3.4 Present Status of Computerization

All computerized systems used in Tashkent City Vodokanal to gain an understanding of the nature and utilization of computers in its business activities.

We reviewed the computerized tariff collection system in detail. We also inspected how the computerized tariff collection systems are actually handled, by reviewing the tariff collection procedures.

3.4.1 Computer Systems at Tashkent City Vodokanal

(1) Outline of Computer Systems

Tashkent City Vodokanal began to introduce automatic systems for water supply in 1970, and computerization started in 1989. The Board of Vodokanal decided to develop the system and Vodokanal developed these systems at its own expense by its own employees.

At present, Tashkent City Vodokanal has over 30 computers grouped into 7 systems: salary calculation system, prime cost calculation system, fixed assets system, water customers system, emergency system, hydraulic system and legal information system.

However, they have not any system documentation on file. After they made the systems, they had to make many changes in the programs during the subsequent period. And now they cannot be certain about these systems.

Vodokanal has an automated system in its Operation Department and one computer program specialist.

They have one local area network located at the Water Sales Department where six computers are connected. They have identification codes and passwords for each computer, but do not have these for personal user ID. Basically, the operation and security of the computers depends on human factors.

They recognize the importance of expanding the computer systems, especially from a technological perspective for the water treatment and sewerage treatment plants; however, they do not have sufficient funds in their budget nor do they have adequate capable human resources to do so.

(2) System Functions

We reviewed the system functions and the specifications for the seven systems in Tashkent City Vodokanal. The main functions are shown in Table 3.4.1 as follows:

Table 3.4.1 System Functions

Computerized System	System Function
Water Customer System	To issue the payment order and identify the payment and nonpayment
Salary Calculation System	To calculate the salary of 4,500 employees
Prime Cost Calculation System	To keep accounting information and make "financial sheets"
Fixed Assets System	To control fixed assets
Emergency System	To input the accidental information everyday
Hydraulic System	To determine diameters of pipes, pressure, speed etc. to plan the best network
Legal Information System	To check the justice by using the water supply law database

The functions of the six systems other than the water customer system are outlined below.

1) Salary Calculation System

The salary calculation group of the Accounting Department started to use computers in 1990. Ten persons in the group are involved in the computation of the salaries of 4,500 employees of Vodokanal and the facilities are located in Tashkent. The programs include card index records for each employee.

2) Prime Cost Calculation System

The Accounting Department has one computer. The program main menu contains settlements with suppliers, salary calculation, fixed assets accounting, allowances for children, etc.

3) Fixed Assets System

Vodokanal registers all its fixed assets in its computer database. Fixed assets and the information about the fixed assets we verified and input at the end of every year.

4) Emergency System

The main control office operates the emergency system. This department receives information about emergencies at streets in Tashkent City (around 100 cases daily).

5) Hydraulic System

Technical Department is using the hydraulic system to determine the economic advantage, the diameter of pipes, water pressure, and speed of flow, etc., for the purpose of reconstruction and maintenance of the network in Tashkent City.

The system is a program of complicated engineering calculations. The Technical Department chooses a district on the computer, the programs choose the quantity of tables containing all hydraulic calculations, with each calculation corresponding to 10 tables. Then the department inputs the data and the program calculates the engineering parameters of the network, the economic advantage of the pipe diameter, etc.

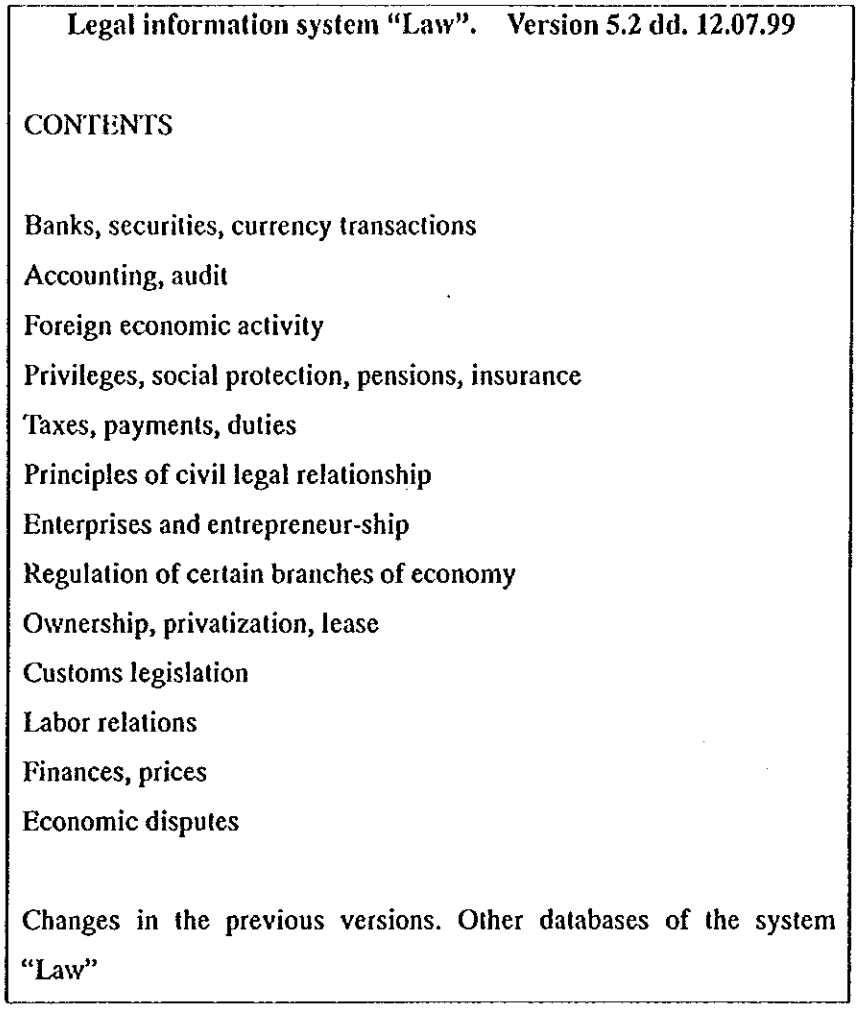
If they have different premises, each is calculated separately, taking into consideration the various factors applicable to each case. For example, if it is working on the reconstruction of a large building, the program will calculate several versions and they can choose the project with minimal expenses.

The program can also search for narrow points in the pipes that can be repaired at a low cost. The program includes all piping information.

6) Legal Information System

This system is designed to search the various laws issued by the Government. Three organizations have prepared this system, but the main source is AVIA Bank. The contents are installed monthly. When they change the tariff table, they can compare it with the law by using the legal information system. They keep the law about water supply. The main menu is as follows.

Fig 3.4.1 Legal Information System Menu Flow



7) Specifications

The programs were installed in 1990's and since that time Vodokanal programmers have regularly improved the programs and the data. The programming language used is Pascal.

The system specifications are shown in Table 3.4.2.; however, certain information has not been fully identified.

Table 3.4.2 System Specifications

System	Dept.	OS	Database	Number of Programs	Total Size (kb)	Hardware	Number of Units	Date
Salary Calculation System	Accounting	MS-DOS	-	151	1500	286	2	1990
						386	2	
Hydraulic System	Production and Technical	MS-DOS	-	100	-	286	1	1991
Legal Information System	Production and Technical	MS-DOS	-	100	-	386	1	1991
Emergency System	Production and Technical	MS-DOS	FOX Pro 2.5	16	330	Pentium	1	1992
Fixed Assets System	Accounting	MS-DOS	FOX Pro 2.5	52	800	Pentium	1	1993
Prime Cost Calculation System	Accounting	MS-DOS	FOX Pro 2.5	24	540	Pentium	1	1994
Water Customer System	Water Sale and Operation of Water Measure Economy	MS-DOS	FOX Pro 2.5	200	-	Pentium	4	1998
						386	3	
						486	1	

(3) Water Customer System

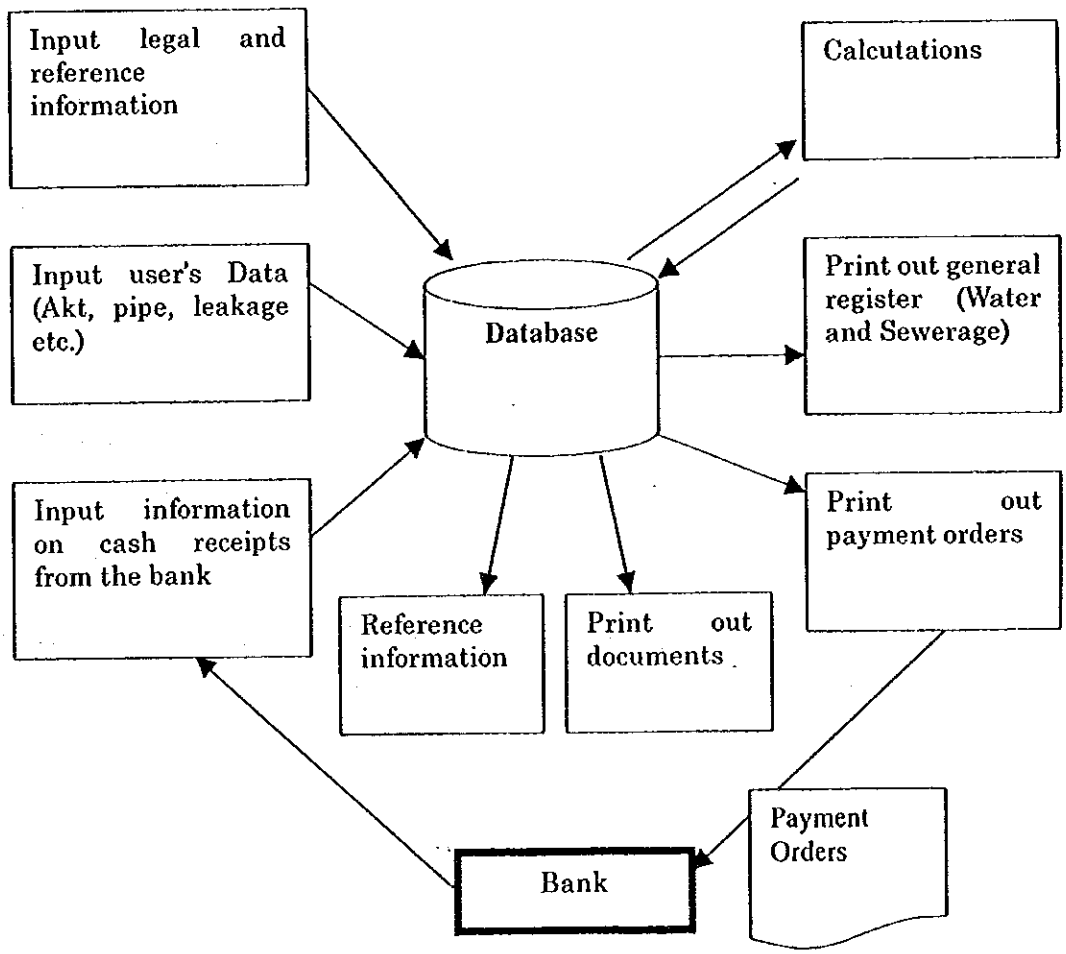
We investigated the Water Customer System in detail.

The Water Customer System not only has digital information about all users but also can issue payment orders to banks. The local area network is located in the Water Sales Department.

It includes six computers for handling settlements with users.

The system flow chart is shown in Fig 3.4.2.

Fig 3.4.2 System Flow Chart for the Water Customer System



The computer network is not connected to any outside organizations. Each computer as well as program has a password. The department chief is responsible for using the computers and believes that no one each outside Vodocanal can access the programs.

The work with customers includes the system of registration of and calculations of the separate tariffs for the three groups of users: industry (industrial enterprises), communal services sector (municipal enterprises), and the population (households in privet houses and apartment buildings).

For example, the information on private houses includes the number of residents land area, cars, gardens etc.

The 3 computers in the Water Sales Department handle the databases for the population. They began to input information about private owners only this year, and 7 out of 10 districts of Tashkent have already been registered in the computer system. The Water Sales Department also maintain a book for the registration of all houses but this data is achieved only for 3 years.

The department calculates water and sewerage consumption for the industry and communal service sectors as well as for private houses. Fig 3.4.3 shows the main menu.

3.4.2 Tariff Collection Procedures

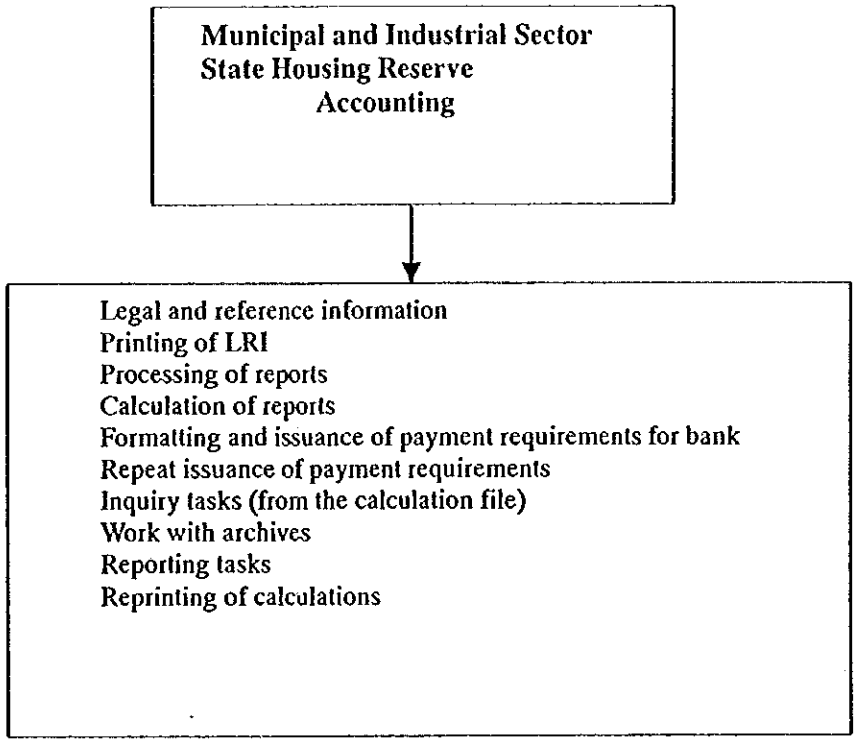
We review each procedure along the flow of the operations. Before this, we explain the four categories of water sales revenue, which are industry, communal services sector, houses, and apartment buildings.

Industry includes production companies, private enterprises, etc. and the communal services sector consists of budgetary organizations and self-supporting organizations. Houses refer to an owner of a house and apartment buildings are the residents of apartment block units.

Tariff Collection

The tariff collection system is outlined prior to the study of the collection procedures.

Fig 3.4.3 Water Customer System Menu Flow



(1) Industry, Communal Services Sector

We review the tariff collection procedures for the industry and communal services sectors, for houses and apartment buildings in turn.

The tariff collection procedures for industry and communal service are shown in Fig. 3.4.4.

1) Application for Water Supply

First of all, a newcomer receives technical documentation from the Production and Technical Department of Vodokanal, and fills in the forms. Then they submit the completed technical documents to the Water Sales Department, with a detailed scheme for the water meter installation.

Each new comer must install the meter at their own expense, and then the staff of the Water Sales Department inspect the meter, install it, place a seal on it and registers it. The user can remove the seal only in case of fire.

The new user enters into a contract with Vodokanal to supply the water. The contract contains a code for each user which must be input into the computer in the Water Sales Department. There are 5 codes in the computer corresponding to the 5 tariff groups. All data on the user are simultaneously recorded in a record book at Vodokanal.

2) Change in Status or Situation

If an enterprise leaves, it must cancel the contract by sending a letter of notification to Vodokanal 5 days in advance. The Water Sales Department checks for an overdue account in the computer of the user has a legally accepted successor, any overdue account may be transferred to the successor. If not, Vodokanal must collect the unpaid amount from the out-going user.

When the user closes his business, Vodokanal cuts the off water and deletes the information from the computer after all procedures have been processed.

When the status or situation of the user changes, the user must inform to Vodokanal. Then the Water Sales Department inputs this information into its computer system.

3) Billing

Every month, a controller visits the industry, reads the meter, and agrees the water consumption volume and the amount to be paid with the user. He prepares a duplicate blank document ("Akt"), writes the water consumption and the amount on the Akt and gives one copy to the user as a bill. Vodokanal does not issue the bill again.

In the Communal Service Sector, a controller prepares an Akt detailing the water use once per quarter in conformity with the contract. The number of communal service sector enterprises was 8,740, of which 4,027 were holders of settlement accounts in banks with contracts as of August 1999.

After they receive the Akts, 10 operators input the monthly data into the computer system. The computer calculates each amount automatically and they subsequently verify these calculations.

If an enterprise has a meter, the Water Sales Department computes the calculation according to the meter reading, but if not, the calculations are determined according to the formula in the computer. Calculations are based on the rules for water usage and the examination reports (made in the presence of 2 representatives, 1 on each side) according to Vodokanal's contract with each enterprise.

Vodokanal also has a special payment order schedule for each district. After the Water Sales Department finishes the billing procedures for a certain district, they print out payment orders. A payment order consists of 4 copies for of the user's bank and Vodokanal's bank. The Water Sales Department brings these payment to its bank every day and the bank then sends them to the user's banks.

4) Tariff Receipts

Payment for Vodokanal's services is collected via banks. A small number of enterprises, however, pay at the cash office of the People's Bank.

By Law, Vodokanal has the right to withdraw money from a user's bank account without the approval of the user. If the user has money in his bank account, the bank is authorized to transfer the amount indicated in the payment order which it received from Vodokanal. The bank sends the information received to Vodokanal.

Certain payment orders include a portion of the prepayment postponed from the previous month to the current month if this is acceptable under the contract between Vodokanal and the user.

The Water Sales Department inputs all information into the computer using the lists of transactions from the banks.

On the first or second day of the following month, the Water Sales Department prints out a summary of sales and collection of receivables and brings this to the Accounting Department.

5) Control of Overdue Accounts

The Water Sales Department monitors overdue receivables every month. There are 2 ways to check on overdue account. One is to check these against the bank's information. The other is to research these manually by searching for overdue account users in the computer or through Vodokanal's documents at the end of the month.

If a controller finds an overdue account, he hands the user a notification when he visits the district. The overdue account should be paid within 3 days after notification, otherwise Vodokanal has the right to cut off the water or to take the matter to court.

If a controller collects an overdue account from a user, he follows the same procedures as these for normal collection. from users. The Water Sales Department also follows the same procedures as those for normal collection from users.

(2) Houses

The tariff collection procedures for residential users are shown in Fig 3.3.9.

This portion includes users who live in apartment buildings which have water meters. They are treated the same as homeowners.

1) Application for Water Supply

According to a Government decree, Vodokanal is required to make individual houses install meters at their own expense (1999). There are 110,000 homeowners in Tashkent, and only 6,700 meters were installed as of August, 1999. An individual house cannot be sold without the installation of a water meter.

A new user must go to Vodokanal to obtain the technical documents and fill in them. The Technical Department receives the documents and drafts a scheme for the meter installation.

The user must pay the costs of installation. After that, Vodokanal places a seal on the meter and enters into a contract with the user.

The Water Sales Department inputs all information into the computer. In 1999 it was planned that private sector information be input into computer. They had input several districts' information into the computer as of September 1999, but the plan was for information on every district to be entered by the end of 1999.

2) Change in Status or Situation

The tariff collection procedure is almost the same as that for enterprises.

3) Billing

The water charges differ depending on water consumption, the house environment, etc. The water rates increased in 1999; however, the revenue from users in private houses was only 3% of Vodokanal's total income.

Each house is issued a Customer Book which consists of blank receipt forms for the year.

The controller reads the meter once every three months. He takes the meter reading and agrees the figure with the user. Then he fills in the number and amount into the Customer Book. Half of the form in the Customer Book is for his records and the other half is retained by the user. Thus, the controller does not have to issue any other separate bill. The Water Sales Department then inputs the data into the computer system.

4) Tariff Receipt

Homeowners can pay their water tariff at cash offices, post offices, Vodokanal or at their own house. Users who have small businesses are also included in this category of residential users.

Vodokanal has a contract with the banks, the People's Bank and post offices (over 280 local branches). Based on Customer Book which controller filled in, the resident pays the tariff at a bank branche, a cash office or a post offices.

Users who have installed meters at their houses can make their payments once per quarter or per year.

On the other hand, users without meters almost pay for the whole year in advance because the monthly amounts to be paid are very small for these users. In this case, Vodokanal has advanced received at the beginning of year. However, if a user cannot pay the entire amount at once, Vodokanal prepares a contract for collection on a quarterly basis.

Residential users may come to Vodokanal once a year to check their payments and receive their Customer Book. If they cannot visit Vodokanal, the controllers have to visit the users' houses to give the Customer Books to them, directly.

Tariff collection procedures through banks or post offices are almost the same as those followed for enterprise enterprises.

Sometimes a controller collects the payments in cash, especially in the case of a relatively large overdue account. After a controller has collected the money, he notes the date of collection and obtains the signature of the user and sign off on the collection himself. He then deposits the money at the cash office of Vodokanal.

The settlement information is transmitted daily to the Water Sales and Accounting Department via the bank. The Water Sales Department then inputs this information into its computer.

5) Control of Overdue Accounts

Once per quarter, the controller checks for any users in the district allocated to him who have not paid. If a user does not pay, the controller hands him a notification. The case of non-payment within 3 days of this notice, Vodokanal is authorized to cut off the user's water supply. However, in actual practice they do not cut off the water for delinquent users, since they do not have a sufficient number of controllers (only 22 controllers for 252 Mahallas) to manage the overdue accounts.

(3) Apartment Buildings

The tariff collection procedures for apartment users are shown in Fig 3.4.6.

Very few rates are installed at apartment buildings. This portion of the report excludes apartment residents who have meters. They would betreated as homeowners (above).

1) Application for Water Supply

The Housing Maintenance Office (JEK) has a contract with Vodokanal. JEK handles collection of the tariff from apartment residents as well as interior repair services relating to the water supply.

A newcomer first goes to JEK and JEK registers him and issues him a Customer.

Every month JEK must provide Vodokanal with all information on apartment residents and all changes. Then the Water Sales Department inputs the information into its computer system.

2) Change in Status or Situation

When a user's situation changes, the user must go to JEK to inform them of the change.

Vodokanal receives the information about any changes from JEK's monthly report. The Water Sales Department inputs the information into its computer system once a month.

3) Billing

The fixed rate per resident is 31.08 sp (water and sewerage, September 1999).

Vodokanal receives from JEK a summary list of the number of regular and privileged resident, and the Water Sales Department multiplies the total number of residents by 31.08 sum.

The Water Sales Department prints out the payment orders and brings these to the bank every month.

4) Tariff Receipt

Payments from apartment users are collected by JEK every month. The Water Sales Department brings the payment orders to the bank. 50% of the amount collected from the users is distributed to JEK for collection and for repair and maintenance, 6% is distributed to JEK as bank commission, and 44% goes to Vodokanal. The 44% is deducted from JEK's bank account without acceptance in the same manner as for enterprises.

Even if JEK cannot collect all accounts, Vodokanal gets the amount calculated at 44% as indicated above.

This information is also input into the computer system at the Water Sales Department.

5) Control of Overdue Accounts

The Water Sales Department has 20 controllers who check the reports from JEK.

If JEK can not collect sufficient money, it becomes indebted to Vodokanal and they would have the right to apply for a court order.

3.4.3 Analysis of Tariff Collection Systems

(1) Analysis of Computer Systems at Tashkent City Vodokanal

1) It would be difficult to modify the existing system to implement a revised tariff policy

If Vodokanal does not develop a new computer system, the present computer systems may not be compatible with the new tariff policies and system modification will be required to some extent.

i) Changes in Water Tariff Table

If the proposed tariff table is adopted, it may be assumed that the formulas for tariff calculation will have to be revised. The current tariff tables vary depending on whether the user is from industry, communal services or the general population, and different

formulas are used to calculate the applicable fixed rate tariffs However, the revised tariff will be calculated according to the readings from the water meters which will be installed at all user sites.

ii) Increase in Transactions

If a meter is installed at each house, more data will have to be inputted into the computer system and processed. It is thus necessary to modify and upgrade the present system in order to process a large amount of data. For example, modification of the input screen and the calculation logic will be required.

Furthermore, Vodokanal should consider implementing new way of data capture methods in order to improve efficiency, e.g., hand-held terminals, optical character readers (OCRs).

2) Many tasks are manually duplicated

The current computer system is utilized efficiently mainly to generate the payment orders which are submitted to the banks. This task is automated and the computerized information is handled efficient.

Many other tasks, however, we being done manually and the related data capture for the computer system is done later, namely the tasks are duplicated on paper and in the computer system. It is assumed that certain tasks in the overall process are not yet computerized and therefore these manual steps are segment the into the process between the computerized steps.

i) Duplicate Tasks performer by the Controllers

For example, the meter readings are input into the computer system and they are also recorded manually. The payment information is also recorded both electronically and manually. In this way, the controller has duplicate information on each user in his district.

It is generally considered that the computer system could generate an electronic payment order to the bank and could also transfer the billing information from the calculation

system to the payment system. The current procedure is that each controller hardles this manually while an operator inputs the data into the computer system. In other words, the computer system is utilized only as data storage, not a processing tool.

ii) Data exchange with banks

Information is exchanged between Vodokanal and banks using paper documents. The payment orders submitted to the banks by Vodokanal are printouts from the computer system. Similerly, the information received is in the form of printouts from the banks computer systems.

The accuracy and efficiency of data exchange would be substantially improved floppy disks were utilized instead. However, it must be noted that the computer systems of the banks need to be modified. Electronic data can also be utilized effectively for the control of overdue accounts.

iii) Data Transfer to the Accounting Department

The monthly data on sales and credit are also submitted to the Accounting Department on paper. There is no distinction between advance receipts and receipts of accounts receivable.

It is proposed that the information held in the computer system be fully utilized and that the balance of each user's account be electronically transferred to the Accounting Department for accurate and appropriate processing.

3) The computer hardware is outdated

Many computers installed at Tashkent City Vodokanal are more than five years old and are too outdated to run modern software. Computer technology is rapidly changing and the average lifetime of personal computers is said to be less than five years. Vodokanal has personal computers whose central processing units (CPUs) are only 286 or 386. It may be difficult to obtain spare parts in the case of breakdowns. The harddisk capacity is limited and Vodokanal must also upgrade its data storage. The network infrastructure is weak and needs to be improved as well. The software used at Vodokanal includes MS-DOS and

FoxPro which the developer, Microsoft, is no longer willing to support.

4) The Computer Section needs to be reinforced

Almost every year since 1990 a new system has been implemented. It seems that these computer systems generally conform to the user requirements and operate well. Currently, Vodokanal staff have the technical skills required to develop, operate and maintain the system.

It is estimated, however, that further strengthening of the current IT team will be required to develop a more powerful integrated system which reflects result technological innovations.

i) Lack of Computer Training

A new computer training scheme may be required. Both the Salary Calculation System developed in 1990 and the Water Customer System developed in 1998 were developed an the MS-DOS platform using Pascal, which is not considered an appropriate programming tool for applications.

The mainstream platform now is Windows and many good programming tools are available in the market. It seems that these have not yet been used at Tashkent City Vodokanal, and that there is no training system or program inplace to help the IT staff learn the modern technology.

It is recommended that a computer training be developed so that Vodokanal staff may acquire the new information technology which they require for their work.

ii) Lack of Security and Backup System

The security of the current system highly depends on human factors. The network is limited within Vodokanal and therefore it may not be risky in terms of computer security.

However, it will be necessary to implement a security system when a WAN (wide area

network) or larger LAN (local area network) system is implemented. It is also suggested that identification codes and passwords be allocated to each operator, not to each computer. The passwords should be changed periodically.

A backup system will also be important if the computer system is fully utilized for Vodokanal's business, because any loss of data affect the operations.

Physical security is another item to review. For example, limiting access to the computer room, prohibiting installation of unauthorized software, etc must be considered.

(2) Analysis of Tariff Collection Procedures

1) Each user is served and administered by one controller

Each user is served and administered by one controller. The controllers are given their assignments by user (the controller is a generalist), not by task (the controller is a specialist). This means that every task (such as meter reading, tariff collection, updating the Customer Book, etc) for a particular user is handled by one controller. One advantage of being a generalist is that a controller can understand each detail of a user's account. However, if meters are installed at all houses in the future, the clerical workload will increase. Vodokanal will need to review how tasks can be more efficiently assigned to the controllers.

i) Improvement of Efficiency of Business

The more meters are installed, the more controllers must visit their customers to read the meters. It will become more complicated to calculate the water tariff and process the payments when the fixed rate system has been abolished because the tariff will vary according to the amount of water used. It is assumed that more clerical manpower will be required.

It is recommended that each controller be specialized to handle only a particular task (controller is a specialist in a particular task) rather than be assigned to a particular group of users (controller is a generalist handling all tasks) so that business procedures can be

improved efficiently. For example, one controller may devote himself to meter reading, and another controller can focus on tariff collection.

As for tariff collection, it is recommended that financial institutions such as banks and post offices be utilized as collection agencies and that more people open accounts at banks, instead of direct tariff collection by Vodokanal staff. It is suggested that if possible, the automatic deduction services of the banks be implemented for water tariff collection. The whole tariff collection procedure will be made more efficient by utilizing computerized calculation of the water tariffs and by monitoring unpaid accounts electronically.

It is essential for Vodokanal to restructure its tariff collection procedures by introducing a system of specialists to improve efficiency.

ii) Internal Control

It is generally known that incorrect operations may be monitored and prevented by separating the controllers who bill the users and the controllers who collect from the users. If two or more controllers serve the same user, errors or fraud will be prevented by a segregation of duties for effective internal control.

2) It takes a lot of time to read meters

It takes a lot of time to read the meters because meter reading is currently done by the controller in the presence of the user.

i) Introducing meter reading by controller only

If a meter is installed at each house, there will be no need to ask the user to confirm the meter reading. If the controller can read the meter without the user being present, the meter reading will not be delayed if the user is not at home and this will achieve greater efficiency.

It is essential that the water meters be installed outside if the controller is to read the meter by himself. If possible, there should be a rule as to where a meter can be installed.

ii) Introducing New Bills to Replace the Customer Book System

Currently a Customer Book, which belongs to a residential user, is maintained to record the amount water used and the tariff. Using this Customer Book system eliminates the need to issue bills, but requires the user to attend the meter readings with the controller.

If the controller were to issue a bill specifying a description of the services instead of maintaining the Customer Book, there would be no need for the users to attend the meter readings. This would also reduce the time spent reading the meters and would improve the efficiency of the business.

3) Management of Unpaid Accounts

Control of overdue accounts in the general population are not monitored properly at present, especially by Tashkent City Vodokanal. It is true that the amount collected from residential users is not high, thus and it may not be so important to monitor and manage the collection of those overdue accounts strictly.

i) Utilizing Aging Analysis

There is a clear need to establish a system to accelerate the collection of overdue accounts, particularly if the water tariff for the population increases and a new tariff table based on meter readings is implemented. The computer system should be modified to enable it to generate an aging analysis automatically for each user.

An aging analysis, which details all the overdue accounts by user and period, should be utilized so that the overdue account collectors can determine the priority of recovery. If certain controllers become specialists in overdue account collection, this task will be handled smoothly if the controllers have the benefit of a computer generated aging list.

3.5 Water Supply System and Operation and Maintenance

3.5.1 History

Current water supply system in Tashkent was completed on 1988.

The oldest facility which was constructed as modern water supply facility is Boz-su WTP, withdrawing raw water from Boz-su canal. It was completed in May, 1931 and commissioned. In 1955, Kibrai WTP, groundwater intake facility and later, Sergeri WTP were constructed and commissioned.

Though the old town of Tashkent and above-mentioned existing facilities were heavily damaged by earthquake in 1966, restoration work supported by USSR and the Government of Uzbekistan has rapidly formed the new town areas in present.

Restoration and construction works for water supply facilities were also started. In 1968, Kadirya WTP was commissioned and water distribution reticulation designed for the new town area was completed. The whole system was refurbished.

Vigorous construction works were succeeded to cope with the expansion of the city and the population growth and in 1988, modern water supply system was completed. It was comprised of two (2) surface water treatment plants, namely Kadirya and Boz-su WTP, and five (5) groundwater treatment plants, namely Kibray, Sergeri, Bektemir, Kara-Su, South and water supply reticulation and booster pump stations.

In recent years, six (6) units of filters were newly constructed at Kadirya WTP in 1996, while wells were also newly drilled at Kibray and South. Additional booster pump stations were constructed as well and as to Chilranzar pump station, of which 50 % of facility was completed in 1995, construction works are still on-going.

However, Future investment will be concentrated on replacement and expansion of distribution pipelines.

3.5.2 Location of Water Supply Network and Water Treatment Plants

Locations of water treatment plants and their water sources in Tashkent City were shown in Figure 3.5.1. Existing water sources are; two (2) surface water intake pump station at surface water treatment plants, five(5) groundwater intake plants. Each capacity of these plants, water sources, foundation year and site area are shown in Table 3.5.1.Distribution pumps are provided at the each plants, aside from 92 booster pump stations.

Out of these plants, Kadirya WTP has the biggest capacity and owing to the site elevation, 60 m higher than the City center, large part of its treated water is conveyed to the City or other pumping stations by gravity. On the other hands, other plants are supplying their treated water to the City or booster pump stations by pumping.

Table 3.5.1 Existing Water Sources and Plants

Name	Capacity (cu.m/day)	Water Sources	Completion Year	Site Area (ha)
Boz-su	235,600	Boz-su Canal	1931	72
Kadirya	1,375,000	Boz-su Canal	1968	138
Kibray	455,200	Groundwater	1955	986
Sergeri	40,000	Groundwater	1966	13
Bektemir	25,000	Groundwater	1969	20
Kara-Su	52,200	Groundwater	1960	41
South	143,000	Groundwater	1961	60
Total	2,326,000			1,330

The role of each plant is as follows;

- Boz-su WTP : Water supply to the City center
- Kadirya WTP : Cover almost the whole of the City, excluding some parts covered by other plants. Supply 270,000 to 360,000cu.m/day of treated water to Kibray WTP.
- Kibray WTP : Production capacity is 450,000 cu.m/day. Receiving 270,000 to 360,000 cu.m/day from Kadirya WTP, supply water to the southern area of the City.
- Sergeri WTP : Water supply to Sergeri area which was rapidly urbanized with large scale apartment. The area is partially supplied by Kibrai and South WTP.
- Bektemir WTP : Water supply to the surrounding areas
- Kara-Su WTP : Water supply to the surrounding areas

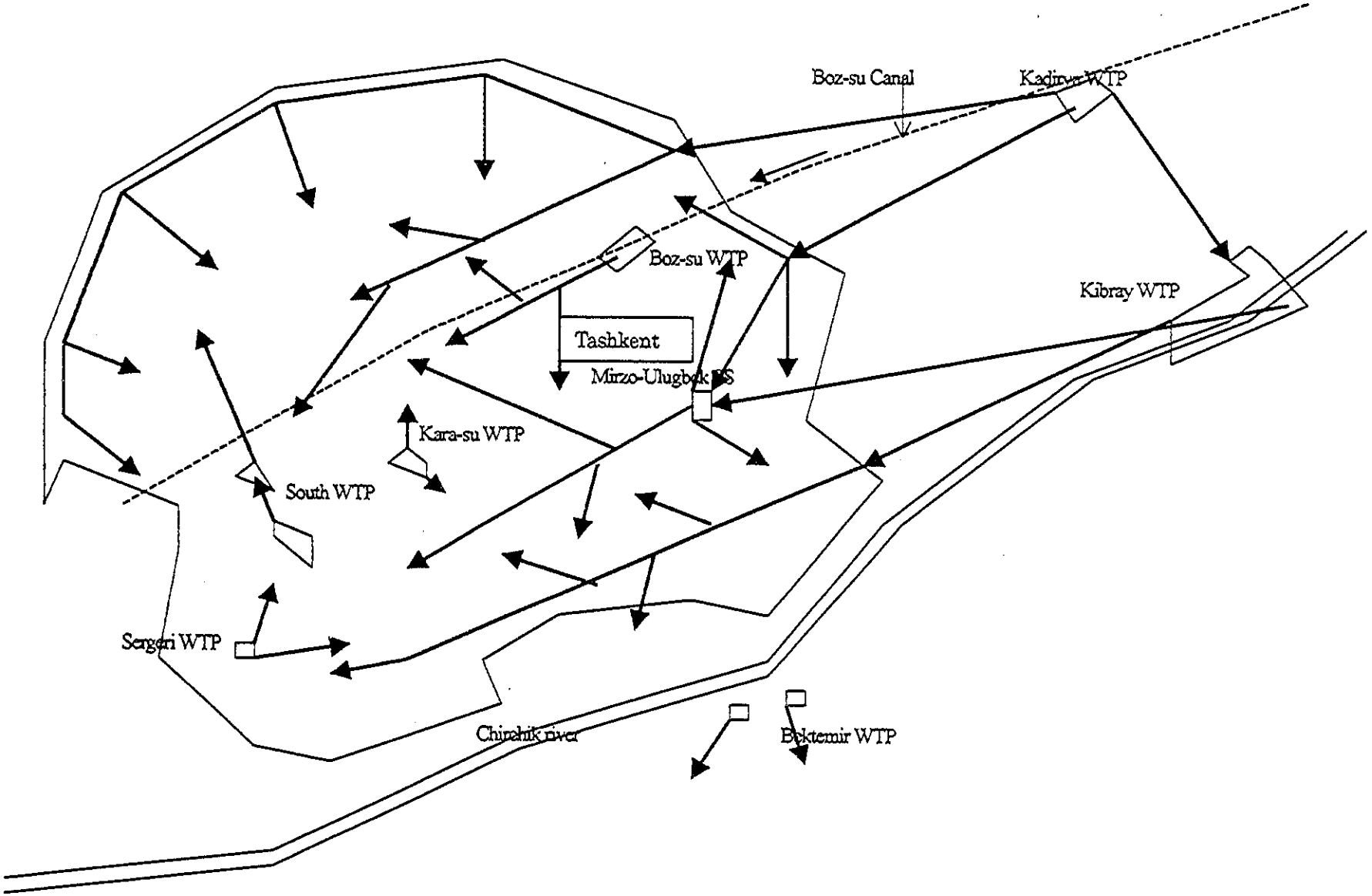


Figure 3.5.1 Plan of Water Supply System in Tashkent City

- South WTP : Water supply to Chilanzar area, mainly. Part of water is also supplied to Sergeri WTP.

Figure D.3.5.1(1) and (2) shows the outline of these facilities.

3.5.3 Pump Stations

Aside from the ones belong to WTPs, there's 92 pump stations in the City. Except for the areas served by gravity flow from Kadirya WTP and by pumped from other WTPs, the City is served by pumping. Excluding Mirz Ulugbek, Chilanzar and Sergeri pump station which has three (3) units of reservoirs with capacity of tatal 25,000 cu.m , two (2) units of these total 25,000cu.m and two (2) units of these total 12,000cu.m, other pump stations are withdrawing water directly from the pipeline. Although such pumping method is simple and requires less equipment, pump operation is difficult since pressure fluctuation will be severe if incoming and withdrawal volume is unbalanced.

Tashkent water supply system is characterized by remarkably small volume of reservoirs compared to the total distribution volume, as shown in Table 3.5.2 as Chirchik.

An overall retention time of these reservoirs is 1.55 hours (=148,650/2,296,000x24). Owing to this insufficient storage capacity, the distribution pumps are required to have the maximum distribution volume and their operations are very complicated.

Table 3.5.2 Volume of Reservoir

Name		Capacity cu.m/day	Reservoir cu.m/day	Detention Time hr
WTP	Boz-su	235,600	29,900	3.0
	Kadirya	1,375,000	30,000	0.5
	Kibray	455,200	10,000	0.5
	Sergeri	40,000	4,000	4.8
	Bektemir	25,000	2,750	2.4
	Kara-Su	52,000	0	0.0
	South	113,200	10,000	2.1
	Total	2,296,000	86,650	0.9
PS	Mirzo-Ulugbek		25,000	
	Chilanzar		25,000	
	Sergeri		12,000	
Total Volume			148,650	

The list of the pump stations in the City is shown in Table D.3.5.1.(1) to (4). According to these tables, most of them have capacities less than 1,000 cu.m/hr. Bigger ones are;

- Ibn Sino, B-1, SV-4B, Chilanzar, Sergeli pump station : 3,000cu.m/hr
- CVRU(Chilanzar) pump station : 7,200cu.m/hr
- Mirzo-Ulugbek Pump station : 30,000cu.m/hr

3.5.4 Water Treatment Plants and Water Sources

(1) Boz-su WTP

1) Outline

Boz-su WTP is situated in eastern area of the City. The area has Zoo, Botanical Garden and lot of arbor and also designated as Aspect Preservation Area.

In May of 1931, this plant was commissioned by the original capacity of 12,000 cu.m/day. In 1960's, modernization and expansion of the facility were carried out and reached to the present nominal capacity of 235,600cu.m/day by successive improvement and expansion works. This WTP is the oldest one not only in Tashkent City but also in Central Asia. Plant area is 72 ha, of which 30 % is occupied by facilities and buildings, 15 % by Boz-su canal and sedimentation basins and remaining 55 % is covered by fruit and tree zone. Upon designing, special care was taken to harmonize with the surrounding aspect.

The water source is Boz-su canal, downstream of the irrigation canal from Charvak Dam Lake and intake water right of 3.1cu.m/sec was accepted. Raw water is poured into large sedimentation basin, reconstructed from the existing old canal, by gravity. Treated water is pumped to filter and filtered water flows into reservoir and supplied to the City center by pumping. General flow sheet is shown in Figure 3.5.2

2) Structure

WTP's main structures are sedimentation tank, filter basin, reservoir tank, pump buildings, administrative building and others. These lists are shown Table 3.5.3.

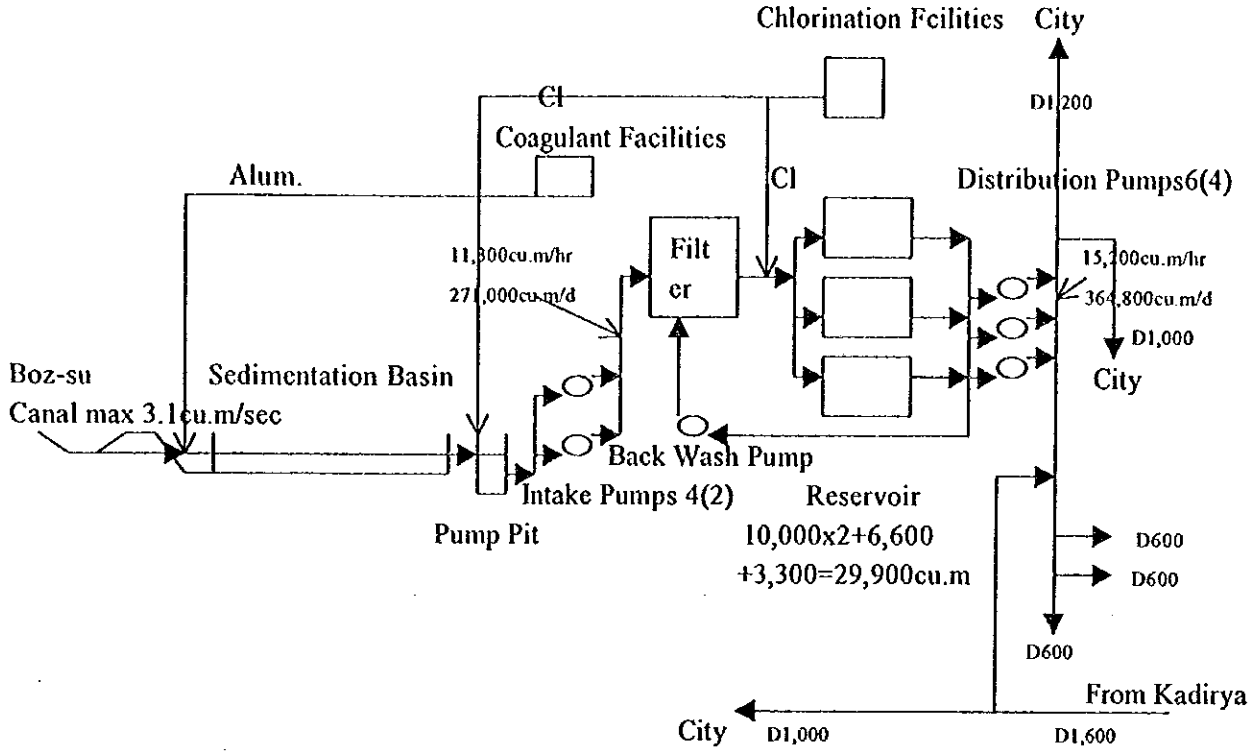


Figure 3.5.2 Flow Sheet of Boz-su WTP

Facilities except for sedimentation basins and relating structures are installed inside of the building. Two (2) sedimentation basins are allocated in parallel divided by embankment 5 m in width. Buildings and structures are mainly made of brick.

3) Intake and Sedimentation Facilities

The list of intake and sedimentation facilities, including chemical dozing equipment is shown in Table 3.5.4.

Retention time of sedimentation basin is large: 7.2 hrs and 10 hrs in No.1 and No.2 basin respectively. Sludge is withdrawn by air lift pump through perforated pipe installed at the bottom of the basins. Sludge is dumped into the canal. Treated water is collected by overflow chamber and sent to intake pump pit then pumped to filters.

There are four (4) units of intake pumps in three (3) types. Out of these, two (2) units are stand-by and the total capacity of the remaining ones is 11,300cu.m/hr=271,000cu.m/day.

Alum, $Al_2(SO_4)_3$-H_2O is adopted as coagulant and its dozing rate is about 15mg/L.

Table 3.5.3 Major Structures of WTP

Item	Flocculation Basin	No.1 Sedimentation Basin	No.2 Sedimentation Basin	Outlet Chamber	Feeding canal	Intake Pump Feeding Pit	Intake Pump Building
Type	Chamber	Soil Bank	Soil Bank	Prefabricated Panel	Reinforced Concrete	Concrete	Brick Structure
Number	1	1	1	1	4	2	1
Dimension	W4mxWH3 mxL150m, v:7,200cu.m	W40mxWH2 .6mxL350m, v:37,100cu. m	W40mxWH3 .6mxL368m, v:52,900cu. m	W2.4mxH4 mxL90m	W2.4mxH4 m	W10mxL15 mxH4m	W12mxL24 m
Others		Artificial	Old Canal				
Item	Filter(1)	Filter(2)	Filter Building	Machine Shop Building	Chlorination Building	Purewater Reservoir(1)	Purewater Reservoir(2)
Type	Reinforced Concrete	Reinforced Concrete	Prefabricated Building	Brick Structure	Brick Structure	Reinforced Concrete	Reinforced concrete
Number	6	12	1	1	1	1	1
Dimension	Rectangular: W6mxL10m, 60.94sq.m	Circle Dia.8.2m, A=52.8sq.m	Approx. W37mx 73m	W12mx L36m	2 Stories, W11mxL20 m	W36xL48xH 3.8 V:6600cu.m, Divided Two	W36xL24xH 3.8 V:3300cu.m
Others				Washing Pump			
Item	Purewater Reservoir(3)	Distribution Pump Station	Coagulation Building	Administrative Building	Factory Building		
Type	Reinforced Concrete	Brick Structure	Brick Structure	Brick Structure	Brick Structure		
Number	2	1	1	1	1		
Dimension	W40xL48xH 3.8 V:10,000cu. m Divided two	W12mxL28 m	W10mxL20 m	Aprox.W12 mxL25m	Aprox.W12 mxL20m		
Others							

Examination to measure the effective component contained in Aluminum Coagulant by Alumina, Al_2O_3 (molar weight 94) can be expressed by conversion value. Alumina conversion value of $Al_2(SO_4)_3$-H_2O (molar weight 362.5) is 94/362.5=0.26. Alumina content ratio of local liquid alum is 8 %, while that of local solid alum is 16 %, which is greater than the ratio of Japanese products. 5 % of alum solution is sent to measurement chamber and flows into inlet cannel of the flocculation basin.

Table 3.5.4 Intake and Sedimentation Facilities List

Item	Aluminum Solution Tank	Sedimentation Basin No.1	Sedimentation Basin No.2	Sludge Drainage Pump	Intake Gate	Intake Pipe
Type	Reinforced Concrete	Horizontal	Horizontal	Air lift Pump	Mortarized	Steel Pipe
Number	6	1	1	2	4	4
Dimension	Dia.2.8mx H1.0m, V:6.15cu.mx6= 36.9cu.m	V:37,100cu.m DT:7.2hr Average Horizontal Speed: 14.0mm/sec	V:52,900cu.m DT:11.0hr Average Horizontal Speed: 11mm/sec	400cu.m/hr	W2.4mxH4 m	Dia.900mm
Others	Included Mixer					
Item	Intake Pump(1)	Intake Pump (2), (3)	Intake Pump(4)	Ceiling Crane	Electric Facilities	Electric Power Equipment
Type	Centrifugal Pump	Centrifugal Pump	Centrifugal Pump	Ceiling Type	Control Panel	Standing Panel
Number	1	2(1)	(1)	1	4	1
Dimension	Q:5,000cu.m/h (83.3cu.m/m) H:26m, kw:500 24NDS	Q:6,300cu.m/h (105cu.m/m) H:27m, kw:630 32D19	Q:4,000cu.m/h(66.7cu.m/m) H:22m, kw:320 32D19	W12m		
Others	Included Motor Valves	Included Motor Valves	Included Motor Valves			

4) Filter System

Filter related facilities are listed on Table 3.5.5.

There are two types of filers, namely rectangular and circular. There are six (6) units of rectangular filter with area of 60.9 sq.m, while 12 units of circular filter having area of 52.8 sq.m, so, the total filter area is 633.6 sq.m. Filtration rate is 170 m/day, excluding stand-by units.

Providing that area of drainage channel is about 20 % of the whole system, actual filtration rate will be 235 m/day × 1/0.8 = 293 m/day.

Depth of lower supporting layer is 1.5 m and upper filtration layer has dual structure. Depth of lower quartz sand layer is 0.6m, that of upper anthracite layer is 0.2m.

Back washing is adopted as filter washing measure and washing rate shall be around 12L/sec/sq.m=0.72m/sec, as standard. While the back washing pump capacity is big enough to allow the washing rate of 50 m/hr = 0.8 m/min for filters with area of 60.9 sq.m.

Table 3.5.5 Filter Facilities List

Item	Filter(1)	Filter(2)	Filter Layer(1) (2)	Filter Wash-ing Pump	Gates and Valves	Electric Facilities
Type	Rapid	Rapid	Quartz Sand &An-thracite	Centrifugal	Motor valve	Control Panel
Number	6	12	18	2(1)	18	18
Dimension	(1)w6.25xL10m Area:60.9m2 (2)Dia.8.2m = 52.8sq.m Filtration rate: 235m/d(no stand-by) Washing Method: back Wash Wash-Speed0.7m/min, Washing Time Approx. 12to15min, Water consumption of washing:Approx. 10,000to12,000cu.m/d		A : 60.9or 52.8sq.m lowest-layer: Lobble-stone (160to50mm)t: 0.5m, Second-Gravel (30to20mm):0.5m ,Third-Gravel (20to4mm) : 0.5m, Quartz-sand (0.6to2mm) :0.6m Anthracite (3to2.5mm) : 0.2m	20TDN Q:3200cu.m/ hr (53.3/min) H:17m kw:320	In-let:d500m m Out-let: d400mm Drain:d500 mm Back-wash: d500mm	Manual operation of valve & washing facilities
Others				Included Motor Valves		

Back washing duration is 12 to 15 minutes per filter and washing is mainly conducted during the nighttime. Total wastewater volume is 10,000 to 12,000 cu.m/day and discharged into Boz-su canal.

While back washing, filter particles are washed by floating in general. For this purpose, washing rate of 0.6 to 0.7 m/min, thus washing speed of the Boz-su WTP is cofort that.

5) Other Facilities

Dimensions of other major facilities, such as chlorination and distribution facilities are shown in Table 3.5.6.

One (1) ton gas cylinder is applied for this facility. Chlorine gas flows through evaporator - chlorine flow meter - ejector and dosed in upstream of distribution reservoir. Gas is dosed to the treated water from sedimentation basin, when needed. For safety work, gas mask, ventilation fan and emergency water tank for leaking chlorine gas cylinder are equipped.

Three (3) units of chlorinator with capacity of 10kg/hr are installed.

Specifications of distribution pumps are shown in Tables 3.5.6.

Table 3.5.6 Chlorination and Distribution Facilities

Item	Chlorination Facilities			Distribution Facilities				
	Chlorinator	Ejector	Sefity Equip-ment	Distribu-tion Pump(1)	Distribu-tion Pump(2)	Distribu-tion Pump(3)	Eletric Facilities	Electric Power Facilities
Type	Evaporate by Gas Cylinder	Vacuum Ejector	----	Centrifugal	Centrifugal	Centrifugal	Control Panel	Standing Panel
Number	2	3	1	3(1)	1	2(1)	4	1
Dimen-sion	10kg/hr, Model; LON II 100x3unit, 1t Sylinder	Pre-Chlorina-tion & Second Chlorina-tion	Gas mask , Ventila-tion Equip-ment,A pit of Diving into	Q:3,200cu. m/hr(53.3/ min) H:55m KW:500 22NDS	Q:2,500cu. m/hr(41.7/ min) H:62m KW:500 18NDS	Q:6,300cu. m/hr(105/ min) H:27m KW:325 32D19	----	----
Others				Included Motor valve	Included Motor valve	Included Motor valve		

Six (6) units of distribution pump are installed and total capacity excluding stand-by units is 15,200 cu.m/hr = 364,800 cu.m/day. As shown in Table 3.5.3, there are 1 unit of reservoir with capacity of 3,300 and 6,600 (3,300×2) cu.m, respectively and 2 units of that with capacity of 10,000(5,000x2) cu.m and total capacity is around 30,000 cu.m. It equivalent to retention capacity of 3 hrs against the nominal capacity of the WTP.

List of distribution pipeline from Boz-su WTP is presented in Table 3.5.7.

(2)Kadirya WTP

1) Outline

Kadirya WTP is situated in pastoral area in 10 km away from eastern city boundary of Tashkent City. In August of 1968, Kadirya WTP was commissioned with the original capacity of 250,000 cu.m/day. In the course of successive expansion works, No.1 filtration building with 24 filters was completed in 1976 and in 1996, six (6) units of filters were added to No.2 filtration building and current 48 units of filters were completed.

Table 3.5.7 Distribution Pipes List

No.	Diameter (mm)	Volume (cu.m/hr)	Route
1	600	1,400	Av.Sofiyshiy, Str.ming-Uryuk, USV
2	600	1,100	Str.Chitiskaya, Gvardeyskaya, Novgoradskaya, Jel-cznovodskaya,Akhmad-Danish
4	600	1,400	Av.Sofiyshkiy, Str.MingUryuk, Furdansi, Timiryazev, Kablukov,C-4,Levin
5	1,000	2,900	Str.Karamurtskaya, Connected Central water pipe line
6	1,200	3,500	Str.Chitiskaya, Gvardeyskaya, Shakhristanskaya, 9lines of Kislovodskaya, Gred. Colonel Khodjaev. Etc
Total		10,300	

Current nominal treatment capacity is 1,375,000cu.m/day, quite huge and the biggest water treatment plant in Central Asia.

Plant area is 138 ha and the elevation of water level in the lowest facility, No.1 sedimentation basin, is 528 m. While those of other facilities are ranging from 535 m to 550m, 50 to 60 m higher than the elevation of the City center. Utilizing this natural water head, treated water is supplied to the City by gravity except for the higher areas served by pump.

Raw water is withdrawn from Boz-su canal, downstream of the irrigation canal from Charvak Dam Lake and 21 cu.m/sec out of the capacity of this canal, 60 cu.m/sec, is accepted as intake water right.

Raw water is directly flows into large scaled sedimentation basin by gravity. Treated water is pumped to filter and then mainly supplied to the City by gravity but partially sent to reservoir and sent to higher areas by distribution pump.

General flow sheet is presented in Figure3.5.3 and Figure D.3.5.3.

2) Structures

List of major structures in Kadirya WTP is shown in Table3.5.8.

The existing old canal was reconstructed into No.1 sedimentation basin with capacity of 1,000,000 cu.m, while No.2 sedimentation basin with bare soil bottom and walls has capacity of 500,000cu.m.

Table 3.5.8 Major Structure of WTP

Item	Flocculation Chamber No.1	Flocculation Chamber No.2	No.1 Sedimentation tank	No.2 Sedimentation tank	No.1 Intake Chamber	No.2 Intake Cannel
Type	Reinforced Concrete Chamber	Reinforced Concrete Chamber	Soil Bank	Soil Bank	Reinforced Concrete Chamber	Reinforced Concrete Chamber
Number	1	1	1	1	6	2
Dimension	Inlet Section: Holed wooden pad, W8mxL25m	Inlet Section: holed wooden pad, W6mxL3m+ D125m	W50to250m xWH1.5to 9mxL1,500m, V:1,000,000cu.m, A:112,500 sq.m	W250m xWH1.5to 5mxL600m, V:500,000cu.m, A:120,000sq.m	W2.1mxL5.9m	W4mx H4mx L10m
Others			Old Canal	Artificial		

Item	No.2 Intake Basin	No.1 Intake Pump Building	No.2 Intake Pump Building	Filter(1)	Filter(2)	Filter Building (1)
Type	Concrete	Brick Structure	Prefabricated Building	Reinforced Concrete	Reinforced Concrete	Prefabricated Building
Number	2	1	6	24	24	1
Dimension	Depth10m, V:10,000cu.m	W18mxL84m	W18mxL90m	Rectangular: 108.8sq.mx 12basin+118sq.mx 12basin= 2,722sq.m	Rectangular: 166sq.mx 24basin= 3,884sq.m	Approx. W36mx 168mx H9, 15m
Others						

Item	Filter Building (2)	Boiler House	Coagulation Building	Coagulant Dissolving tank	Coagulant Solution Tank 1	Coagulant Solution Tank 2,3
Type	Prefabricated Building	Brick Structure	Brick Structure	Reinforced Concrete	Reinforced Concrete	Reinforced Concrete
Number	1	1	1	4	1	2
Dimension	Approx. W48mx 186mx H15m	Approx. W5mx 30m	W12mxL30m	W3mxL12mx3.3m=120cu.m	W30xL25mx H4=1,500cu.mx2= 3,000cu.m	Dia.25.2mxH 4=2,000cu.m
Others						

Item	Coagulant Operatinal Tank	Chlorination Building	Purewater Reservoir	Distribution Pump Station	Administrative Buildings	
Type	Reinforced Concrete	Prefabricated Building	Reinforced Concrete	Brick Structure	Brick Structure	
Number	4	1	3	1	1	
Dimension	24sq.mxh2.8m=60cu.m Total:240cu.m	2 Stories, W16mxL60m	W36xL56 xH5.0 V:10,000cu.m, Divided Two	W15mxL64m	Approx. W12mxL25m	
Others						

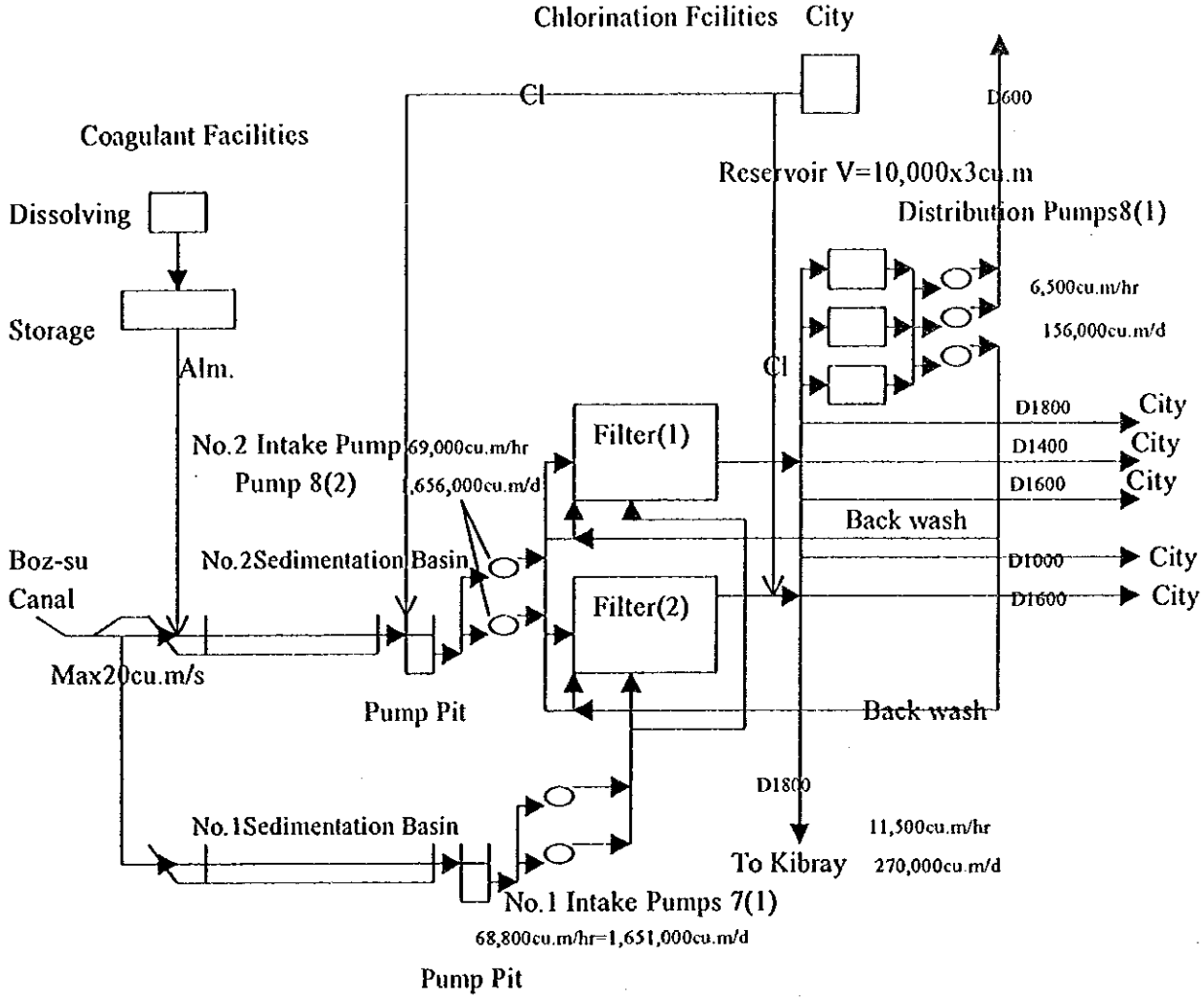


Figure 3.5.3 Flow Sheet of Kadirya WTP

These two basins were located in different elevation, namely, LWL of No.1 basin is 527.2 m and LWL of No.2 basin is 534 m.

No.1 and No.2 filtration buildings have 24 units of filters and quite large scaled.

Most of the buildings are made of pre-cast concrete

3) Intake and Sedimentation Facilities

List of intake and sedimentation facilities is shown in Table 3.5.9.

Seven (7) units of pumps are installed in No.1 intake pump station and one (1) unit is stand-by.

Total pump capacity excluding stand-by unit is 68,800 cu.m/hr = 1,651,000 cu.m/day.

Table 3.5.9 Intake and Sedimentation Facilities List

Item	Sedimentation Basin No.1	Sedimentation Basin No.2	No.1 Suction Dredger	No.2 Suction Dredger	Air Feeding Blower	Coagulant Pouring Pump
Type	Horizontal	Horizontal	Micro Pumping Boat	Micro Pumping Boat	Air blower	Centrifugal Pump
Number	1	1	1	1	3	2(1)
Dimension	V:1,000,000cu.m DT:17.5hr Horizontal Speed: 3 to 10mm/sec	V:500,000cu.m DT:8.7hr Horizontal Speed: 3 to 5mm/sec	PZU-M400 Q:400cu.m/hr	PZU-M800 800cu.m/hr	RMC4 Pump	
Others						
Item	No.1 Intake Chambers	No.2 Intake Chambers	No.2 Intake Screen	No.2 Intake Gate	No.1 Intake Pipe	No.2 Intake Pipe
Type	Open Corridor	Open Cannel	Bar Screen	Moter Gate	Steel Pipe	Steel Pipe
Number	6	2	2	4	6	2
Dimension	W2.1mxH5.9m	W4mxH4mxL10m	W4mxH4m	W4mxH4m	Dia.1,600mm	Dia.2,500mm
Others						
Item	No.1 Intake Pump(1)	No.1 Intake Pump(2)	No.2 Intake Pump(1)	No.2 Intake Pump(2)	No.1 Transmission Pipe	No.2 Transmission Pipe
Type	Centrifugal Pump	Centrifugal Pump	Centrifugal Pump	Centrifugal Pump	Steel Pipes	Steel Pipes
Number	5	2(1)	6(1)	2(1)	4	3
Dimension	Q:12,500cu.m/h(208.3cu.m/min) H:29m kw:1000 48D22	Q:6,300cu.m/h(105cu.m/min) H:29m kw:650 32D12	Q:12,500cu.m/h(108.3cu.m/min) H:29m kw:1,000 48D22	Q:6,500cu.m/h(108.3cu.m/min) H:29m kw:650 32D19	Dia.1,400mm	Dia.2,000x2 +1,400x2
Others	Included Motor Valves	Included Motor Valves	Included Motor Valves	Included Motor Valves		
Item	Ceiling Crane	Ceiling Crane	No.1 Electric Facilities	No.2 Electric Facilities	No.1 Electric Power Equipment	No.2 Electric Power Equipment
Type	Ceiling Type	Ceiling Type	Control Panel	Control Panel	Standing Panel	Standing Panel
Number	1	1	7	8	1	1
Dimension	W18m	W18m				
Others						

Eight (8) units of pumps are settled in No.2 intake pump station and the total pump capacity, except for the stand-by units, is 69,000 cu.m/hr = 1,656,000 cu.m/day.

This means that either of No.1 or No.2 intake pump station has enough capacity exceeding the nominal treatment capacity of the plant. According to the explanation of the operator of the plant, No.1 intake pump station is mainly used and No.2 is used as supplement. When the raw water quality is good, No.2 intake pump station is used for back washing of filters.

Both of No.1 and No.2 sedimentation basins are planned to receive the whole raw water volume. As shown in Table 3.5.9, calculated retention time for these basins is 17.5hr and 8.7hr, respectively.

Sludge is withdrawn from No.1 and No.2 sedimentation basin by micro-pump boat and discharged into canal.

Same as Boz-su WTP, Alum is used as coagulant. Alum is agitated and resolved in concrete tank. Alum resolution by 5 % is stored in storage tank with capacity of 5,000 cu.m and sent to operation tank then poured at influence channel of sedimentation basin by injection pump.

4) Filter Facilities

Dimensions of filter facilities are shown in Table 3.5.10.

All filters are rectangular. In No.1 filtration building there are filters with areas of 108.8 sq.m and 118 sq.m. Number of these filters is 12 each, total 24 units. While, 24 units of filters having areas of 168 sq.m are installed in No.2 filtration building.

Buildings are also huge as follows;

No.1 filtration building : ^{W}36 m $\times^{L}$168 m $\times^{H}$9 to 15 m

No.2 filtration building : ^{W}48 m $\times^{L}$186 m $\times^{H}$15 m

Filtration rate is 205 m/day, excluding stand-by units. Providing 20 % of the filtration area is occupied by drainage channel, actual filtration rate will be 205/0.8 = 256 m/day, relatively fast.

Depth of filtration layer is 1 m, which is divided into lower quartz sand, 0.5m and upper sliced ceramics, 0.5m.

Table3.5.10 Filter Facilities List

Item	Filter(1)	Filter(2)	Filter Layer(1) (2)	Filter Washing Pump	Gates and Valves	Electric Facilities
Type	Quick	Quick	Quartz Sand & Sliced Sermics	Centrifugal	Moter Valve	Contorol Panel
Number	24	24	48	--	48	48
Dimension	(1)Area:108.8X12unit+118x12 unit=2,722qu.m (2)Area:166x24 = 3,984sq.m Filting speed: 205m/d(no reserve) Washing method: back wash, Washing speed: 0.7m/min, Washing time: Approx 15min, Water consumption of washing:Approx 100,000cu.m/day		A : 108.8to166 qu.m lowest Layer:Gravel :t=0.5to 1.0m, Gravel(40to5mm three layers) : t=0.25m , Quartz sand (0.6to 2mm) :0.5 to 0.6m , Sliced ceramics (0.8to1.8mm) : 0.5 to 0.7m, Total filter layer thickness:0.9to 1.0m	No.1 Intake Pumps or Disitribution Pumps are used. Capacity: 6,500cu.m/hr (108.3cum/min)	(1)Inlet:d800 Outlet:d800 Drain:d800 Back wash:d600mm (2)Inlett:d800 Outlet:d800 Drain:d1000 Back wash:d800	Manual opration of valve & washing facilities
Others						

Back washing is employed as filter washing method and washing rate is 0.72 m/min, same as the case in Boz-su WTP.

If the raw water quality is good, raw water pumped by No.1 intake pump station is used for back washing, while if the quality is not applicable, treated water pumped by distribution pump is used. Since the total capacity is 6,500 cu.m/hr = 108 cu.m/min, washing rate of 0.8 m/min can be secured, even in case of the biggest filter with area of 166 sq.m×0.8=132.8.

5) Other Facilities

Dimensions of other major facilities, such as chlorination facilities and distribution facilities are shown in Table 3.5.11.

Though chlorination facilities are divided into two (2) trains and large scaled, system is same to Boz-su WTP.

Table 3.5.11Chlorination and Distribution Facilities

Item	Chlorination Facilities			Distribution Facilities				
	Chlorinator	Ejector	Sefity Equipment	Dis-tribution Pump(1)	Dis-tribution Pump(2)	Dis-tribution Pump(3)	Electric Facilities	Electric Power Facilities
Type	Evaporate by gas cylinder	Vacuum Ejector	----	Centri-fugal	Centri-fugal	Centri-fugal	Control Panel	Standing Panel
Number	8	14	1	3(2)	(3)	(2)	8	1
Dimen-sion	66kg/hrx2, Model; LON II 100x8unit, 1t Sylinder	Pre-Chlori-nation & Second Chlori-nation	Gas mask , Ventilation Equip-ment,A pit of Diving into	Q:6,500cu.m/hr(108.3/min) H:29m KW:63932D19	Q:6,500cu.m/hr(108.3/min) H:60m KW:50024NDS	Q:2,500cu.m/hr(41.7/min) H:58m KW:33518NDS	----	----
Others				Included motor valve	Included motor valve	Included motor valve		

One (1) ton gas cylinder is applied. Chlorine gas flows through evaporator - flow meter - ejector and dosed. General dosage point is outlet of filter but if needed, it will be dosed at the outlet of sedimentation tank. Two (2) units of chlorinator with capacity of 66 kg/hr are installed. Each of them, four (4) gas cylinders are settled but weigher is equipped one (1) each. Safety measures are gas mask, ventilation fan and emergency water tank for leaking chlorine gas cylinder, just as Boz-su WTP.

As aforementioned, since most of treated water is supplied by gravity, only one (1) pump is daily operated out of eight (8) distribution pumps. Some of them are used for back washing of filters. As presented in Figure 3.4.4, there are nine (9) lines of distribution pipes supplying water from this WTP and they are listed on Table 3.5.12.

Since the capacity of reservoir is 30,000 cu.m, retention time against the plant's nominal capacity is only 30,000/1,375,000×24=0.52 hr, quite short. In actual operation, large part of the treated water is transmitted directly to the large scale distribution main, without passing through the reservoir and this distribution main, with length of more than 10 km, is working as another reservoir.

Table 3.5.12 Distribution Pipes List

No.	Diameter Mm	Volume *1 cu.m/hr	Route
1	1,600	15,600	ToYunusabad
2	1,400	10,800	ToYunusabad
3	1,000	1,200	Tashkent Province
4	1,800	7,800	Tashkent Province
5	1,800	20,400	To Kibray WTP
6	1,000	7,800	Mirzo-Ulugbek
7	1,600	14,400	Mirzo-Ulugbek
8	600	---	Ulugbek Province
Total		78,000	

*1: Measured Value

(3) Kibray WTP

1) Outline

Kibray WTP is located in eastern outskirts of Tashkent City, 8 km away from the city boundary. This plant commissioned in May 1955, the oldest facility in Tashkent City. Situated along Chirchic River, its site is long and slender and total site area is 986 ha.

Water source is groundwater from wells constructed along Chirchic River with total production capacity of 455,200 cu.m/day. Receiving about 270,000 cu.m/day of treated water from Kodirya WTP, the plant supplies 732,000 cu.m/day of treated water to the southern area of the City.

There are 95 units of wells along the both banks of Chirchik River and older and bigger wells are located in right bank. Main facilities are constructed in right bank and only wells and transmission pipes are existing in left bank.

Treatment facilities consist of wells, transmission pipe, reservoir, distribution pump, chlorination facility and laboratory. Fruit trees are cultivated within of the site. Flow sheet of Kibray WTP is presented in Figure 3.5.4 and Figure D.3.5.4.

2) Wells and Intake facilities

Intake facilities, including wells and pumps, are listed in Table 3.5.13.

The characteristic of intake facility of this WTP is installation of filter pool in left bank of Chirchik River.

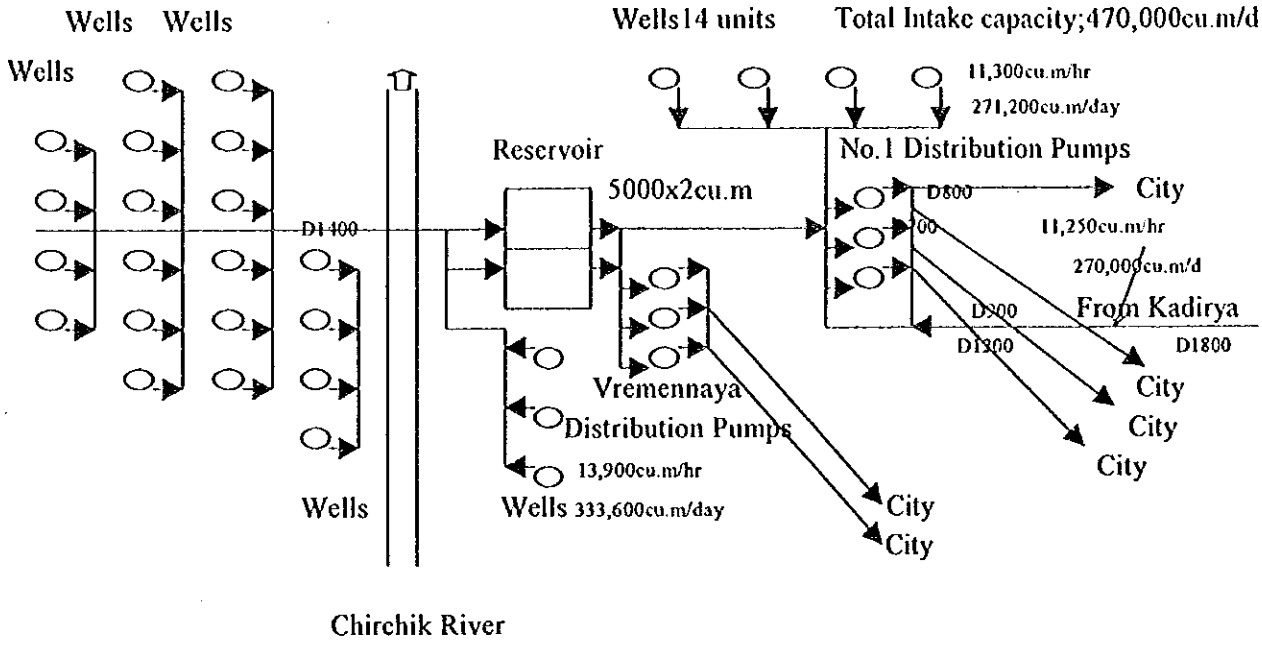


Figure 3.5.4 Flow Sheet of Kibray WTP

Depth of this pool is 1 to 1.5 m and it facilitates the river water penetration from the river. Total area is 28 ha. This filter pool is periodically cleaned, once in two years.

Well diameter and depth are ranging from 400mm to 600mm and 30 m to 50 m, respectively. Out of 95 units of wells, 15 units are stand-by and 80 units are daily operated.

Pumps are divided into dry pit type and submergible type. Recently, submergible pumps are adopted frequently.

Though design pump volume is 38,223 cu.m/hr = 917,352 cu.m/day, such volume can not be pumped in actual operation.

There are two (2) reservoirs with capacity of 5,000 cu.m. Receiving pumped groundwater from wells, they work as pump pit for No.1 pump station and Vremennaya pump station.

Since the retention time is quite short, 10,000/455,200×24 hr/day=0.5 hr, adjustment on intake and distribution volume fluctuation will be difficult, actually.

3) Distribution Facilities

A shown in Figure 3.5.4, there are two (2) distribution pump stations in Kibray WTP. Their facilities are listed in Table 3.5.14.

Table 3.5.13 Wells and Intake Facilities List

Item	Filter Pools(1st range)	Filter Pools(2nd range)	Filter Pools(3rd range)	Wells	Intake Pump(1)
Type	Opend Reser-voir	Opend Reservoir	Opend Reser-voir	Deep Well	Dry pit type
Number	20	8	21	95(15)	67(13)
Dimension	8,000sq.mx20= 160,000sq.m	8,000sq.mx8=64,000sq.m	2,800sq.mx21= 58,800sq.m	Dia; 400to 600mm Depth;30to 50m Filter depth 8to13, 23to25m	20A18-1, 604cu.m/hr(26.7/min) , 28mH、Kw:75kw
Others					
Item	Intake Pump(2)	Intake Pump(3)	Electrical Fa-cilities	Covered House	Reservoir
Type	Dry pit type	Submergible type	Control Panel	Brick Structure	Reinforced con-crete
Number	1	27(6)	95	95	2
Dimension	ATN-14, 252cu.m/hr(4.2 /m) , 60mH、Kw:75kw	ECV12, 255cu.m/hr(4.25/min), 30mH, Kw:32	----	7mx5.6m	V=36mx32mx wH4.5m= 5,000cu.m
Others					

Table3.5.14(1) Distribution Facilities list(1)

Item	Distribution Pump Station No.1						
	Distribution Pumps			Electric Facilities	Electric Power Facilities	Pump House	Ceiling Crane
Type	Centrifugal	Centrifugal	Centrifugal	Control Panel	Standing Panel	Brick structure	Ceiling type
Number	1	2(1)	2(1)	5	1	1	1
Dimen-sion	Q:2,500cu.m/hr (41.7cu.m/m) H:62m D:800,600mm kw:375 Model:18N DS	Q:3,600cu.m/hr (60cu.m/m) H:55m D:800,600mm kw:800,630 Model:22N DS	Q:5,200cu.m/hr (86.7cu.m/m) H:52m D:1000,800mm kw:630 Model:24N DS	----	----	W12mx48m	W12m
Others	Included Motor Valve	Included Motor Valve	Included Motor Valve				

Table 3.5.14(2) Distribution Facilities list(2)

Item	Vremennaya Pump Station					
	Distribution Pumps		Electric Facilities	Electric Power Facilities	Pump House	Ceiling Crane
Type	Centrifugal	Centrifugal	Control Panel	Standing Panel	Sub-Basement Brick structure	Ceiling type
Number	2(1)	3(1)	5	1	1	1
Dimension	Q:2,500cu.m/hr (41.7cu.m/m) H:55m D:800,600mm kw:375 Model:18NDS	Q:5,200cu.m/hr (86.7cu.m/m) H:52m D:1000,800mm kw:1000 Model:24NDS	----	----	W8mx40m	W8m
Others	Included Motor Valve	Included Motor Valve				

In No.1 pump station, some pumps are used to supply only pumped groundwater from No.1 - No.14 wells, while others are operated to distribute the water sent from Kadrya WTP together with aforementioned produced groundwater. Diameters of four (4) distribution mains are 1,200 mm, 900 mm, 800 mm and 700 mm. These No.1 – No.14 wells are large scaled wells having diameter of 600 mm and depth of 50 m.

Vremennya pump station has pumps distribute pumped groundwater from No.15 – No.95 wells, including 15 units of stand-by wells. Expansion work for this pump station has been suspended. There are two (2) distribution mains with diameter of 1,200 mm and 1,400 mm.

Total pumping capacity of No.1 pump station is 11,300 cu.m/hr = 271,200 cu.m/day, while that of Vremennaya Pump Station is 13,900 cu.m/hr = 333,600 cu.m/day, grand total is 604,800 cu.m/day.

Total well production of 455,200 cu.m/day plus water supply from Kodrya WTP of 270,000 cu.m/day makes total water production of 725,200cu.m/day. Thus, the difference between this water production and pumping capacity; 725,200 − 604,800 = 120,400 cu.m/day, is distributed by gravity utilizing hydraulic head of supplied water from Kadrya WTP.

4) Other Facilities

Chlorination buildings and facilities are listed on Table 3.5.15. Exactly same system installed in Boz-su and Kodirya was introduced in this plant. Chlorine gas from 1 ton cylinder flows into evaporator and flow meter then dosed by ejector. Chlorinated water is injected at inlet pipe to the reservoir.

Two (2) trains of chlorinator are installed in two (2) cholonation buildings and four (4) units of injector are equipped. Same safety facility is also set in both buildings.

Table 3.5.15 Chlorination Buildings and Facilities

Item	Chlorination Facilities and Structures					
	Chlorinator (1)	Chlorinator (2)	Ejector	Safety Equipment	Chlorination Building(1)	Chlorination Building(2)
Type	Evaporate by Gas Cylinder	Evaporate by Gas Cylinder	Vacuum Ejector	----	Brick Structure	Brick Structure
Number	4(2)	4(2)	8	1	1	1
Dimension	10kg/hr, Model; LON II 100 4unit, 1ton Sylinder	10kg/hr, Model; LON II 100 4unit, 1ton Sylinder	---	Gas mask , Ventilation Equipment, A pit of Diving into	W10mxL1 6m	2 Stories, W9mxL12 m
Others						

There are seven (7) distribution pipes and their dimensions are shown in Table 3.5.16.

In addition, transmission line from Kadirya WTP is installed and its diameter is 1,800 mm.

(4) South WTP

1) Outline

Located in south of Tashkent City, South WTP is divided into two (2) sites. First area has an area of 12 ha and stands near to Yuzhnyi railway station, while second area is situated in several km away from first area, crossing loop road and its area is 48 ha.

Major structures such as; administration building, reservoir, pump house and chlorination building are constructed within first area.

Table 3.5.16 Distribution Pipelines

No.	Diameter Mm	Flow out from	Water source	Volume * 1 Cu.m/hr	Route
Intake	1,800	Kadriya	Kadirya	(20,400)	From kadirya
1	900	PSNo.1	Kadirya+ Kibray	4,200	Ring road in Karasu regien
2	1,200	PSNo.1	Kadirya+ Kibrai	8,400	Near Chengeldy Village,near Tashkent poultry farm
4	700	PSNo.1	Kibray	1,800	Through collective farm field, near Durmen villege to the Tash-kent Chirchik road, go to Mirzo-Uzbek PS
5	1,400	Vremen-naya	Kibray	11,700	Parallel Chirchik Rever, Through the Chengeldy villege near Tazel villege
6	1,200	Vremen-naya	Kibray	8,700	Parallel Chirchik Rever,
7	800	PSNo.1	Kadirya+ Kibray	1,200	Prallel kadriya line
Total				36,000	

* 1 : Measured Value

There are only wells and warehouse in second area. Chlorine cylinder storage building of Tashkent Vodokanal is located adjacent to second area.

South WTP is located in the elevation of 420 m, 130 m lower than Kodrya WTP. Nominal plant capacity is 113,200 cu.m/day and large part of its treated water is supplied to Chilanzar district.

Water source is groundwater. Aquifer is located in right bank of Chirchik River, 2 – 60 m below the ground surface, consist of grayish clay intruded by volcanic gravel. First area was developed in 1961 followed by the construction of second area in 1964. Recently drilled six (6) units of wells are supplying water directly to Sergeri district without boosting by pumps in first area.

Flow Sheet of South WTP is shown in Figure 3.5.5 and Figure D.3.5.5.

2) Wells and Intake Facilities

Table 3.5.17 presents wells and intake facilities.

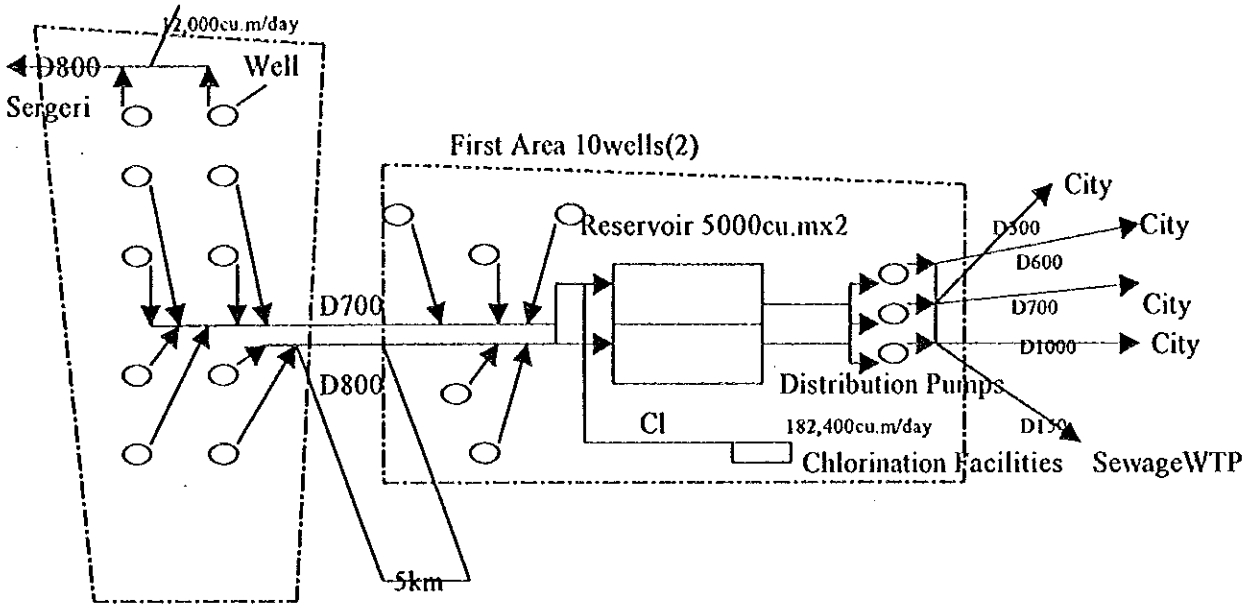


Figure 3.5.5 Flow Sheet of South WTP

Out of 29 units of wells, 10 units belong to first area and the remaining 19 units are installed in second area. All new wells were drilled in second area.

Diameter of well and filter pipe is ranging from 325 to 400 mm and from 250 to 300 mm, respectively. Depth of older wells are about 58 m but new wells are shallower, 25 to 30 m deep. Further, older pump houses are made of brick but new ones are made of prefabricated concrete. Dry pit type pumps are used to be adopted but recently, cheaper and efficiency submergible pumps are used. However, compared with dry pit type pump, the durable life of submergible pump is short. While dry pit type pump can be operated over 20 years, submergible pump is operational only 4 years.

Out of 13 units of submergible pump, six (6) units are supplying water to Sergeri district and the volume is 220 cu.m/hr×6=1,320 cu.m/hr=31,680 cu.m/day. Reportedly, the water volume sent from this plant is 12,000 cu.m/day.

Remaining total capacity of well pumps is 252 cu.m/hr×16+220×(13−6)=5,572 cu.m/hr= 133,728 cu.m/day, exceeding the nominal plant capacity. However, this capacity is included the capacity of stand-by pumps.

Table 3.5.17 Wells and Intake Facilities List

Item	Wells	Intake Pump(1)	Intake Pump(2)	Electrical Facilities	Pump House	Reservoir
Type	Deep Well	Dry pit type	Submergible type	Control panel	Brick structure or Pre-fabricated concrete	Reinforced concrete
Number	29	16	13	29	27	2
Dimension	Dia;Wells 325to 400mm, Filter pipe250to 300mm Depth;25to	ATN-14, 252cu.m/hr(4.2/ m) , 65mH, Kw:75kw	ECV12, 220cu.m/hr(3.7/min), 65mH, Kw:32or 45	----	Brick:6mx6m or 2x3m, Pre-fab.:5mx8m	V=24mx20m x wH5.7mx2= 2,500cu.mx2 =5,000cu.m
Others	58m					

Since the reservoir capacity is 5,000 cu.m, retention time against the nominal plant capacity is 5,000/113,200×24=1.06 hr. This retention time is enough as pump pit but insufficient as distribution reservoir.

3) Distribution Facilities

Table 3.5.18 listed the distribution facilities.

Table 3.5.18 Distribution Facilities List

Item	Distribution Pumps		Eletric Facilities	Electric Power Facilities	Pump House	Ceiling Crane
Type	Centrifugal	Centrifugal	Control Panel	Standing Panel	Brick structure	Ceiling type
Number	3(1)	2(1)	5	1	1	1
Dimension	Q:2,000cu.m/hr (33.3cu.m/m) H:100m kw:800 Model:D2000 /100	Q:3,600cu.m/hr (60cu.m/m) H:55m kw:630 Model:1250/ 125	----	----	W9mx40m	W9m
Others	Included Motor Valve	Included Motor Valve				

4) Other Facilities

Single stage high lift pump is employed in smaller pump and quite high pitched operation noise is observed.

Total capacity of distribution pump is; 2,000×2+3,600=7,600 cu.m/hr=182,400 cu.m/day, exceeding the nominal plant capacity.

As other facilities, chlorination facilities and relevant buildings are shown in Table 3.5.19.

Table 3.5.19 Chlorination Facilities and Other Buildings

Item	Chlorinator (1)	Ejector	Sefity Equipment	Clorination Building	Adm. Building
Type	Evaporate by Gas Cylinder	Vacuum Ejector	----	Brick structure	Brick structure
Number	1	4	1	1	1
Dimension	10kg/hr, Model; LON II 100 1unit, 1ton Sylinder	---	Gas mask , Ventilation Equipment, Pit of Diving into.	W6mx110m	W20mx40m+ W6mx10m
Others					Included Labolatory
Item	Store House in First PS	Work shop House	Cetral Store House	Chlorine Gas Cylinder Storage Building	
Type	Brick structure	Brick structure	Cosutructed by steel plate	Prefabricated Building	
Number	1	1	1	1	
Dimension	W12mxL20m	W12xL20	W25xL40m	2stories W24mxL142 m	
Others				Neighboring	

Chlorination facility consists of 1 ton chlorine gas cylinder, evaporator, gas flow meter and ejector, just as the other WTPs. One (1) unit of 1 ton cylinder and evaporator and four (4) sets of flow meters and ejectors are installed. Same safety facilities are also adopted here.

As other building, there is administrative building, store house and workshop house. There is also a chlorine cylinder storage building of Vodokanal, adjacent to second area.

Table 3.5.20 presents incoming and outgoing pipes of South WTP. Most of the outgoing pipes are connected to Chilanzar district.

Table 3.5.20 Distribution Pipe List

No.	Diameter mm	Volume * 1 cu.m/hr	Route
--		---	From Kibray
1	600	300	To Chilanzar
2	700	2,300 to 1,500	To Chilanzar
3	1,000	6,000 to 3,600	To Chilanzar
4	300	---	To Bengelsky
5	150	---	To Sewer WTP
6	800	500	To Sergeri
Total		9,100 to 5,900	

* 1 :Measured Value

(5)Sergeri WTP

1) Outline

Rapid population growth was observed at Sergeri district. Sergeri WTP is located in this district, crowded with apartment houses.

Although the nominal plant capacity is 40,000 cu.m/day, Sergeri WTP is playing main role in south Tashkent, conducting water quality analysis for Kara-Su WTP and Bektemir WTP, supervision of five (5) pump stations in this area and assistance for large scaled facility improvement works in Kara-Su WTP and Bektemir WTP.

Site area is 13 ha, the smallest WTP in the City. Eight (8) units of wells, reservoirs, distribution pump facilities are allocated within the site.

Flow sheet of plant is shown in Figure 3.4.6.

All of the treated water is supplied to Sergeri district.

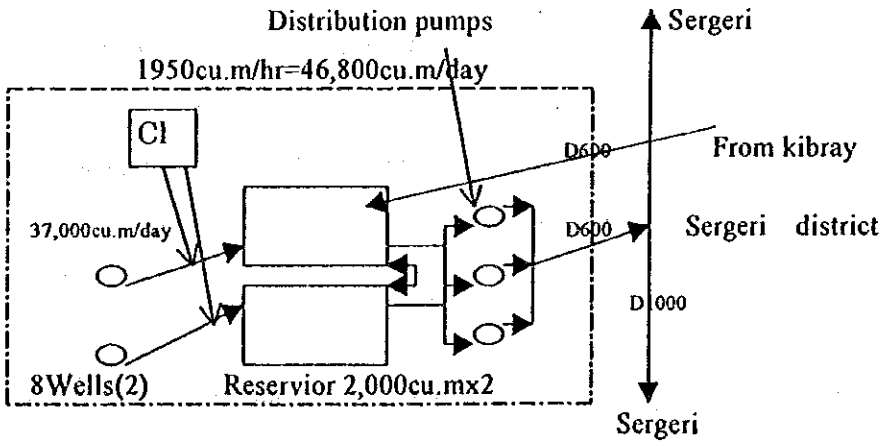


Figure 3.5.6 Flow Sheet of Sergeri WTP

2) Wells and Intake Facilities

Wells and intake facilities are listed up in Table 3.5.21.

All pumps are submergible type and maximum pump capacity excluding stand-by units is as follows:

210 cu.m/hr × 1 + 220 cu.m/hr × 6 = 1,530 cu.m/hr = 36,720 cu.m/day

It is smaller than nominal capacity but reportedly real capacity of well pumps is proper. Retention time of reservoir against the nominal capacity of plant is relatively large; 4,000/40,000 × 24 = 2 hr.

In case of the shortage in well production, treated water will be sent from Kibray WTP and flow into the reservoir.

Table 3.5.21 Wells and Intake Facilities List

Item	Wells	Intake Pump(1)	Intake Pump(2)	Electrical Facilities	Pump House	Reservoir
Type	Deep Well	Submergible type	Submergible type	Control panel	Brick structure	Reinforced concrete
Number	8(1)	1	7(1)	8	8	2
Dimension	Dia;300mm, Depth;50to 70m	CEB10, 210cu.m/hr(3.5/ m), 60mH Kw:32	CEB12, 220cu.m/hr(3.7/min), 60mH, Kw:32	----	W3.0mxL4.5 m	V=2,000+ 2,000= 4,000cu.m
Others						

3) Distribution Facilities

Table 3.5.22 presents the dimensions of distribution facilities.

Based on the table, stand-by units of distribution pump are four (4) out of six (6). Distribution capacity except for the stand-by units is 1,600 + 350 = 1,950 cu.m/hr = 46,800 cu.m/day. These pumps are operated almost 24 hrs during summer time. Since this distribution capacity is exceeding the intake pump capacity of 37,000 cu.m/day by 10,000 cu.m/day, equivalent volume is supposed to be supplied by Kibray WTP.

4) Other Facilities

Dimensions of chlorination facilities and administration building are shown in Table 3.5.23.

Table 3.5.22 Distribution Facilities List

Item	Distribution Pumps		Electric Facilities	Electric Power Facilities	Pump House	Ceiling Crane
Type	Centrifugal	Centrifugal	Control Panel	Standing Panel	Brick structure	Ceiling type
Number	5(4)	2(1)	7	1	1	1
Dimension	Q:1,600cu.m/hr (26.7cu.m/m) H:30m D:600,500mm kw:315,250 Model:12NDS	Q:3,500cu.m/hr (5.8cu.m/m) H:30m D:300,250mm Kw:75 Model:8NDS	----	----	W12mx24m	W12m
Others	Included Motor Valve	Included Motor Valve		1		

Table 3.5.23 Chlorination Facilities and Others list

Item	Chlorinator	Ejector	Safety Equipment	Cllorination Building	Laboratory House	Adm. Building
Type	Evaporate by Gas Cylinder	Vacuum Ejector	----	Brick structure	Brick structure	Brick structure
Number	1	3	1	1	1	1
Dimension	10kg/hr, Model; LON II 100 1unit, 1ton Sylinder	---	Gas mask , Ventilation Equipment,A pit of Diving into.	W6mxL12m	W10mxL20m	2stories W12mxL24m
Others						

Even in a relatively small scaled Sergeri WTP, chlorinator with 1 ton chlorine gas cylinder is used, just like the other WTPs. As aforementioned, water quality test for Kara-Su and Bektemir WTPs adding Yakkasarai district is covered here, appropriate equipment is installed in laboratory.

(6) Kara-Su WTP

1) Outline

Kara-Su WTP is irregular plant having two (2) units of double wells and two (2) units of ordinary wells in site adjacent to Tashkent International Airport and also having eight (8) units of city wells in surrounding area. Nominal plant capacity is 52,000 cu.m/day. Groundwater is directly sent to service area without reservoir and distribution pump.

Japanese prisoner of War reportedly constructed some of the double wells on 1945. Site area is 41 ha. and four (4) units of wells are scattered in this vast site.

Pump station control center is established here and supervising pump stations within the City, excluding five (5) in Sergeri district.

As aforementioned, water quality test is covered by Sergeri WTP. Plant flow sheet is shown in Figure 3.5.7. Treated water is supplied to surrounding Kara-Su disrtrict.

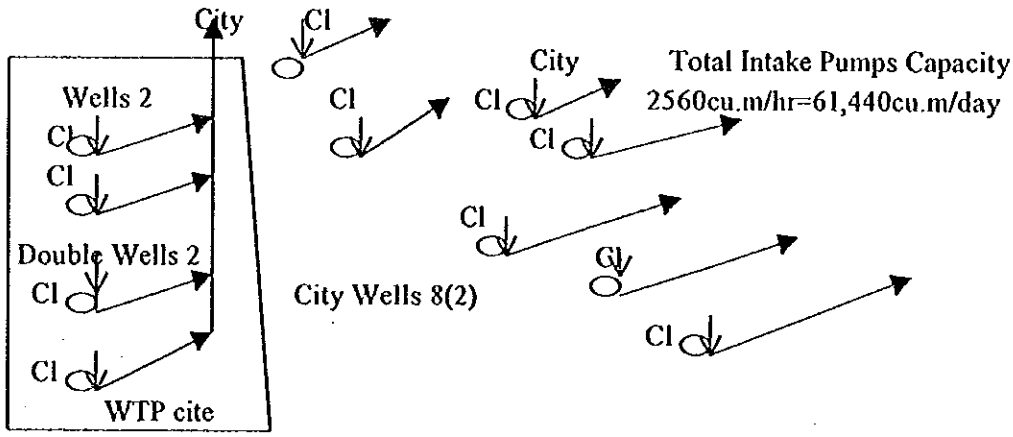


Figure 3.5.7 Kara-Su WTP Flow Chart

2) Facilities

Dimensions of facilities in Kara-Su WTP are shown in Table 3.5.24.

Out of two (2) units of double wells, the oldest has diameter of 8 m and depth of 10 m. In basement, another well having diameter of 400 mm and depth of 20 m is constructed and groundwater is pumped by dry pit type pump. However, most of well pumps are submergible type and total pump capacity, excluding stand-by units id as follows;

$800 \times 2 + 120 \times 8 = 2{,}560$ cu.m/hr $= 61{,}440$ cu.m/day

No reservoir is constructed.

Both of double and ordinary well have ground pump house. Chlorination is done by gravity injection of hypochlorine resolution for each well.

Table 3.5.24 Wells and Intake Facilities List

Item	Double Wells	Wells	Intake Pump(1)	Intake Pump(2)	Intake Pump(3)
Type	Double	Deep Well	Centrifugal	Submergible type	Dry pit type
Number	2	10(2)	4(2)	8(1)	(1)
Dimension	Under ground well dia.8mxh10m +deep well,Dia400mmxH20m	Dia;Wells 400mm, Filter pipe250to 300mm Depth;30to 50m	8NDB, 800cu.m/hr(13.3cu.m/min), 56mH, Kw:160 Installed at double wells	ECB12, 120cu.m/hr(2cu.m/min), 65mH, Kw:32	ATN8, 120cu.m/hr(2cu.m/min), 60mH, Kw:37
Others					

Item	Electrical Facilities	Pump House (double)	Pump House(wells)	Chlorinator
Type	Control panel	Brick structure and Reinforced concrete	Brick structure	Hypochlorine dissolved
Number	8	2	8	1
Dimension	----	On ground W7.0mxL7m Under ground dia.5mx7mH	W5.0mxL5m	Dessolving tank and pouring facilities
Others				

(7)Bektemir WTP

1) Outline

Bektemir WTP is located in south of Chirchik River and in east of Sergeri district. Water source is groundwater. Wells and distribution pump stations are allocated in both of Bektemir district and Vinokor district.

Total site area is 20 ha. In Bektemir district, there are four (4) wells, one (1) reservoir with capacity of 1,000 cu.m and one (1) distribution pump station within the site and one (1) well outside of the site. In Vinokor district, there are six (6) wells and two reservoirs with capacity of 1,000 cu.m and 750 cu.m, respectively and two (2) distribution pump stations. In addition, there is a small pump station in Fyerk district.

Nominal plant capacity is 25,000 cu.m/day, and water quality test is conducted by Sergeri WTP. Vodokanal's working team for earth works within the City is stationed here.

Plant flow sheet is show in Figure 3.4.8. Treated water is served to southern area of Chirchik River.

2) Wells and Intake Facilities

Dimensions of wells and intake facilities are listed on Table 3.5.25.

All pumps are submergible type and maximum pump capacity excluding stand-by units is as follows;

160×8=1,280 cu.m/hr=30,720 cu.m/day

Retention time of reservoir against the nominal plant capacity is 2,750/25,000×24=2.6hrs, maximum in WTPs in the City.

3) Distribution Facilities and Others

Dimensions of distribution facilities and other structures are listed in Table 3.5.26.

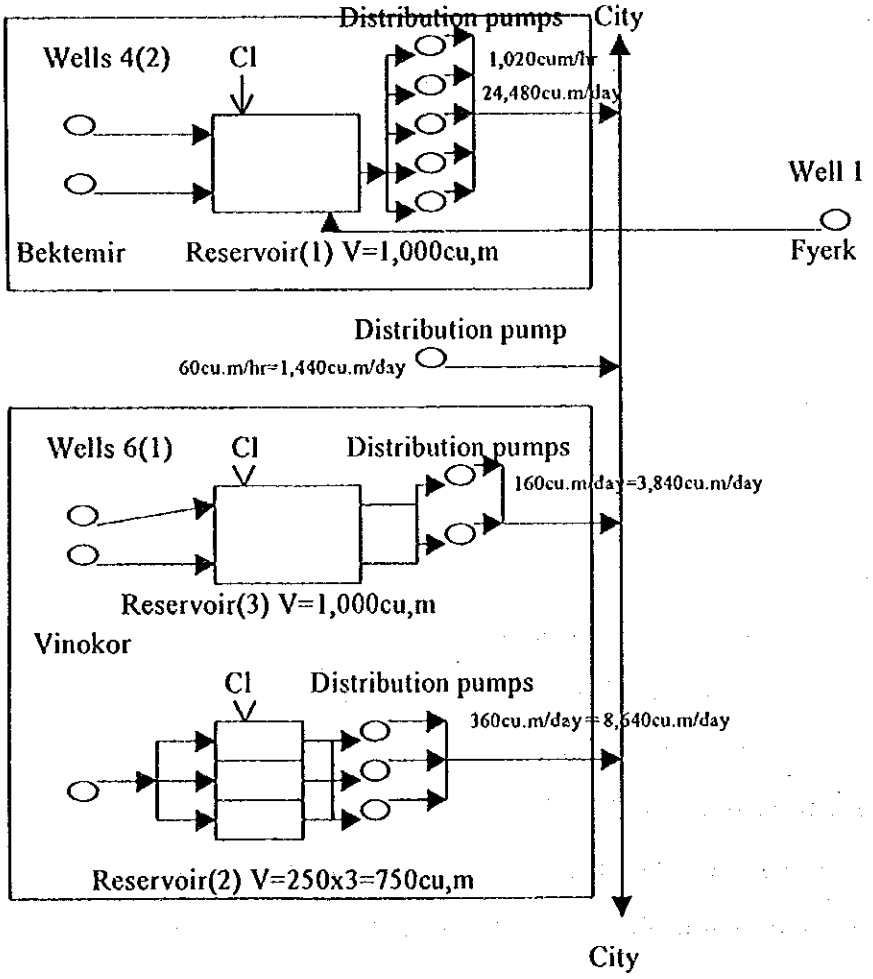


Figure 3.5.8 Bektemir WTP Flow Chart

Table 3.5.25 Wells and Intake Facilities List

Item	Wells	Intake Pump(1)	Intake Pump(2)	Intake Pump(3)	Electrical Facilities
Type	Deep Well	Submergible type	Submergible type	Submergible type	Control panel
Number	11(3)	9(1)	(1)	(1)	11
Dimension	Dia;300mm, Depth;50to 70m	ECB10, 160u.m/hr (2.6cu.m/m), 40mH 、 Kw:32	ECB12, 160cu.m/hr (2.6cu.m/m), 40mH 、 Kw:32	ATN8, 30cu.m/hr(0.5 /min),40mH, Kw:18.5	----
Others					

Item	Pump House	Reservoir(1)	Reservoir(2)	Reservoir(3)
Type	Brick structure	Reinforced concrete	Reinforced concrete	Reinforced concrete
Number	7	1	1	1
Dimension	W3.0mxL4.5 m	V=1,000cu.m	V=1,000cu.m	V=250cu.mx 3= 750cu.m
Others				

Table 3.5.26 Distribution and Others Facilities List

Item	Distribution Pump for Reservoir(1) in Bektemir		Distribution Pump for Reservoir(2)	Distribution Pump for Reservoir(3)		Distribution Pump
Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal	Centrifugal
Number	3	2(1)	2(1)	(2)	1	(1)
Dimension	Q:320cu.m/hr (5.3cu.m/m) H:50m, kw:55 Model:320/50	Q:60cu.m/hr (1.0cu.m/m) H:100m, kw:37 Model:6K8	Q:160cu.m/hr (2.7cu.m/m) H:50m, kw:37 Model:6K8	Q:320cu.m/hr (5.3cu.m/m) H:70m, kw:110 Model:320/70	Q:320cu.m/hr (5.3cu.m/m) H:50m, kw:55 Model:320/50	Q:60cu.m/hr (1.0cu.m/m) H:90m, kw:37 Model:6K8
Others						

Item	Eletric Facilities	Distribution Pump House(1)	Distribution Pump House(2)	Distribution Pump House(3)	Distribution Pump House	Chlorinator
Type	Control Panel	Brick structure	Brick structure	Brick structure	Brick structure	Hypochlorine dissolved
Number	4	1	1	1	1	1
Dimension	For all Disitribution pump	W5.0mxL12m	W5.0mxL8m	W5.0mxL6m	W3mxL3m	Dissolving tank and Pouring facilities
Others						

According to the table, distribution pump stations are allocated in four (4) districts and their pump capacities are small. Maximum distribution capacity, excluding the stand-by units is; Reservoir (1) : 320×3+60=1,020 cu.m/hr, Reservoir (2) : 160 cu.m/hr, Reservoir (3) : 320 cu.m/hr, distribution pump station : 30 cu.m/hr, grand total is 1,530 cu.m/hr=36,720 cu.m/hr which is almost equivalent to the maximum pump capacity of 30,720 cu.m/day. Chlorination is done by hypochlorine resolution injected to reservoirs.

3.5.5 Booster Pump Stations and Distribution Pipes

(1) Booster PS in the City

Dimensions of booster pump stations are shown in Tables D.3.5.1 (1) to (4). Excluding Mirzo-Ulugbek, Chilanzar and Sergeri pumping stations, they don't have reservoirs and are withdrawing water directly from distribution pipe and boosting.

Figure 3.5.9 shows the schematic diagram of general pump station, quite simple. While system of pump station has reservoir as presented in Figure 3.5.10 and their dimensions are shown in Table 3.5.27.

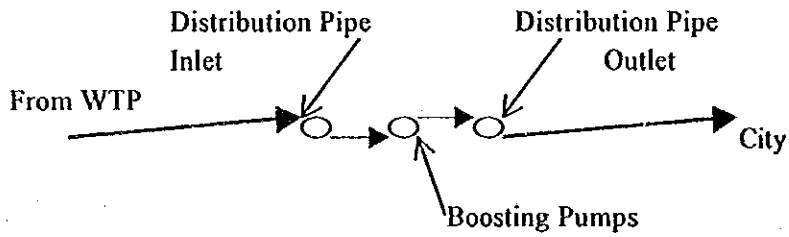


Figure 3.5.9 Schematic Diagram of General Pump Station System

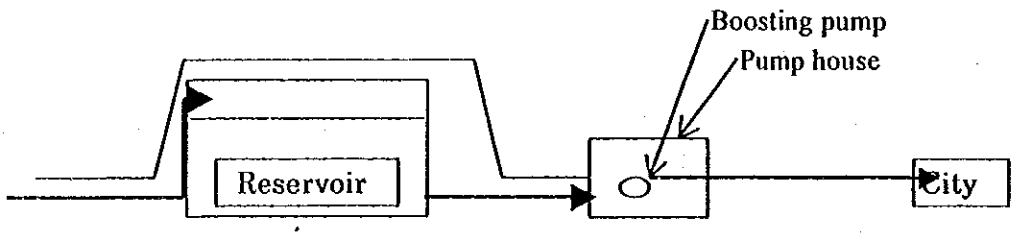


Figure 3.5.10 Pump Station with Reservoir

Table 3.5.27 Pump Station with Reservoir

PS Name	Pump Capacity	Constructed Year	No.	Type	Pump Dimension			Number	Reservoir Volume
					cu.m/hr	mH	kw		
Sergeli- 3/5	3,000	1993	1	D1250/67	1,250	67	350	4 (2)	6,000x2=
			2	D320/50	315	50	75	3	12,000cu.m
CVRU (Chiranzar)	7,200	1998	1	D1600/90	1,600	90	630	3 (2)	12,500x2=
			2	D630/90	500	60	160	3(2)	25,000cu.m
			3	D200/90	200	90	90	3(1)	
Mirzo-Ulugbek	30,000	1988	1	24NDC	6,500	79	1700	7 (4)	10,000x2+5,000
			2	22NDC	4,500	55	850	1	=25,000cu.m

(2) Distribution Pipe Line

Table 3.5.28 shows length of distribution pipe by diameter and by pipe age, period from the installation. Since the pipe length by diameter is based on the record in 1998, the total length is greater than that of length by pipe age which is based on the record in 1997.

Table 3.4.28 Composition of Distribution Pipes

Diameter (mm)	Length(m)
19 to 30	87,689
38 to 150	1,567,952
100 to 350	1,074,443
300 to 500	198,799
600 to 700	201,981
800 to 900	56,494
1000 to 1200	248,625
1400 to 1800	105,698
Total	3,541,681
Material	Length(m)
Steel	2,330,984
Ductile iron	1,203,695
Others	7,002
Total	3,541,681

Note) Record in 1998

Diameter (mm)	Total Length (km)	Pipe Length by Pipe Age (km)				
		>5	>10	>20	>30	<30
<50	87.0	2.1	1.0	13.5	27.5	42.9
50	336.2	12.1	2.9	54.3	110.9	156.0
63	18.2	0.1	0.3	1.2	5.1	11.5
75	97.6	13.5	1.9	12.9	41.1	28.2
100	555.2	71.1	27.9	102.1	255.9	98.2
125	26.8	1.0	0.2	1.7	14.5	9.4
150	477.0	74.7	34.2	116.8	167.5	83.8
200	376.5	36.5	37.8	97.8	144.2	60.2
250	88.9	2.9	5.4	29.3	18.7	32.7
300	505.3	24.2	82.6	155.2	172.4	70.9
325	70.0	20.6	22.8	22.8	2.0	1.8
350	22.9	0.9	3.9	7.7	3.4	7.0
400	131.3	21.2	20.4	40.2	32.8	16.7
500	56.5	9.2	12.1	12.0	16.0	7.2
600	173.8	7.0	17.5	43.5	70.4	35.4
700	21.1	-	1.9	12.2	3.8	3.2
800	31.3	3.9	11.3	6.3	9.4	0.4
900	20.0	-	0.2	1.9	11.9	6.0
1,000	86.3	14.6	3.9	27.0	38.7	2.1
1,200	148.9	20.0	9.2	31.0	88.3	0.4
1,400	91.2	2.1	17.8	39.2	29.7	2.4
1,600	11.6	-	-	0.2	11.4	-
1,800	3.9	-	1.7	2.2	-	-
Total	3,437.5	337.7	316.9	831.0	1,275.6	676.4

Note) Record in 1997

According to this table, large part of pipe length is occupied by small diameter less than 350 mm. Major pipe material is steel, corresponding 66 % of the total length.

As to pipe age, the largest proportion is occupied by 20 to 30 years, followed by more than 30 years. This means that the pipe installation was most active in 1970's.

Table D.3.5.2 shows pipe length by diameter, pipe age and pipe materials namely steel and cast iron.

Steel pipe is adopted for small diameter pipes less than 75 mm and particularly in recent 10 years, only steel pipe is used for the said diameter.

During 1960's to 1980's, steel pipe and cast iron pipe are used for small and medium diameter pipe less than 300 mm but recently steel pipe is mainly used.

Pipes older than 50 years are still remaining in relative length and are made of steel and cast iron. Steel pipe has insufficient outer coating and no inner lining. It can be easily get rusted. In case of cast iron pipe, water might leak from spigot joints by water hammer. Thus, it can be said that water leakage might be incurred due to the structure of distribution pipes.

3.5.6 Operation and Maintenance ("O&M")

(1) Staff Allocation and O&M of Facilities

1) Allocation of O&M staff

Total Number of Vodokanal in Tashkent City is 4,500. Table 3.5.29 shows staff of O&M for water supply facilities allocation.

They are classified into Manager including technical chief, Technical staff consisting of plant/machine operator and Others. Number of night shift staff is also indicated.

Composition of engineer, educated in specific technical course and general staff is shown in this table, excluding manager.

As shown in the table, 1,695 staffs are allocated in WTPs. Adding 51 repair staff of Vodokanal, 1,746 staffs equivalent to 39 % of the total staff, are engaged in O&M of water supply system. They are managing WTPs, PSs, distribution pipelines and others in the City.

Table 3.5.29 Staff Arrangement for O & M

WTP Name	Total menber								Night workwer
	Manager	Operation	Machine	Electric	Repair	Laboratory	Others	Total	
Bozsu	6	40	2	18	12.5	16	77.5	172.0	8
Kadiriya	7	79	5	11	53.5	25	76	256.5	25
Kibrai	9	38	31	35	17	10.5	56	196.5	12
South	5	14	1	11	10	13.5	80	134.5	20
Sergeli	4	47	6	32.5	30	5	31	155.5	11
Karazov	18	443	7	58	56	0	56	638.0	10
Bectemir	3	61	2	43	25	0	8	142.0	4
Total	52	722	54	208.5	204	70	384.5	1695.0	90

WTP Name	Engineers						
	Operation	Machine	Electric	Repair	Laboratory	Others	Total
Bozsu	10	2	2	1	10	2	27
Kadiriya	14	5	3	2	9	3	36
Kibrai	15	4	3	2	4.50	6	34.5
South	10	1	2	1	3.5	2	19.5
Sergeli	20	3	3	5	2	8	41
Karazov	18	2	3	3	0	1	27
Bectemir	10	1	1	1	0	0	13
Total	97	18	17	15	29	22	198

WTP Name	Workers						
	Operation	Mechine	Electric	Repair	Laboratory	Others	Total
Bozsu	30	0	16	11.5	6	75.5	139
Kadiriya	65	0	8	51.5	16	73	213.5
Kibrai	23	27	32	15	6	50	183
South	4	0	9	9	10	78	110
Sergeli	27	3	29.5	25	3	23	110.5
Karazov	425	5	55	53	0	55	593
Bectemir	51	1	42	24	0	8	126
Total	625	36	191.5	189	41	362.5	1475

O&M staffs are divided into Manager, Electrician, Mechanic, Operator, Repair, Laboratory, Clerk, Others and so on. Cleaning and caretaker of fruit trees are classified as Others.

WTPs and PSs shall be operated 24 hrs and 90 staffs are working during the night. Compared to other WTPs, larger number of staffs are allocated to Sergeri, Kara-Su and Bektemir WTP and reason will be explained later.

2) Staff Allocation and O&M in Surface WTP

i) Boz-su WTP

172 staffs are assigned in Boz-su WTP together with 33 managers and engineers.

Large number of staff is assigned as plant operator and to laboratory and this is because of the operation of the plant. Since the water source of this plant is surface water and the plant operation is complicated compared with the plants applying groundwater. Mechanics are not allocated here but some of the plant operator will act as.

Large number is also assigned as others and they are supposed to do supporting works when necessary. Since the plant is located in aspect preservation area and has vast site area, large number of caretaker will be needed to keep the plant clean.

ii) Kadirya WTP

Kadirya WTP is the largest plant in the City and largest number of staff, 256.5 is assigned here. Number of manager and engineer is 43.

Just like in the case of Boz-su WTP, large part of staff is allocated to plant operation and laboratory but the number of operation and repair is especially large. Mechanics are not allocated here as well but some of the plant operator will act as.

3) Staff Allocation and O&M in Groundwater WTP

i) Kibray WTP

196.5 staffs are allocated in Kibray WTP and out of them, 43.5 are managers and engineers.

Large number of mechanics and electricians are assigned here to maintain 95 units of production wells scattered within vast site area of 986 ha. Most of plant operator of groundwater WTPs are related to chlorination facilities.

ii) South WTP

134.5 staffs are assigned in South WTP and 24.5 staffs are managers and engineers. This plant has the smallest number of staff.

Large number of staff is assigned to vehicle operation and this might be because of the site condition of the plant, divided into two sites. Further, large number of staff allocated in laboratory is characteristic of this plant and the number is greater than that of in Kibray and even in Sergeri WTP, where conducting water quality test for three WTPs including itself.

iii) Sergeri

This plant is undertaking the management of five (5) pumping stations and repair works for pipelines within Sergeri district and large scaled repair work in neighboring WTPs namely Kara-Su and Bektemir WTP. The laboratory is carrying out water quality test for Kara-Su and Bektemir WTP, including Sergeri itself. Thus, large number of technical staff is assigned here.

iv) Kara-Su

This plant is engaged in management of 87 booster pump stations in the City. Therefore, number of staff for WTP is less than 80 but that of for pumping station is the maximum. 23.5 staff is assigned in the largest pumping station, Mirzo-Uzbek and even in case of ordinary pump station, eight (8) staff are assigned each, two (2) staff by four (4) shifts.

v) Bektemir

WTP is divided into Bektemir and Vinokor. Staffs are also assigned respectively. WTP is operated by staffs less than 80 but another staffs are needed for pipe repair and installation in the City.

4) Staff Allocation and O&M in PS in the City

i) Mirzo Ulugbek PS

23.5 staffs assigned in Kara-Su WTP are maintaining Mirzo Ulugbek pump station. Large portion of staffs consists of operator, electrician and repair worker. Four (4) staffs are assigned in night shift.

ii) CVRU (Chilanzar) PS

CVRU (Chilanzar) pump station has current pump capacity of 7,200 cu.m/hr and reservoir capacity of 25,000 cu.m. Reservoir expansion work is on going. 39 staffs are allocated here including five (5) night shift staffs.

iii) Sergeri PS

Caretaker is dispatched from Sergeri WTP and 51 staffs are assigned for pump station operation.

iv) Others

In other small pump stations, eight (8) staffs consisting of operator, mechanics and electrician are assigned and are working by team in four (4) shifts.

(2) Water Volume Control

1) Water Distribution Volume of Each Water Source

Although differential pressure flow meters are installed in major distribution pipes in Tashkent City, most of them are malfunctioning. Distribution volume is supposed to be assumed based on past measurement data and pump operation data. Calculation results are shown in Table 3.4.30, as of 1998.

Annual average distribution volume is 2.465 thousands cu.m/day. Providing the city population is 2.26 million, per capita distribution volume is 1.09 cu.m/person/day, quite huge.

Water is supplied mainly by four (4) major WTPs namely Kadirya, Kibray, Boz-su and South WTP which distribute water volume corresponding to 62 %, 18 %, 10 % and 6 % of the total volume. So, 96 % of total volume is supplied by these WTP. Monthly consumption fluctuation ratio by maximum and minimum consumption is 2,845/2,286, = 1.24.

2) Operation of Boz-su

Figure 3.5.2 shows the flow sheet of Boz-su WTP.

Nominal capacity of Boz-su WTP is 235,600 cu.m/day and intake water right from Boz-su canal is 3.1cu.m/sec = 268,000 cu.m/day. While, excluding the stand-by units, intake pump capacity is 11,300 cu.m/hr=271,000 cu.m/day and equivalent to intake water right, distribution pump capacity is 15,200 cu.m/hr=364,800 cu.m/day, too large.

Table 3.5.30 Water Dstribution Volume of WTP in Tashkent City

x1000cu.m

Year	Month	1000cu.m	Boz-su	Kadirya	Kibray	South	Sergeri	Karazov	Bektemir	Total
1999	July	cu.m/month	8,387	43,747	12,412	4,818	1,739	1,094	727	72,924
		cu.m/day	270.548	1,411.194	400.387	155.419	56.097	35.290	23.452	2,352.387
	June	cu.m/month	8,124	41,141	11,222	4,667	1,683	1,059	704	68,600
		cu.m/day	270.800	1,371.367	374.067	155.567	56.100	35.300	23.467	2,286.667
	May	cu.m/month	7,772	44,792	12,431	4,050	980	961	727	71,713
		cu.m/day	250.710	1,444.903	401.000	130.645	31.613	31.000	23.452	2,313.323
	Apl.	cu.m/month	6,906	44,166	11,723	3,754	918	906	704	69,077
		cu.m/day	230.200	1,472.200	390.767	125.133	30.600	30.200	23.467	2,302.567
	Mar.	cu.m/month	7,151	46,483	12,514	3,981	948	778	727	72,582
		cu.m/day	230.677	1,499.452	403.677	128.419	30.581	25.097	23.452	2,341.355
	Feb.	cu.m/month	7,147	49,464	15,315	4,208	1,285	703	657	78,779
		cu.m/day	255.250	1,766.571	546.964	150.286	45.893	25.107	23.464	2,813.536
	Jan.	cu.m/month	7,913	55,644	17,067	4,655	1,423	778	727	88,207
		cu.m/day	255.258	1,794.968	550.548	150.161	45.903	25.097	23.452	2,845.387
1998	Dec.	cu.m/month	7,758	42,372	12,425	4,657	1,423	778	727	70,140
		cu.m/day	250.258	1,366.839	400.806	150.226	45.903	25.097	23.452	2,262.581
	Nov.	cu.m/month	7,515	41,755	13,527	4,210	918	753	704	69,382
		cu.m/day	250.500	1,391.833	450.900	140.333	30.600	25.100	23.467	2,312.733
	Oct.	cu.m/month	7,455	43,972	13,963	3,727	949	778	727	71,571
		cu.m/day	240.484	1,418.452	450.419	120.226	30.613	25.097	23.452	2,308.742
	Sep.	cu.m/month	7,560	46,645	15,077	4,664	1,683	906	704	77,239
		cu.m/day	252.000	1,554.833	502.567	155.467	56.100	30.200	23.467	2,574.633
	Aug.	cu.m/month	8,354	55,662	17,101	4,815	1,739	1,094	727	89,492
		cu.m/day	269.484	1,855.400	570.033	160.500	57.967	36.467	24.233	2,983.067
Total			92,042	555,843	164,777	52,206	15,688	10,588	8,562	899,706
			252.170	1,522.858	451.444	143.030	42.981	29.008	23.458	2,464.948
Rate(%) Ave.			7,670	46,320	13,731	4,351	1,307	882	714	74,976

In actual, monthly average distribution volume to the City is 270,000 cu.m/day in maximum and 230,000 cu.m/day in minimum. Considering this consumption volume, plant and pump capacity, treatment volume depends on intake pump capacity. Further, actual intake volume exceeds intake water right of Boz-su canal.

Filtered water is chlorinated, stored in reservoir and then supplied by distribution pump.

Pipeline from Kadiriya WTP and by-pass line is connected to the distribution pipeline. Water is served to the City by five (5) trunk mains with diameter of 1,200 mm, 1,000 mm and three (3) lines of 600 mm.

3) Operation of Kadirya WTP

Figure 3.5.3 shows the flow chart of Kadirya WTP.

Nominal plant capacity is 1,375,000 cu.m/day, equivalent to 60 % of total capacity of WTPs in the City, 2,261,000 cu.m/day. While actual distribution volume is ranging from 1.4 million cu.m/day to 1.8 million cu.m/day, exceeding nominal plant capacity. This means the plant is operated in overloaded condition.

Intake water right from Boz-su canal is 21.19 cu.m/sec=1,830,000 cu.m/day. Intake pump capacity excluding stand-by units is 68,800 cu.m/hr=1,651,200 cu.m/day and 69,000 cu.m/hr=1,656,000 cu.m/day in No.1 or No.2 intake pump station, respectively. Both of them are equivalent to intake right and are also exceeding the nominal plant capacity. Therefore, either of No.1 and No.2 pump stations can act as supplemental facility. In actual operation, No.1 is mainly operated and No.2 is used as filter back washing pump when the turbidity of raw water is low.

Treated water is distributed by gravity utilizing its higher elevation, 60 to 140 m higher than city center. Out of eight (8) distribution pumps, only one (1) unit is daily operated and others are used as filter back washing pump or as stand-by units.

There are six (6) gravity pipelines and one (1)of them is connected to Kibray WTP. Although most of the remaining water is supplied to the City, part of treated water is sent to areas in higher elevation by distribution pump. Pump capacity is 6,500 cu.m/hr = 156,000 cu.m/hr, corresponds about 1/10 of plant capacity.

4) Operation of Kibray WTP

Figure 3.5.4 presents the flow chart of Kibray WTP having 95 units of wells in both banks of Chirchik River.

Based on the pump capacity recorded in data of Vodokanal, well production is calculated as 37,223 cu.m/hr=917,352 cu.m/day, excluding stand-by units. However, comparing the actual output of similar type of pumps installed in other WTPs, actual pumping volume is assumed as 20,000 cu.m/hr=500,000 cu.m/day. Actual distribution volume of Kibray WTP is around 470,000 cu.m/day.

As aforementioned, treated water is also supplied from Kadirya WTP, 270,000 to 360,000cu.m/day, and thus total distribution volume of Kibray system is around 720,000 to 810,000 cu.m/day.

On the other hand, the pump capacity of No.1 distribution pump station, where pipeline from Kadirya WTP is connected is just 11,300 cu.m/hr=271,200 cu.m/day, only equivalent to supplied water volume from Kadirya WTP. However, groundwater is also inflows into this pump station, part of supplied water from Kadirya WTP is assumed to be served to the City directly without passing through this pump station.

Adding pump capacity of Vremennaya distribution pump station, 13,900 cu.m/hr=333,600 cu.m/day, total capacity is 24,200 cu.m/hr=604,800 cu.m/day. Since the distribution volume from Kibray system is around 720,000 to 810,000 cu.m/day, directly distributed volume by gravity, without passing through the pump stations in Kibray system is assumed as (720~810−605=115~205)thousands cu.m/day.

Same as Chirchik City, On-Off operation of pumps is done by manual in Tashkent City. In case of Kibray WTP, it has reservoirs with small capacity of 10,000 cu.m and retention time against the nominal plant capacity of 455,200 cu.m/day is only 0.5 hr. In such case, reservoir shall be kept full by regulating pump operation against the incoming groundwater from wells. From the viewpoint of efficient operation and water source preservation, automatic On-Off operation shall be introduced.

5) Operation of South WTP

South WTP is supplying water mainly to Zilanzar and Sergeri districts. Though its nominal plant capacity is 113,200 cu.m/day, actual supply volume is around 130,000 to 155,000 cu.m/day, exceeding the said plant capacity. Flow chart of this plant is shown in Figure 3.5.5.

Sergeri district is served directly by well pumps, while other areas are served by distribution pump withdrawing stored groundwater in reservoir located in First Area.

Providing the distribution volume to Sergeri district is 12,000 cu.m/day as shown in Figure 3.5., remaining volume is around 120,000 to 140,000 cu.m/day and the retention time of reservoir is around 2.0 to 1.7 hr.

Compared with other reservoirs, it has relatively large capacity but still insufficient for stable water supply. Noteworthy point is that water level indicator is still operational. Every one (1) m, water level inside of the reservoir is indicated by lighting of lamps and operator control pumps according to the water level. It supposed that same indicators have been installed in other reservoirs but all are malfunctioning.

6) Operation of Sergeri WTP

Nominal plant capacity of Sergeri WTP is 40,000 cu.m/day. Total well pump capacity except for stand-by units is 37,000 cu.m/day, while that of distribution pump is 46,800 cu.m/day. Flow chart is shown in Figure 3.5.6. When water level of reservoir is lowered, treated water is supplied from Kibray WTP.

Actual distribution volume from Sergeri WTP is ranging widely from 30,000 to 55,000 cu.m/day, exceeding total well pump capacity. This volume gap is supposed to be covered by Kibray.

7) Operation of Kara-Su WTP

The nominal plant capacity of Kara-Su WTP is 52,000 cu.m/day. Only four (4) wells are situated within the site of WTP and other eight (8) wells including stand-by units are scattered in surrounding areas. Flow chart is shown in Figure 3.5.7.

Biggest characteristic of this plant is that it has no reservoir, distribution pump and groundwater is served to the City directly by intake pumps. Total intake pump capacity is 2,560 cu.m/hr= 61,440 cu.m/day, almost corresponding to the plant capacity.

However, actual distribution volume Is around 25,000 to 35,000 cu.m/day, less than plant nominal capacity and is contrastive to the other WTPs which distribute water volume exceeding their plant capacity. This is because of the well operation. Wells are scattered in plant site and in the City and groundwater disinfection is done by Hypochloline resolution injection in every well. In this connection, intake pumps can not be operated by their full capacity.

8) Operation of Bektemir WTP

Nominal plant capacity of Kara-Su WTP is 25,000 cu.m/day and its facilities are divided into two (2) areas. There are four (4) wells, two (2) units out of them are stand-by, within the site of Bektemir WTP. There is one more well located in the area crossing the road, which is pumping/supplying groundwater to reservoir in the plant site. In Vinokor district, there are six (6) wells, including one (1) stand-by unit. Two (2) reservoirs are constructed and distribution pumps are installed in each of them. Flow Chart is shown in Figure 3.5.8. While, Vinokor district has six (6) wells including one (1) stand-by unit and two (2) reservoirs. Distribution pumps are installed in each reservoir.

As to distribution pump capacity, that of Bektemir WTP has larger capacity occupying 1,020 cu.m/hr=24,480 cu.m/day out of the total capacity of 1,530cu.m/hr=36,720 cu.m/day. Total intake pump capacity is 1,280 cu.m/hr=30,720 cu.m/day.

In addition, there is a small booster pump having capacity of 60 cu.m/hr in another site and belongs to Bektemir WTP. Actual distribution volume is around 23,500 cu.m/day throughout a year.

9) Operation of Booster PS

Basically booster pump stations are used to "boost" in-pipe water pressure. Pump stations without reservoirs are operated when incoming water pressure fall down to certain level, disre-

garding volume control.

Retention time of reservoir against pump capacity in booster pump station with reservoir, namely Mirzo Ulugbek, CVRU(Chilanzar), Sergeri pump stations is as follows :

Table 3.5.31 Retention Time of Pump Station

PS Name	Capacity	Reservoir Volume(cu.m)	Retention time(hr)
Sergeli- 3/5	3,000	12,000	4.00
CVRU(Chranzar)	7,200	25,000	3.47
Mirzo-Uzbek	30,000	25,000	0.83

In combination of reservoir and pump, there's volume fluctuation between incoming volume to reservoir and pump distribution volume. Therefore, certain retention time is needed to regulate this fluctuation. In case of auto On-Off pump operation by water level, the minimum retention time shall be 10 minutes to prevent idle pump running. While in case of manual On-Off operation, the minimum retention time shall be more than 30 minutes. Therefore, reservoirs with retention time of less than 30 minutes, can not play their original role of "Volume Control". Accordingly, reservoir of Mirzo Ulugbek pump station can not act as "volume control reservoir". On the contrary, reservoirs in Sergeri and CVRU pump stations can contribute for the stable water supply by their sufficient storage volume with retention time more than three (3) hours.

(3) Water Quality Control

Water quality control is one of the most important elements in water supply, as well as water volume control. Particularly in surface water WTP, water quality can be controlled by plant operation. However, this also means water with inferior quality might be distributed by inappropriate control. Tashkent City has two (2) surface water WTP, namely Boz-su WTP and Kadirya WTP. In case of groundwater, only chlorine injection can be controlled.

Important things are i) water quality control, ii) water quality analysis and iii) assessment on analysis results. By assessment on water quality analysis, existing water quality control methods shall be altered or improved if necessary. Details are described as follows :

1) Water Quality Control

Water quality control in surface water WTP is conducted as follows :

i) When turbidity of raw water is around 15～25 mg/L, coagulation is not practiced. Raw water flows through flocculation Chamber and sedimentation tank, then pumped to rapid filter. Chlorine is injected to filtered water at inlet of reservoir or at upper end of distribution pipe.

ii) When the turbidity is constantly above the said figure, 5 % solution of solid alum, $Al_3(SO_4)_2$-H_2O is injected at inlet of flocculation chamber. Pre-chlorination is conducted in intake pumps if needed.

iii) Chemical dosing ratio is determined by water quality test that is performed every hour or every three hours.

In case of groundwater WTP, proper chlorine dosing is only quality control. Necessary countermeasure shall be taken when defect is identified by daily or monthly water quality test but it might be difficult.

2) Water Quality Analysis

i) National Standards for Drinking Water

Although high technology equipment such as atomic absorption photometer or gas chromatography are not introduced, careful measurement is performed by epidemic and chemical methods. Sampling points and analysis indices are roughly fixed by the national standards and each cities/towns/water treatment plant are planning their own detailed contents.

Analysis indices and national standard for drinking water are shown in Tables 3.5.32(1) to 4.5.32 (4).

Table 3.5.32 (1) Remnant Chlorine Content

Name of index	Norm	Test method
Remnant chlorine	Concentration of remnant chlorine, mg/l	Necessary contact time for chlorine with water, min., not less than
1. Loose	0.3-0.5	30
2. Binded	0.8-12	60

Table 3.5.32 (2) Microbiological Index

Name of index	Norm	Test method
Microorganizms number in 1 cu.ml.water, not more than	100	Under GOST-18963-73
Number of bacteriums intestinal bacills group in 1 l. Of water (koli-index) no more than		Under GOST 18963-73

Table 3.5.32(3) Chemical Substances Concentration

Name of index	Norm	Test method
Remnant aluminium (Al), mg/l, no more than	0.5	Under GOST 18165-81
Beryllium (Be), mg/l, no more than	0. 0002	Under GOST 18294-81
Molybdenum (Mo). Mg/l, no more than	0.25	Under GOST 18308-72M
Arsenic (As), mg/l, no more than	0.05	Under GOST 4152-81
Nitrates (NO3), mg/l, no more than	45.0	Under GOST 18826-73
Polyacryalamid remnant, mg/l, no more than	2.0	Under GOST 19355-74
Lead (Pb), mg/l, no more than	0.03	GOST 19355-74
Selen (Se), mg/l, no more than	0.001	GOST 19413-81
Strontium (Sr), mg/l, no More, than	7.0	GOST 23950-80-
Fluoride (F0, mg/l, no more for climati-cal regions		
I and II-zones	1.5	
III-zone	1.2	
IV-zone	0.7	

Table 3.5.32 (4) Organpoleptical index

Name of index	Norm	Test method
Smell at 20 ℃ and at heating till 60 ℃, grades, no more than	2	GOST 3351-74
Taste and smack at 20 ℃, grades, no more than	2	GOST 3351-74
Color, degrees, no more	20	GOST 3351-74
Turbidity(Muddness), by standard scale, mg/l, no more than	1.5	GOST 3351-74

ii) Water Quality Tests in Boz-su WTP

In case of surface water WTP, water quality test is conducted on analysis indices tabulated in Table 3.5.33, sampling frequency and sampling points are planned by each WTPs.

In Boz-su WTP, sampling points are four, as shown below.

Table 3.5.33 Analysis indices in surface water WTP

No.	Item	No.	Item	No.	Item
1	Temperature	11	Nitrite	22	Polyphosphates
2	Color	12	Nitrate	23	Zinc
3	Taste	13	Chloride	24	Lead
4	Odor	14	Sulfate	25	Arsenic
5	Turbidity	15	Fluorine	26	Manganese
6	PH	16	Iron	27	BOD
7	Residual chlorine	17	Solid total dissolved	28	Dissolved oxygen
8	Aluminum rest	18	Colonies quantity	29	SAS
9	Hardness	19	Coli- index	30	Radiation
10	Alkalinity	20	Copper	31	Transparency
11	Ammonia	21	Molybdenum		

a) Water sources

b) After Sedimentation

c) After Filtration

d) Distribution Pipeline

Most important points are c) and d). At point c), turbidity of filtered water is measures, while at point d), residual chlorine is measured.

Sampling points and analysis indices by sampling frequency are as follows :

i) Hourly : At point c), turbidity of filtered water. At point d), resudual chlorine.

ii) 1 to 3 times/day : At point a), b) and d) ; Temperature, turbidity, odor, taste, color, pH, ammonia, nitrite, nitrate, alkalinity. At point b) and d), Coli-index.

iii) Monthly : At point a) ,b) and d) ; Out of Hardness, Chloride, Sulfate, Fluorine, Iron, Solid total dissolved, Colonies quantity, Copper, Molybdenum, Polyphosphates, Zinc, Arsenic, Manganese, BOD, Dissolved oxygen, SAS, Radiation, Transparency, the following indices are omitted in each points ;

a) Radiation

b) BOD, Dissolved oxygen, SAS, Radiation, Transparency

c) BOD, Dissolved oxygen, SAS, Transparency

iii) Water Quality Tests in Kadirya WTP

Sampling points are same to Boz-su WTP. As to point c), filtered water is taken only in conjunction point instead of each filter outlet channels and as to point d), water is sampled from eight (8) distribution mains.

Sampling points and analysis indices by sampling frequency are as follows :

i) Hourly : As to point c), Temperature and Turbidity. As to point d), Residual chlorine.

ii) 2 times/day : At points a), b) and d) ; Temperature, Turbidity, Odor, Taste, Color, pH, Ammonia, Nitrite, Nitrate, Alkalinity, Chloride, Hardness. At point b) and d) ; Coli-index.

iii) Monthly : At point a), b) and d) ; Out of Hardness, Chloride, Sulfate, Fluorine, Iron, Solid total dissolved, Colonies quantity, Copper, Molybdenum, Polyphosphates, Zinc, Arsenic, Manganesum, BOD, Dissolved oxygen, SAS, Radiation, the following indices are omitted at each points ;

a) Radiation,

b) BOD, Dissolved oxygen, SAS

c) BOD, Dissolved oxygen, SAS, Radiation

iv) Water Quality Tests in Kibray WTP

In case of groundwater, water quality shall be monitored at distribution facilities, namely distribution mains. Analysis indices are shown in Table 3.5.34.

Analysis indices by sampling frequency are as follows :

i) Hourly : Residual chlorine

ii) Daily : Temperature, Coli-index

iii) Monthly : Turbidity, Odor, Taste, Color, pH, Ammonia, Nitrite, Nitrate, Alkalinity, Chloride, Hardness, Chloride, Colonies quantity, Sulfate, Fluorine, Iron, Solid total dissolved, Radiation

iv) 2 times/year : Copper, Molybdenum, Polyphosphates, Zinc, Arsenic, Manganese, Chrome

Table 3.5.34 Analysis Indices in groundwater WTP

No.	Item	No.	Item	No.	Item
1	Temperature	11	Nitrite	21	Molibdenium
2	Colour	12	Nitrate	22	Polyphosphates
3	Taste	13	Chloride	23	Zinc
4	Odour	14	Sulfate	24	Lead
5	Turbidity	15	Fluorine	25	Arsenic
6	PH	16	Iron	26	Manganesum
7	Chlorine rest	17	Solid total dissolved	27	Chrome
8	Hardness	18	Colonies quantity	28	Radiation
9	Alkalinity	19	Coli- index		
10	Ammonia	20	Copper		

v) Water Quality Tests in South, Sergeri, Kara-Su and Bektemir WTPs

In South, Sergeri, Kara-Su and Bektemir WTPs, water sampling is conducted in distribution mains. Analysis indices by sampling frequency are as follows :

i) Hourly : Residual chlorine

ii) Daily : Temperature, Coli-index

iii) Monthly : Turbidity, Odor, Taste, Color, pH, Ammonia, Nitrite, Nitrate, Alkalinity, Chloride, Hardness, Chloride, Colonies quantity, Sulfate, Fluorine, Iron, Solid total dissolved, Radiation

iv) 2 times/year : Copper, Molybdenum, Polyphosphates, Zinc, Arsenic, Manganese, Chrome

3) Assessment on Analysis Results

i) Water Quality Analysis Results of Surface Water WTP

As to Boz-su WTP, water quality analysis conducted at Boz-su canal, sedimentation basin outlet, distribution pipelines, of 1998 are presented in Tables D.3.5.3 (1), (2) and (3).

Reportedly, the maximum turbidity in Boz-su canal sometime exceeds 10,000 mg/L but as shown in Table D.3.5.3 (3), actual annual average turbidity is not so high, 37mg/L. Higher turbidity, more than 100 mg/L, is also recorded during Spring season from March to May.

By coagulation, turbidity at outlet of sedimentation basin deceased to 25 mg/L, however, compared with Japanese operational standard, 2 mg/L at outlet of coagulation basin, this figure is extremely high. Further, when turbidity of raw water is low, coagulation is skipped. But, even turbidity of treated water from sedimentation basin is around 25 to 10mg/L, that of filtered water is less than the national standards, 1.5 mg/L. This means that filter is heavily loaded but filter is properly operated by daily back washing during the night.
Although pH and turbidity of treated water is higher than Japanese ordinary drinking water quality, Iron and manganese is lower. Quality is good.

In Table D.3.5.3 (4), water quality of distributed water from Kadirya WTP is presented. Since Kadirya WTP is withdrawing raw water from Boz-su canal, same as Boz-su WTP, raw water quality is omitted. Quality of treated water of Kadirya WTP is good as Boz-su WTP. Higher pH owes to geological condition of water source, chatchment area of Charvak Dam Lake, which consists of limestone. Constantly low water temperature is another characteristic of this raw water.

ii) Water Quality Tests in Groundwater WTP

Tables D.3.5.3 (5) and (6) shows water quality of genuine groundwater of Kibray WTP and mixture of its groundwater and treated water from Kadirya WTP, respectivery. While Tables D.3.5.3 (7), (8), (9) and (10) present water quality of treated water from South, Sergeri, Kara-Su and Baktemir WTPs as of 1998.

As these groundwater contains few Iron and Manganese, they look quite clarified. Only treated water from South WTP does not comply with national standard in terms of Hardness, 7 mg/L. As a whole, solvent concentration is higher and this incurred higher Hardness and Nitrite, Nitrate concentration. There are few differences between groundwater quality in the City but that of in Kibray and Bektemir WTP have lower solvent concentration.

(4) Cost of O&M

1) Electricity

Annual power consumption plan and actual consumption up to the month of June for WTPs in Tashkent City in 1999 is shown in Table 3.5.35 and water distribution volume of January to July is volume in 1999, to August to December is it in 1998. As the plan is almost corresponding to actual consumption, annual power consumption can be estimated as 277 million kwh.

Compared WTPs' power consumption against their water distribution volume, power consumption in Sergeri, Kara-Su and Bektemir WTPs is outstanding. This is because the power consumption in 92 booster pump stations is added to Kara-Su and Sergeri WTPs. Providing the power consumption of these three (3) WTPs is 0.55kwh/cu.m, based on the actual power consumption in South WTP, six (6) months' power consumption by booster pump station can be calculated as below ;

84.828 − 34.838 × 0.55 = 65.667 million kwh

This is equivalent to 65.667/277.565 × 100 = 23.7% of total power consumption of water supply system in the City.

In general, power consumption per distributed water volume is small in surface water WTP, on the contrary, is large in groundwater WTP.

Whole average power consumption per distributed water volume is around 0.3 kwh/cu.m, relatively small. This is because that of Kadriya WTP, the largest WTP in the City, is far smaller ; 0.132 kwh/cu.m, which contributed lowering the figure.

Based on unit electricity of 2.9 sum/kwh, total annual cost is as follows :

277.565 million kwh × 2.9 sum/kwh = 804.938 million sum

As shown in Table 3.5.35, annual average power consumption per unit distribution volume is 0.309 kwh/cu.m, so annual electricity is as follows :

0.309kwh/cu.m × 2.9sum/kwh = 0.90sum/cu.m

Table 3.5.35 Water Distribution Volume and Electricity Consumption

Month	Kadirya			Bos-Su			Kibrai			South			Sergeli,Bectemir,Karazov			Total		
	Distribution volume:Q	Electricity		Distribution volume:Q	Electricity		Distribution volume:Q	Electricity		Distribution volume:Q	Electricity		Distribution volume:Q	Electricity		Distribution volume:Q	Electricity	
		Plan	Real		Plan	Real		Plan	Real		Plan	Real		Plan	Real		Plan	Real
Jan.	55,644	5,900	6,061	7,913	2,000	2,230	17,067	5,256	5,688	4,655	2,400	2,450	2,938	7,312	6,455	88,217	22,868	22,884
Feb.	49,464	5,656	5,650	7,147	1,900	1,905	15,315	5,000	4,978	4,208	2,350	2,223	2,645	6,529	6,660	78,779	21,435	21,416
Mar.	46,483	5,800	5,795	7,151	2,000	2,322	12,514	5,200	5,426	3,981	2,400	2,367	2,453	6,774	6,463	72,582	22,174	22,373
April	44,166	5,850	5,875	6,906	1,900	1,909	11,723	5,300	5,805	3,754	2,300	2,299	2,528	6,751	5,957	69,077	22,101	21,845
May	44,792	5,880	6,224	7,772	2,000	1,997	12,431	5,200	5,445	4,050	2,350	2,282	2,668	6,852	6,401	71,713	22,282	22,349
June	41,141	6,100	6,074	8,124	2,250	2,230	11,222	5,800	5,867	4,667	2,350	2,340	3,446	7,194	6,955	68,600	23,694	23,466
Total	281,690	35,186	35,679	45,013	12,050	12,593	80,272	31,756	33,209	25,315	14,150	13,961	16,678	41,411	38,891	448,968	134,553	134,333
Kwh/cu.m		0.125	0.127		0.268	0.280		0.396	0.414		0.559	0.551		2.483	2.332		0.300	0.299
July	43,747	7,450		8,387	2,450		12,412	6,400		4,818	2,600		3,560	7,525		72,924	26,425	
Aug.	55,662	6,950		8,354	2,450		17,101	6,000		4,815	2,400		3,560	7,395		89,492	25,195	
Sep.	46,645	5,850		7,560	2,200		15,077	5,800		4,664	2,350		3,293	7,260		77,239	23,460	
Oct.	43,972	6,050		7,455	2,100		13,963	5,300		3,727	2,200		2,454	6,970		71,571	22,620	
Nov.	41,755	5,750		7,515	2,150		13,527	5,250		4,210	2,150		2,375	7,149		69,382	22,449	
Dec.	42,372	5,900		7,758	2,300		12,425	5,300		4,657	2,250		2,928	7,113		70,140	22,863	
Total	274,153	37,950		47,029	13,650		84,505	34,050		26,891	13,950		18,170	43,412		450,748	143,012	
Kwh/cu.m		0.138			0.290			0.403			0.519			2.389			0.317	
Total	555,843	73,136		92,042	25,700		164,777	65,806		52,206	28,100		34,848	84,823		899,716	277,565	
Kwh/cu.m		0.132	0.000		0.279	0.000		0.399	0.000		0.538	0.000		2.434	0.000		0.309	0.000

2) Chemical

Table 3.5.36 shows annual distribution volume and chemical consumption by WTPs. As to distribution volume, figures from January to July were taken from actual operation record of 1999, while figures from August to December were taken from 1998. Chemical consumption from January to June were derived from 1999's record and consumption from July to December were estimated based on the past records.

Boz-su and Kadirya WTPa are using alum as coagulant. While Boz-su WTP is using domestic product, Kadirya WTP is adopting high quality products imported from Kazakhstan. Chemical dosing rate in Boz-su WTP is far lager and unit price of coagulant used in Kadirya is higher.

Based on the table, annual chemical cost is 55.582 million sum which corresponds to 6.9 % of annual electricity of 804.938 million sum.

Chemical cost per unit distribution volume is as follows :

55.582/899.714 = 0.06sum/cu.m

Chemical and Electricity consumption is shown in Table3.5.37.

3) Repair and Improvement Cost

Facility repair and improvement cost on 1999 is presented in Table 3.4.38.

Table 3.5.36 Facility Repair and Improvement Plan

Item	Number	Cost(1,000sum)	
		in 1991	in 1999
Repair and Reinstalling of Water pipe line	216	199.3	9,230
Repair of Buildings and These equipment	461	275.7	28,296
Repair of Facilities	252	200.3	18,526
Installation of Meters	10	9.9	588
Improvement of Facilities	14	14.4	554
Plan and design	89	20.4	516
Total		720	57,710

Based on the total annual cost of 57.710 million sum, repair and improvement cost per unit distribution volume is calculated as follows :

57.710/899.714 = 0.06sum/cu.m

Table 3.5.37 Consumption of Chemical

	Kadirya			Boz-su			Kibray		South		Sergeri,Karazov, Bektemir		Total			
Month	Distribution volume:Q (1000	Liquid Chlorine tons	Sulphuric Aluminium tons	Distribution Volume:Q (1000	Liquid Chlorine tons	Sulphuric Aluminium tons	Distribution Volume:Q (1000	Liquid Chlorine tons	Distribution Volume:Q (1000	Liquid Chlorine tons	Distribution Volume:Q (1000	Liquid Chlorine tons	Distribution Volume:Q (1000	Liquid Chlorine tons	Sulphuric Aluminium tons	Total 1000sum
Jan.	55,644	33.5	69.7	7,913	5.3	67.3	17,067	1.9	4,655	1.0	2,938	0.92	88,217	42.57	137.0	
Feb.	49,464	10.4	76.9	7,147	4.3	82.0	15,315	2.0	4,208	0.9	2,645	0.98	78,779	18.57	158.9	
Mar.	46,483	19.9	149.2	7,151	6.8	110.2	12,514	3.9	3,981	1.0	2,453	0.97	72,582	32.57	259.4	
Apr.	44,166	26.7	213.9	6,906	5.8	139.3	11,723	3.9	3,754	0.9	2,528	0.97	69,077	38.26	353.2	
May	44,792	25.1	271.1	7,772	5.8	139.3	12,431	4.8	4,050	1.0	2,668	0.93	71,713	37.59	410.4	
June	41,141	28.9	179.8	8,124	6.6	153.0	11,222	5.6	4,667	1.0	3,446	0.93	68,600	42.96	332.8	
Total	281,690	144.5	960.6	45,013	34.6	691.1	80,272	22.0	25,315	5.7	16,678	5.70	448,968	212.52	1,651.7	
Cost(1000sum)		6,901	14,515		1,582	5,847		989		262		263		9,997	20,361	30,358
July	43,747	48.6	321.5	8,387	5.8	77.7	12,412	4.58	4,818	0.95	3,560	0.95	72,924	60.88	321.5	
Aug.	55,662	47.6	176.8	8,354	7.4	45.2	17,101	6.8	4,815	0.95	3,560	0.95	89,492	63.7	176.8	
Sep.	46,645	48.3	0	7,560	7.3	33.7	15,077	4.62	4,664	0.95	3,293	0.95	77,239	62.12	0	
Oct.	43,972	33.5	0	7,455	3.9	35	13,963	4.7	3,727	0.95	2,454	0.95	71,571	44	0	
Nov.	41,755	26.6	0	7,515	6	30	13,527	4.82	4,210	0.97	2,375	1.00	69,382	39.39	0	
Dec.	42,372	24.8	88.5	7,758	5.4	5	12,425	3.87	4,657	0.96	2,928	0.92	70,140	35.95	88.5	
Total	274,153	229.4	586.8	47,029	35.8	226.6	84,505	29.39	26,891	5.73	18,170	5.72	450,748	306.04	586.8	
Cost(1000sum)		10,956	8,867		1,637	1,917		1,318		264		264		14,440	10,784	25,223
Total	555,843	373.9	1,547.4	92,042	70.4	917.7	164,777	51.4	52,206	11.4	34,848	11.4	899,716	518.6	2,239	
Total Cost(1000sur		17,857	23,381		3,219	7,764		2,307		526		527		24,437	31,145	55,582
pouring rate(mg/L)		0.67	2.78		0.76	9.97		0.31		0.22		0.33		0.58	---	

Table 3.5.38 **Cost for Coagulant and Electricity**

Item	Distribution	Chlo-rine		Alum		Electricity		Total	Cost
Unit Cos	Volume	47,100Sum/Ton		13,910Sum/Ton		2,900Sum/1000kwh			
Unit	Cu.m/month	Ton	1000Sum	Ton	1000Sum	1000kwh	1000Sum	1000Sum	Sum/cu.m
Jan.	88,217	42.57	2,005	137.0	1,906	22,884	66,364	70,274	0.80
Feb.	78,779	18.57	875	158.9	2,210	21,416	62,106	65,191	0.83
Mar.	72,582	32.57	1,534	259.4	3,608	22,373	64,882	70,024	0.96
April	67,077	38.26	1,802	353.2	4,913	21,845	63,351	70,066	1.04
May	71,713	37.59	1,770	410.4	5,709	22,349	64,812	72,291	1.01
June	68,600	42.96	2,023	332.8	4,629	23,466	68,051	74,704	1.09
July	72,924	60.88	2,867	321.5	4,472	26,425	76,633	83,972	1.15
Aug.	89,492	63.70	3,000	176.8	2,459	25,195	73,066	78,525	0.88
Sep.	77,239	62.12	2,926	0.0	0	23,460	68,034	70,960	0.92
Oct.	71,571	44.00	2,072	0.0	0	22,620	65,598	67,670	0.95
Nov.	69,382	39.39	1,855	0.0	0	22,449	65,102	66,957	0.97
Dec.	70,140	35.95	1,693	88.5	1,231	22,863	66,303	69,227	0.99
Total	897,716	518.56	24,424	2,238.5	31,138	277,345	804,301	859,862	0.96
Ave.	74,810	43.21	2,035	186.5	2,595	23,112	67,025	71,655	0.96

4) Total Operational Cost

Total operation cost of WTP is calculated below :

Electricity	804.938 million sum
Chemical cost	55.582 million Sum
Repair cost	57.710 million Sum
Total	918.230 million Sum

Total operation cost per unit distribution cost is :

918.230 million sum／899.716cu.m＝1.2 Sum/cu.m

Therefore, certain retention time is needed to regulate this fluctuation.