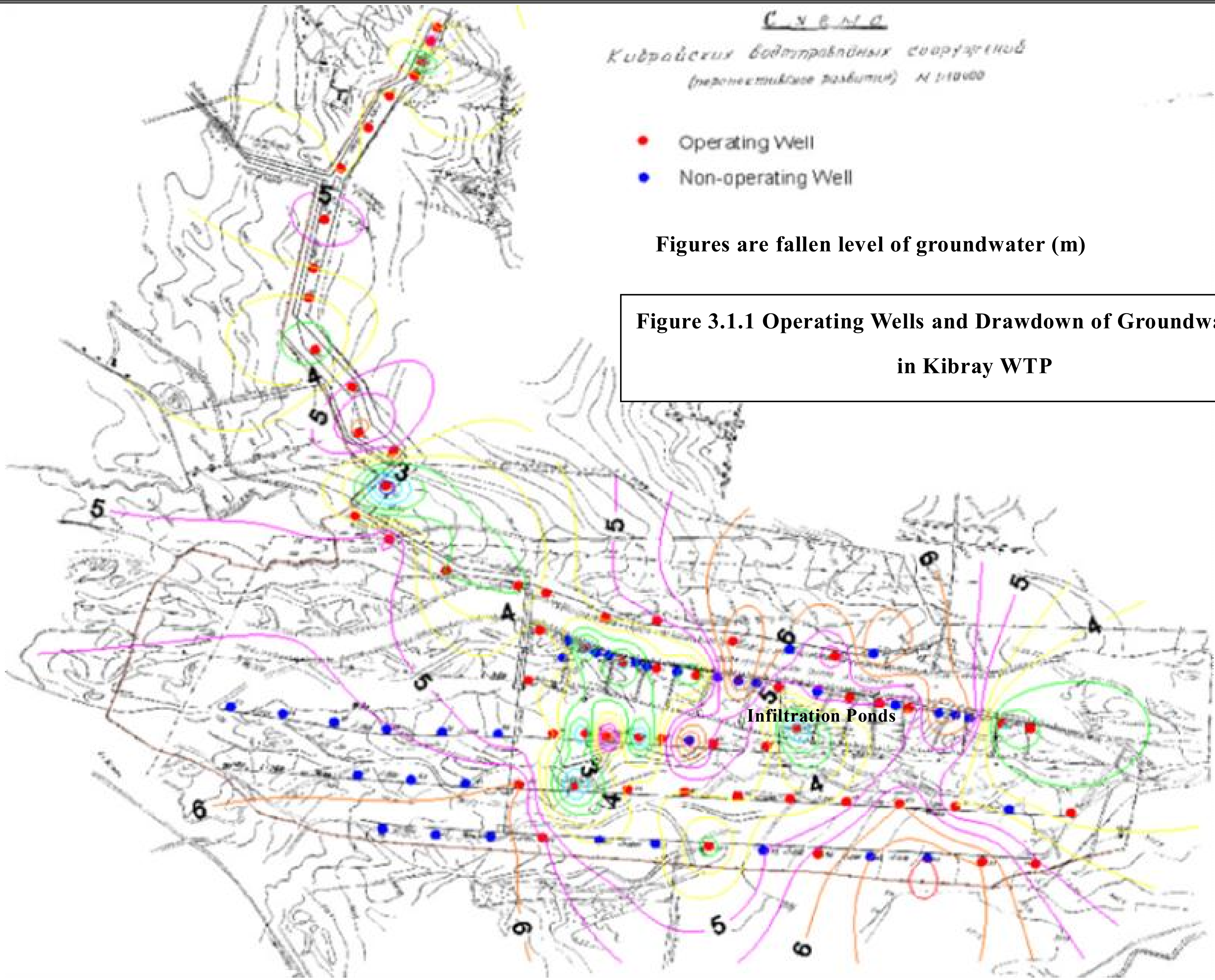


Figure 3.1.1 Operating Wells and Drawdown of Groundwater Level in Kibray WTP

3.1.4 Inefficient Distribution Network and Operation (Details are referred to S 3.1.4)

(1) Inefficient Distribution System of the City

The main service area of the City is divided into five zones as shown in Table 3.1.7 and Figure 3.1.2. The Kadirya and Kibray WTPs, the key water supply facilities for the City, cover about 85% of the distribution volume.

The ground elevation of the main service area supplied from these sources ranges from 400 to 490 m, while, Kadirya and Kibray WTP are situated on an area with a ground elevation of approximately 540 and 500 m, respectively. This means that differences in the elevation among these key facilities and the lowest service area are more than 100 m. Because of the high water pressure, pipes are known to burst in specific areas.

Table 3.1.7 Service Area by Water Source

Water source	Service area	Ground elevation	Distribution volume	Distribution system
Kadirya WTP	A.Ikramov Yunusabad S.Rahimov Shayhanta-hur Yakkasaray Mirabad (part) Mirzo-Ulugbek (part) Khamza (part) Chilanzar (part)	410-490 m	2,100,000 m^3/d	Gravity system
(from Mirzo-Ulugbek PS)	Mirzo-Ulugbek (part) Khamza (part)	440-510 m	500,000 m^3/d	Pumping system
Boz-su WTP	Yunusabad Khamza (part) Mirabad (part)	440-480 m	250,000 m^3/d	Pumping system
Kibray WTP	Khamza (part) Mirzo-Ulugbek (part) Mirabad (part) Sergeli Yakkasaray (part) Bectemir (part)	400-470 m	660,000 m^3/d (incl. 350,000 m^3/d transmitted from Kadirya WTP)	Pumping system
South WTP	Chilanzar Yakkasaray (part)	410-430 m	150,000 m^3/d	Pumping system
Others				
Sergeli WTP	Sergeli (part)	390-410 m		Pumping system
Kuiluk WTP	Sergeli (part)	410 m		Pumping system
Kara-su WTP	Sergeli (part)	430 m		Pumping system
Bectemir WTP	Bectemir (part)	420-440 m		Pumping system
Total			2,900,000 m^3/d	

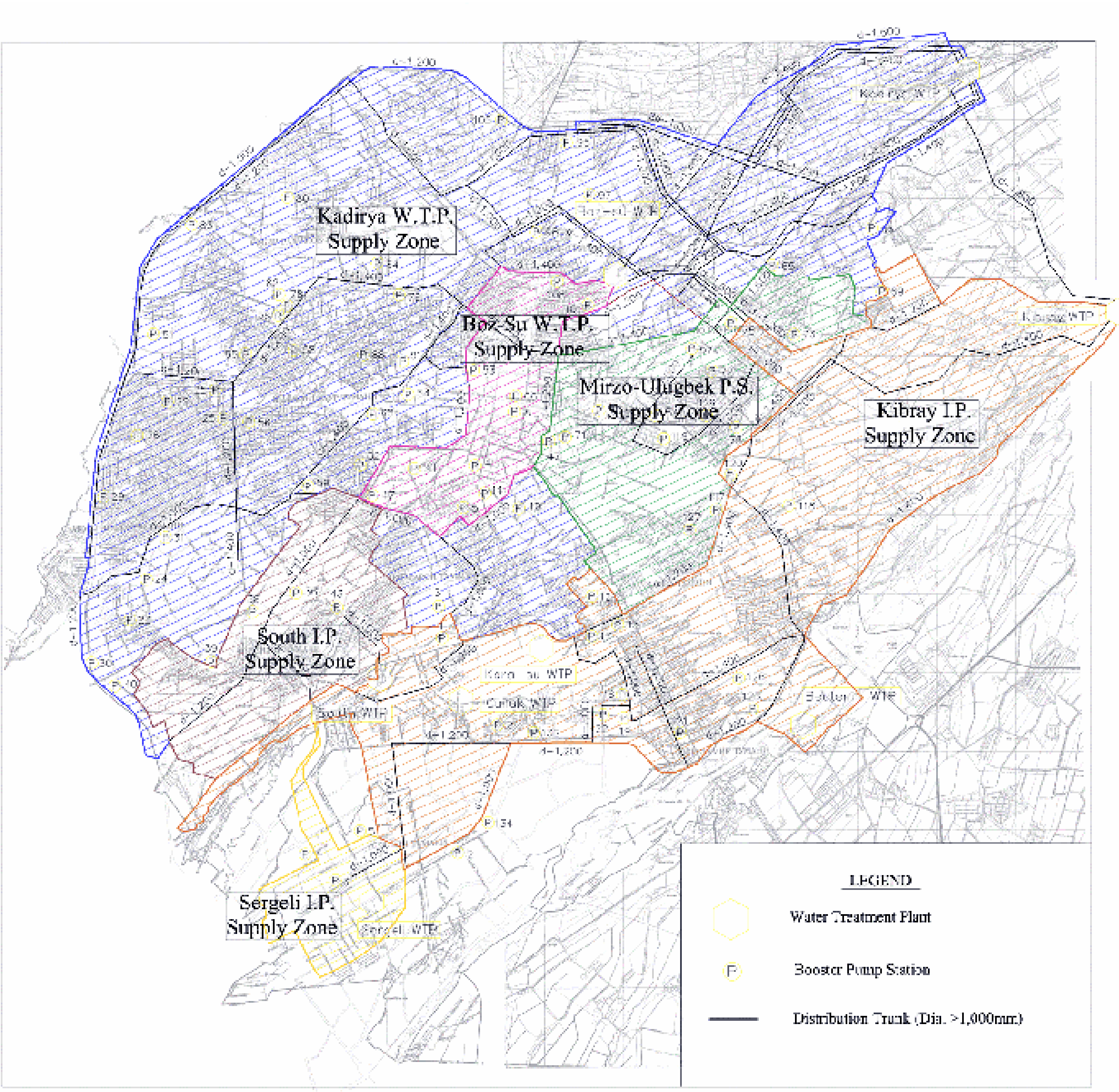


Figure 3.1.2 Major Water Supply Zones in Tashkent City

To correct this situation, Vodokanal has been regulating water pressure to less than 20m water head for the areas of detached houses and around 26m for the areas of apartment buildings by operating the valves throughout the City.

For five-story buildings, 26m of water head (10m for 1st floor ＋ 4m/stories x 4=16m, total

26m) is sufficient. However, for nine-story buildings, the pressure needed is 42m of water head. This pressure is too high to be kept in the distribution network area. As shown in Figure 3.1.3, the pressure in the distribution network could not be currently maintained to more than 26m in most part of the City.

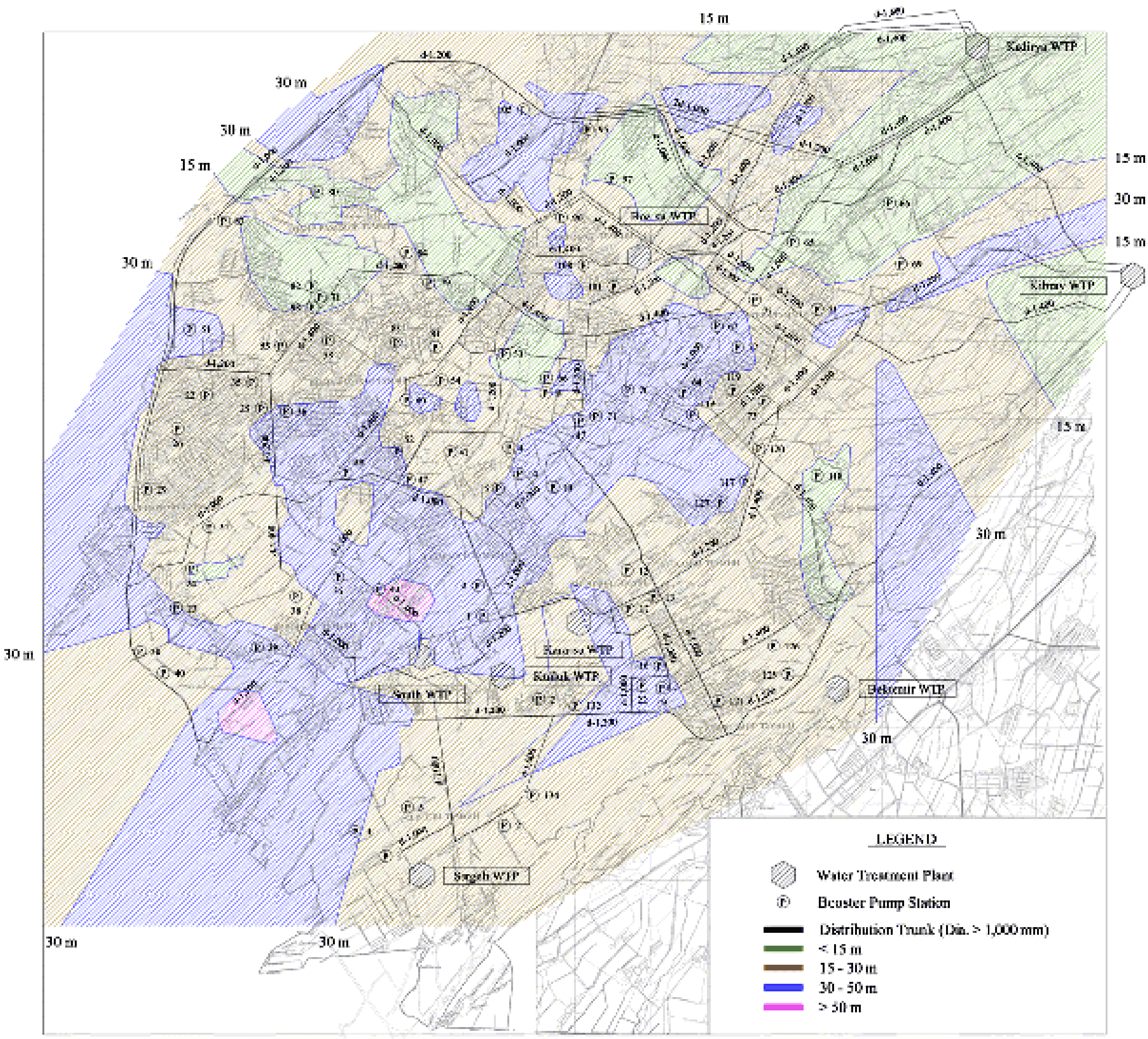


Figure 3.1.3 Present Water Pressure in Distribution Network

Accordingly, pumps need to be operated to distribute water even to low-story apartment buildings. As a result, the system requires having more than 100 booster pump stations in the distribution network. As shown in Figure 3.1.4, if valves of the network are not regulated, the pressure goes up sharply. Therefore, establishing and operating a proper distribution system in the City would mean that water should be distributed by gravity to a majority of low-story buildings. The distribution network should be improved by introducing proper pressure control system to reduce the number of booster PSs in use. The hydraulic analysis in this Study showed that some elevated areas such as nearby areas of Kadirya, Kibray and Boz-su WTPs and Boz-su PS be supplied by pumping system and the remaining areas can be supplied by gravity except for nine-story buildings.

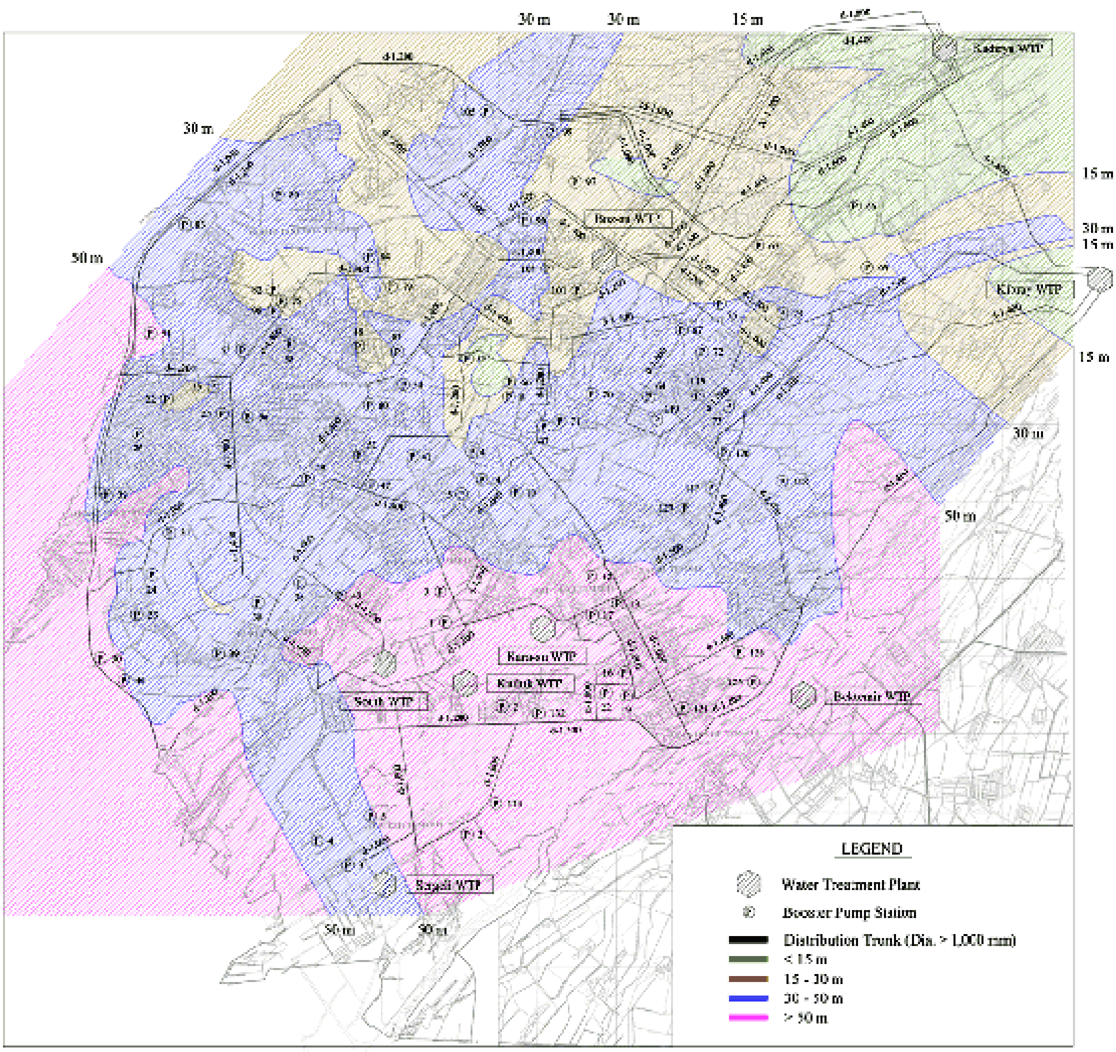


Figure 3.1.4 Water Pressure in Distribution Network in the case of no Regulation of Valves

(2) Inefficient Distribution and Booster PS

1) Distribution PSs of WTPs

Based on the hydraulic calculation, all distribution PSs located in the WTPs are necessary. However, if the distribution network is redesigned, many of the capacities of these PSs can be reduced.

Small WTPs, such as South, Sergeli, Kara-su, Kuiluk and Bectemir distribute to their immediate surrounding areas. But in the future, when the water demand in the City will be reduced, these WTPs may be abandoned. The distribution PS in the Kadirya WTP distributes -1,600m^3/hr only to the surrounding high areas. Two distribution PSs in Kibray WTP distribute the well's yield to the City and the surrounding areas; but in the future, this can be done by gravity. The distribution PS in Boz-su WTP distributes to the City's government area. The elevation of the WTP is relatively high, at 485m. But since the areas of the City are also high, boosting pumps are necessary.

Accordingly, based on the projection of future water demand, the distribution system from the WTPs should be examined and be changed to the gravity system.

2) Booster PSs

As of 2002, 134 booster PSs operate in the City, as listed in Table 3.1.8. Over 200 of other small pump stations are installed for buildings, which are operated by TSZh's staff. The biggest one is Mirzo-Ulugbek PS, which distributes not only to the areas with high elevations and to apartment buildings. Based on the hydraulic calculations, the capacity could be reduced to 1/10 of the existing capacity.

Table3.1.8 List of Booster PSs ***(Source: Vodokanal)***

Capacity: m^3/hr	Number	Total capacity		Average pump head: m
		m^3/hr	1000m^3/d	
30,000	1	30,000	720	51
7,200	1	7,200	173	90
3,000	5	15,000	360	53
1,000	43	43,000	1,032	49
800	3	2,400	58	50
600	11	6,600	158	45
500-300 (402)*	9	3,618	87	43
200-100 (164)*	10	1,640	39	35
Under 100 (38)*	51	1,938	47	38
Total	134	101,396	2,674	

( )* Average

If the distribution system is properly designed, most of the four and five-story apartments can receive water distributed by gravity. For six to nine- story apartment buildings, water needs to be pumped up. Note that the residents of these apartment buildings make-up around 28% of the total population of apartment, while for over 10-story buildings, pump for each building has already been installed.

The water consumption of apartment residents and related entities, such as schools, hospitals, public offices and public facilities, is assumed to be 849,000 m^3/d as shown in Table 3.1.9.

Table 3.1.9 Water Consumption by Apartment and related Entities

Consumption category	Quantity (1000m^3/d)
Apartment	650
Budgetary organization excluding distribution amount to Tashkent Region	161
Small industries	111
Total	849

Target population = 849,000 x 0.28 = 238,000m^3/d

Necessary pump's head: 50m

Pump's efficiency: 0.6

Necessary Electricity: 238,000m^3/d x 0.163 x 50/0.6 x1/60 = 53,900kWh/d

Actual electricity consumption in 2002: 88,827x1000kWh/year=243,000kWh/d

If the improvement of the PSs is carried out as planned, then the consumption of electricity can be reduced at 53,900/243,000 = 1/4.5. However, in the future, when water consumption will be reduced, consumption of electricity will follow suit. Boosting water quantity in 2002 is calculated as follows:

The electricity consumption in 2002: 243,000 kWh/d

Average pump head of the PSs is 50m and actual of them assumed at 45m.

Necessary kW = 0.163 x1/60 x QH/ η Q: discharge volume m^3/h, H pump head m

η :pump efficiency :0.6

243,000 kWh/d = 0.163 x 1/60 x Q x 45/0.6x24hr

Q = 243 x10^3/(0.163 x 45 x 24/(60 x 0.6)=50,000 m^3/hr=1,200,000 m^3/d

Based on the survey, around 40% of low-story buildings are being distributed with water by gravity. The ratio of flat (house) number of low-story buildings out of that of all apartments in the City is approximately 70%, based on the TKEO's Data and the survey results in Kibray distribution area.

Therefore, 70% x 40% =28% of consumption should be reduced from the consumption shown in Table 3.1.9. However it was assumed that 25% of water is lost in the form of leaks. The modified consumption amount is calculated as follows:

849,000 x (1-0.28) /(1-0.25) = 719,000 m^3/d.

The difference between the boosted water quantity (1,200,000m^3/d) and the modified consumption amount (719,000m^3/d) is quite huge. The reason seems to be the low efficiency of pump operation, because the pumps installed in PSs have a bigger capacity than its discharge volume, discharging much smaller volume of water than design capacity. If the modified consumption amount is the actual boosted water quantity, the pump efficiency is calculated as follows:

η = 0.163 x QH/kW=0.163 x 1/60 x 719 x103 x 45/(243,000) = 0.36

If the value is actual, it is quite low compared with practical value of 0.6-0.8.

On the other hand, compared to the design capacity of PSs, the actual capacity is much less so that the design capacity of PSs should be made smaller.

In addition, since pumps for booster PSs are operated manually, the number of assigned operators or O&M staff has reached 794 in 2002, including 585 shift operators. The number can be drastically reduced if the use of PS is replaced with an auto-control system with monitoring system.

3.1.5 Lack of Regulation Ability for Distribution System

In Tashkent City, most WTPs distribute water with constant flows. South WTP increases its distribution flow in the evening. To change distribution flow, one or two pumps are manually turned on or off. The distribution flow pattern in the City in 2003 is assumed as shown in

Figure 3.1.6 based on previous JICA Study conducted in 1999, which measured the total of water amount distributed from major WTPs.

Currently the retention time of all reservoirs in Tashkent City is only 0.6 hours, and it may be enough to ease the present hourly variation of the distribution flow. However, after completion of the project formulated by this LTDP, flow pattern is expected to change in 2015 (hourly rate =1.12) as shown in Figure 3.1.5. The necessary minimum retention time of reservoirs is calculated to be about 1.35 hours. Therefore, the volume of the reservoir requires expansion in the future.

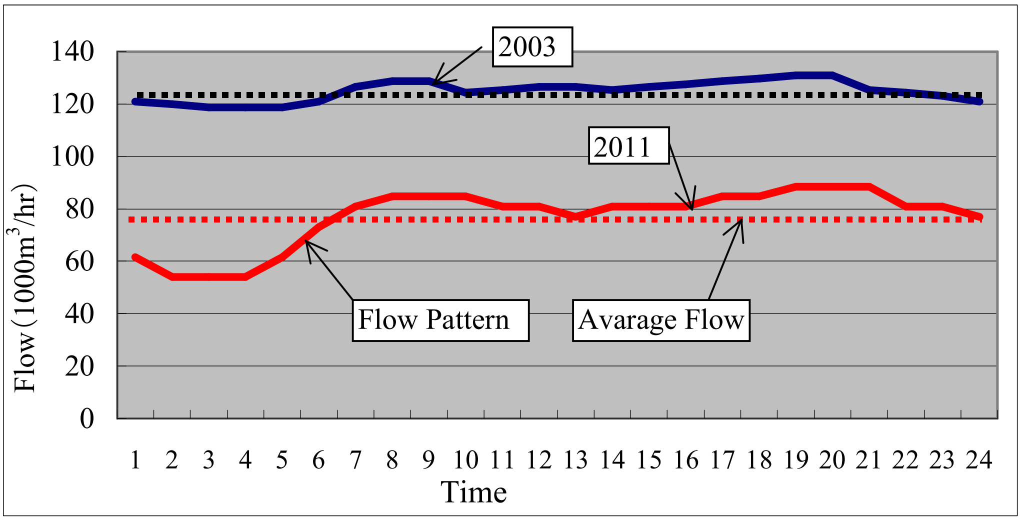


Figure 3.1.5 Flow Fluctuation in the Future

Additionally, all pumps are manually operated, and there is no automatic shutdown for low water level and no breakdown alarms. Instrumentation for automatic pump operation and monitoring needs to be introduced.

3.1.6 Insufficient Training for Operation and Maintenance Staff

(1) Training for Proper O&M

Details of necessary O&M works are shown in Table 3.1.10, which include decision-making, recording, reporting and response to emergency situations. For carrying out those tasks, tools for O&M, adequate number of properly trained and skilled staff and manuals for each O&M task are needed.

Table 3.1.10 Details of O&M Works

Items	Contents
Civil structures	Patrolling, checking, repair for incipient defect, requesting repair
Buildings	Checking, repair for insignificantly item, ordering to repair
Pumps	Operation, checking, oiling/lubrication, replace lubricant and parts, overhauling, painting, repair for insignificantly item, ordering to repair
Other machines	Operation, checking, oiling/lubrication, replace lubricant and parts, overhauling, painting, repair for insignificant item, ordering to repair
Electrical facilities	Operation, checking, testing function, replace parts, painting, repair for small item, ordering to repair
Pipes	Patrolling, checking, repair, painting, repair for insignificant item, requesting repair

(2) Current Situation in Tashkent City

Vodokanal lacks the following resources to carry out proper O&M:

- Budget for O&M is decided based on the expense of previous years, which can only be used to operate the system and to respond to emergency incidents;
- The O&M budget for each plant is inadequate to replace deteriorated facilities;
- The staff does not have enough O&M skills and O&M training is seldom carried out; and
- There are no practical operation manuals for facilities.

3.2 Non-Revenue Water in the Tashkent City

3.2.1 Water Wastage by Domestic Customers (Details are referred to S 2.3.4 and S 13.1)

(1) Assumed Water Consumption for the Domestic Customers

In the City, cold water (drinking water) and hot water are supplied to consumers. Per capita consumption of the metered domestic customers is much smaller than that of the customers without water meters. Many survey for domestic customers have been carried out in Tashkent City. The results of the five surveys are summarized in Table 3.2.1.

Table 3.2.1 Various Survey Results of Consumption for Domestic Customers (Lpcd)

Customer	Category			Survey Result (Lpcd)					
	Water meter		Sewer connection	JICA in 2003 (1)[*1]	JICA in 2003 (2)[*2]	Vodokanal in 2001[*3]	JICA in 1999	Repair by Pilot Project[*4]	
	Cold	Hot						Before	After
Apartment	○	○	○	131					
	○	×	○	92					
	○	?	○		124	161			
	×	×	○			583	540[*5]	631	354
Detached house	○	×	○		212		230-300[*6]		
	○	×	?		176	203			
	×	×	×				540-180(300)[*7]		

*1: Surveyed directly for two apartments
*2: analysis for meter reading records
*3: Analysis for meter reading records, referred to Table 2.3.5
*4: by Pilot study referred to S 13.1
*5: Measured by ultra-sonic flow meter in apartment
*6: Metered system was already introduced
*7: Meters were installed by JICA and metered system was not introduced
in ( ) is average

Features for domestic customers shown in Table 3.2.1are summarized below:

- The difference of water consumption by metered customers with hot water meters (92 Lpcd) and without them (131 Lpcd) is large as shown Table 3.2.1. It means that the metered apartment customers without hot water meters may mainly use hot water for cooking, showering and laundry to save their water charges of cold water;
- The survey results conducted by the Team shows that consumption by metered apartment customers was less than the results of the survey conducted by Vodokanal;
- The survey results for metered customers living in detached houses conducted by the Team have similar results with that carried out by Vodokanal; and

- The survey conducted by JICA in 1999 is the only one made for consumption of detached houses without water meters. The difference in consumption between summer and autumn/winter seasons is quite large, however the annual average consumption was assumed at 300 Lpcd.

As mentioned in Chapter 2.3.4, per capita consumption of domestic customers is shown in Table 3.2.2 and the current largest water consumption is domestic customers living in apartment without meters. Consumers are serviced with around 300,000 m^3/d of hot water besides heating water. Hot water distribution per capita to domestic customers is calculated as shown in Table 3.2.2. The hot water distribution to consumers is assumed at 80% of the supplied cold water to the heating plants. 76 % of hot water was distributed to domestic customers in 2002.

The results of this calculation show that the hot water consumption for domestic customers is 84 Lpcd, meaning that total consumption of apartment residents and residents living in detached house with meters are 234, and 284 Lpcd, respectively. The values are considered to be sufficient for these customers. Accordingly, the future per capita consumption for domestic customers is set at the metered consumption as shown in the table. In this case, the difference of the consumption between customers with meters and those without meters is considered to be wastage.

Table 3.2.2 Assumed Water and Hot Water Consumption

Division	Meter installation	Per capita consumption (Lpcd)*	Population (× 1000)	Consumption (1000m^3/d)	Hot water
Apartment	○	150	128	19	300x0.8x 0.76/2,171x1000 =84 Lpcd
	×	500	1,263	632	
Detached house	○	200	259	52	
	×	270	521	141	
Total			2,171	844	

*: Derived from Table 2.3.7

(2) Water Wastage by the Domestic Customers (Details are referred to S 13.1)

A pilot project, which included repair works of water leakages in apartments, was conducted in this Study. The difference in the actual water consumption between before the repair work is decreased by 44% as shown in Table 3.2.3. In the table, real demand was set at the value of consumption with meter as mentioned earlier.

Table 3.2.3 Estimated Water Consumption in Apartment

Water division	Consumption (Lpcd)	Ratio (%)
Real demand*1	150	30
Wastage	130	26
Leakage*2	220	44
Total	500	100

*1: The consumption with meters is set at as real demand
*2: Leakage from water service equipment, such as valves of toilet low tank, showers and faucets

The wastage and leakage for domestic customers are calculated as shown in Table 3.2.4 when the metered consumption is set at as real demand. It is around two times bigger as the required consumption.

Table 3.2.4 Calculation of Wastage and Leakage for Domestic Customers

Category	1) Real demand (Lpcd)	2) Population (x1000)	3) Required consumption (1000m^3/d)	4) Current consumption (1000m^3/d)	5) Wastage and leakage (1000m^3/d)
Apartments	150	1,419	151.4	650.7	499.3
Detached houses	200	732	146.4	192.5	46.1
Total		2,171	297.8	834.2	545.4

Note: 1) x 2)=3), 4)-3) =5)

In the case of detached houses, since many of them have gardens and livestock, per capita water consumption is higher compared to the other seasons. However water wastage in apartment buildings as shown in Table 3.2.4 is much larger than detached houses.

3.2.2 Water Wastage by Large Consumers

(1) Water Consumption by Large Consumers

Water consumption by large consumers in Tashkent City has decreased in the last five years, as shown in Figure 3.2.1 due to progress in installation of water meters.

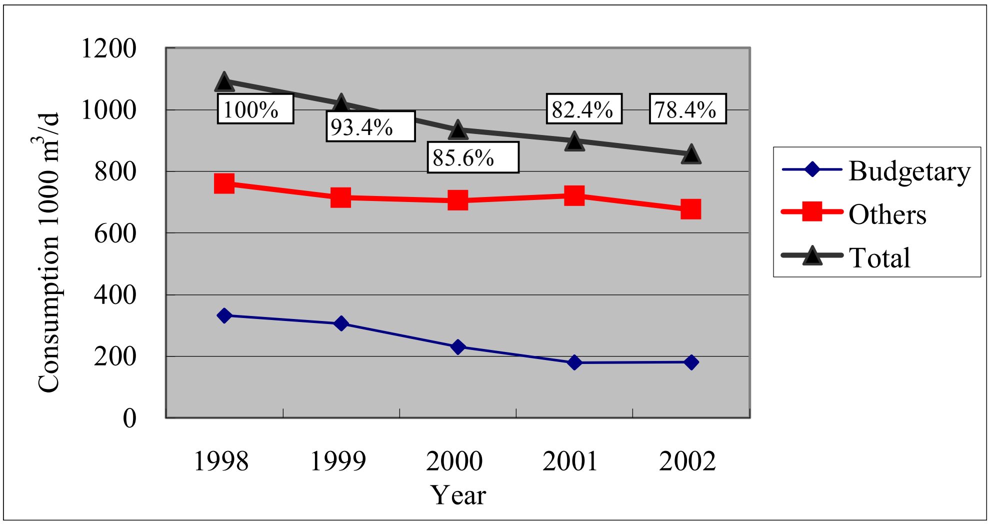


Figure 3.2.1 Propensity of Large Consumers to Consume Water ***(Source: Vodokanal)***

(2) Water Wastage by Large Consumers

Table 3.2.5 shows the breakdown of water consumption by large consumers. In the table, consumption of hot water plants accounts for 55%, and it is reported that these plants and its distribution system have low efficiency for distributing hot and heating water. Since meter installation ratio is low for domestic customers, people are wasting hot water instead of cold water. Although huge investments will be necessary to improve the hot water system, TKEO is planning to implement the upgrade of the hot water system in the near future.

The consumption of large consumers should be reduced by appropriate countermeasures, because the Study Team observed leakage from toilets in public offices, restaurants and shops.

Table 3.2.5 Composition of Consumption by Large Consumers

Division		Population (x1000)	Consumption 1000m³/d	Consumption Lpcd	Rate %
Budgetary		2,171	234	108	26
Industries			56	26	6
Hot water	Domestic customers		347	160	39
	Large		148	68	17
	Sub-total		495	228	56
Small industries			111	51	12
Sub-total			896	412	100

3.2.3 Total Water Loss in the Water Supply System

(1) Water Losses from Distribution Lines

As shown in Section 2.3.6, there are huge losses in the distribution lines. The difference between total supply and the estimated real demand is shown in Table 3.2.6. The loss is composed of water loss from the distribution network and wastage of consumers, giving a total loss ratio at 63%.

Table 3.2.6 Calculation of Water Losses

Category	Meters	Per capita consumption (Lpcd)	Statistic Department: Population (x1000)	Statistic Department: Current consumption (1000m³/d)	Statistic Department: Real demand (1000m³/d)
Total Supply				2,900*1	
Apartments	with	150	128	19	19
	without	500	1,263	631	189
Detached houses	with	200	259	52	52
	without	270	521	141	104
Sub-Total			2,171	843	365
Large consumers				896	717*2
Total consumption				1,739	1,082
Loss/wastage value				1,161*3	1,818*4
Water loss				40.0	62.7

*1: Total amount of water distributed as estimated by the Team
*2: 80% of the current consumption
*3: Loss from distribution line= (total supply - total consumption)
*5: Loss by consumers = (Total supply – total consumption)

The Study Team, with the assistance from Vodokanal measured distribution flow in Sergeli District (part). The result showed 25% of water losses from the distribution lines. (Details are referred to S 2.3.6 in Supporting Report).

(2) Total Wastage in the City

Table 3.2.7 and Figure 3.2.2 show the breakdown of water distribution to the City. The effective consumption of the City is only 37.3%, and the total loss of 62.8 % consists of 40% of losses from distribution pipes, 14.4% of wastage by consumers and 8.2% of NRW from housing. The wastage by consumers and the NRW from housing can be reduced easily by the installation of water meters, because consumers will reduce excessive water consumption to save on their water charges. However, the reduction of the NRW from the distribution pipes requires huge investments for pipe replacement and efforts of Vodokanal to find and eradicate/illegal connections and improper usage.

The existence of water waste, which can be reduced, will entail unnecessary cost to the customers as well as be financial burden to Vodokanal.

Table 3.2.7 Composition of Water Distribution

Category	Name		No.	Value (1000m³/d)	Rate (%)	Formula	Note
Total water distribution			①	2,900	100.0	---	Estimated by the Team
Real distribution to consumers			②	1,739	60.0	---	Domestic: Population x estimated actual consumption Lpcd *1, Large: Accounted for consumption *2
Component of water demand	Real demand	Domestic customers	③	365	12.6	---	Population x consumption with meter Lpcd *3
		Large consumers	④	717	24.7		Current accounted for consumption x0.8
		Total	⑤	1,082	37.3	③+④	Required water amount for consumers
	Wastage by consumers		⑥	418	14.4	⑦-⑤	Wastage including collected water charge
	Counted for water		⑦	1,500	51.7	---	By Vodokanal record
	NRW from housing		⑧	239	8.2	②-⑦	Difference between accounted for water and actual distribution
	NRW from pipes (Losses)		⑨	1,161	40.0	①-②	Including leakage from pipes and improper usage, such as illegal connection
	Total NRW		⑩	1,400	48.2	①-⑦	
	Total			2,900	100.0		

Real demand: Total of real demand for domestic customers and large consumers, and is composed of real demand of metered domestic customer (Lpcd with meters x population categorized with meters), that without meters (estimated Lpcd without meters x population categorized without meters), and accounted for consumption water of large consumers

Real consumption: Total of real consumption for domestic customers and large consumers. It is composed of real consumption for domestic customers (Lpcd with meters x total population, because meters will be installed for all customers) and 80% of accounted for water of large consumers

Water demand: Including water loss

*1: Apartment residents with meter: 150Lpcdx128,000=19,000m³/d
Apartment residents without meter: 500Lpcdx1,263,000=631,000m³/d
Detached house residents with meter: 200Lpcdx259,000=52,000m³/d
Detached house residents without meter: 270Lpcdx521,000=141,000m³/d

*2: Large consumers: 896x10³m³/d

*3: Apartment residents: 150Lpcdx 1,391,000=209,000m³/d
Detached house residents: 200Lpcdx780,000=156,000m³/d

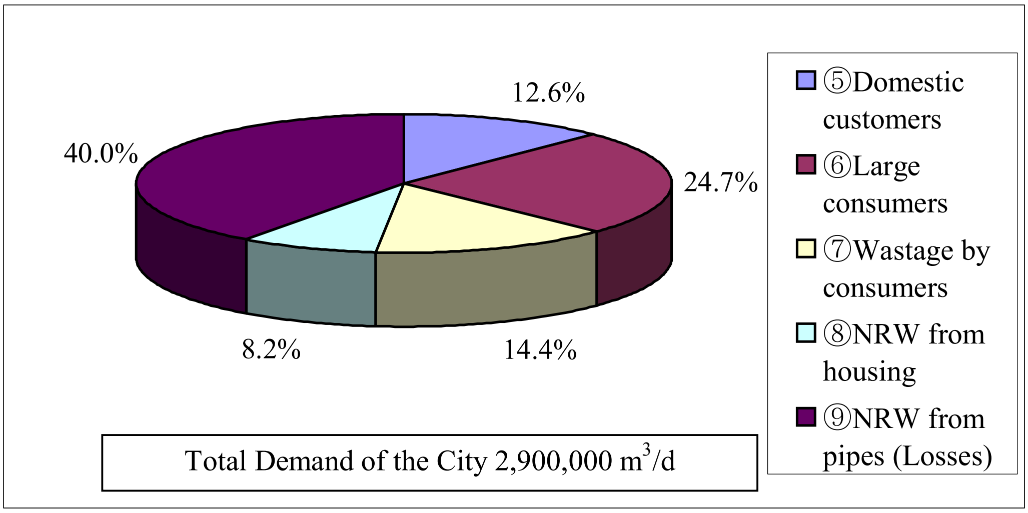


Figure 3.2.2 Composition of Water Demand

3.3 Problems in Attaining Efficient Management

Attaining current and future water supply stability for Vodokanal does not depend on solving its facility and financial problems alone. One of the more important aspects is strengthening top management's vision, direction, and way of doing things. Management must lead the entire organization toward change, and encourage the employees to embrace quality and excellence at all times. This will enable all the levels of management to make the right decisions, and the employees to work more efficiently.

3.3.1 Problems on Organizational Culture and Capacity

(1) Attitude towards Solving Problems

Top management is responsible for the over-all supervision over the operations of Vodokanal and maintaining cost-efficiency over all its different functions. Top management must develop a problem-solving attitude and lead its employees at formulating appropriate solutions to the identified problems. Plans, goals and targets must be set together with the employees, because it is with these same employees that strategies will be executed strategies and solutions implemented. Top management must always solicit the active participation of its employees toward improving the quality of its service and the stability of its water supply operations on a long term basis. Vodokanal rarely understood the magnitude of the current problems and the counter measures needed in the long-term perspective.

(2) Employee Awareness

Top management must take extra effort to involve all employees and make them aware of the problems being faced by Vodokanal. The empowerment of the employees will mean making their opinion matter, as they openly contribute their ideas in enhancing specific areas of Vodokanal's operations or solving identified problems. It will also result in making it easier to get the employees' commitment in implementing solutions to problems. However, there is a need to institutionalize or systematize the manner by which employees can be made to voluntarily participate and speak out. This can be done through empowerment meetings or conference meetings where the method of management decision-making is participatory (bottom-up) rather than autocratic (top-down). It will also be helpful if the contribution of the employee is reflected in his/her performance evaluation, and such employee is rewarded based on the nature of the input and its contribution to the efficient operations of Vodokanal.

(3) Employee Training

Relevant training is important in improving employee competence (knowledge and skills) which has, of course, a direct impact on organization capacity as a whole. Expanding knowledge and upgrading skills should not only be on the technical or engineering aspects, but also on general management, finance and accounting, and human resources. Moreover, training should not be limited to newly hired employees. More importantly, education and training should be provided to the older employees so that they can begin to cope with the many changes and demands in the management and operations of Vodokanal.

3.3.2 Information Management

For the top management and the persons in charge to correctly understand and analyze the current problems, it is necessary to have accurate information and that such information is shared with all the persons involved. However, the reliability even for basic information is questionable, such as the status of current facilities' operation and financial information, including supporting data necessary for analysis. In addition, information gathering and analysis is still done manually, limiting the collection of accurate data.

3.3.3 Relationship with the Domestic Customers

Water supply is a public service and maintaining of good relationship with the customers, especially the domestic consumers, is extremely important. However, public relations activities have been insufficient so far, since there is no integrated program to inform and educate the public of vital information on the operations of Vodokanal. That is why the public is indifferent, and this can be gleaned from very low involvement and understanding of the customers on the relationship behind metering and water conservation measures, or of having to pay for the right amount of consumption without resorting to collusion with the collectors and inspectors.

The above-mentioned problems that Vodokanal is facing in the process of achieving a stable water supply operation are summarized in Table 3.3.1

Table 3.3.1 Summary of the Issues in Securing a Stable Water Supply

Issues in securing a stable water supply	Current Problems	
Facilities to secure a stable water supply	Rehabilitation of facilities	-Frequent accidents due to deteriorated facilities -Overstaffed facilities and large energy expenses due to inefficient system's organization - No fund reserves for facility rehabilitation
Securing necessary funds	Reduction of large NRW	-There are large water losses from distribution lines mainly due to pipeline deterioration -There is large water wastage by the consumers because of the delay of meter installation -Operation of facilities for NRW needs high water treatment and conveyance costs -An important opportunity to gain income is lost
	Improvement of financial status	-Shortage of long-term investment funds -Shortage of short-term operating capital -Government policy: no financial support
	Reform for tariff system and management	-Due to capital shortage problems, revising the tariff table is necessary, but raising tariff levels is limited -Problems arising in the transition to the Metered System: 1) in efficient meter reading method and 2) reduction of income from tariff collection -Problems regarding tariff collection: 1) inconvenient tariff collection system due to the residents' not having their own bank account
Efficient management	Rebuilding the organizational capacity	-Problems on Organizational Culture and Capacity: 1) lack of active attitude toward solving problems, 2) insufficient employees awareness and 3) inefficient and insufficient employee training
	Information management	-Information required for management is not correctly gathered, analyzed and transmitted due to delays in information management
	Formulation of good a relationship with domestic consumers	-Information disclosure for domestic consumers and promotional and PR activities are not sufficient

3.4 The Need for the Long-Term Development Plan

As described in Section 3.2, there are significant water losses from the existing distribution pipelines and wastage by the consumers. Water demand in Tashkent City has been on a downward trend for the past few years as a result of progress in the installation of water meters. However, since the water leakage ratio is anticipated to increase if deteriorated pipelines and equipment are not regularly replaced, the rate of increase will eventually exceed the rate of decrease. This is expected to cause serious breakdowns of intake and distribution pumps (i.e., shaft wear, burn-out of electric motors, erosion of pump impellers), thus significantly decreasing water supply capacity.

Unless the deteriorated facilities are replaced, frequency and cost for repairs will increase in geometric progression (generally, because the frequency of breakdown for machines and electrical equipment increases geometrically with deterioration after a certain period, the repair cost will exceed the replacement cost), and further repair would become very difficult to carry out. In the long run, it will become impossible to supply the demand for water.

The operational stability of the water supply facilities will mean a reliable and adequate supply of water to all the consumers. The need, therefore, of carrying out comprehensive repair and rehabilitation of the facilities, to include replacement of some, is urgent.

Towards this end, short-term measures will be insufficient. The more prudent action is the preparation of long-term plans that will provide longer lasting solutions. Firstly, the extent of deterioration of the pipelines and facilities indicates that these cannot be repaired, rehabilitated, or even replaced in the short-term. This brings us to the second point. Significant investments will be required to replace or rehabilitate the facilities. Even if subsidies will be granted, these will not be sufficient to cover the replacement and repair requirements. A long-term fund procurement or financial plan will also necessary, taking into consideration repayment schemes through tariff collection. The Soviet-style of management is still alive in Vodokanal, and it is therefore necessary to include changes in management as part of the long-term plan, because any change cannot be efficiently achieved overnight.

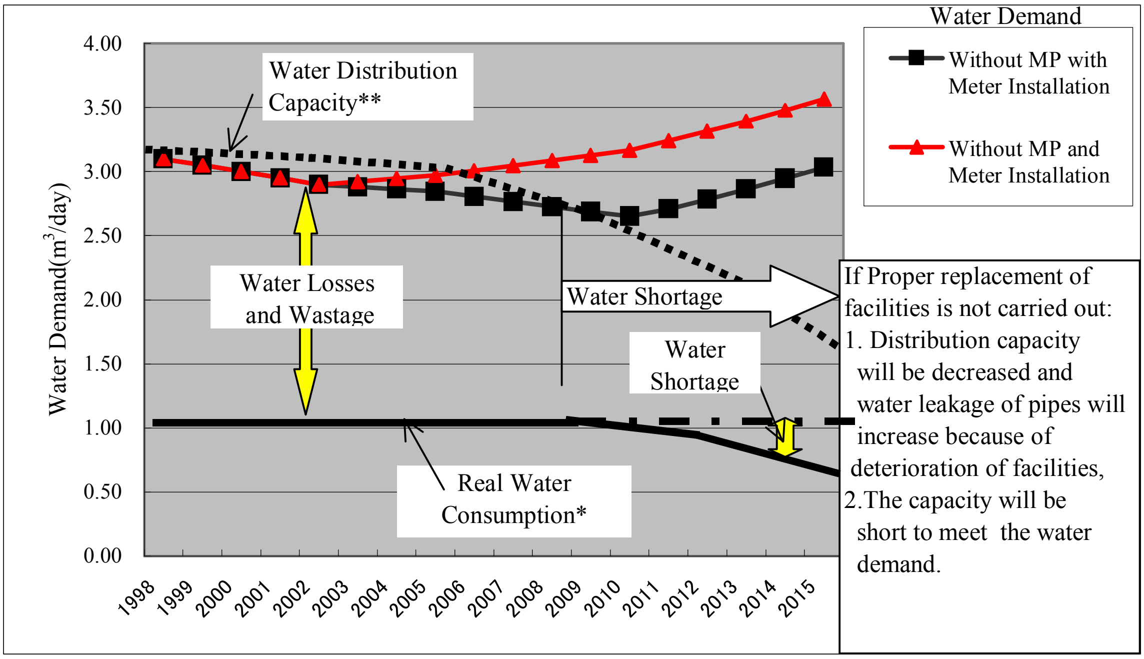


Figure 3.4.1 Projected Reduction of Distribution Capacity in the Future

* Real necessary water consumption for customers (Base of numerical value: Table 3.2.7), and the volume is assumed as constant,

** Water distribution capacity will be decreased due to the breakdown of intake and distribution pumps.

3.5 Approaches for the Long-Term Development Plan

(1) Concept for the LTDP

Figure 3.5.1 presents a method to formulate the LTDP. The water demand projection is required to be implemented before the technical planning of the facilities. In addition, the NRW reduction program is a precondition for the water demand projection because in the case of planning of facilities rehabilitation and O&M, the smaller the planned demand of water is, the more advantageous this plan will be in terms of costs.

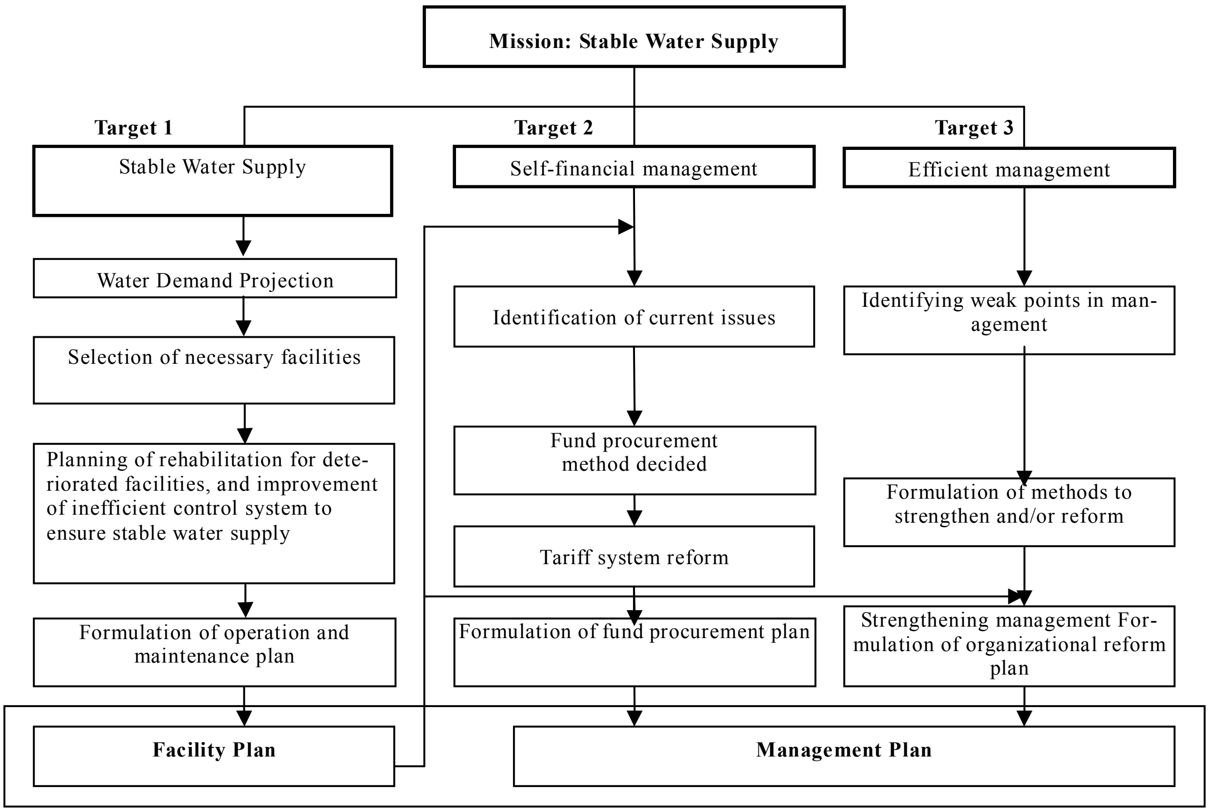


Figure 3.5.1 Formulation of Long Term Development Plan

(2) Formulation of the LTDP for the Technical Portion

The LTDP, including the NRW reduction program is divided into the technical and management portions. Pipe replacement is planned under the technical portion of the NRW reduction program, and after water demand has been calculated. Facilities necessary to secure a stable water supply will be selected. Planning for the replacement of deteriorated facilities, improvement of inefficient systems and rehabilitation to ensure stable control will be carried out.

Chapter 4 Planning Fundamentals for Development Plan

Chapter 4 Planning Fundamentals for Development Plan

4.1 Population Projection

Population projection for Tashkent City provided by the Tashkent City Statistics Department is shown in Table 2.2.1. The population of the City is estimated to remain flat until 2015, which is the target year of the Master Plan.

The number of customers of Tashkent Vodokanal is smaller than the population provided by the Statistic Department as shown in Table 4.1.1. The reasons behind this difference could be any of the following: 1) the actual population decreased within and outside the City boundaries; 2) some of the domestic customers live in company apartments and therefore their consumption was included under that of Large Consumers; 3) many families intentionally declare a smaller than the actual number of family members in order to save on water charges.

Table 4.1.1 Population Projection in Tashkent City (x1000)

District	By Statistics Department of the City					By Vodokanal: 2002		
	2002	2004	2005	2010	2015	Apart-ments	Detached houses	Total
A. Ikramov	226.6	226.4	226.4	226.8	227.1	97.1	87.8	184.9
Bektemir	28.2	28.1	27.7	27.8	27.8	17.3	3.8	21.1
Mirabad	122.1	121.7	121.7	121.9	122.1	68.5	33.0	101.5
M. Ulugbek	245.9	244.7	245.6	246.0	246.4	153.1	42.3	195.4
S. Rahimov	152.7	151.9	151.8	151.9	152.1	111.9	31.1	143.0
Sergeli	281.9	282.6	282.0	282.4	282.8	101.8	82.4	184.2
Khamza	207.0	206.3	207.2	207.5	207.8	104.2	58.4	162.6
Chilanzar	215.4	214.5	215.8	216.1	216.3	115.6	41.0	156.6
Shayhantahur	261.4	262.4	260.6	261.0	261.4	91.4	86.4	177.8
Yunusabad	287.3	286.7	286.3	286.6	287.1	154.6	59.9	214.5
Yakkasaray	110.6	110.2	111.1	111.2	111.3	47.0	25.0	72.0
Total in the City	2,139.1	2,135.5	2,136.2	2,139.2	2,142.2	1,062.5	551.1	1,613.6
Kibray						0.9	16.7	17.6
Ata						13.1	20.6	33.7
Other vicinity towns						0.0	12.5	12.5
Total served population in vicinity area						14.0	49.8	63.8

The result of the Pilot Project conducted by the Team shows that the number of residents with contracts with Vodokanal is much smaller than the actual number in the apartment buildings with 200 flats. The rate of difference was seen at 22%, while the difference between the population provided by the Statistic Department and Vodokanal is around 32%. Thus the reason as sited in “3” above is considered to be major factor.

The population projected by the Statistics Department is regarded more accurate in predicting future water consumption/water demand than using the actual number that have contract with Vodokanal.

Table 4.1.2 shows the population projection to be served by housing type. The current ratio of the population living in apartments / total number of population, provided by Vodokanal (1,062.5/1,613.6 =65.8%), has been applied to the population projected by the Statistics Department. The served population in the City is assumed to remain at the current service coverage level of 98.5 %, because the rest of the people will be able to use abundant groundwater. In projecting the served population for the vicinity areas, a 5% annual growth rate was adopted for those residing in detached houses, which is the same annual population growth rate obtained from the Vodokanal data. The current served population living in apartments in these vicinities was assumed to remain constant at around 14,000 up to 2015.

Table 4.1.2 Projection of Served Population by District and by Housing Type (x 1000)

District	By Statistic Department								By Vodokanal: 2002	
	2002		2005		2010		2015		Apart -ment	Detached house
	Apart	Detached	Apart	Detached	Apart	Detached	Apart	Detached		
A. Ikramov	117.2	106.0	117.1	106.1	117.3	106.1	117.5	106.2	97.1	87.8
Bektemir	22.8	5.0	22.4	4.9	22.5	4.9	22.5	4.9	17.3	3.8
Mirabad	81.2	39.1	81.6	39.4	81.7	39.4	81.2	39.1	68.5	33.0
M. Ulugbek	189.8	52.4	189.5	52.5	189.9	52.5	190.2	52.5	153.1	42.3
S. Rahimov	117.7	32.7	117.0	32.5	117.1	32.5	117.2	32.6	111.9	31.1
Sergeli	153.5	124.2	153.5	124.4	153.7	124.4	153.9	124.6	101.8	82.4
Khamza	130.7	73.2	130.8	73.4	131.0	73.4	131.2	73.5	104.2	58.4
Chilanzar	156.6	55.5	156.9	55.7	157.1	55.7	157.3	55.8	115.6	41.0
Shayhantahur	132.4	125.1	132.0	124.9	132.2	124.9	132.4	125.1	91.4	86.4
Yunusabad	204.0	79.0	203.3	78.8	203.5	78.8	203.8	79.0	154.6	59.9
Yakkasaray	71.1	37.8	71.4	38.0	71.5	38.0	71.6	38.1	47.0	25.0
City Total	1,376.8	730.2	1,375.5	730.7	1,377.4	730.7	1,378.6	731.4	1,062.5	551.1
Kibray	0.9	16.7	0.9	19.3	0.9	24.7	0.9	31.5	0.9	16.7
Ata	13.1	20.6	13.1	23.8	13.1	30.4	13.1	38.8	13.1	20.6
Other vicinity towns	0.0	12.5	0.0	14.5	0.0	18.5	0.0	23.6	0.0	12.5
Total vicinity population	14.0	49.8	14.0	57.6	14.0	73.6	14.0	93.9	14.0	49.8
Total served population	1,390.8	780.0	1,389.5	788.4	1,391.4	804.3	1,392.6	825.3	1,076.5	600.9
All served population	2,170.8		2,177.8		2,195.7		2,218.0		1,677.4	

4.2 Water Demand Projection

4.2.1 Method of Water Demand Projection (refer to S 4.2 for details)

In water demand projection, customers were divided into two categories - domestic customers and large consumers. The domestic customers' category was further broken down into (a) apartment residents, and (b) those living in detached houses. Likewise, the large consumers' category was classified into (a) budgetary organizations, (b) hot water plants and (c) small industries. It was observed that there is huge amount of water wasted by those in the domestic customers' category, either through leakages or wasteful use.

Since there is a huge water loss in the distribution network as mentioned in Chapter 3.2, reduction of this water loss according to the progress of NRW Reduction Program will also be considered in water demand projection. Accordingly, future water demand was projected on precondition that the NRW Reduction Program will be implemented.

Water demand of domestic customers is projected based on per capita consumption. The per capita consumption for domestic customers living in apartment, who account for 66% of the total population in the city, is estimated at 150 Lpcd if water meter is installed. This consumption is relatively small; however since these users seem to use an additional 84 Lpcd of hot water supply, total per capita consumption reaches 234 Lpcd. This is considered to be sufficient, as mentioned in Chapter 3.2.

Water demand is projected for three cases, as follows: Case 1: maximum effect of NRW reduction program will be expected, Case2: medium effect and Case 3: minimum effect. For designing water supply facilities, the projected water demand in Case 2 will be employed, therefore, the estimated value of Case 2 is presented in this report.

Other cases of projection are presented in S 4.2.

4.2.2 Water Demand Projection for Domestic Customers

Water demand projection for domestic customers was made considering the extent of the progress of meter installation for reducing water consumption.

The followings are the assumptions for the water demand projection:

- The most recent modified meter installation plan prepared by Vodokanal is adopted, where the implementation of the plan has been behind schedule due to lack of budget;
- The per capita consumption of apartments and detached houses will be flat, because living standards of people will be improving with the economic growth even if the PR program on water conversation is carried out in the future.

Based on the above scenarios, water demand for domestic customers was projected as shown in Table 4.2.1 and Figure 4.2.1. In the table and figure, the projection for 2009 is employed, because this is the year that Vodokanal plans are to be completed. However, based on experience, the possibility of delay is apparent, hence completion may move to 2010.

Table 4.2.1 Water Demand Projection for Domestic Customers

Division		Demand/meter installation ratio					Demand (Lpcd)				
		2002	2005	2009	2010	2015	2003	2005	2009	2010	2015
Total population in the city (x1000)		2,139.1	2,136.2	2,138.6	2,139.2	2,142.2					
Service population	Surrounding area (1x1000)	63.8	71.6	87.0	87.6	107.9					
	Total (x1000)	2,170.8	2,177.8	2,193.6	2,195.7	2,218.0					
Demand for apartments	Population (x1000)	1,390.8	1,389.5	1,391.0	1,391.4	1,392.6					
	With flat meter (%)	9.2	30	85	100	100	150	150	150	150	150
	Without meter (%)	90.8	70	15	0	0	500	500	500	500	500
	Demand (x1000m^3/d)	650.6	548.9	281.7	208.7	208.9					
Demand for detached houses	Population (x1000)	780.0	788.3	802.5	804.3	825.4					
	With meter (%)	33.2	60	100	100	100	200	200	200	200	200
	Without meter (%)	66.8	40	0	0	0	270	270	270	270	270
	Demand (x1000m^3/d)	192.5	179.7	160.5	160.9	165.1					
Total demand (1000m^3/d)		843.1	728.6	442.2	369.6	374.0					

Note: 1.Demand value without meter is modified as shown in 2.3.4.

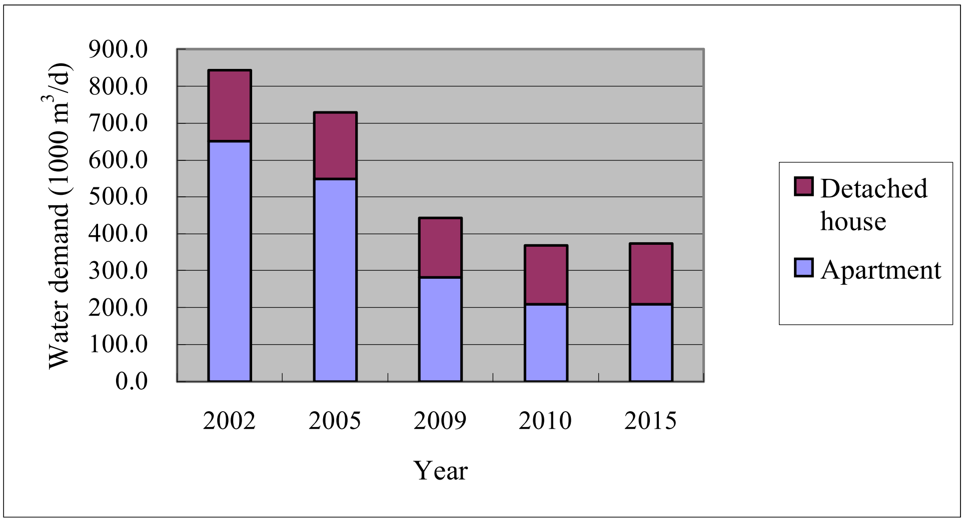


Figure 4.2.1 Water Demand Projection for Domestic customers

4.2.3 Water Demand Projection for Large Consumers

Large consumers are composed of budgetary organizations (public offices/facilities, hot water plants, schools and public hospitals), large industries and small industries (including small commercial enterprises). Because countermeasures to reduce wastage and to save water will be introduced in Tashkent City in the future (which are discussed in Section 5.2), some categories of consumers are seen to save water, especially hot water plants. Table 4.2.2 and Figure 4.2.2 show the calculated results of water demand projection for large consumers.

Table 4.2.2 Water Demand Projection for Large Consumers

Division		Water demand (1000m^3/d)					Transition of ratio (%)				
		2002	2005	2009	2010	2015	2002	2007	2009	2010	2015
Total service population (x1000)		2170.8	2177.8	2193.6	2195.7	2218.0					
Budgetary organizations		234.0	223.2	208.8	205.2	187.2	100	95	92	91	80
Large Industries		56.0	57.3	59.0	59.4	61.6	100	104	105	106	110
Hot water plant	Domestic	347.0	327.0	300.3	293.6	260.3	100	90	87	85	75
	Large	148.0	148.0	148.0	148.0	148.0	100	100	100	100	100
Small Industries		111.0	115.3	117.0	117.8	122.1	100	104	105	106	110
Total		896.0	851.1	833.1	824.1	779.2	100	95	93	92	87

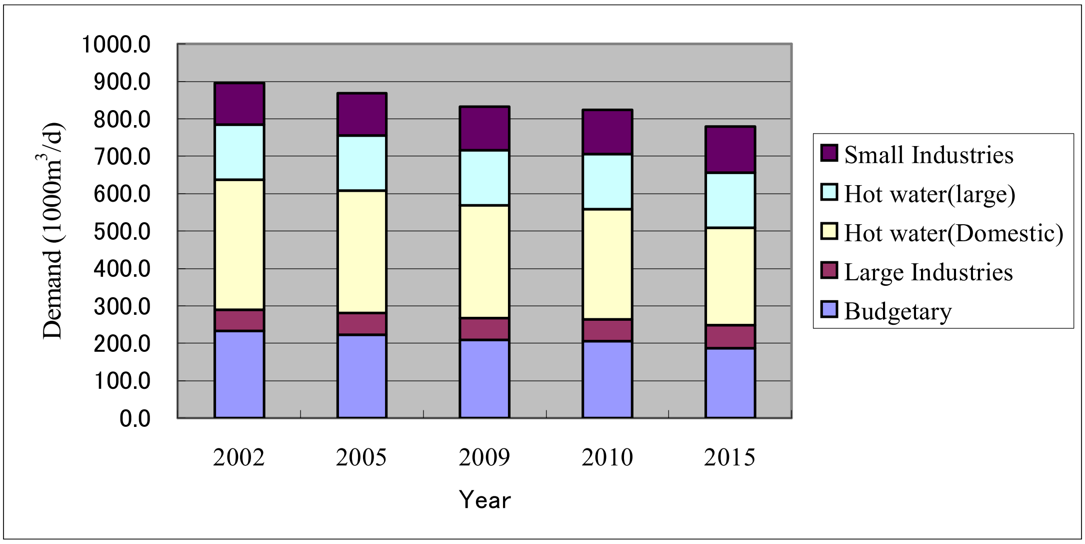


Figure 4.2.2 Water Demand Projection of Large Consumers

The following are the grounds for determining the increase/decrease ratio in each customer category based on discussions with Vodokanal:

- Eighty percent of water meters for large consumers have already been installed, meaning that over 95% of water charges have already been collected based on the Metered Tariff System. Therefore, the effect of progress of meter installation is seen to be not significant as a whole;
- Consumption by budgetary organizations (public/government offices including water supply organizations supplying to surrounding area of the City and public facilities) will be reduced. Right now, much of the water leakage of these offices have not been repaired and unit consumption of 110 L/capita/day to total population is considered too large (refer to Table 4.2.2, water demand of budgetary organization (234,000 m^3/d) x 1,000 / Total service population (2,170,800)). The consumption in 2015 is anticipated to decrease to 80% of the present level;
- Consumption of industries is very small partly due to the recession of Uzbekistan economy; however this may recover in future;
- Consumption of hot water is quite high in the city, leading to a waste of water and energy. TKEO has decided to improve the system, to include the installation of meters for hot water and heating water. Therefore, the demand by domestic customers for the hot water will be reduced, just like that for the cold, by around

25% of the present level in 2015, while that by large consumers will not be reduced because of the anticipated economic recovery; and

- Consumption of small industries as well as large industries may pick up as the economy improves. The future consumption is predicted to be 110% of the present level in both industries. This category's consumption has been decreasing since 1998 with the recession, however the figure in target year of 2015 will be the above level, following the industrial growth rate in Uzbekistan from 2001 to 2002, which was around 5 %.

4.2.4 Projection of Water Loss from Distribution Network

The estimated water balance in 2002 is shown in Table 4.2.3. The water loss is assumed to have been 40% of the total water production.

Table 4.2.3 Estimated Water Balance in the City in 2002

Consumers		Volume (1000m^3/d)
Water distribution (m^3/d)		2,900
Water consumption	Domestic Customers	843
	Large Consumers	896
	Total	1,739(60%)
Water loss	Leakage	725(25%)
	Improper usage	436(15%)
	Total	1,161(40%)

The leakage ratio from the distribution pipelines is set at 25%, which was the result of the water leak survey in Sergeli District, as shown in S 2.3.6. According to Vodokanal, many illegal connections along the transmission pipes have been found, getting water for use in watering gardens and parks in apartment buildings. Thus, it is proper to assume that the consumption of illegal connections can reach around 15%.

Assumptions in projecting the reduction of water losses are as follows:

- When the NRW Reduction Program including the pipes replacement of 420km is implemented, leakage from pipes will decrease as the replacement of pipes progresses. However, the reduction ratio may only reach half the level of the existing condition because other old pipes will begin to leak;

- Since pipe replacement will commence by 2007 in highland area of the City where the pipes are the oldest, some effect will be felt by the end of the year. By the end of 2011, around 57% of pipes will be replaced, except for the lowland area of the City, where the pipes are the newest. By this time, it is expected that pipe leaks will be greatly reduced; and
- Illegal connections should be eradicated. However, it seems that those illegal connections used to get water for watering parks and gardens may be difficult to stop. Therefore, it is assumed that 25% of water consumption by illegal connections will continue.

Projection of water loss is shown in Table 4.2.4, and additional projection for 2007 and 2011 are carried out.

Table 4.2.4 Projection of Water Loss

Division	Consumption (1000m^3/d)							Reduction ratio (%)						
	2002	2005	2007	2009	2010	2011	2015	2002	2005	2007	2009	2010	2011	2015
Leakage	725	725	616	544	508	471	363	100	100	85	75	70	65	50
Improper usage	436	436	371	262	218	174	109	100	100	85	60	50	40	25
Total	1,161	1,161	987	805	726	646	472	100	100	85	69	62	56	41

4.2.5 Projection of Total Water Demand

Table 4.2.5 shows the projected water demand for domestic customers and large consumers, water losses from distribution network and total water demand. Figure 4.2.3 shows the projection of the total water demand. As shown in Table 4.2.5, although quantity of water loss will sharply decrease, the loss ratio will not be reduced so much because total water demand will also decrease.

Table 4.2.5 Total Water Demand Projection (1000m^3/d)

Division	2002	2005	2007	2009	2010	2011	2015
Domestic customers	**843.1**	**728.6**	**585.4**	**442.2**	**369.6**	**370.5**	**374.0**
Large consumers	**896.0**	**851.1**	**842.1**	**833.1**	**824.1**	**815.1**	**779.2**
Water losses	**1,161.0**	**1,161.0**	**986.9**	**805.4**	**725.5**	**645.7**	**471.5**
Total	**2,900**	**2,741**	**2,414**	**2,081**	**1,919**	**1,831**	**1,625**
Water loss ratio (%)	**40.0**	**42.4**	**40.9**	**38.7**	**37.8**	**35.3**	**29.0**

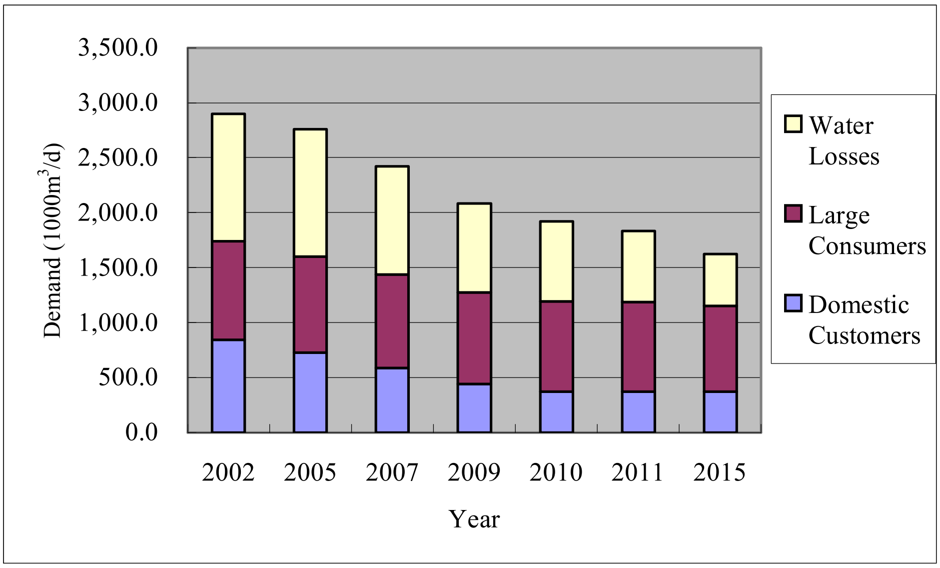


Figure 4.2.3 Total Water Demand Projection

4.2.6 Estimation of Daily and Hourly Maximum Flow

The maximum daily water demand is adopted as a design flow for WTPs. For distribution systems the maximum hourly flow is adopted.

The current daily and hourly factors are very low at 1.07 and 1.03 respectively. They are assumed to be relatively low also in the future because water loss ratio has been assumed to improve gradually. Table 4.2.6 shows that the daily factor (daily maximum water demand/daily average water demand) will gradually increase as water losses and wastage are reduced. The factor in the target year is set at 1.12.

The hourly factor is considered to also gradually increase, in accordance with the progress of NRW Reduction Program. The other JICA Study in Astana City, the capital of Kazakhstan, shows 1.07 of hourly factor in its water supply (150,000m^3/day: 300,000 of the served population and 500 Lpcd of per capita consumption). On the other hand, the "Japanese Guidelines for Waterworks Technical Management" shows around 1.35 of hourly factor to 1.5 million m^3/day of water supply.

Considering the above, the hourly factor of Tashkent City is assumed to increase in the future as shown in Table 4.2.6. Therefore, the factors in the target year are set at 1.12.

Table 4.2.6 Calculation of Daily and Hourly Maximum Flow

Division	2002	2005	2007	2009	2010	2011	2015
Total daily average distribution (1000m^3/d)	**2,900**	**2,741**	**2,414**	**2,081**	**1,919**	**1,831**	**1,625**
Water loss ratio (%)	**40**	**42**	**41**	**39**	**38**	**35**	**29**
Total daily max distribution (1000m^3/d)	**3,100**	**3,015**	**2,656**	**2,289**	**2,130**	**2,051**	**1,820**
Daily factor	**1.07**	**1.1**	**1.1**	**1.1**	**1.11**	**1.12**	**1.12**
Total hourly max distribution (1000m^3/d)*1	**3,200**	**3,165**	**2,921**	**2,518**	**2,365**	**2,297**	**2,038**
Hourly factor	**1.03**	**1.05**	**1.1**	**1.1**	**1.11**	**1.12**	**1.12**

*1: m^3/hrx24hr

Chapter 5 Long-Term Development Plan

Chapter 5 Long-Term Development Plan

5.1 Strategy Development

5.1.1 Targets to Ensure Stable Water Supply

In order to provide long term solutions to the various problems facing Vodokana (mentioned in sections from Section 3.1 to 3.2), the Long-Term Development Plan has been formulated as described below. Three targets were set to help resolve each of the problems, within the target year of 2015 (see Figure 3.5.1).

(1) Stable Water Supply

The first target is to attain maximum system efficiency. To achieve this, water supply must be stable in order to provide a reliable and adequate water supply to the service area. This would mean the construction of new facilities to replace the deteriorated ones, plus the rehabilitation of the distribution system.

(2) Self-financial Management

The second target is to achieve financial independence. To do so, a long-term procurement plan must be formulated in order to cover for shortfalls adequately.

(3) Efficient Management Organization

The third target is to realize an efficient management organization. It is not enough to have plans for facilities improvement and fund procurement. What is important is that these plans are put into action, or are implemented by a strong management organization. Since the current organization is in a period of transition, further improvements are required to achieve better organization and management.

To achieve these three targets, the following plan was formulated, also related to problems currently faced by Vodokanal.

- Reduction of Non-Revenue Water (NRW)

- Replacement and rehabilitation of deteriorated facilities and improvement of inefficient distribution system
- Reform of financial status
- Reform of the tariff system
- Reform of organization and management
- Information maintenance and sharing
- Promote cooperation with the activities targeting the domestic consumers

5.1.2 Formulation of the LTDP

Based on above-mentioned three targets, Table 5.1.1 summarizes necessary plans (management plans) to solve the problems corresponding to the targets. Above all, the NRW reduction is the precondition to optimize the capacity of facilities to reduce O&M costs. In addition, water meters installation is one of important components of the NRW Reduction Program, which has the highest priority. The proposed NRW reduction program, and technical and management strategic plans are described below.

(1) NRW Reduction Program

The NRW Reduction Program must be planned as an action to be implemented with the top priority under the LTDP. Facilities rehabilitation plans will be implemented based on the water demand estimated on the assumption that the NRW Reduction Program is actually implemented.

(2) Strategic Facilities Plans for an Optimum System

The Strategic Facilities Plans are presented below:

1) To select necessary facilities to cope with the reduced future water demand (minimizing number/scale of facilities);
2) To formulate a replacement plan for necessary facilities based on the result of diagnosis;
3) To improve necessary facilities to carry out stable operation in the future:
    - To change the intake system of Kibray WTP from deep wells to intake gallery,
    - To construct facilities to be able to cope with flow fluctuation,

- To introduce minimum requirements of monitoring and automatic-control, such as monitoring of flow, water level of tanks and water pressure for distribution pipes, and automatic-control for pumps with water level,
- To improve coagulant dosing facilities in Kadirya WTP to conduct continuous dosing,
- To improve analysis equipment for the laboratory in Kadirya WTP.

4) To improve the distribution network in order to carry out gravity distribution, which can abolish most of the booster PSs, and

5) To formulate a proper O&M plan

(3) Strategic Management Plans

The Strategic Management Plans will be set as follows according to their goals:

1) To establish a planning and implementation program for LTDP to cope with the re-habilitation plan for facilities,

2) To establish an improvement plan for financial status,

3) To establish an improvement plan for the tariff system,

4) To establish a strengthening program for management and organization,

5) To establish a development program for information to be used for management, and

6) To establish PR program.

Table 5.1.1 Issues and Necessary plans with Legal, Institutional and Organizational Reforms

Targets	Current problems	Improvement Plan	Details	Desired actions from the government	Organizational Reform
Stable water supply	－Frequency of accidents are high due to deteriorated facilities. Operation and maintenance costs are also high due to the inefficient structure of the system －Lack of funds for renewal of facilities	Renewal of deteriorated facilities and improvement of inefficient distribution systems	－Implementing the renewal of deteriorated facilities and improvement of inefficient water distribution system －Implementation of the plan after verifying its appropriateness through technical and financial evaluations. (Progress will be monitored constantly throughout the PDCA Cycle －Formulation of a fund procurement plan for the implementation of the facilities investment plan		－Establishment of a task force for the promotion of the facilities improvement plan
Self-financial management	－Large water leakages from deteriorated pipes －Low water saving awareness due to the delay in meter installation －Operation and maintenance costs that originally are not necessary exist, due to NRW	Reduction of NRW	－Renewal of pipes －Implementing the plan for the transition to a metered system －Implementing the NRW reduction plan（promotion of meter installation, renewal of distribution pipes, strengthen control of stolen water）		－Establishment of a team to strengthen control of stolen water
	－Lack of a long-term financial plan －Insufficient short-term working capital －Due to government policies, no subsidies can be expected from now on	Improvement of financial status	－Formulation of a long-term financial plan based on a tariff level that takes into consideration of domestic consumers' affordability and the amount of funds that need to be collected －Collection of accumulated bad debts from governmental agencies and reduction of NRW －Considering fund procurements from third parties	－Joint effort with the government is required for solving the collection of accumulated bad debt －the government's guarantee is necessary for borrowings	
	－On one hand, there is a need to reform tariff table in order to secure long-term investment funds, on the other hand, tariffs cannot be raised easily －Following problems might arise as the transition to a metered system progresses: 1）Improvement in the water reading method 2）Temporary decrease of income from bill collection due to water saving by consumers －Problems on bill collection: 1）As domestic consumers do not have a bank account, automatic transfer is difficult 2）Bill collection process is mainly done manually	Improvement of tariff system	－Early transition to a metered tariff system －The tariff table needs to be revised once cost reduction has been implemented and domestic consumer's affordability as well as required funds for the renewal of facilities has been fully taken into consideration －Outside meter installation －A tariff structure reform is necessary in order to guarantee the reduction of income from bill collection in the transition to a metered system －Improvement of bill collection operations by collecting bills jointly with other public services －Implementation of bill collection based on IT	－Governmental approval is necessary for the introduction of a new tariff table as well as a new tariff system	
Efficient management organization	－Problems on the organization's environment such as: 1）Measures for deteriorated facilities and other issues that require periodical review are insufficient 2）An environment in which the voice from job-site are not reflected in management due to the top-to-bottom decision making process, 3）Insufficient employee training system	Improvement of management and organization	－Management has to give a thorough explanation of the LTDP to the government －Transition to a more performance and capacity-oriented wage system in order to give incentives to employees －Invigoration of the organization and promotion of more efficient operations through participation of private sector and spin over of some departments －Introduction of employee training system by outsourcing to outside consultants and aid agencies	－Governmental approval and support is necessary for the LTDP as well as the procurement of funds －Governmental approval is necessary for the introduction of a performance-based wage system	－ Spin off specific departments －Outsourcing of specific departments
	－Necessary management information does not flow correctly due to delays in development and sharing of information	Development and sharing of information	－Strengthening internal control (checking the consistency and credibility of data produced from different departments）. It will cover the contents of all operational activities in Vodokanal, including non-financial activities. However, it should be noted that it will not be considered objective for the outside. －Introduction of International Accounting Standards and external auditing in order to strengthen the reliability of financial information and to secure transparency. External auditing will only cover financial information but will be considered objective for the outside. －Strengthen utilization of IT	－Governmental approval is necessary for the introduction of International Accounting Standards and external auditing	－ Establishment of an independent Internal Audit Department directly under control of the general director in order to strengthen internal control － Establishment of an IT Department
	－Insufficient public relations regarding water supply operation, as well as promotion of water saving awareness	Promotion of cooperation from domestic consumers	－Prepare and distribute brochures and a short video to be broadcasted on TV in order to promote water saving and reduction of NRW under the Norm system		Establishment of PR Division

5.2 NRW Reduction Program

5.2.1 Policy Formulation of NRW Reduction Program

As described in the previous section, various countermeasures for reduction of NRW as well as water demand are considered, and they are integrated into the items 1) - 3) provided below. Concrete action programs for respective items will be discussed in next sub-sections.

1) Promotion of meters installation

Promotion of meters installation will be a core of the action programs to be undertaken, since this has been proven to reduce water consumption/demand particularly of domestic customers as shows the progress of meters installation.

2) Replacement of pipelines

Since water leakage from the distribution pipes is considered as one of the major causes of NRW, Vodokanal already identified a total of 420 km of the distribution pipes where water leakage occurs. Thus, urgent replacement of these pipes is strongly advisable. Considering that Vodokanal has repaired water leakages immediately as soon as these are discovered, there is no problem in the current system of repairing leakage. Accordingly, it is advisable to complete the said pipe replacement as early as possible.

3) Strengthening of management

In order to realize the countermeasures described in the previous section, required activities on strengthening of management will be proposed as follow:

i) Accurate understanding of the amount of water distributed from the WTPs;
ii) Accurate understanding of the water consumption and leakages;
iii) Calculating water losses other than consumption and leakages i) – ii);
iv) Formulating hypotheses in regards to water losses other than leakages;
v) Verifying each hypothesis;
vi) Formulating and implementing countermeasures when problems such as inappropriate collection of water charges and illegal connections are discovered; and
vii) Evaluating the effects of the countermeasures.

5.2.2 Promotion of Meters Installation

It is clear from the records obtained that when the Metered System was introduced, water wastage by domestic consumers was reduced. Therefore, the completion of meter installation is the most important component of the NRW Reduction Program.

In 2003, the Government's target was to achieve 100% meter installation by 2009. This target has been postponed for the last five years since the previous JICA study conducted in 1999, and a meter installation program was set up. Therefore, it is highly recommended that the latest schedule be followed strictly. The main reason why the installation of water meters did not proceed as scheduled was because the meters had to be paid by each of the domestic consumers outright. To make it easier and more affordable for the domestic consumer, Vodokanal implemented a recommendation that the cost of the meter and its installation be included in the water tariff.

However, Vodokanal experienced an increase in electrical and operational costs, not to mention the difficulty in collecting the meter installation cost together with the water charges. Thus, there was a return to the previous manner of installing meters. A discussion held between the Study Team and Vodokanal produced a number of countermeasures, such as introducing a long-term loan system in order to share the burden of the installation cost, and the use of bulk meters in order to avoid individual installation of meters in the case of apartments. The details are indicated as follows. However, according to Vodokanal, although these countermeasures are theoretically sound, the social reality will make implementation difficult.

(1) Difficulties Related to Water Meters Installation

1) Analysis of installation costs burden

According to Vodokanal's information, the installation costs of water meters in the apartments and detached houses are 33,000 soum and 38,000 soum, respectively. If the installation process goes as planned (installation of approximately 80,000 water meters per year) it will cost 2,740 million soum a year (assuming the proportion of apartments to detached houses to be 3:1). If we divide this amount by the total number of households, which is 577,000 (2002 data), in order to recover this cost through the tariff, each household's portion will be 4,750 soum per year or 395 soum per month, which constitutes almost half of the current water charges. This will not have a small impact on the customers; however, because of the following reasons, it would be appropriate for installation costs to be recovered through the tariff:

- If each customer bears the water meter installation costs individually, there could be some problems, especially with the families that have a low level of income and Vodokanal may end up with the failure to follow the determined schedule of water meters installation.
- If a customer purchases a water meter, the ownership will obviously belong to that customer, and it will be the customer's decision on where and how to install that water meter. Since there is a high probability that the customers prefer to install water meters indoors, it will definitely create some management problems for Vodokanal in the future.
- Domestic customers resist installing water meters outdoors because of the high probability of water meters being stolen or damaged. This risk could even rise due to the fact that stolen water meters could be resold to other customers if the customers were allowed to purchase water meters by themselves.
- Certainly, in case the installation costs are included into the tariffs, the tariffs will become approximately 1.5 times higher than the current ones. However, if we consider that the useful life of water meters is 8 years, it will not be necessary to collect all installation costs within a year. In this case, and in the long run, the tariff level will not be exactly 1.5 times higher but it may be lower. Moreover, if it is decided to use only bulk meters for apartment buildings and ignore the installation costs for bulk meters due to their small amount, the annual total installation costs could go down to ¼ of the calculated annual cost because the proportion of apartments to detached houses is 3:1.

2) Analysis of the water meters installation system

There is a need to have water meters installed outdoors, in order to improve the efficiency of reading the meters. The problem is that when a water meter is installed indoors, reading process cannot be performed smoothly during the customer's absence.

As for detached houses, if Vodokanal's new installation method performs well both technically and in terms of costs, it would be preferable to start installing water meters outdoors for detached houses. As for apartments, outdoor installation is desirable, but there can be technical difficulties in implementing this method, especially in old apartments. It could be desirable to install individual water meters in each apartment in terms of the payment system based on the water consumption volume. However, it is difficult to say how far it could spread because of the cost issue. In this case, using bulk meters instead of installing individual water meters in each apartment could be considered.

3) Bulk Metered Tariff System

Vodokanal had been installing bulk meters in apartment buildings before it stopped doing so in 2002. The reason why Vodokanal stopped installing bulk meters was the failure of an experiment, which was carried out under the payment system based on bulk meter figures with respect to apartments without individual water meters. The experiment failed because the new water charges, which were calculated by allocating the bulk meter figures among the customers evenly, became higher compared to the one existed under the Norm Tariff System. The high level of wastage could be thought of as the main reason of the water charges increase. Since the bulk meter figures were the reference for the water charges determination, the customers were supposed to pay for the water leaking indoors and therefore the water charges increased. However, if the leaking pipes indoors were repaired and the water charges based on the Bulk Metered Tariff System is implemented, it will be beneficial for domestic customers. This statement could be supported by the results of the pilot project conducted during this Study period. Both Vodokanal and domestic customers could get some benefits if this method were implemented.

4) Merits for domestic customers under the Bulk Metered Tariff System

In the case that domestic customers reduce water usage in consideration of the Metered Tariff System after all leaking devices indoor are repaired, the volume of water consumption will not exceed the volume assumed under the Norm Tariff System. As a result of the pilot project conducted by the Study Team, the volume of water consumption after repairing was quite smaller than the volume assumed under the Norm Tariff System. This means that the amount of water charges based on the Bulk Metered Tariff System will not exceed the amount of water charges based on the Norm Tariff System. In some cases, the domestic customers can enjoy a decrease of water charges.

5) Merits for Vodokanal under the Bulk Metered Tariff System

- Cost of repair work on leaking devices is said to be 7,240 USD for 196 apartments. The cost per apartment will be 37 USD, which will not differ much from the cost of individual water meter installation mentioned above. However, the Metered Tariff System will be expanded very rapidly compared to the case when individual water meters are installed in each apartment.
- Once the indoor leakage problem is solved, the unaccounted for water supply volume will decrease.
- Efficiency of reading bulk meter figures will be high since bulk meters are installed outdoors. Also, it may help with bulk meters maintenance work.

6) Demerits or considerations under the Bulk Metered Tariff System

To apply the Bulk Metered Tariff System, it will be necessary to solve a number of issues. Thus, cooperation of TSZh is necessary in order to read bulk meters and collect water charges. In case the bulk meters are read by TSZh, there will not be any need for Vodokanal to send inspectors to each apartment. Moreover, after reading the bulk meter, it will be necessary to allocate the total volume of consumption and also the total water charge to dwellers of each apartment. In this case TSZh are expected to carry all these functions on their “shoulders”. However, in order to achieve this, it will be necessary to review the water supply agreements between the customers and Vodokanal and, as one of the options, to change them to agreements between TSZh and the customers. Also there should be some directions on how to cope with the situation when not all apartments in the same apartment building give their consent to the implementation of this method.

7) Vodokanal's remarks

In respect to the installation of water meters elaborated above, Vodokanal has given the following remarks:

- The collection of installation costs for water meters by including them in the water tariff is not an option for the moment, as further water charge increases will be difficult.
- As for the installation of water meters outside houses/apartments, Vodokanal basically approves this idea; however, it might not be applicable considering the risks and costs of theft and failure, which may arise especially for apartment buildings.
- With regard to the bulk meters, it will be difficult to use them because domestic customers do not support the idea.

8) Pilot Project

A meter installation pilot study by Vodokanal was then made for 25 detached houses. Each water meter was enclosed in a steel box by the roadside, and connected to the house, making reading and inspection of meters easier. However, the cost of the materials and equipment for this water meter installation method came up to thrice the usual. As of this time, the final water meter installation method has not been decided on.

(2) Planning and Keeping an Exact Installation Schedule

For meter installation to be completed, it is important to solve technical and financial problems, and to provide incentives to promote the transition from the Norm System to a Metered System. Specifically the following plan is to be implemented:

- Evaluating both the technical and financial aspects of the pilot project regarding installation of water meters, including problems with regard thereto in detached houses conducted by Vodokanal and considering whether it should be adopted or not;

- Carrying out a technical investigation on meter installation methods for apartment buildings, with emphasis on installation costs or technical issues with the installation, while looking into the possibility of using bulk meters;
- Obtaining and evaluating the report on the results of the technical investigation on meter installation methods for apartment buildings;
- Determining water meter installation methods;
- Considering external loans, in order to raise funds for installing water meters;
- Planning the exact installation schedule up to 2009; and
- Designating a responsible person in order to follow the schedule as planned.

(3) Revision of the Norm Tariff System

1) Revision of the standard consumption volume

In regard to determining water tariffs according to the Norm Tariff System, the standard consumption volume of water will be increased based on the actual usage. A sample for revision of the Norm Tariff System for domestic customers living in apartments is examined.

Preconditions:

The standard consumption volume under the current Norm Tariff System is 330 lpcd

The number of persons per family is 4 (Persons)

Water charge rate is 22 (soum/ m^3)

Meter installation cost is 33,000 soum.

Average indoors repair cost for an apartment is 37 USD as calculated in Table S.13.1.12.

Meters installation and repairing costs are depreciated over 8 years.

Meter installation costs including the cost of water meter is recovered through water charges collection.

Table 5.2.1 Norm Tariff Revision

No		**Consumption**		**Water charge**	**Additional Costs**	**Total**
		Actual	**Norm**			
	unit	(m^3/month)		(soum/month/family)		
	formula	a	b	c=4*22*a, b*30/1000	d	=c+d
1	Current- Norm	580	330	871		871
2	**Revised- Norm**	**580**	**580**	**1,531**		**1,531**
3	Metered (not repaired)	580		1,531	344 Note 1	1,879
4	Metered (repaired)	150		396	729 =(344+385) Note 2	1,125

(Note1) Meter installation 344=33,000/12/8
(Note2) Indoors repair cost for an apartment 385=37 USD * 1000/12/8

As shown in Table 5.2.1, domestic customers under the current Norm Tariff System do not have an incentive to shift from the Norm to the Metered Tariff System because their water charge under the Metered Tariff System is 1,125 soum even though they save water, which is higher than 871 soum under the Norm Tariff System. However, if the standard consumption volume under the Norm Tariff System is changed from 330 lpcd to 580 lpcd - the actual consumption volume - the customers who currently use the Norm Tariff System will be attracted shifting to the Metered Tariff System because their water charge will increases to 1,531 soum after this change.

2) Bulk Metered Tariff System

If authorities disagree with such a revision of the Norm Tariff System, introducing the Bulk Metered Tariff System will be considered. The Bulk Metered Tariff System means that the actual consumption volume of water at each apartment building is measured by a bulk meter, and each apartment is billed based on the bulk meter readings. If some of apartments disagree with this system, they have to install a water meter individually. (Under the current system, the domestic customers will have to bear the cost of installing the meter). Which is preferable for domestic customers; applying the Bulk Metered Tariff System or installing a water meter individually, depends on their opinion. In order to introduce this Bulk Metered Tariff System alternative, it is necessary to set up a new law. This new law will mention how to install bulk meters, who bears the costs of installing bulk meters and how to allocate water charges among the customers.

(4) Considering Funding Resources for Water Meters Installation

If water meters installation does not progress as planned, one of the main reasons would be the funding problems. Under the current situation, the funding problems arise due to the fact that domestic customers can not bear the installation costs. In addition, if neither subsidies nor capital injections from the government can be expected, the need for an external loan will arise. In case of the need to consider such a loan, Vodokanal must prepare the following data:

- Computation of the required investment amount to install water meters and calculation of the corresponding loan
- Securing funds for the repayment of the loan

  In the case that domestic customers can not bear the installation costs individually, alternative sources required for the repayment of the loan are either cutting costs through decreasing the proportion of unaccounted for water supply volumes by using the Metered Tariff System, or increasing income through real term growth of water tariffs, which would include inflation rates. Generally speaking, it will be difficult to receive a loan from aid agencies to renew the debt. Therefore, if Vodokanal or *Hokimiyat* expect to obtain funds from such agencies, it will be necessary to change the current law and to collect the costs of installing water meters through the collection of water charges. In any case, it will be imperative to plan for securing of funds according to the loan repayment schedule.
- Guarantee and collateral

  It will be quite difficult to borrow from the private sector. There seems to be no other way except to obtain a loan from aid agencies, for which a guarantee from the government will be necessary. In this regard, cooperation with *Hokimiyat* as well as TKEO will be indispensable.

(5) Necessary Funds and Laws

Each one of the above methods will be examined in order to select the appropriate ones, so as to identify the amount of necessary funds as well as the laws and systems that must be revised. Necessary actions and schedules will be formulated including procurement of funds. On that basis, Vodokanal must submit such revisions to the government based on consistent and credible data. In its turn, the government must immediately discuss such revisions and adopt them accordingly.

In addition, together with the progress in meters installation, a revision of the tariff table as well as a reform of the tariff system must be carried out simultaneously.

5.2.3 Replacement of Pipes (Details are referred to D 5.2.3 in Volume 4: Data Report)

As mentioned in Chapter 3.1, 420 km of pipes at 528 points need to be urgently replaced. Suitable pipe materials need to be selected. Table 5.2.2 shows a comparison of pipe materials and Table5.2.3 shows a consideration in selecting pipe materials based on diameter range. Based on these selection considerations, Table 5.2.4 shows recommended materials for the pipes replacement.

Table 5.2.2 Comparison of Pipe Materials

Material	Advantage	Disadvantage	Adoptable diameter
Steel	-Strong and endurable -Strongest to shock and pressure -Easy for processing -Stable lining for small diameter	-Weak to corrosion -High cost for lining -Easy to generate electric corrosion	15-50 >800
Ductile iron	-Strong and endurable -Strong to shock and pressure -Joint is flexible and expansive -Easy for execution -Relative corrosion resistance	-Heavy -Joint protection is necessary -High cost for small and large diameter	100-1000
Vinyl chlo-ride	-Excellent corrosion resistance -Low cost for small diameter -Light and easy to execution -Easy for processing -Stable inner roughness	-Weak to shock in low temperature -Weak to heating and ultraviolet -Low strength -Joint protection is necessary	13-150
Polyethylene	-Excellent corrosion resistance -Very flexible -Easy for execution for small di-ameter -Stable inner roughness -Relative strong and endurable	-Lack of adjustable joint for large diameter -Relatively high cost	15-500

Table 5.2.3 Recommended Pipe Materials by Diameter

Diameter range (mm)	Suitable pipes
13-25	Vinyl chloride pipe, galvanized steel pipe, polyethylene pipe, vinyl lining steel pile, stainless pipe
25-75	Vinyl chloride pipe, galvanized steel pipe, vinyl lining steel pile, polyethylene pipe
75-150	Vinyl chloride pipe, ductile iron pipe, polyethylene pipe
150-500	Ductile iron pipe, polyethylene pipe
500-800	Ductile iron pipe, Lining steel pipe
800-1500	Lining steel pipe, ductile iron pipe
Over 1500	Lining steel pipe

Table 5.2.4 Diameter Range and Suitable Pipe Material for Replacement

Diameter Range (mm)	Length (km)	Suitable materials
25-150	285.2	Vinyl chloride pipe, polyethylene pipe
200-600	120.4	Ductile iron pipe
700-1400	14.5	Steel pipe
Total	420.1	

Considerations for pipe material selection are:

- Vinyl chloride pipes are basically less than 150 mm because the strength is enough within this range of diameters and installation of these pipes is of the least cost;
- From 200 to 600 mm, ductile iron pipes are the most reliable at reasonable cost; and
- Over 700 mm, lining steel pipes are at reasonable cost and the inner side of the pipes can be painted by the workers to prevent rusting.

As shown in Table 5.2.5, the distribution pipes to be replaced are scattered in many districts of the City. Since the number of the sites is quite large and pipes' length to be replaced per site is short, it is anticipated that construction works will affect the traffic seriously. According to Vodokanal, in order to obtain a permission for the construction works, annual length to be replaced would be limited to 60 km. In this case, it will take seven years to complete

Table 5.2.5 Selected Priority Pipes in Each District

District name	Length (m)	Selected
Mirzo Ulugbek	67,265	46
Sabir Rahimov	28,242	4
Akmal Ikramov	52,700	94
Hamza	34,317	39
Yunusabad	30,162	24
Sergeli	51,520	39
Bektemir	8,420	54
Chilanzar	33,248	67
Shayhantahur	47,996	65
Yakkasaray	31,066	63
Mirabad	35,145	33
Total	420,081	528

a total of 420 km of pipes replacement. Thus, it is strongly advisable for Vodokanal to start the project as soon as possible.

5.2.4 Strengthening the Management

In order to improve the current situation with water losses, specific actions, which are listed below, must be carried out. In addition, it is important that both Vodokanal's technical and sales divisions have a clear knowledge and understanding of the real situation of water demand and supply. In order to make sure that this information is reliable, it must be verified by each of the divisions as well as an internal audit department. It must also be mentioned that factors such as seasonal variations, time variations and regional differences must be taken into account fully in this process.

The specific actions that must be taken to decrease water losses are the following:

(1) Accurate data collection of the amount of water distributed from the WTPs,
(2) Accurate data collection of the water consumption and leakages,
(3) Calculating water losses other than consumption and leakages (1) - (2),
(4) Formulating hypotheses in regards to water losses other than leakages,
(5) Verifying each hypothesis,
(6) Formulating and implementing countermeasures when problems such as inappropriate water charges collections and illegal connections are discovered,
(7) Evaluating effects of the countermeasures.

(1) Accurate Understanding of the Amount of Water Distributed from the WTPs

The Study Team made its own estimations of the amount of distributed water. The amount obtained is 2,900,000 m^3/day, which differs considerably from the amount given by Vodokanal. Since this specific figure is crucial when calculating water losses other than leakages, Vodokanal must recalculate it in order to have an accurate knowledge and understanding of the amount of water distributed from the WTPs.

(2) Accurate Understanding of the Water Consumption and Leakage

Indoor water consumption volume was also estimated, including those domestic customers that are currently under the Norm Tariff System. However, since some of the data (e.g. number of people from whom water charges are collected), are unreasonable, it can hardly be said that water charges collection is conducted in a thorough manner to all customers. On the other hand, if this is not correctly done, the real consumption volume cannot be obtained. Therefore it is necessary to confirm that water charges collection is complete, covers all customers, in order to obtain the correct consumption volume.

In addition, it is also necessary to correctly understand the amount of water leakage from the distribution pipelines. Although this information is quite difficult to calculate, the Study Team conducted its own leakage rate estimations in Sergeli. It is necessary that the methodology used in the Sergeli estimation be used as a reference to estimate leakages from the whole distribution system.

(3) Calculating Water Losses other than Consumption and Leakages (1) - (2)

By subtracting the consumption and leakage volume obtained in (2) from the amount of distributed water obtained in (1), it is possible to calculate water losses other than leakages.

(4) Formulating Hypotheses in regards to Water Losses other than Leakages

Hypothetical reasons for the existence of water losses other than leakages should be formulated. Possible reasons, given the fact found in (2) that water charges collections is not complete, are the following:

- Illegal connections (stolen water, water illegally used for irrigation),
- Technical problems and errors in the distribution system.

(5) Verifying each Hypotheses

Validity of each hypothesis must be verified while also conducting field exploratory investigations, in order to obtain an accurate understanding of the real situation of water losses other than leakages.

(6) Formulating and Implementing Countermeasures when Problems such as Inappropriate Water Charges Collections and Illegal Connections are discovered

When the causes of water losses other than leakages are clarified, strict countermeasures must be applied. Obviously, countermeasures will differ on a case-by-case basis. Additional water charges collections, disconnecting water services, fines and legal sanctions will be considered and applied accordingly.

(7) Evaluating Effects of the Countermeasures

The results of implementing the countermeasures must be evaluated in order to verify whether the expected improvements have actually taken place. If not, applied countermeasures must be revised accordingly.

5.3 Strategic Facility Plan for Optimum System

5.3.1 Planning Condition

(1) Design Flow

The design flow for water supply systems is presented in Table 5.3.1. The daily maximum flow is used for the design of WTPs and hourly maximum flow is used for the distribution facilities.

Table 5.3.1 Design Flow for Water Supply (1000m^3/d)

Year	2002	2005	2007	2009	2010	2011	2015
Daily average flow	**2,900**	**2,741**	**2,414**	**2,081**	**1,919**	**1,831**	**1,625**
Daily maximum flow	**3,100**	**3,015**	**2,656**	**2,289**	**2,130**	**2,051**	**1,820**
Hourly maximum flow*1	**3,200**	**3,165**	**2,921**	**2,518**	**2,365**	**2,297**	**2,038**

*1: Maximum hourly flow (m^3/h) x 24hours

(2) EBRD Project

The Tashkent Water Supply Improvement Program (the EBRD Project), which is financed by EBRD (The European Bank for Reconstruction and Development), has commenced since 2004. The project includes the rehabilitation plan of three WTPs as shown in Table 5.3.2. For the LTDP, the contents of the project are set as preconditions of the Study.

Table 5.3.2 Contents of the EBRD Project

Place	Items	Contents
Kadirya WTP	Replacement of No.1 and No.2 Intake PS	15 units of pumps with valves, transformers and control panels
	Filter improvement / replacement	Replacement of 50% of valves, introduction of automatic filter washing
	Laboratory equipment	Replacement of all equipment
Boz-su WTP	Replacement of intake and distribution PS	Pumps with valves, transformers and control panels
	Replacement of filters	New construction of rapid filters with capacity of 100,000m^3/d
Kibray WTP	Replacement of well's pump	63 units of pumps
Lisunova PS	New construction	Capacity of 1000m^3/hr
Oktyabrskiy Pipe	Purchase and setting up of equipment; overflow-pipe construction	Reinforcement of pipes D1000 and D1200 Total length=2km

As of February 2005, the selection of the consultant for the Project was underway. According to Vodokanal, the anticipated completion dates of the main project components are as follows:

1) Replacement of intake pumps in Kadirya WTP: middle of 2007
2) Replacement of well pumps in Kibray WTP: early 2006
3) Replacement of intake and distribution pumps in Boz-su WTP: middle of 2006
4) Replacement of filters in Boz-su WTP: late 2008

5.3.2 Selection of Necessary WTPs for Future Water Demand

(1) Evaluation of WTPs

Tashkent City is served by three large-scale WTPs in the highland, and by five small-scale WTPs dispersed in the lowland areas of the City. Kadirya and Boz-su WTPs take surface water from Boz-su Canal, while others take groundwater pumped from deep wells.

Treated water from three highland WTPs is supplied to a water distribution network covering the most of the City. Other WTPs supply water only to their surrounding areas (Figure 2.3.14).

Table 5.3.3 Comparison of WTPs in Tashkent City

	WTP name	Founded year	Production capacity				Elevation (m)
			Design capacity (1000m^3/d)	Share (%)	Actual production amount (1000m^3/d)	Share (%)	
Large-scale in highland	Kadirya	1969	1,375.0	58.5	2,200.0	71.0	540
	Kibray	1955	455.2	19.4	350.0	11.3	500
	Boz-su	1931	235.6	10.0	260.0	8.4	485
	Sub-total		2,065.8	87.9	2,810.0	90.7	
Small-scale in lowland	South	1961	143.0	6.1	160.0	5.2	420
	Sergeli	1966	40.0	1.7	45.0	1.5	400
	Kara-su	1960	52.2	2.2	35.0	1.1	420
	Kuiluk	1962	25.0	1.1	35.0	1.1	420
	Bectemir	1966	25.0	1.1	15.0	0.5	400
	Sub-total		285.2	12.1	290.0	9.3	
Total			2,351.0	100.0	3,100.0	100.0	

As shown in Table 5.3.3, the actual production of some WTPs exceeds their respective design capacity, among which the largest excess is seen at Kadirya WTP. Decrease in well production is generally observed at groundwater WTPs.

Kadirya WTP was constructed in 1969 after a big earthquake, while others were constructed earlier. Therefore, presently the WTPs, which still rely on small-scale WTPs dispersed throughout the City, making it inefficient. Only Kadirya WTP has been augmented from time to time. Other WTPs have not been rehabilitated nor improved since 1970. As a result, their production has decreased considerably.

Table 5.3.4 shows the operational costs (electricity and chemicals) and the number of staff in major WTPs.

Table 5.3.4 Unit Cost for Operation and Number of Staff at WTPs

WTP name	Actual maximum production capacity ($1000m^3/d$)	Unit operation cost ($soum/m^3$)			Staff number	Staff/capacity ratio ($number/1000m^3/d$)
		Electricity & chemical	Labor	Total		
Kadirya	2,200	1.2	0.1	1.3	180	1
Kibray	350	3.4	0.8	4.2	193	6.9
Boz-su	260	2.6	0.8	3.4	140	6.7
South	160	2.9	1.1	4.0	115	9
Others	116	1.9	3.0	4.9	210	22.6

As shown, Kadirya WTP is the most efficient in terms of unit cost and manpower, while other small WTPs expend the highest costs. In addition, since there is a large number of staff members operating other small-scale WTPs, further labor costs will increase, rising unit operation costs.

(2) Required Capacity of WTPs in the Future

Table 5.3.5 shows that the water demand in the City will decrease in the future. Therefore, the capacity of the existing WTPs will exceed future water demand. The WTPs can be consolidated to enable it to operate efficiently as a system, even if the production capacities of these WTPs may also decrease due to deterioration.

Since Kadirya WTP distributes as much as 72% of the total water supply in the City, its operation will be indispensable in the future. The water right for Kadirya WTP (1.83 million m^3/d) is equivalent to the projected water demand of the whole City in 2015. But as discussed in the previous section, the WTP should be operated within its design capacity of 1.375 million m^3/d. Furthermore, it would be of a great risk for the whole City to rely on sole WTP.

The projected maximum daily water demand and the required capacity of Kadirya and other WTPs are shown in Table 5.3.5. The operation of the Kadirya WTP is presently overloaded. Its capacity should, as soon as possible, be reduced to less than the intake right of 1.83 million m^3/d or to around 1.7 million m^3/d. This is the maximum capacity which meets the standard velocity of the rapid filters including 10% of standby filters regulated in SNIP. Kadirya WTP will be operated at design capacity of 1.375 million m^3/d in the target year. The balance to the total water demand in the City shall be produced by the other WTPs.

Table 5.3.5 Water Demand and Required Production of WTPs (1000m^3/d)

Year		2002	2005	2007	2009	2010	2011	2015
Projected maximum daily water demand		**3,100**	**3,015**	**2,656**	**2,289**	**2,130**	**2,051**	**1,820**
Required production capacity	Kadirya	**2,200**	**2,165**	**1,830**[*1]	**1,830**[*1]	**1,700**[*2]	**1,500**	**1375**[*3]
	Others	**900**	**850**	**826**	**459**	**430**	**451**	**445**
Total production quantity		**3,100**	**3,015**	**2,656**	**2,289**	**2,130**	**2,051**	**1,820**

*1: Capacity meeting the amount of the water intake right
*2: Maximum capacity meeting the SNIP Standard
*3: Design capacity

As shown in the table, the required capacity of 445,000 m^3/d out of 1,820,000 m^3/d must be supplied by other WTPs in 2015.

(3) Selection of Necessary WTPs

In order to meet the future demand in 2015, the WTP(s) that will supply 450,000 m^3/d must be selected. Proposed selection criteria of such WTPs whose operation will be maintained in the future are: i) a highland location because of the advantage to distribute treated water by gravity, ii) low rehabilitation cost, and iii) low O&M cost.

Deterioration of the facilities has been observed in all WTPs of Vodokanal. For efficiency of investment, the larger WTPs should be improved and rehabilitated; while the small-scale WTPs will be made to supply water only for the surrounding areas by a pumping system. Accordingly, Kibray and Boz-su WTPs fit the above conditions using above criteria i) and ii).

Although the unit O&M cost per m^3 of Kibray WTP is the highest in the City, it can be reduced by improving the pump operation and distribution system, which will be discussed later. Thus, Kibray and Boz-su WTPs are considered as candidates for selection.

1) Kibray WTP

As stated earlier, the water production amount of Kibray WTP has been declining year by year. However, the Evaluation of Groundwater Source for Kibray WTP (refer to S.3.1.3) shows that the aquifer potential is sufficient to secure the capacity of 350,000 m^3/d; but only if the operation of wells is improved; i.e., wells are properly selected and replacement of old pumps with pumps that operate automatically.

The EBRD Project includes the replacement of well pumps in Kibray WTP, the capacity of which matches the well's yield capacity, allowing automatic operation in accordance with the water levels in the wells. Thus, Kibray WTP will be able to secure the capacity of 350,000m^3/d continuously by implementing this Project. In addition, by replacing well pumps with those of suitable capacity, breakdowns will be prevented and the electricity consumption will be sharply reduced.

2) Boz-su WTP

In Boz-su WTP, the intake and distribution facilities are so seriously deteriorated that some rapid filters need to be urgently replaced. While a 1997 Cabinet Resolution tried to address this problem, budget constraints suspended the construction work and four filtration basins were left uncompleted.

A new rapid filter with the capacity of 100,000m^3/d will be constructed in the EBRD Project as replacement, with the old filters. Also, the Project includes the replacement of intake and distribution pumps with accessory facilities, which will enable Boz-su WTP to continuously produce a maximum of 100,000m^3/d of treated water in the future. Thus, the total capacity of Kibray and Boz-su WTP can be kept at the required capacity of 450,000m^3/d.

5.3.3 Utilization Plan for Existing WTPs

As discussed above, Tashkent City is to be ultimately served with drinking water by three WTPs namely, Kadirya, Kibray and Boz-su in the target year of 2015. For the short or middle term, however, since the projected water demand will gradually decrease, other existing WTPs cannot be closed unless the capacity of these three WTPs meets the total water demand in the City. It is, therefore, necessary to establish a utilization plan for the existing WTPs that are scheduled to be closed in the target year, considering the remaining life of existing facilities and rehabilitation schemes in each plant. A scenario for making use of each existing plant is summarized as follows:

Kadirya WTP

It will be continuously used. Replacement of intake pumps will be carried out by 2006 during the EBRD Project. As stated earlier, the capacity shall be slowly decreased to 1.83 million m^3/d by 2007, 1.70 million m^3/d by 2010, and 1.375 million m^3/d in 2015.

Kibray WTP

It will also be used continuously. When the well pumps will be replaced as the EBRD Project is being implemented, the present capacity of 350,000 m^3/d can be maintained up to the target year of 2015.

Boz-su WTP

The existing filters will be used until the new facility is constructed in 2008 during the course of the EBRD Project. The capacity of the existing filters is assumed to decrease to 250,000 m^3/d in 2007, as their conditions deteriorated further. From 2009, only new filters with a capacity of 100,000 m^3/d will be put in operation.

South WTP

The existing facilities shall be used until 2011. However, its capacity is assumed to decrease as their conditions worsen. The capacity is assumed to be 130,000 m^3/d in 2005, 120,000 m^3/d in 2007 and 50,000m^3/d from 2009 to 2011.

Other WTPs

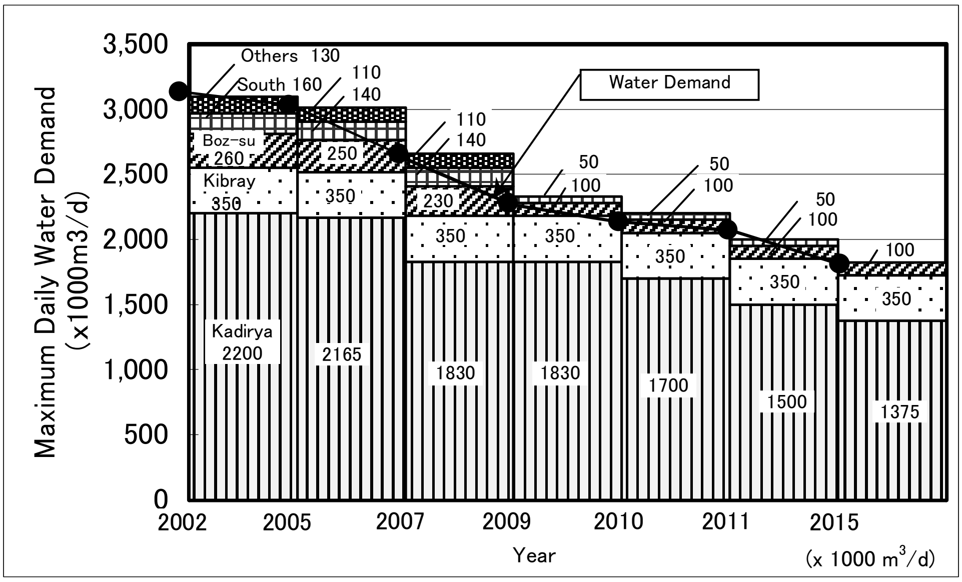
The existing facilities shall be used until 2007. Their capacity is assumed to decrease to 110,000 m^3/d, after 2005 continued deterioration.

Based on the above scenario, the utilization plan for the existing STPs can be presented as shown in Table 5.3.6 and Figure 5.3.1

Table 5.3.6 Transition of Capacity of WTPs (1000 m^3/d)

WTP name	2002	2005	2007	2009	2010	2011	2015
Kadirya	2,200	2,165	1,830	1,830	1,700	1,500	1,375
Kibray	350	350	350	350	350	350	350
Boz-su	260	250	230	200	170	160	100*
South	160	140	140	100	70	50	-
Others	130	110	110	-	-	-	-
Total	3,100	3,015	2,660	2,330	2,200	2,000	1,825
Water demand	3,100	3,015	2,656	2,289	2,130	2,060	1,820

*: Capacity of new filters



Total Capacity	3,100	3,015	2,660	2,330	2,200	2,000	1,825
Water Demand	3,100	3,015	2,656	2,289	2,130	2,060	1,820

Figure 5.3.1 Schedule of Abandonment for small WTPs

5.3.4 Establishment of Gravity Flow Water Distribution System

(1) Review of Pipeline Network and Booster PSs

Figure 5.3.2 shows the location of the existing distribution mains. Figures 5.3.3 (1) and (2) show the longitudinal profiles from Kadirya and Kibray WTPs to the City. As shown in the figures, the distribution from Kadirya and Kibray WTPs to the City can be carried out by gravity. Therefore, the current distribution system should be reexamined so as to enable gravity flow water supply for the City.

Features of the existing distribution system from each WTP are summarized as follows:

Distribution from Kadirya WTP

The WTP facilitates small distribution pumps, used only for surrounding areas of the site. The quantity of water supplied by these pumps is also small, and most of the treated water is distributed by gravity to the major downstream areas.

Distribution from Kibray WTP

The distribution network from this plant is divided into two systems. One is for the groundwater yield from the wells and distributed by pumps. The other is for the treated water transmitted from Kadirya WTP and distributed by gravity to the City. As mentioned earlier, the pump distribution system needs to be changed to the gravity system because the elevation of the plant site is much higher than the distribution areas.

Distribution from Boz-su STP

Water from Boz-su WTP is distributed with the use of pumps because of the small difference in the elevations between the distribution areas and water level of the reservoir. The majority of the areas have a high elevation that water cannot be distributed by gravity even from Kadirya WTP. Since the capacity of Boz-su WTP is to be reduced, the areas where water is being distributed need to be reviewed.

In addition, the current distribution network is accompanied by many booster-pumping stations, helping it distribute water mainly to apartment buildings. Although Vodokanal has plans to distribute water to low-story buildings of no more than five-story by gravity, the majority need the pump system, because the required pressure cannot be maintained.

The reason behind the low supply pressure is the undue controlling of valve which is carried out manually, avoiding high pressure areas where there are detached houses, and where there are deteriorated pipelines. Furthermore, additional PSs are necessary for Vodokanal to distribute water to at nine-story buildings.

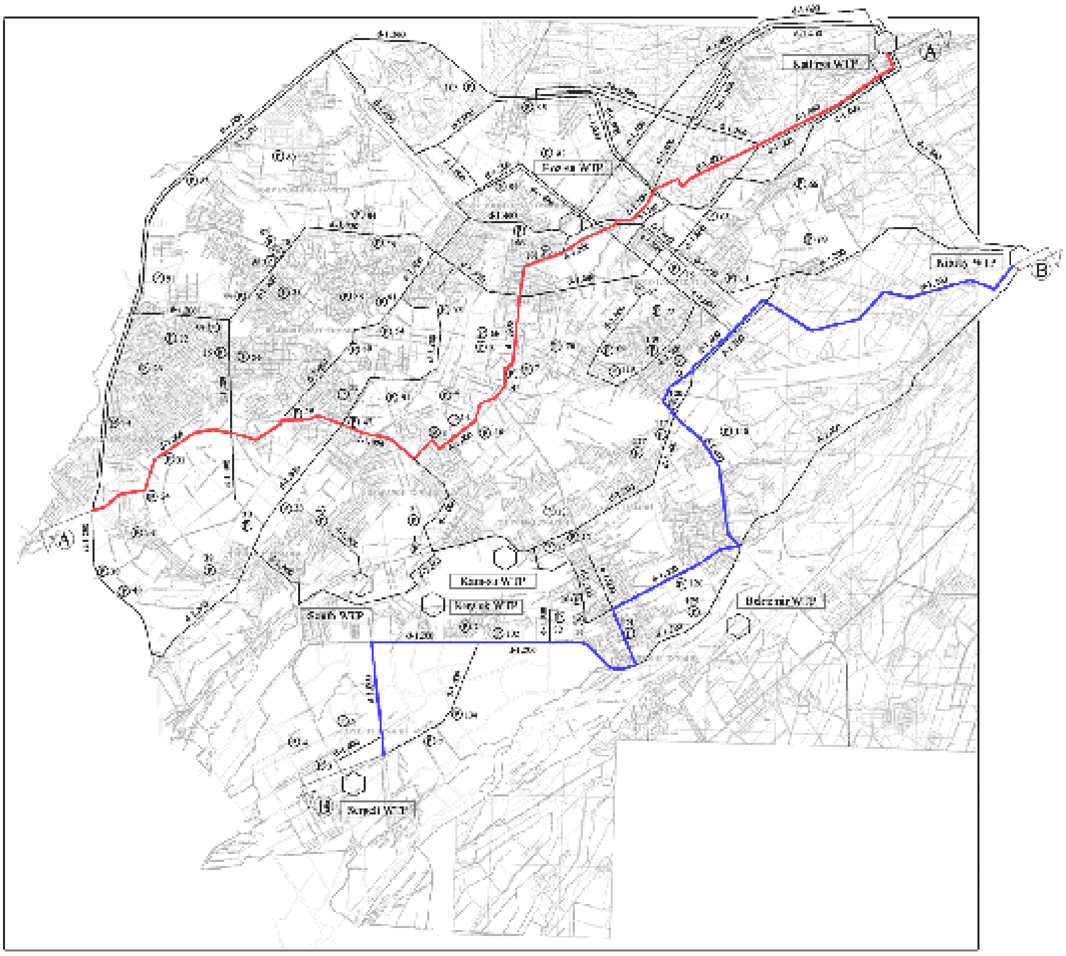


Figure 5.3.2 Location of Distribution Mains

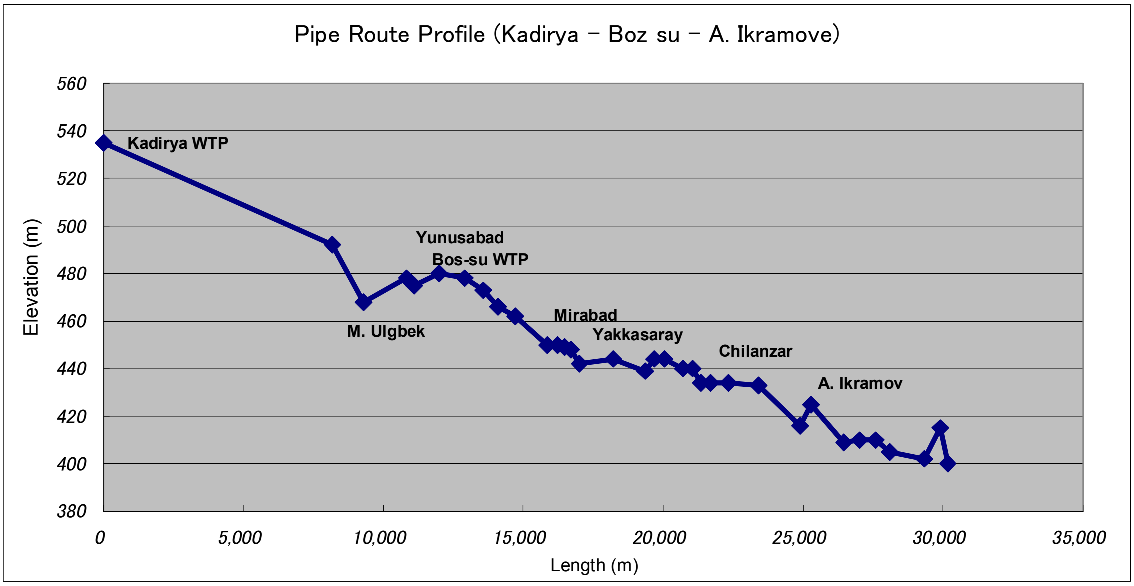


Figure 5.3.3 (1) Longitudinal Profile from Kadirya WTP to the City

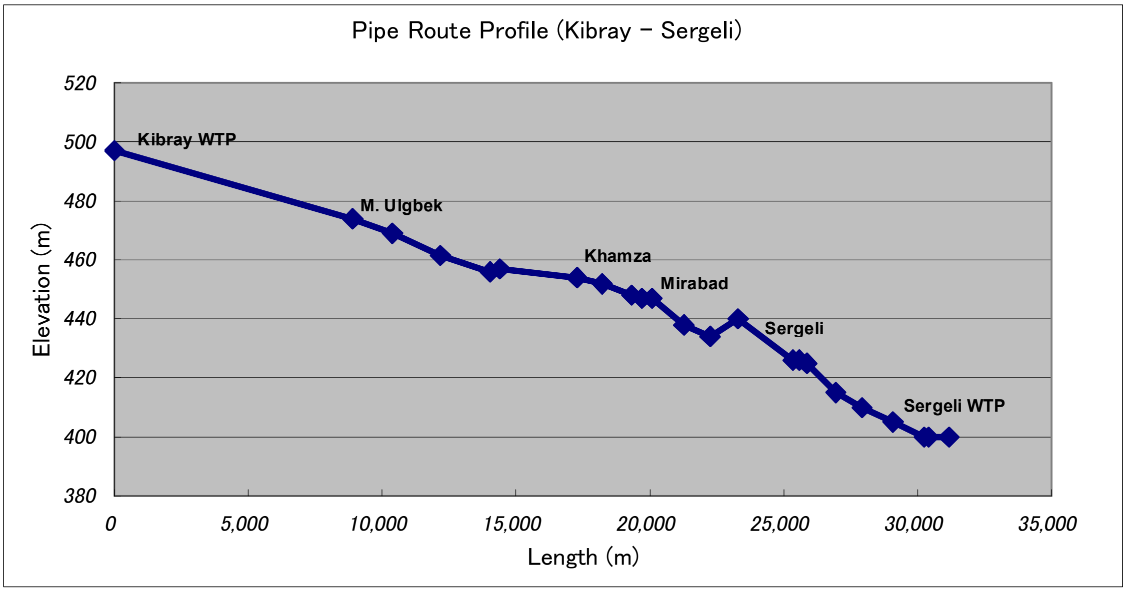


Figure 5.3.3 (2) Longitudinal Profile from Kibray WTP to the City

As a result, the total capacity of PSs is estimated to be around 2.6 million m^3/d and the electrical consumption to be 243,000kWh/d (equivalent to boosting water to 1.2million m^3/d). The capacity is obviously excessive as is the consumption of electricity. Such a waste of capital investments and O&M costs must be avoided by changing to a more efficient distribution system.

(2) Improvement of Water Distribution System

1) Distribution network

In order to establish an efficient distribution system, Vodokanal should make full use of the water head that is naturally generated from the elevation difference between water treatment plants and supplied areas.

A hydraulic analysis for the target year shows that when a proper pressure regulation system with auto-pressure regulation valves is introduced, most of the city areas can be kept over 26m of water head, which is enough pressure to distribute to 5-story buildings, without booster PSs. However because some areas remain lower than 26m of water pressure in the City, booster PSs for low story buildings will need to be operated continuously.

Now, many booster PSs are operated for both low story (no more than 5-story) and high story (mainly 9- story) buildings. Even if the pressure of the area supplied by a booster PS is raised over 26m, the PS will continuously need to supply water for 9-story buildings. Accordingly, the PS cannot be simply abandoned in this case.

However if a PS supplying to buildings can be changed to supply for only for 9-story buildings, the capacity of the PS can be reduced because water for the low story buildings can be supplied directly by the improved gravity pipeline.

If the number of 9-story buildings for a supply area of PS is small, pump units to supply for one to several buildings will be installed, and the existing PS can be abandoned. However, when either it is difficult to separate supply area or the number of 9-story buildings is large, the supply population by the PS cannot be reduced.

Although the number of PSs will not reduced so much, the total discharge capacity and electricity consumption will be reduced drastically.

3) Necessary Works

Table 5.3.7 shows the contents of replacement/improvement works needed for establishing the efficient water distribution network in Tashkent City. The contents of the works include replacement/improvement of distribution pipes and refurbishment/improvement of booster PSs.

Table 5.3.7 Replacement/improvement for Water Distribution System

Item	Replacement	Improvement	Abandonment
Pipeline network	-Pipeline 420 km,	-Installation of automatic pressure/flow regulation valves, -Reinforcement of pipes to rise pressure in the City -Introduction of Pressure/flow monitoring system	
Distribution PSs	-Boz-su PS	-To change distribution system -New small PS at Kibray WTP	-Existing PS at Kibray WTP
Booster PSs		-Improvement of existing booster PSs to be needed continuously with introduction of automatic control and monitoring system	- Existing PSs not to be needed

(3) Cost Evaluation for the System (Details are referred to S 5.3.4)

Comparison between the existing system and the proposed gravity distribution system is shown in Table 5.3.8

Table 5.3.8 Comparison between Existing and Proposed Gravity Distribution Systems

Item		Contents	Unit	Existing pump system	Proposed gravity system	Note
PS construction/replacement	Construction/replacement cost	-2015	1000USD	15,000	37,435	
		2015-2035	1000USD	21,000	7,400	
		Total	1000USD	36,000	44,835	
Operation	Annual consumption	Electricity	GWh	90	20	30USD/1000kWh
		Staff	Number	794	356	600 USD/y.p
	Annual cost	Electricity	1000USD/y	2,670	600	
		Personnel	1000USD/y	476	213	
		Total	1000USD/y	3,146	813	

Pipeline replacement is not included in this comparison because the costs for each system are the same. In case of the existing system, as 24 PSs were identified to be replaced, these replacement costs are counted until 2015 and later replacement costs for other PSs are counted. For the proposed system, repair costs are counted. Even though investment costs for the proposed gravity system are higher than for the existing system, the operation costs will be much lesser.

Based on the results of cost evaluation provided in Chapter 6.2, the PV (preset value) for the gravity system (41 million USD) is less than those for the existing system (47million USD). In addition, the proposed gravity system mainly consists of pipes and pressure regulation valves, and their replacement/repair costs will be smaller than those for the existing system. Therefore, the proposed gravity system is obviously advantageous.

5.4 Proposed Construction Projects

Based on the Optimum Facility Plan selected in the previous chapter, this presents details of the rehabilitation/improvement plan needed for individual facilities incorporating the contents of the EBRD Project, of which implementation had been already confirmed.

5.4.1 Rehabilitation of Kadirya WTP

(1) Replacement of Deteriorated Facilities

As a result of the diagnosis, the facilities which need to be urgently replaced are shown in Table 5.4.1.

Among the facilities, replacement of the intake pumps is the most important, because these are major facilities, along with rapid sand filters, which are also deteriorated. Their intake capacities have been decreasing; while the frequency of breakdowns increasing. This is a very serious problem, since breakdowns will mean the interruption of around 70% of City's water distribution. Replacement of the intake pumps is to be carried out in the EBRD Project.

Table 5.4.1 Facilities Requiring Urgent Replacement

Facilities	Name	Specification x number	Remarks
Sedimentation Basin	Dredger	800m^3/hrx1unit, 400m^3/hrx1unit	
No.1 intake PS	Main pump	12,500m^3/hr x 5units	Included in EBRD
		6,300m^3/hr x 2units	ditto
	Power panel	1unit	ditto
	Control panel	8units	ditto
No.2 intake PS	Main pump	12,500m^3/hr x 6units	ditto
		6,300m^3/hr x 2units	ditto
	Power panel	1unit	ditto
	Control panel	8units	ditto
Rapid filters	Valves	Appropriately half valves	ditto
Distribution PS	Main pump	2,500m^3/hr x 2units	
	Power panel	1unit	
	Control panel	8units	
Laboratory	Analysis equipment	Including electro-measure devices	Included in EBRD
Chlorinator	Chlorinator	1unit	
	Disinfection building	1unit	
Monitoring	Flow-meter	8units	

(2) Repair for Facilities

Since Kadirya WTP will be kept as major water source for Tashkent City, all deteriorated facilities need to be replaced or repaired. Required repair works for the WTP are shown in Table 5.4.2.

Table 5.4.2 Contents of Repair Works

Facilities	Contents
Intake	-No.1 Intake gates -No.1 intake screens -No.2 Intake gates
Coagulant dosing	-Dissolving tank
Intake PS	-Pipes and valves -Building -Steel ladder, floor and handrail
Rapid sand filter	-Filter building -Pipe and valves -Replacement filter materials
Distribution and washing pump	-Building -Pipes and valves
Others	-Pipeline and valves in site

(3) Improvement for the System

Kadirya WTP has some functional defects and these can be solved by some remedial measures as shown in Table 5.4.3.

Table 5.4.3 Defects of the Facilities and Countermeasures

Defects	Current status	Countermeasure	Note
Ineffective service pipe for coagulation	Too late reaction of dosing because of too long service pipe	Installation of feeding tank and feeding pump	
Non-functioning rapid mixing	Lack to contact floc and suspended solid	Relocation of coagulant feeding trough	Figure 5.4.1
Lack of flocculation	Since floc is not formed properly, SS does not settle.	Provision of baffle plates	Figure 5.4.1
Manual control of rapid sand filter/ too large outlet velocity	Filter washing is manually operated.	Introduction of automatic washing by timer	Included in EBRD
	No flow control in filtration	Installation of weirs in outlet part	

In addition, control system improvements will be necessary, as follows:

- Monitoring and control on the treatment process and status of distribution construction of a control room and installation of measuring equipment such as flow/level meter. The concept of the control and monitor system is described in Section 5.4.3; and

- Regulation of fluctuation flow of distribution quantity: As mentioned in Section 3.1.5, the necessary retention time is assumed at 1.35 hour, therefore minimum requirement has been decided at two hours.

Table 5.4.4 shows contents for improvement of the facilities. Figure 5.4.1 presents how to improve rapid mixing and flocculation, as an example of the No.1 Intake mouth.

Table 5.4.4 Improvement of the Facilities

Facilities		Specifications x number
Administration building	Administration function +control & monitoring room,	Repair for existing building+ 600 m^2 of expansion
Coagulant dosing facilities	Feeding tank	10 m^3 x 4
	Feeding pump	200 l/min x 7 units
Flocculation basin	Injection pipes and troughs	2 units
	No.1 flocculation basin	Sheel pile wall
	No.2 flocculation basin	Provision of baffle wall
Rapid sand filter	Filter control panels	48 units
	Discharge weir	2 sets
Reservoir	New reservoirs	45,000 m^3 x 2 units
Monitoring Facilities	Intake capacity by level meter	2 units
	Level meters for reservoir	5 units
	Ultra-sonic flow meters at distribution pipes	8 sets (to be installed by Vodokanal)

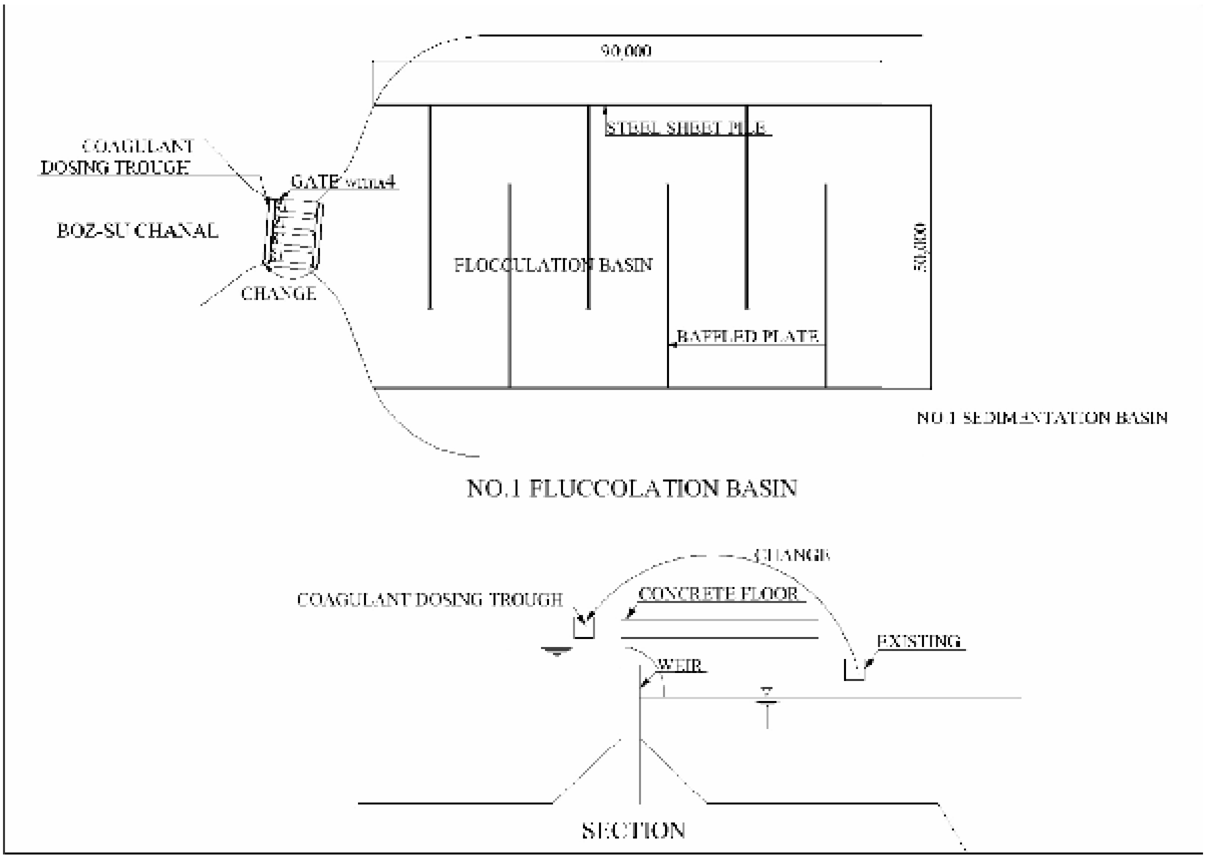


Figure 5.4.1 Improvement of Rapid Mixing and Flocculation for No.1 Intake Mouth

The required volume of reservoir for Kadirya WTP is calculated below:

Total capacity of existing reservoirs: 30,000 m^3

Required volume: 1,375,000 m^3/day x 2/24 – 30,000 = 84,600 m^3

Decided volume: 45,000 m^3 x 2 units = 90,000 m^3

Location of the proposed reservoirs is shown in Figure 5.4.2. Improved treatment process of Kadirya WTP is shown in Figure 5.4.3.

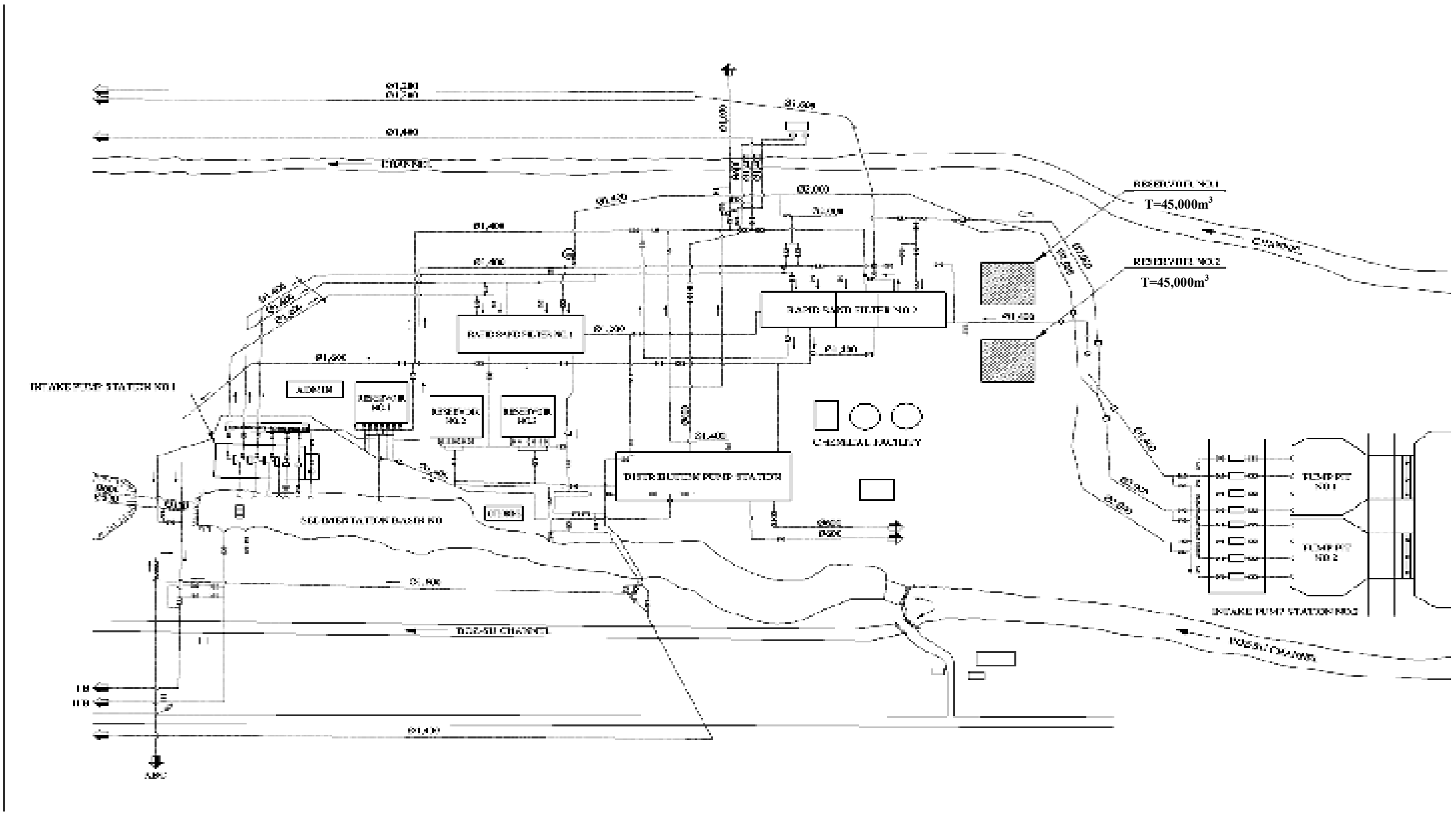


Figure 5.4.2 Location of Proposed Reservoirs

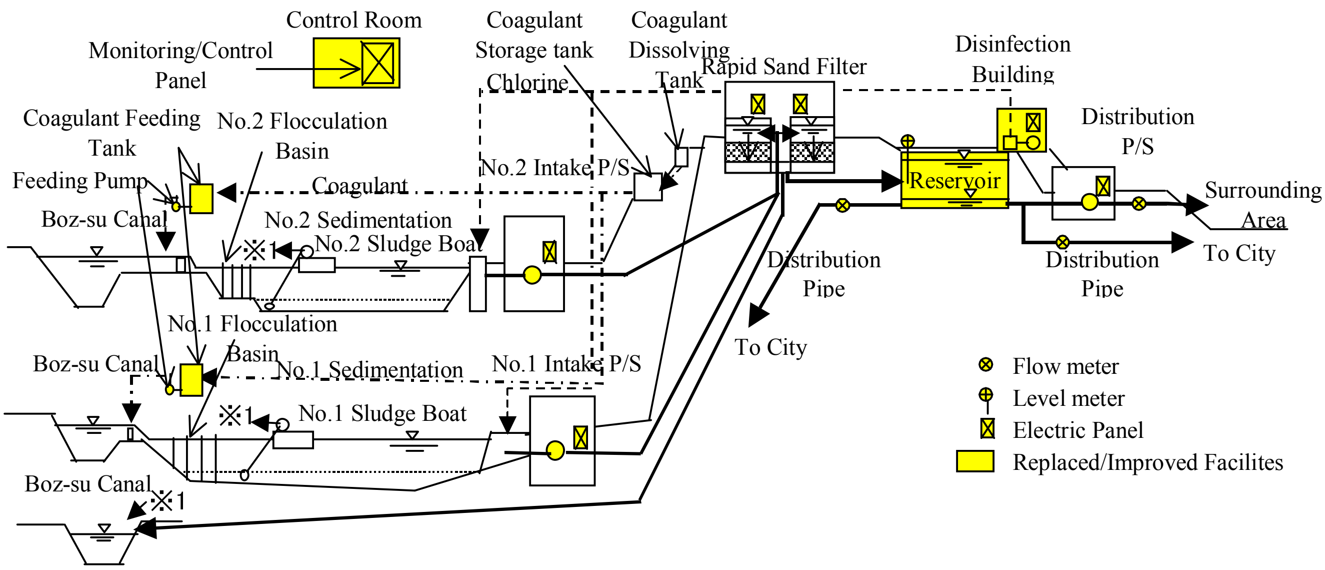


Figure 5.4.3 Improved Treatment Process of Kadirya WTP

5.4.2 Rehabilitation of Kibray WTP

(1) Rehabilitation of Well System (Details are referred to S 3.1.3)

As stated earlier, the frequent and rapid/large drop of wells' water level is the main problem for the present well systems. Among the reasons of the drop in water level is the narrow interval between each well. Thus the number of wells should be decreased and wells that will operate continuously should be properly selected. The new replacement pumps should have a capacity matched by the well's yield capacity, and should have automatic operation functionality in order to prevent the drop of groundwater level. According to the evaluation of the groundwater source conducted in this study, 19 wells at the right bank and 37 at the left bank (56 wells in total) have been selected to ensure the planned water production of 350,000 m^3/d. The recommended location of these wells is shown in Figure 5.4.4.

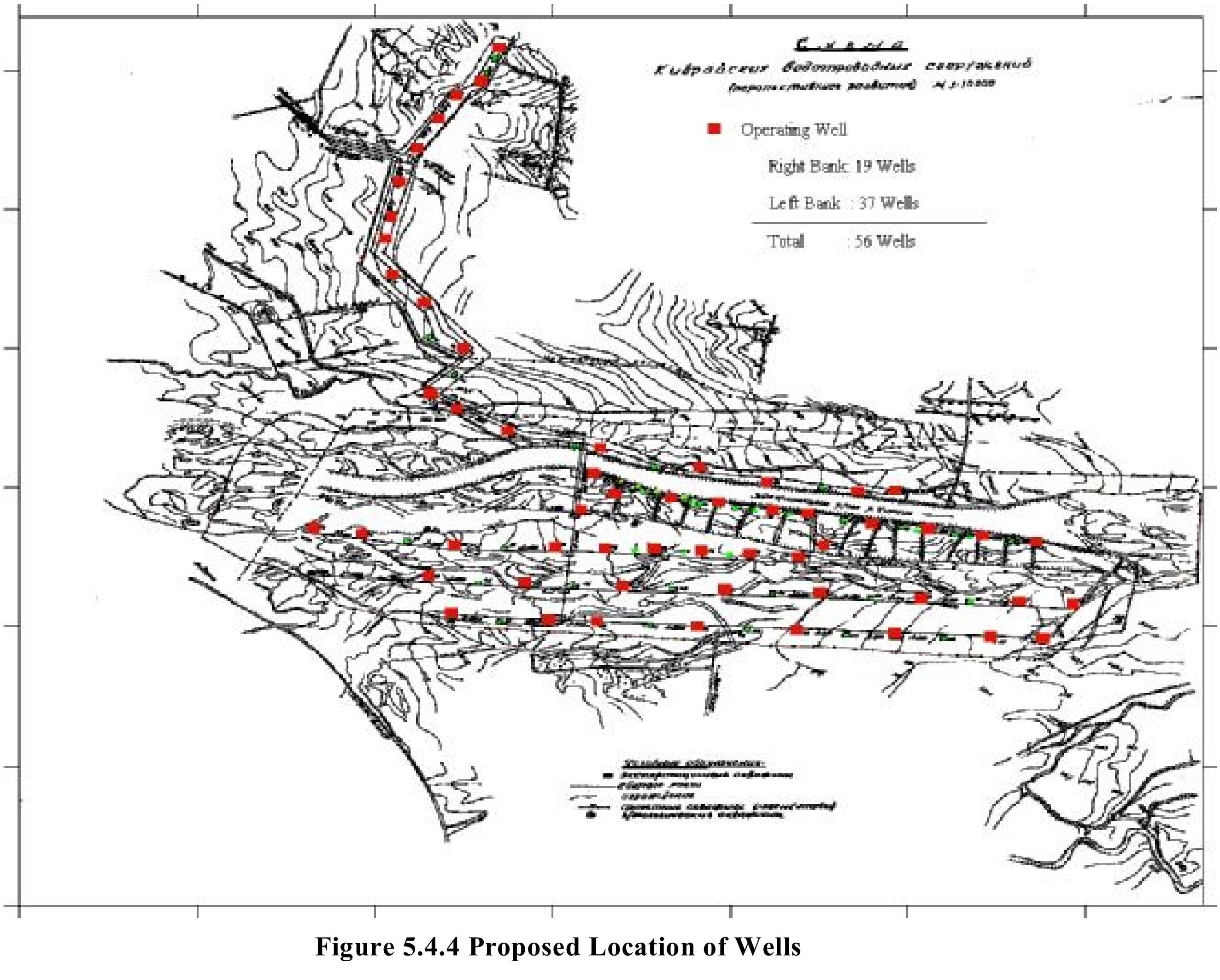


Figure 5.4.4 Proposed Location of Wells

The replacement of 63 well pumps is proposed in the EBRD Project. However, the plan in the Project does not consider the proper selection of the wells to be operated. Hence, it is strongly recommended that the location of wells to be replaced by the EBRD Project be consistent with this Maser Plan. It is also proposed that the transmission pipes from wells at the downstream area in the left bank be improved, as shown in Figure 5.4.5. By installing by-passes at the downstream sides, water can be conveyed without much negative force.

The Study Team also proposes the rehabilitation of the infiltration ponds. The ponds, which have a total area of 28 ha, are located in the left bank along the Chirchik River. The river water is conveyed to the ponds by open channels. Although ponds are effective at supplying water to groundwater layers, a large amount of sludge is presently accumulated at the bottom of the pond, which interferes with water infiltration. Therefore, the ponds should be dredged periodically to improve aquifer recharge.

Such improvement will highly contribute to preventing the frequent breakdowns of pumps due to dry operation as well as the abnormal vibration by excessive closing of the discharge valves. Also, power wastage caused by these phenomena will be avoided; while the yield amount of each well will increase by the automatic operation, providing an efficient on-off sequence.

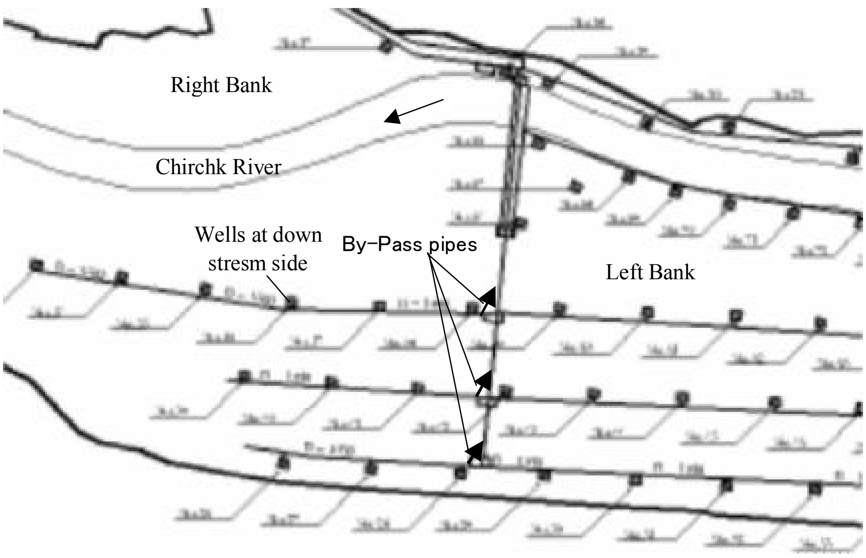


Figure 5.4.5 Improvement of Transmission Pipes

(2) Gravity Distribution

As earlier mentioned, the ground level of Kibray is much higher than distribution area of the City. Therefore, it is recommended that the distribution from Kibray WTP be carried out by gravity, and a small PS be placed in the surrounding area where water cannot be distributed by gravity. The reservoir shall be expanded to ensure stable water distribution in the future. The minimum retention time in the reservoir shall be two hours.

The current distribution system from Kibray WTP to the City is shown in Figure 5.4.6. Water sources for Kibray WTP are the well's yield water consisting of two groups, and the treated water transmitted from Kadirya WTP. The list of distribution pipes is shown in Table 5.4.5.

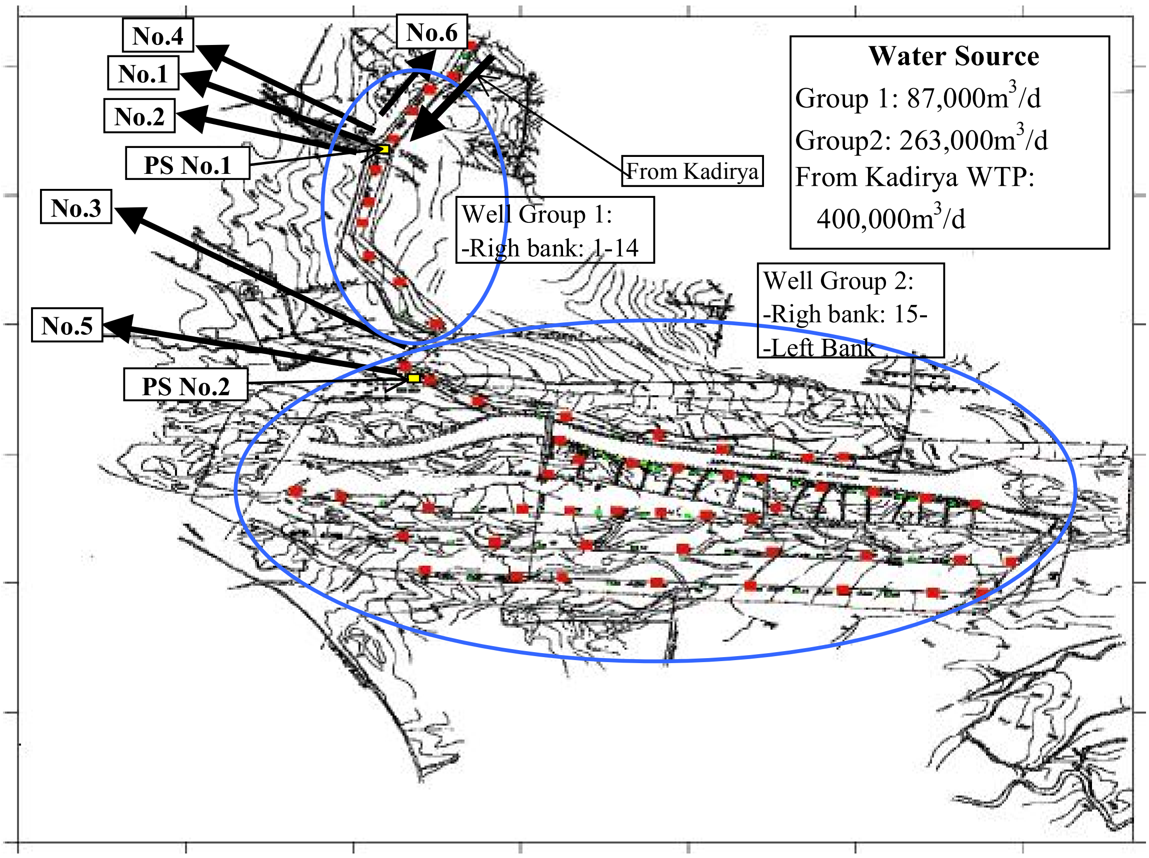


Figure 5.4.6 Current Distribution System of Kibray WTP

Table 5.4.5 List of Distribution Pipes

Pipe No.	Diameter mm	Approximate flow		Velocity m/sec	Pressure m	Water source
		Hourly (m^3/h)	Daily (m^3/d)			
1	700	1,500	36,000	1.08	3	Kadirya
2	1,200	7,800	187,200	1.92	4	Kadirya+ Well 2
3	1,200	6,800	163,200	1.67	6	Kadirya+ Well 2
4	900	2,000	48,000	0.87	24	Well 1
5	1,400	11,500	276,000	2.08	1	Kadirya+ Well 2
6	800	1,000	24,000	0.55	30	Well 1
Total		30,600	734,400			

There are two distribution PSs in Kibray WTP. PS No.1 discharges to Pipes No.4 and 6, and their pressures are high. PS No.2 discharges to Pipes No.2, 3 and 5, and their pressures are kept very low. The reason for keeping such low pressure is that the transmitted water from Kadirya WTP is mixed with the water discharged by PS No.2 and, therefore, the pressure cannot be raised anymore. For Pipe No.1, water can be distributed by gravity pipe from Kadirya WTP.

The elevation difference between this WTP and the distribution area of the City is quite big, creating high friction loss especially when large amounts of water flow into the pipeline. The result is low water pressure in the City. Therefore, gravity distribution cannot be applied to this WTP under the current conditions.

In the future, water demand of the City will be reduced, at which time gravity distribution can be introduced. The transition plan from pump to gravity distribution is described in Section 8.2.3 in detail.

(3) Water Quality

The water yield of some wells at the right bank has a high concentration of nitrate, exceeding the Standard value of drinking water at 45mg/L. Table 5.4.6 shows the assumed nitrate concentration calculations.

Table 5.4.6 Calculation of Nitrate Concentration

Location	Well No.	NO_3 (mg/L)	Intake amount (m^3/day)	NO_3 load (kg/day)	Location	Well No.	NO_3 (mg/L)	Intake amount (m^3/day)	NO_3 load (kg/day)
Right Bank **Group 1**(No-1-14)	1	29.90	9,850	294.5	Left Bank **Group 2**	43	9.08	2,189	19.9
	2	28.80	8,400	241.9		44	7.08	9,000	63.7
	3	26.40	3,758	99.2		45	11.91	9,960	118.6
	4	26.40	10,056	265.5		46	6.64	8,184	54.3
	5	27.70	8,688	240.7		47	8.19	8,304	68.0
	6	28.80	8,160	235.0		48	6.64	7,728	51.3
	7	28.80	8,472	244.0		49	5.31	9,000	47.8
	8	29.90	10,920	326.5		50	6.64	10,272	68.2
	9	45.20	8,688	392.7		51	10.00	10,000	100.0
	10	47.40	11,256	533.5		52	10.20	12,336	125.8
	11	53.60	4,080	218.7		53	10.00	7,000	70.0
	12	59.80	8,520	509.5		54	5.76	7,000	40.3
	13	59.80	8,352	499.4		55	N.A.	0	0.0
	14	62.00	9,420	584.0		56	10.00	7,000	70.0
	Total	40.8	106,462	4,344		57	N.A.	0	0.0
Right Bank Group 2 (No.15-25)	14a	62.00	5,700	353.4		58	7.08	7,920	56.1
	15	64.70	10,056	650.6		59	7.08	8,520	60.3
	16	57.60	8,304	478.3		60	7.08	11,040	78.2
	17	57.60	2,880	165.9		61	6.64	7,380	49.0
	18	46.60	2,880	134.2		62	6.64	3,120	20.7
	19	62.00	4,944	306.5		63	11.91	11,160	132.9
	20	62.00	8,256	511.9		64	7.53	8,532	64.2
	21	52.70	7,056	371.9		65	8.31	5,904	49.0
	22	57.60	5,760	331.8		66	9.08	12,672	115.1
	23	N.A.	0	0.0		67	10.00	9,000	90.0
	24	62.00	7,200	446.4		68	N.A.	0	0.0
	25	59.80	7,200	430.6		69	10.20	4,920	50.2
	Total	59.6	53,400	3,182		70	8.87	4,920	43.6
Right Bank		47.1	159,862	7,526		71	7.53	0	0.0
Left Bank Group 2	26	10.00	7,200	72.0		72	10.00	4,920	49.2
	27	N.A.	0	0.0		73	6.64	4,920	32.7
	28	10.00	7,200	0.0		74	10.00	4,920	49.2
	29	11.91	8,832	105.2		75	7.08	4,920	34.8
	30	N.A.	0	0.0		76	5.31	4,896	26.0
	31	11.91	6,000	71.5		77	8.19	4,260	34.9
	32	8.84	5,400	47.7		78	N.A.	0	0.0
	33	5.76	5,500	31.7		79	7.53	4,300	32.4
	34	6.64	6,000	39.8		80	7.53	5,940	44.7
	35	6.10	6,500	39.7		81	8.31	4,440	36.9
	36	5.56	0	0.0		2G	9.08	5,700	51.8
	37	9.21	7,440	68.5		15P	10.00	4,000	40.0
	38	12.85	8,256	106.1		33P	8.19	2,664	21.8
	39	10.00	8,200	82.0		34P	3.99	4,800	19.2
	40	N.A.	0	0.0		35P	N.A.	0	0.0
	41	10.00	3,000	30.0		Total	8.5	171,365	1,464
	42	12.55	11,952	150.0	Group 2		20.7	224,765	4,646

(Shaded) Selected Wells as shown in Figure 5.4.6

The values of nitrate were derived from the well's data in March 2000, when the average value at the right bank was the highest since the year 2000. The flow values were derived from the average flow data from July to December 2004. The calculation was carried out for the wells marked with gray, which are selected as shown in Figure 5.4.4.

The table shows that the mixed concentration of Well Group 1 is 40.8mg/l, and that of Group 2 is 20.7mg/l. Since the values of nitrate concentration meet the standard value when the water yielded by Group 1 and Croup 2 are mixed, the distribution system of Kibray WTP is formed as shown in Figure 5.4.6. Vodokanal should keep monitoring the water quality carefully, and if necessary, a countermeasure for preserving the water sources should be planned.

(4) Construction of Reservoir and New Distribution PS

1) Reservoir

The required retention time of water at the reservoirs was decided to be two hours. The volume of the necessary reservoir is calculated as follows:

Volume of the existing reservoir: 10,000 m^3

Total flow through the reservoir: 330,000m^3/d

Necessary quantity: 330,000 x 2/24=27,500m^3

New reservoir: 27,500 – 10,000=17,500m^3, it is decided at 20,000m^3

2) Distribution PS

A reservoir should be constructed in Kadirya WTP for the transmission water. Since the water source for Pipe No. 6 is the yield water of Well Group 1 and the quantity is only part to the total yield (22%), it is considered that a reservoir for Pipe No.6 does not need to be constructed.

The aforementioned distribution PS is planned as follows:

The necessary capacity of PS: 1,000m^3/hr

Pumps: 500m^3/hr x 40mh x 90kW x 4 units (2 stand-by)

With electricity facilities for pumps

The existing No.1 pump building will be used for the PS.

(5) Rehabilitation for Other Facilities

1) Disinfection facilities

Disinfection facilities are so deteriorated that these should be replaced as follows:

For the area of Well Group 1

- Maximum injection ratio: assumed 1mg/l;
- Necessary injection quantity: 280,000m^3/d=11,700 m^3/hr x1 mg/l x10^{-3} = 11.7 kg/hr;
- Chlorinator: 10 kg/hr x 3 units; and
- Chlorination building (to repair existing building)

For the area of Well Group 2

- Maximum injection ratio: assumed 1mg/l;
- Necessary injection quantity: 420,000m^3/d=17,500 m^3/hr x1 mg/l x10^{-3} = 17.5 kg/hr;
- Chlorinator: 10 kg/hr x 3 units; and
- Chlorination building (to repair existing building)

2) Others

The following facilities should be rehabilitated:

- Power receiving facilities: 1 unit;
- Flow meters: required for transmission pipes from Kadirya WTP and all distribution pipes;

Presently, even though Kibray WTP has a laboratory, water quality of the groundwater sources has not changed significantly. Since the distance between Kadirya and Kibray WTP is only around seven km, it is recommended that the laboratory shall be located only at Kadirya WTP and should be provided with the latest and precision analysis equipment. However, the function of monitoring residual chlorine will be also necessary for Kibray WTP.

The following facilities for monitoring are necessary:

- Flow meters for each distribution pipes
- For monitoring of operational status of well pumps;
- Level meter: required distribution reservoir; and
- A monitoring panel for this monitoring equipment.

(6) Reduction of Electricity Consumption

Because of inefficient system operations, the unit cost of electricity at Kibray WTP is the highest among the WTPs in Tashkent City, and the number of its operations staff is the biggest. If the proposed facilities are introduced for Kibray WTP, the electricity cost will be sharply reduced. The reduction is estimated as follows::

Electricity consumption in 2002: 0.42kWh/m^3

<u>In the future for well pumps</u>

Average right bank intake 150,000m^3/d: 330m^3/hrx30mh: required power:38kWx19

Left bank intake 200,000m^3/d: 225m^3/hrx30mh: required power: 36kWx37

<u>In the future for distribution pumps</u>

Distribution 20,000m^3/d: 90kW x 2 x 0.7=63x2kW

(39x19+36x37+63x2) x 24/350,000=0.151kWh/m^3,

For safety purposed, it will be assumed at 0.2kWh/m^3

5.4.3 Rehabilitations for Boz-su WTP

Boz-su WTP was established in 1931, and it distributes to the City center including the Governmental area. Many of its structures were constructed before 1966. When a big earthquake took place in Tashkent City in this same year, the structures for the rapid filters were damaged. Despite the damage, these structures were still utilized.

The EBRD Project includes not only reconstruction of the rapid filters, but also replacement of the intake and distribution pumps. The contents are listed in Table 5.4.7. When the Project is completed, the treatment capacity of over 100,000m^3/d will be ensured.
The location of the new rapid filters is shown in Figure 5.4.7.

Based on the hydraulic calculations, the surrounding area of Boz-su WTP, which is one of the highest areas of the City, cannot be distributed by gravity even from Kadirya WTP.
In the future, distribution pumps will be installed continuously at the Boz-su WTP.

Table 5.4.7 Contents of the EBRD Project for Boz-su WTP

Category	Facilities	Equipment/system	Contents
Replacement	Intake PS	Main pump	6300 m^3/hr x 2 units
			4,700 m^3/hr x 1 units
			3,000 m^3/hr x 1 units
		Power panel	1 unit
		Control panel	4 unit
	Distribution PS	Main pump	6,300 m^3/hr x 1 units
			4,300 m^3/hr x 4 units
			2,800 m^3/hr x 2 units
		Power panel	1 unit
		Control panel	7 units
	Rapid filters	Filters	25,000m^3/d x 4 units
		Control system	Automatic-washing system

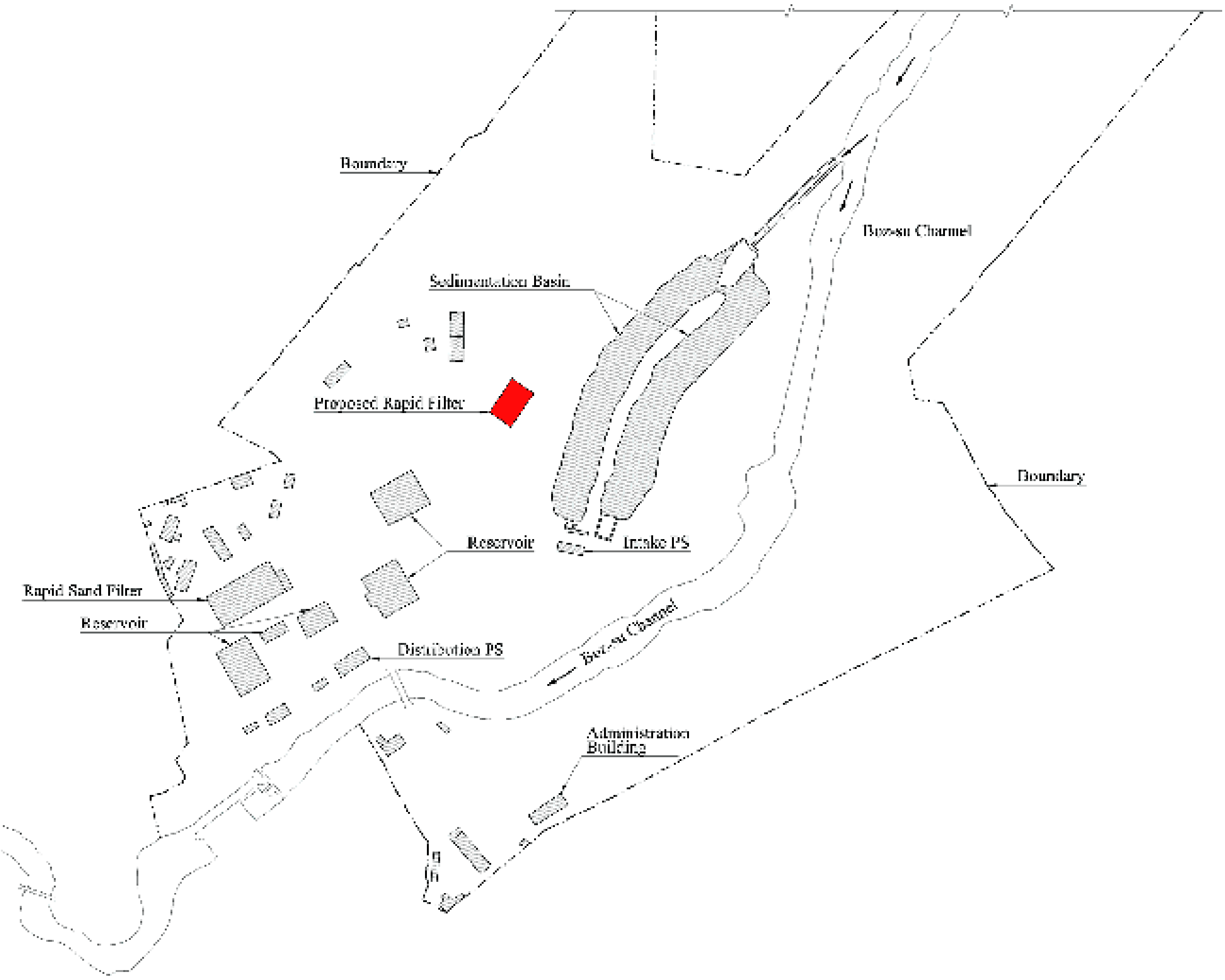


Figure 5.4.7 Location of New Rapid Filters

5.4.4 Proposed Remote Monitoring System

The water supply system, comprising WTPs, transmission pipelines and distribution networks with booster pump stations, is widely dispersed in Tashkent city. It will be appropriate to set up a remote monitoring system (the System) at a central station that would observe/monitor the status of the WTPs and the water distribution networks. This system is normally composed of the central station, the remote stations and telecommunication links as a data transmission channel.

(1) Monitoring and Control System for each Water Treatment Plant

Since there is no automatic control system at any water treatment plant in Tashkent, the introduction of automatic control system is essential for the WTPs to operate securely and effectively.

A monitoring and control system is proposed at each WTP as an individual system, such as Kadirya WTP, Kibray WTP and Boz-su WTP to achieve the automatic operation. Personal computers (PCs) and a server shall be arranged in the central monitoring room, while PLCs (Programmable Logic Controllers) shall be arranged in each local control station to build up the monitoring and control system. Furthermore, instrumentation devices will also be required to complete the automatic operation for each process.

This monitoring and control system will be established as a hierarchy structure for a reliability purpose in which the central room is in the upper and the local control room is in the lower hierarchies. These units of equipment are linked over an open network such as Ethernet to collect the plant load status and to send start/stop command to each plant load and set value to each loop control such as flow control of coagulant dosage.

The unified monitoring and control system enables efficient operation and maintenance work of the water treatment plant, because any information about the whole plant is monitored from the central supervisory room.

(2) Monitoring and control System for the Water Distribution Network

There are over 100 booster pump stations in the water distribution networks covering wide area of Tashkent city. Operating staffs are on duty at each booster pump station to control pump equipment manually and to monitor their status.

Automatic operations at the booster pump stations is proposed to improve the existing situation of the water distribution networks, while a unified monitoring system for the networks will be introduced. Vodokanal Headquarters will be the master station in this study. The automatic operation for the booster pumps can be achieved at each booster pump station by components of a controller, control panels, pressure meters and a flow meter. The number of duty pumps is controlled according to the discharge side flow rate measured by the flow meter to keep the pressure at a pre-set value. It is also useful that all the information such as the pressure value, the flow rate and the pumps status is gathered at the master station of Vodokanal Head quarters to have a complete picture of the distribution network situation.

(3) Introduction of the System in the Entire City

It is desirable to build-up the System for the water supply facilities in Tashkent City and to monitor their status and to gather data from remote stations at the master station over tele-communication links. In this Master Plan, Vodokanal Headquarters will be proposed as the master station. The monitoring and control system at each WTP will be established as one of the component of the remote monitoring system, while a radio system will be newly proposed as a telecommunication channel utilizing the existing frequency of 40.050 MHz to monitor the status of the WTPs at the mater station.

On the other hand, the monitoring components comprise of two PCs, one server, two large scale screens, two printers and a radio device will be provided at the master station to receive and monitor the status of the booster pump stations, and pressure/flow-regulating points. Other frequencies will be allocated to the data communication between the master station and each booster pump station, and each pressure/flow-regulating regulating point to complete the unified monitoring system for the water distribution networks.

There are three different frequencies of radio used in Vodokanal; 37.325 MHz for sewage treatment plant, 40.05 MHz for the Vodokanal headquarters and WTPs, and 46.6 MHz for between the Kara-su WTP and each booster pump station. Although these radio systems are currently used for only voice communication, it will be possible to utilize these frequencies as data communication medium in the future. If there are many booster-pump stations to be retained, some more frequencies will be required to be allocated among the groups. The entire monitoring system diagram is shown in Figure 5.4.8.

(4) Improvement of Operation and Maintenance

At present, all the facilities in the water supply system in Tashkent City are manually-controlled operations even for simply linked operations of a pump and a discharge valve. Any logging work, such as recording of pressure values at pump stations or power consumption, is also executed manually. After completion of the System for the entire water supply system, automatic operations or automatic logging work will be enabled

1) Automatic backwashing for rapid sand filters

A backwash procedure for each filtration unit is required once or twice a day. There are 48 filtration units in Kadirya WTP, and this backwash is performed manually at each local operation panel.

The PLC will enable a full automatic operation for the backwash of each filtration unit based on a pre-set timing sequence programmed in the PLC. Furthermore, the backwash schedule of all the filtration units will also be programmable in the PLC. Both the period and frequency of the backwash will be adjusted at the upper class PC and at the PLC.

2) Linkage operation for pumps

Pumps, such as intake and distribution, are operated in conjunction with relevant delivery valves. The PLC will easily make it possible for automatic linkage operation of the pumps and the discharge valves.

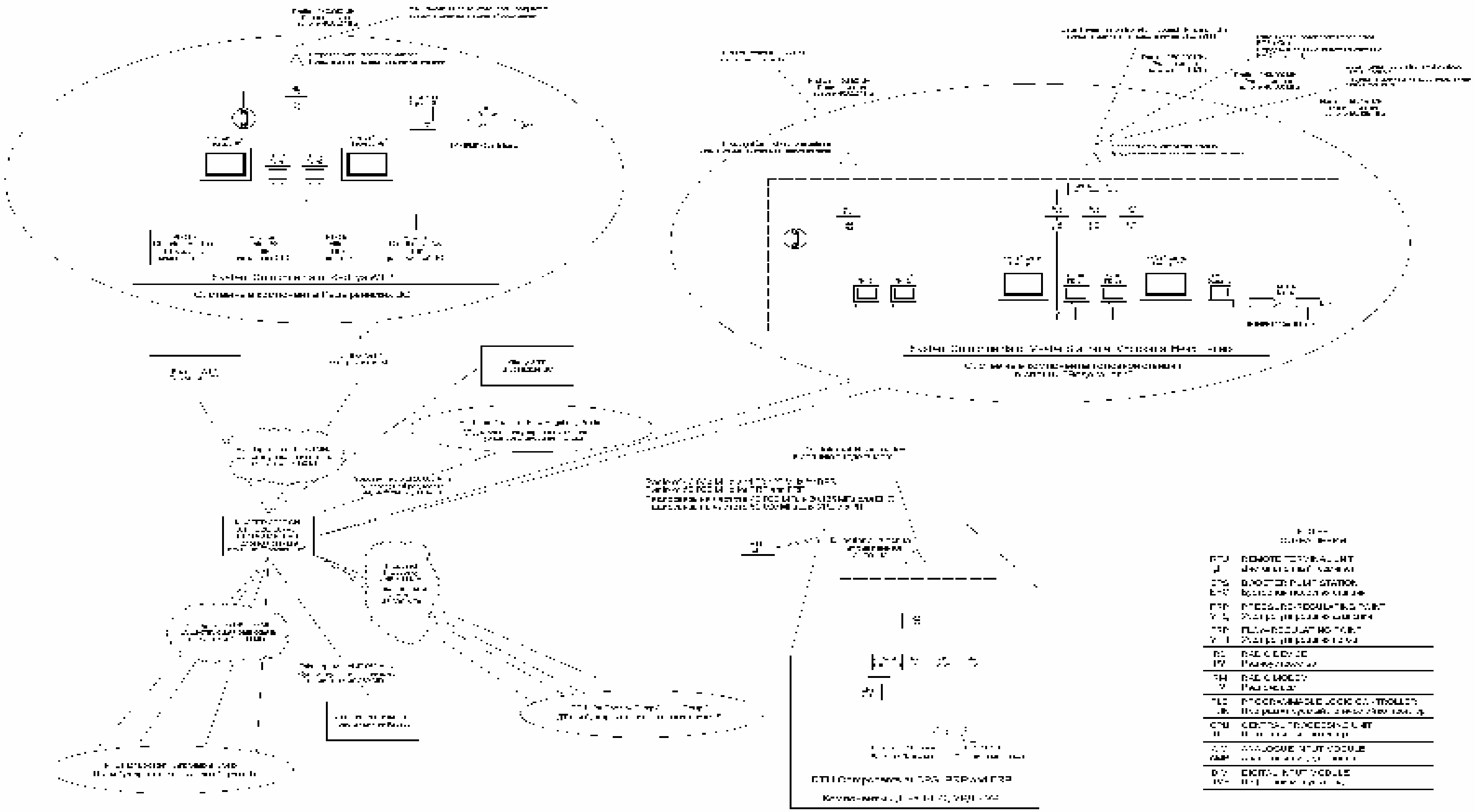


Figure 5.4.8 Entire Monitoring System in Tashkent

3) Constant pressure control for distribution pumps and booster pumps

Distribution pump facilities are proposed for both Kadirya WTP and Kibray WTP to cover the water supply to the surrounding areas. Water will be distributed by gravity to some areas, and for the other areas by the booster pump stations. There is a required distribution water pressure level for water to be properly supplied to each customer. An automatic control for the distribution pumps to keep discharge pressure at the certain level can be introduced based on the PLC and the pressure meters installed on the discharge pipes. The pressure constant control is achieved by step control of working pumps, which is according to the discharge flow rate, or by the combination of the step control and variable speed control of a motor if necessary. This control method can also be applied to the booster pumps in the water distribution networks. The system of constant pressure control is shown in Figure 5.4.9.

4) Monitoring and logging of distribution network system

Some of the existing booster-pump stations will be retained to cope with forecasted water demand in the target year, while some of the existing pressure regulating valves will be replaced with motor-driven type ones to control the discharge side pressure automatically and keep it at a pre-set value. The data collected from the booster pump stations, and the pressure-regulating or flow-regulating points will be monitored on the PC screen, and logged automatically in a daily report and a monthly report at the master station by the proposed monitoring system for the water distribution network. These reports will then be utilized to analyze water demand fluctuations or will be used for other purposes. The data to be collected from the water distribution network are shown as Table 5.4.8.

5) Monitoring and logging of water treatment plant

Process values and status of each plant load of the each water treatment plant will be monitored and logged at each WTP. Furthermore these data will also be monitored at the master station of Vodokanal Headquarters by the proposed remote monitoring system.

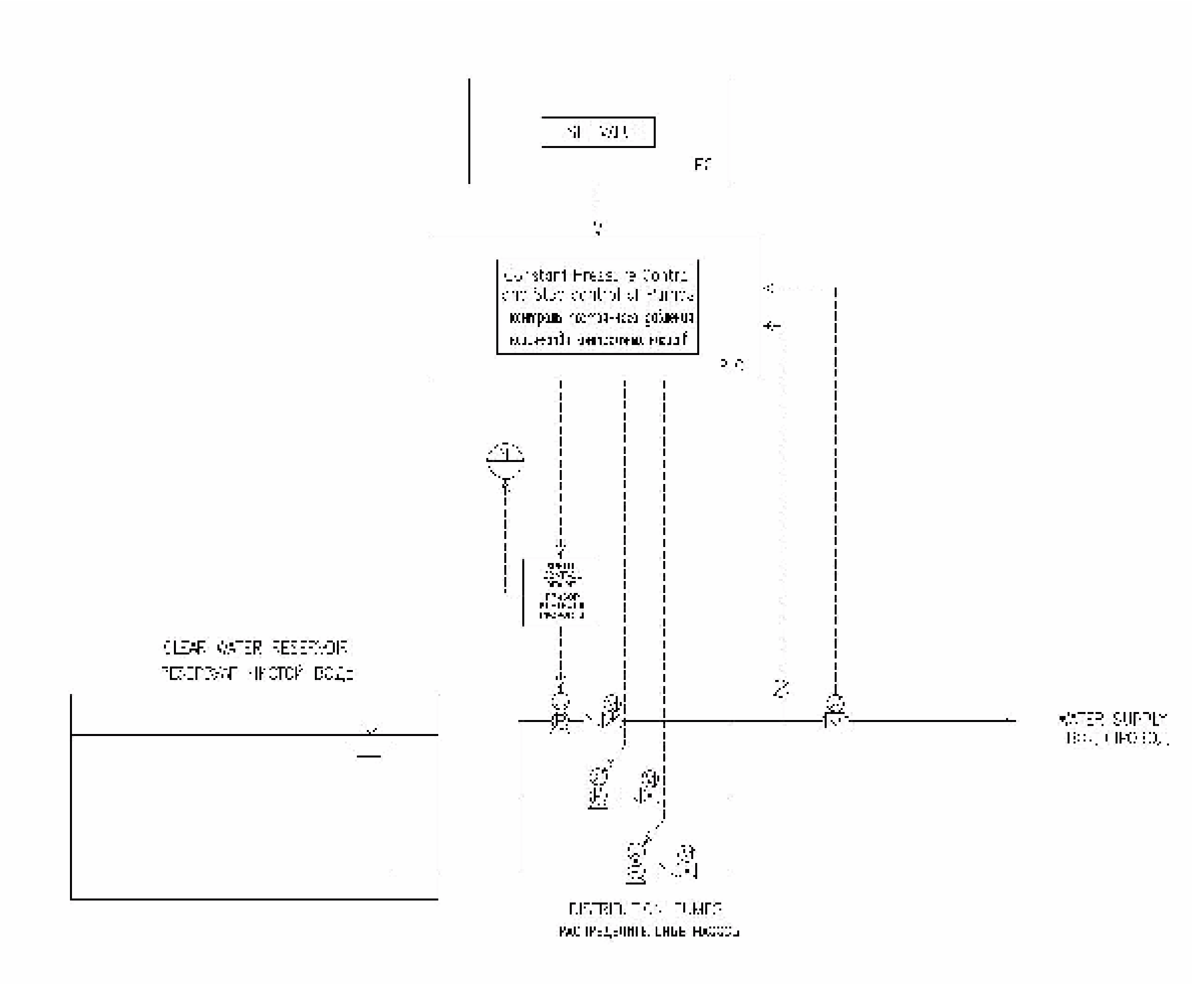


Figure 5.4.9 Constant Pressure Control

Table 5.4.8 Collection Data from Distribution Network

Facility Name	Data
Booster pump stations	Suction side pressure
	Discharge side pressure
	Discharge flow and its integrated value
	Pump fault
	Power consumption in kWh
	Power interruption
	Door open
Pressure/flow-regulating points	Primary side pressure
	Secondary side pressure
	Discharge flow and its integrated value
	Valve fault
	Power consumption in kWh
	Power interruption
	Door open

5.4.5 Improvement of Distribution Network (Details are referred to S 5.4.5)

(1) Planning of the System by the Target Year

1) Division of the distribution network

In the target year, the water sources of Tashkent City will only be Kadirya, Kibray and Boz-su WTP. The current distribution system distributes from eight WTPs, and the whole distribution network is connected. Thus, it is such a huge and complicated system that is difficult to operate properly. Accordingly, the network should be divided into several distribution areas.

A new distribution network plan, which is divided into five areas (Northern area of Kadirya, Central area of Kadirya, Southern area of Kadirya, Kibray and Boz-su) based on the hydraulic calculations in the target year, is shown in Figure 5.4.10. Water supply zones will be re-arranged as shown in Table 5.4.9. They will be basically isolated depending on the water source: Kadirya and Kibray WTP, from which the treated water will be distributed by gravity, and Boz-su WTP, which will distribute water by pumps. Coverage of these areas was decided considering design capacities of each WTP and the served population in the respective areas.

2) Pressure control

In the network, elevation differences are so large that a water pressure control system is necessary. Currently, the control is carried out by manually regulating the valves without hydraulic simulations. However, when flow fluctuations increase in the future in line with the reduction of water wastage and leakage, manual control will not be able to cope with such fluctuations. Therefore, an automatic pressure control system should be introduced.

For this purpose, the pressure control system utilizing automatic valves as shown in Section 5.4.4 should be used.

Figure 5.4.11 shows the calculated result of the water pressure distribution in the target area, when these control facilities are adopted. In the figure, control points in the network are also shown.

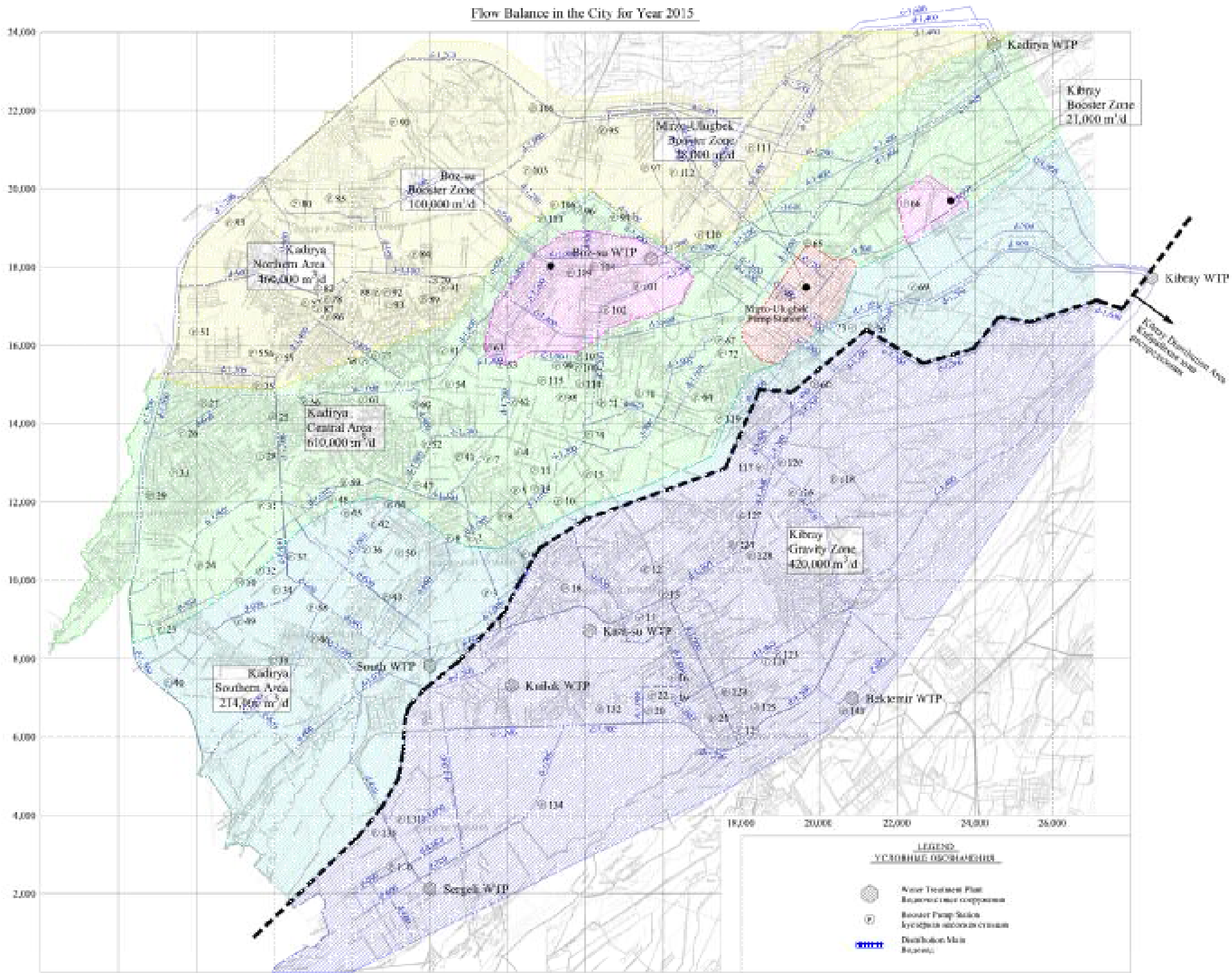


Figure 5.4.10 Division of Water Distribution Areas in the City

As shown in the figure, the bigger part of the area can keep the proper pressure of 26-50 m to secure direct water supply to low-story buildings by gravity flow. Booster PSs mainly distribute to apartment buildings, which include 2- to 9-story buildings, while the number of flats (family) for low-story apartment buildings account for over 70% of the total flats of the City.

The capacities of the existing booster PSs are to be drastically reduced. Since the distribution to high-story buildings requires high pressure, e.g. 42m of water head for

9-story buildings, booster pumps need to be installed for these buildings. For over 10 story buildings, a booster pump for each building was already installed.

Table 5.4.9 Division of the Pipeline Network in the City

Water source (Production volume)	Supply zone	Service area	Elevation (m)	Max. daily water demand (m^3/day)	Distribution method
Kadirya WTP (1,375,000 m^3/day)	Kadirya Northern Area	S. Rahimov Yunusbad (part) Shayhantahur (part) Mirzo-Ulugbek (part)	410-495	460,000	Gravity
	Kadirya Central Area	Shayhantahur (part) Mirzo-Ulugubek (part) Mirabad (part) A. Ikramov (part)	400-510	610,000	Gravity (Pressure reducing)
	Kadirya Southern Area	Chilanzar Yakkasaray (part) Mirabad (part)	400-470	214,000	Gravity
Kibray WTP (350,000 m^3/day)	Kibray Gravity Zone	Khamza Sergeli Bectemir Mirabad (Part)	395-480	420,000*	Gravity (Pressure reducing)
	Kibray Booster Zone	Vicinity area of Kibray WTP	>490	21,000	Booster pump
Boz-su WTP (100,000 m^3/day)	Boz-su Booster Zone	Shayhantahur (part) Yunusbad (part) Mirzo-Ulugbek (part)	450-480	100,000	Booster pump
Total				1,825,000	

* 420,000 m^3/day includes water from Kadirya WTP

The existing PSs need to continuously distribute water to around 6- to 9 story buildings, which account for 27% of all flats of apartments in the City. For the areas where there are detached houses, the water pressure should be properly controlled and kept at less than 20 m because pipes in these areas are deteriorated.

(2) Rehabilitation of Booster PS

1) Control of PSs

Currently, almost all PSs in Tashkent City are operated manually, and therefore an operator is needed to continuously observe the operation status, necessitating a big number of PS operators. Automatic operation for booster PSs as shown in Chapter 5.4.4 needs to be instituted to reduce the number of operators and to ensure more precise control.

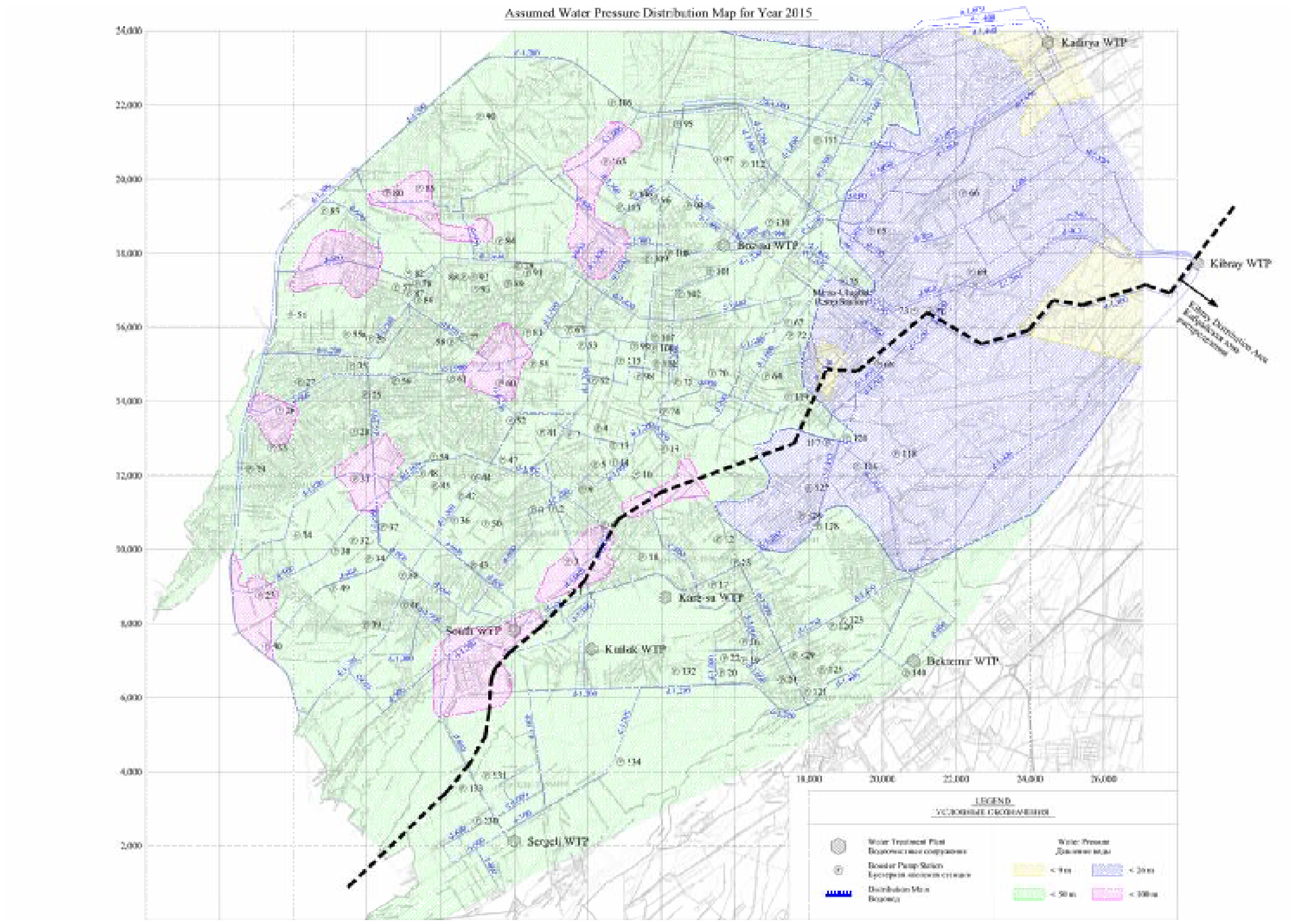


Figure 5.4.11 Assumed Water Pressure Distribution Map

2) Mirzo-Ulugbek PS

The capacity of Mirzo-Ulugbek PS is currently the biggest by far, distributing to large areas in the City. The PS is located at the highest area of the City, and receives water from Kadriya WTP which boosts the pressure to distribute to the high-elevation and surrounding areas. This PS currently distributes water to low-pressure areas from Kadirya WTP, and to other areas where water can be distributed by enough pressure from the WTP if a proper control is carried out.

The distribution flow will decrease in the target year and the area that can be distributed by gravity will no longer be distributed from this PS. The result of hydraulic calculations shows that the discharge capacity of the PS can be reduced at 2,600 m^3/hr. The pressure distribution shown in Figure 5.3.11 is a result of the calculation.

The pump facilities of the PS have already deteriorated based on a diagnosis. Thus, these facilities need to be replaced and their capacity changed. The contents of the replaced facilities are shown as follows:

- Total capacity: 2,600 m^3/hr;
- Booster pumps: 900 m^3/hr x 50 mH x 180 kW x 5 units (two stand-by);
- Electrical facilities: for pumps 5 panels+ power panel; and
- Pump building: W8 m x L25 m

The existing reservoirs with capacities of 10,000 m^3 x 2 units, will be used in the future. The retention time is calculated below:

- 20,000 $m^3 \div 2{,}600\ m^3/hr = 7.7$ hr

3) Other PSs

There were 134 booster PSs operated by Vodokanal in 2002, and this number is gradually increasing. As earlier mentioned, if the pressure will be kept over 26m of water head, water can be distributed to low-story buildings. However, for 6 to 9-story apartment buildings, since water is required to be boosted by pumps, some PSs should be redesigned and the distribution pipes should be rearranged.

The total capacity of PSs is obviously excessive as mentioned in Section 3.1.4, and if the capacity of each PS is reviewed, the capacity and electricity consumption will be drastically reduced.

Table 5.4.10 shows the survey results for existing PSs in four (4) districts. The details are described in Chapter 8.2.5.

Table 5.4.10 Survey Results for PSs in 4 Districts

District	Capacity (m^3/hr)	Number		Population		Required capacity (m^3/hr)		Power consumption (kW)	
		Current	Future	Current	Future	Current	Future	Current	Future
Hamza	5,970	14	3	122,054	56,921	3,232	932	569	100
Mirabat	5,535	13	5	98,912	45,010	2,517	767	511	86
Sergeli	11,000	6	4	161,659	101,872	3,932	1,595	713	175
Bectemir	1,220	3	1	27,217	4,442	657	74	107	21
Total	23,725	36	13	409,842	208,245	10,338	3,368	1,900	382
Ratio	---	1.00	0.36	1.00	0.51	0.44	0.14	1.00	0.20

Based on analysis of the table, future PSs, including distribution PSs in WTPs which will be abandoned, will be changed as follows:

- Number of PSs and service population will be reduced by half;
- The current required capacity of PSs is 51% of the design capacity, meaning the design capacity is much larger than the required capacity in the future;
- In the future, the required capacity of PSs will be reduced to one-sixth of the current design capacity; and
- Power consumption of PSs will be reduced to one-fifth.

5.4.6 Operations and Maintenance

(1) Features of the Proposed System

Location of the proposed system is shown in Figure 5.4.12. In the figure, although South, Sergeli, Kara-su, Kuilul and Bectemir WTP are shown in the Figure, they will be abandoned in Target Year. The features of the proposed system are as follows:

- Water sources are concentrated at Kadirya, Kibray and Boz-su WTPs;
- Kadirya WTP, the major water source of the City, will be thoroughly improved to ensure its stable operation in the future. Replacement of intake pumps and improvement/replacement for rapid filters will be implemented by the EBRD Project. As a result of the Project, 48 units of rapid filters will be operated automatically;

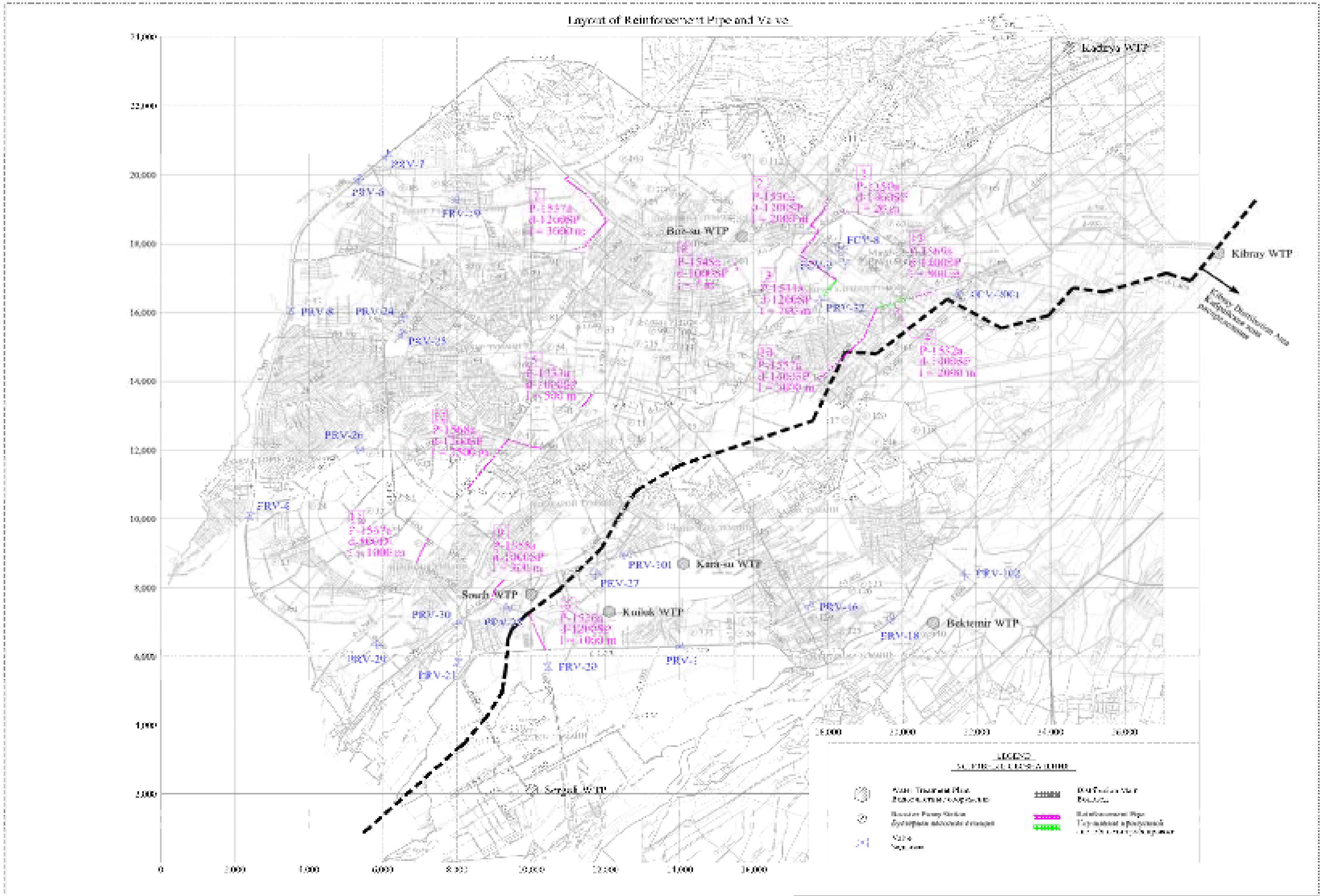


Figure 5.4.12 Location of Proposed Water Supply Facilities (Year 2015)

- Wells at Kibray WTP will be replaced/improved with the EBRD Project, and the production capacity will be recovered to 350,000m^3/d. The improvement of wells includes automatic control of well pumps according to water level. In addition, deteriorated facilities will be replaced;
- Intake and distribution pumps and rapid filters with capacity of 100,000m^3/d will be replaced with the EBRD Project at Boz-su WTP to ensure stable water distribution to the central area of the City;
- Distribution from Kadirya and Kibray WTP will mostly be carried out by gravity, while distribution pumps will be used for the surrounding high-elevation areas only. Therefore, the distribution system of Kibray WTP needs to be changed;
- The distribution system will be able to cope with flow fluctuations, which will occur in the future as water supply gets reduced by expanding the capacity of reservoirs and by the introduction of automatic control of pumps and the monitoring system;
- Information on the operation status in the whole water supply system is concentrated in the monitoring room located in Vodokanal Head Office;
- Needed booster PSs in the target year building will be reduced to less than half. However, over hundred pump units for each apartment building will be installed. These PSs can be controlled from the monitoring room at Vodokanal Head Office. Control and maintenance of PSs will be basically carried out by patrol; and
- Constant pressure regulation valves will be introduced to control the pressure in the distribution pipelines. The valve, which is driven by a motor, will be controlled to have a constant pressure of discharge side by the indicated value of the pressure gauge. Since a flow meter will also be installed, flow and pressure at major points can be monitored from the control room.

(2) Proposed Staff Assignment for Facilities

The proposed system will change the operation status for staff arrangement. Major points are as follows:

- Operators will not need to observe each facility constantly for major facilities in Kadirya, Kibray and Boz-su WTP, since operators in the control room can follow the operational status by alarms or indication of flows and water levels. Therefore, the number of shift operators will be reduced;

- Wells pumps at Kibray WTP will be operated automatically, and since the yield water is mainly distributed by gravity, a small PS will be operated automatically;
- Number of booster PSs will be reduced to be around half, and since the operation can be automatic, operators will not need to observe continuously. Accordingly, the number of booster PSs operations staff can be reduced;
- For the proposed system, decisions on performance of operation and maintenance are so important that the experienced engineers should be assigned.

The plan of the proposed staff assignment in the target year is shown in Table 5.4.11. The assignment for the O&M staff for pipeline network and for meters are not included in the table.

(3) Electricity/ Chemicals Consumption for the Proposed System

1) Electricity consumption

Unit consumption of electricity for Kadirya WTP, kWh/m^3, should slightly increase because the distribution amount from the WTP will be reduced. However, it is assumed to be the same since the efficiency of new intake pumps will improve. The efficiency of Kibray WTP will be improved as shown in Section 5.4.2. Electricity consumption of booster PSs will be reduced by 20% of the current consumption; however, the consumption of the distribution pumps for Sergeli, Bectemir and South WTPs should be added to the current booster PSs consumption. Electricity consumption and costs of Kadirya, Kibray and Boz-su WTPs and Booster PS, as well as total power consumption by facilities for the water supply in the City in the target year are shown in Table 5.4.12.

As shown in the table, the unit electricity consumption in target year will be reduced by 34% of current value. The total electricity cost will be reduced by 63% with the reduction of water consumption.

Table 5.4.11 Staff Assignment for the Proposed Water Supply System

Category	Facility name	Division	Shift operation	Operation	Machine/ electric/ repair	Laboratory	Total
WTPs to be operated continuously	Kadirya	Present	88	60	21	11	180
		Proposed	**60**	**50**	**20**	**20**	**150**
	Kibray	Present	60	87	36	10	193
		Proposed	**30**	**60**	**36**	**4**	**130**
	Boz-su	Present	51	45	33	11	140
		Proposed	**40**	**40**	**30**	**11**	**121**
Abandoned WTPs	South	Present	48	39	16	12	115
	Sergeli	Present	71	33	17	7	128
	Kara-su	Present	42	0	2	5	49
	Bectemir	Present	44	8	9	0	61
	Kuiluk	Present	21	5	9	0	35
	Total	Present	226	85	53	24	388
	Total	Proposed	**0**	**0**	**0**	**0**	**0**
Booster PSs	PS Total	Present	585	173	36	0	794
	Proposed PS	PSs	**56**	**44**	**20**	**0**	**120**
		Patrol	**40**	**60**	**10**	**0**	**110**
		Total	**96**	**104**	**30**	**0**	**230**
Present total		Engineer	41	127	14	20	202
		Worker	969	323	165	36	1,493
		Total	1,010	450	179	56	1,695
Proposed total		Engineer	**40**	**100**	**40**	**20**	**200**
		Worker	**186**	**154**	**76**	**15**	**431**
		Total	**226**	**254**	**116**	**35**	**631**
Reduction		Total	**784**	**196**	**63**	**21**	**1,064**

Table 5.4.12 Power Consumption and Costs

Category	Name	Unit consumption		Water Distribution		Electricity consumption		Cost	
		kWh/m^3		1000m^3/d		GWh/y		mil.soum/y	
		2002	2015	2002	2015	2002	2015	2002	2015
WTPs to be operated continuously	Kadirya	0.105	0.110	2,100.0	1,224.0	80.3	49.1	2,409	1,474
	Kibray	0.423	0.200	353.5	312.0	54.6	22.8	1,638	683
	Boz-su	0.276	0.296	249.9	89.0	25.2	9.6	756	287
	Total	0.162	0.138	2,703.4	1,625.0	160.1	82.0	4,803	2,445
Booster PSs	Existing	-	-	-	-	88.8	-	-	-
	Dis. in WTPs	-	-	-	-	11.0	-	-	-
	Total	-	-	0.0	0.0	99.8	20.0	2,994	599
Others		0.205	0.000	196.6	0.0	14.7	0.0	441	0
Sum-total		0.259	0.171	2,900.0	1,625.0	274.6	101.5	8,238	3,044

Note: 1) Unit electricity price was 8 soum/kWh in 2002, and since it went up to be 30 soum/kWh in December 2004, the price is adapted for calculation and for accurate analysis..
2) Distribution of each WTP is shared out by the ratio of nominal capacity

2) Coagulant dosing ratio and water quality

In Tashkent City, lumps of aluminum sulfate are used as coagulant. The dosing ratio in 2002 is shown in Figure 5.4.13 together with dosing ratio of chlorine. Basically, coagulant is not injected if raw water has less than 15 degrees of turbidity at Kadirya WTP. Turbidity removal ratio of rapid sand filter is set at around 50% when coagulant dosage is not carried out. However, the quality of treated water in Kadirya WTP always meets the Standard, which is less than two degrees. Although there is no quality problem in complying with the Standard, consumers have many complaints about the distributed water quality based on the questionnaire survey of previous JICA Study. The reason of their complaints may be due to the color of the water from the rust of service pipes in the buildings, or insufficient transparency of water.

The proposed improvement plan for Kadirya WTP includes upgrading the rapid mixing and flocculation facilities. Therefore, Vodokanal should pursue the improvement of water quality by increasing coagulant dosing ratio. From this point of view, the annual average dosing ratio in the target year is assumed at 10 mg/l because the current dosing ratio is apparently too small.

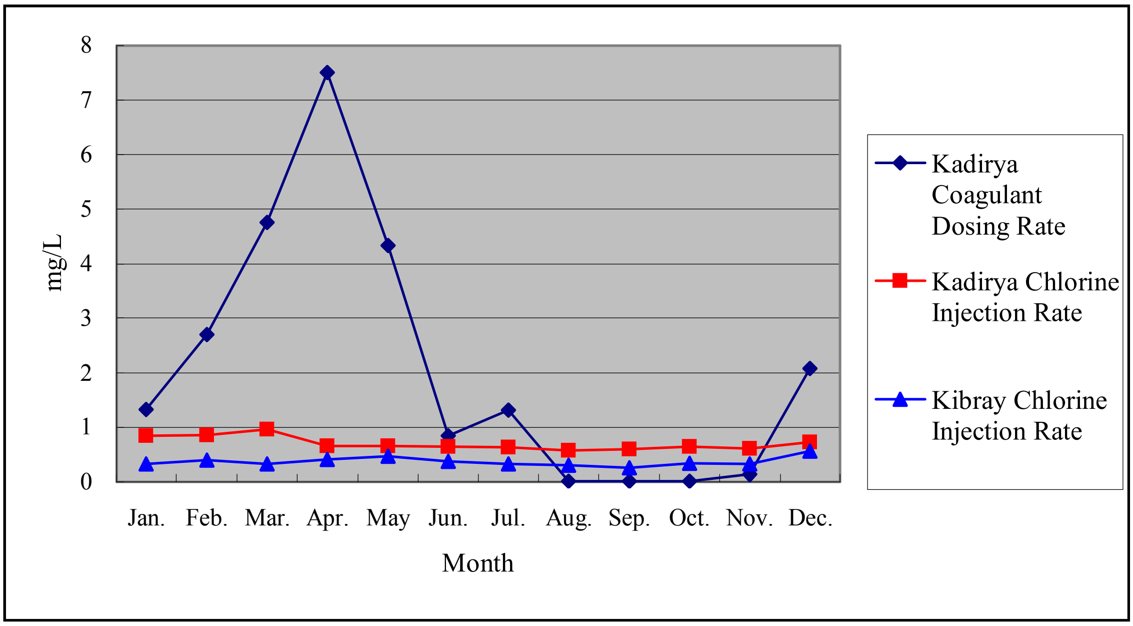


Figure 5.4.13 Monthly Coagulant and Chlorine Dosing Ratio *(Source: Vodokanal)*

In this case, chemical consumption and costs in the target year are shown in Table 5.4.13 compared to the figures in 2002. As shown in the table, increasing coagulant is costly, but this cost is considered necessary for the water supply system to distribute good quality water.

Table 5.4.13 Chemicals Consumption and Cost

WTP Name	Chemical Name	Unit consumption mg/l		Distribution $1000m^3/d$		Consumption t/year		Cost 1000USD/y	
		2002	2015	2002	2015	2002	2015	2002	2015
Kadirya	Coagulant	2.0	10.0*	2,100	1,224	1,533.0	4,467.6	165.3	481.6
	Liquid chlorine	0.7	0.7			523.3	312.7	83.7	50.0
Kibray	Chlorine	0.4	0.4	353	312	46.9	45.6	7.5	7.3
Boz-su	Coagulant	11.5	11.0	250	89	1,048.7	357.3	113.0	38.5
	Liquid chlorine	0.8	0.8			73.6	26.0	11.8	4.2
Others	Liquid chlorine	0.3	–	197	–	18.8	–	3.0	0.0
	Hypochlorite	0.1	–		–	9.7	–	9.7	0.0
Total		–	–	2,900	1,625	–	–	394.0	581.6

* Coagulant injection ratio at Kadirya WTP will be increased in target year

3) Necessary training and preparing operation manual for O&M

i) Necessary Training for O&M Staff

The O&M staff needs to have adequate knowledge and skills in operating the system and its relevant facilities, and to repair /manage the facilities. Currently, trainings are carried out privately at work, and are done unsystematically and in a piece-meal fashion. Thus training lacks the thoroughness required. Vodokanal must establish an efficient and proper training system for its staff. Target staff and contents of trainings are shown in Table 5.4.14.

ii) Preparing necessary operation manuals

For effective and efficient O&M, operation manuals for each facility need to be prepared. Based on these manuals, the staff can carry out their work as follows:

- Staff will be aware of and execute their roles and responsibilities;
- Staff will be equipped with knowledge on how to conduct proper operation;
- Expendable supplies, parts, checking and overhaul can be accounted for; and
- Proper budget can be arranged based on needed materials and work plan.

Table 5.4.14 Target Staff and Contents of Training

<table>
<tr><th colspan="2">Target staff</th><th>Training items for each staff</th><th>Common training</th></tr>
<tr><td rowspan="2">Shift operator</td><td>Engineer</td><td>-Information of detailed system with costs,
-Design concept of system,
-Specifications of facilities/ equipment,
-Training on section management
-Training on operational decision-making
-Training on decision making for emergency countermeasures
-Training how to formulate section budget</td><td rowspan="7">-Their organization in Vodokanal,
-Roles and responsibilities,
-Outline of water supply system in Tashkent City
-Basic knowledge of water supply and treatment
-Countermeasure in case of emergencies
-General management
-Budgeting financial planning</td></tr>
<tr><td>Worker</td><td>-Information for facilities' responsibility
-Training on emergency countermeasures
-Training on facilities' operation</td></tr>
<tr><td rowspan="2">Repair /mechanic /electrician</td><td>Engineer</td><td>-Detailed knowledge for these specialization
- Training on section management
-Training on repair and adjustment of facilities/ equipment
-Training how to formulate section budget</td></tr>
<tr><td>Worker</td><td>-Basic knowledge on work specialization
-Training to operation of tools
-Training on repair and adjustment of facilities/ equipment</td></tr>
<tr><td rowspan="2">Laboratory</td><td>Engineer</td><td>-Detailed knowledge for water quality analysis and water quality
-Knowledge on quality analysis device
-Training on section management
-Training of decision making for emergency countermeasure on water quality
-Training how to formulate section budget</td></tr>
<tr><td>Worker</td><td>-Basic knowledge on work specialization
-Training to operation of tools
-Training on emergency countermeasures</td></tr>
</table>

Operation manuals for the facilities should include the contents as shown in Table 5.4.15.

Table 5.4.15 Necessary Operation Manuals and Contents

Necessary facilities	Necessary contents
Kadriya, Boz-su and Kibray WTP	-Explanation of system including composition of facilities, -Necessary staff and organization, -Each role of staff and the line of command, -Operation and monitoring method from control room, -Operation and regulation method for each facilities, -Necessary function of whole system, -Necessary function of each facilities, - Countermeasures for emergency cases.
Booster PS, each facility in Kadirya, Boz-su and Kibray WTPs	-Composition of facility including capacity of equipment, -Necessary regular checking and overhaul, -Operation method including regulation of equipment and changing condition, -Method of checking and maintenance, -Necessary consumption materials and parts, -Countermeasures for emergency cases.
Pipeline network	-Explanation of network including division of distribution area, -Necessary staff and organization, -Each role of staff and the line of command, -Operation method of valves and monitoring devices, -Proper pressure range of each area, -Countermeasures for emergency cases.

5.4.7 Future Plan including Surrounding Area

Vodokanal is being required by the city government to expand the service area to the surrounding areas of Tashkent City. Since this is where the City government is planning to expand the urban area, Vodokanal requested formulation of a future water supply plan from the Team. However, because the surrounding areas are not included in the original scope of the Study and the urban planning/range of the areas was not clear, the study was limited to a planning outline which mainly carried out water demand projection.