JAPAN INTERNATIONAL COOPERATION AGENCY

MINISTRY OF PUBLIC UTILITIES
STATE COMMITTEE OF UZBEKISTAN FOR NATURE PROTECTION
REPUBLIC OF UZBEKISTAN

THE STUDY ON WATER SUPPLY SYSTEM IN SIX CITIES OF THE ARAL SEA REGION IN UZBEKISTAN

FINAL REPORT

(SUMMARY)

DECEMBER 1996

TOKYO ENGINEERING CONSULTANTS CO., LTD
IN ASSOCIATION WITH
KYOWA ENGINEERING CONSULTANTS CO., LTD.

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PREFACE

In response to the request from the Government of the Republic of Uzbekistan, the Government of Japan decided to conduct the Study on the Water Supply System in six cities of Aral Sea Region and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Uzbekistan a study team headed by Mr. Hidetoshi HAGA, Tokyo Engineering Consultants Co., Ltd. in association with Kyowa Engineering Consultants Co., Ltd., 7 times between September 1994 to October 1996.

The team held discussions with the officials concerned of the Government of Uzbekistan, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Uzbekistan for their close cooperation extended to the team.

December, 1996

Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY
ON
WATER SUPPLY SYSTEM IN SIX CITIES
OF
THE ARAL SEA REGION IN UZBEKISTAN

DECEMBER, 1996

Mr. Kimio FUJITA
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit you the final report entitled "THE STUDY ON WATER SUPPLY SYSTEM IN SIX CITIES OF THE ARAL SEA REGION IN UZBEKISTAN".

This report has been prepared by the Study Team in accordance with the contracts signed on August 1994, May 1995 and May 1996 between the Japan International Cooperation Agency (JICA) and the Joint Venture of Tokyo Engineering Consultants and Kyowa Engineering Consultants.

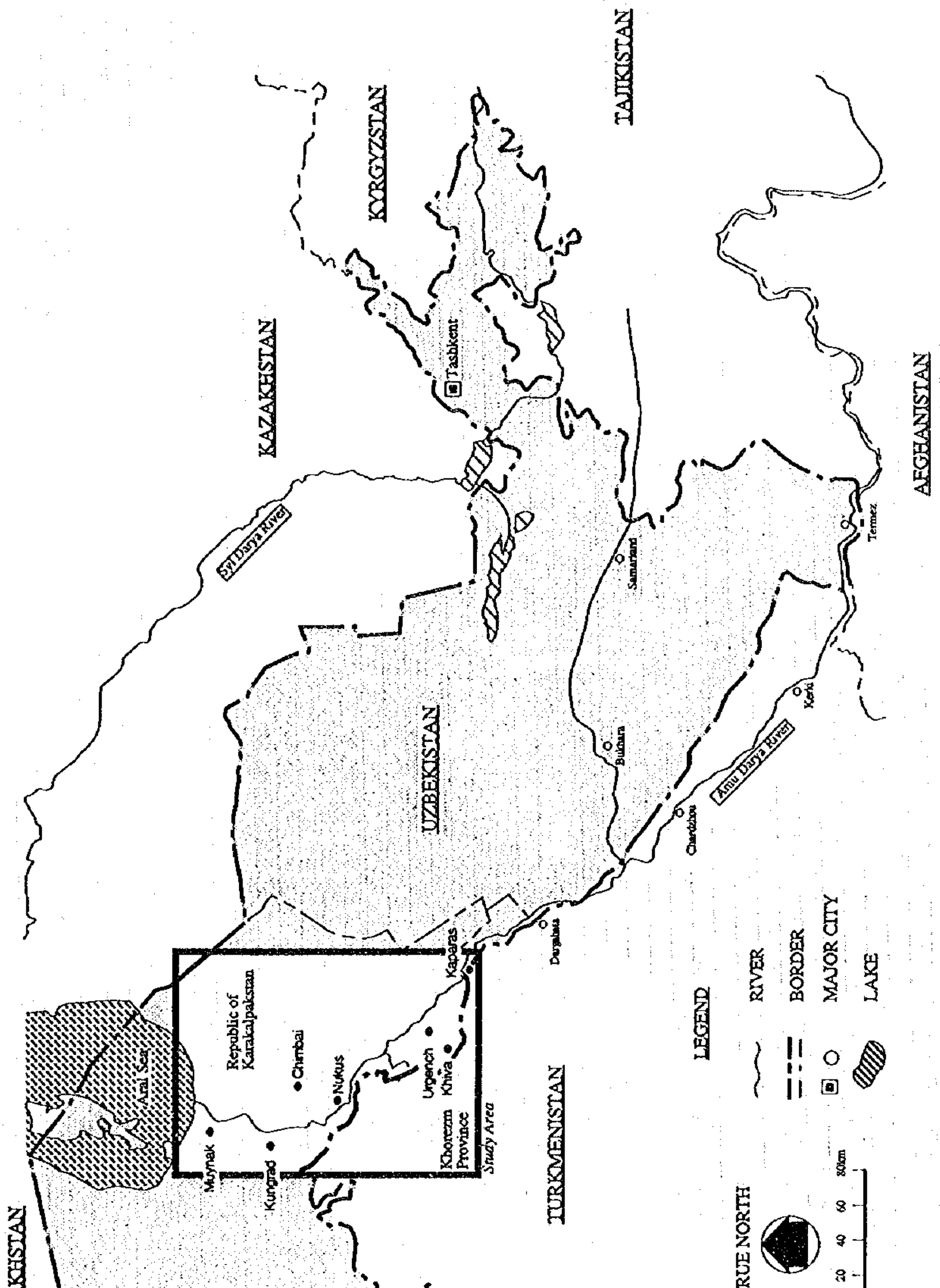
The report consists of the Main Report, Summary Report, Supporting Report and Data Book. The Main Report contains the results of survey, analysis and explains about Basic Plan and Feasibility Study. The Summary Report summarizes the results of all studies. The Supporting Report includes data, details of investigations and analysis. The Data Book contains the results of water quality analysis by the JICA Study Team and Uzbeki counterpart.

All member of the Study Team wish to express grateful acknowledgment to the personnel of your Agency, Advisory Committee, Ministry of Foreign Affairs, Ministry of Health and Welfare and Embassy of Japan in Uzbekistan, and also to the officials of the Government of Uzbekistan for all assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of health and sanitary conditions of people in the Aral Sea Region in Uzbekistan.

Yours faithfully,

芳賀秀寿

Hidetoshi HAGA
Team Leader



Location Map of Study Area

EXECUTIVE SUMMARY

1. Introduction

The Aral Sea region of the Republic of Uzbekistan (ROU), the Study area, is located in the autonomous Republic of Karakalpakstan and Khorezm Province, and in the downstream part of the Amu Darya river. The problems faced by the water supply system in this region are degradation of drinking water quality due to deterioration of quality of the water sources and inability to raise funds to cover maintenance and operation costs because of the low water tariffs. Particularly, the degradation of water quality in the water sources has resulted in adverse effects on the health of the inhabitants. In view of this background, the Study focused on improvements to the quality of drinking water.

2. Existing Water Supply System

Karakalpakstan and Khorezm have the Tuyamuyun-Nukus (T-N) and the Tuyamuyun-Urgench (T-U) inter-regional water supply systems respectively. Regional water supply corporations, Vodokanal (urban water supply) and Agro-Vodokanal (rural water supply), are currently supplying water directly to the residents of these areas by purchasing treated water from the inter-regional water supply systems and adding treated water produced by themselves. The inter-regional water supply systems currently produce about 60% of the total water supply.

3. Measures to Improve the Water Quality

Water supply sources for the Study area are mainly surface water derived from the Amu Darya river and underground water. The degradation of water sources is attributed to the inflow of irrigation waste water containing high concentration of salinity from the large agricultural land. The main problem in water quality is that the evaporated residue (mineralization) and the total hardness do not satisfy the drinking water quality standards. To solve these problems, the Study Team prepared and analyzed alternative plans for improving the water quality. As a result, it is proposed that water should be stored in the Kaparas reservoir during the period when the quality of Amu Darya river water is good and that water should be treated at Tuyamuyun water treatment plant.

4. Basic Water Supply Plan

Based on these measures for improving the water quality, a basic water supply plan with 2010 as the target year was formulated. The Kaparas reservoir will become the main water supply source. The treatment plants in the existing T-N and T-U inter-regional water supply systems will be extended. A part of the regional water treatment plants will also be used. The existing T-N transmission system and the T-U transmission system will be extended and used as trunk transmission pipeline systems. Aged distribution pipelines will be renewed for reducing leakage and new pipelines will be laid for increasing the population served. Water meters will be installed for all resident users for achieving effective utilization of water.

5. Revising the Project

The results of the project assessment showed implementing the entire project would be very difficult due to enormous construction cost. Therefor, the scale of the project was cut down by taking two measures: utilization of the existing transmission pipeline of the Urgench Transgas and cutting down the expansion plan of the water treatment plants. The total construction cost for the rescheduled project was estimated as 603 million US dollars, out of which the construction cost for the first priority project with the target year of 2002 was estimated as 278 million US dollars. A feasibility study was carried out for the rescheduled project. Details of the project and the proposed water supply system are shown in the attached figures.

6. Total Served Population, Demand and Supply

The percentage of population served in the urban area will increase from 76% (Karakalpakstan) and 87% (Khorezm) in 1995 to 100% by the year 2010 for both regions. The served population in the urban area will increase from 502,000 persons and 292,000 persons to 851,000 persons and 397,000 persons respectively in 2010 in the two areas. The maximum daily demand for both areas including urban and rural populations in 2010 is estimated as 413,000 m^3/day (Karakalpakstan) and 415,000 m^3/day (Khorezm). The total maximum daily supply capacity is 828,000 m^3/day and the additional capacity of 325,000 m^3/day (T-N water treatment plant: 145,000 m^3/day; T-U water treatment plant: 180,000 m^3/day).

7. Maintenance and Operation of Water Supply System

The items listed below need to be considered for the successful implementation of this project.

1) Establishment of integrated management system for the Tuyamuyun Hydro-unit including the Kaparas reservoir
2) Effective management between the Vodokanal and the Tuyamuyun water supply systems
3) Adequate response in case of an emergency in the inter-regional water supply system
4) Control of water leakage.

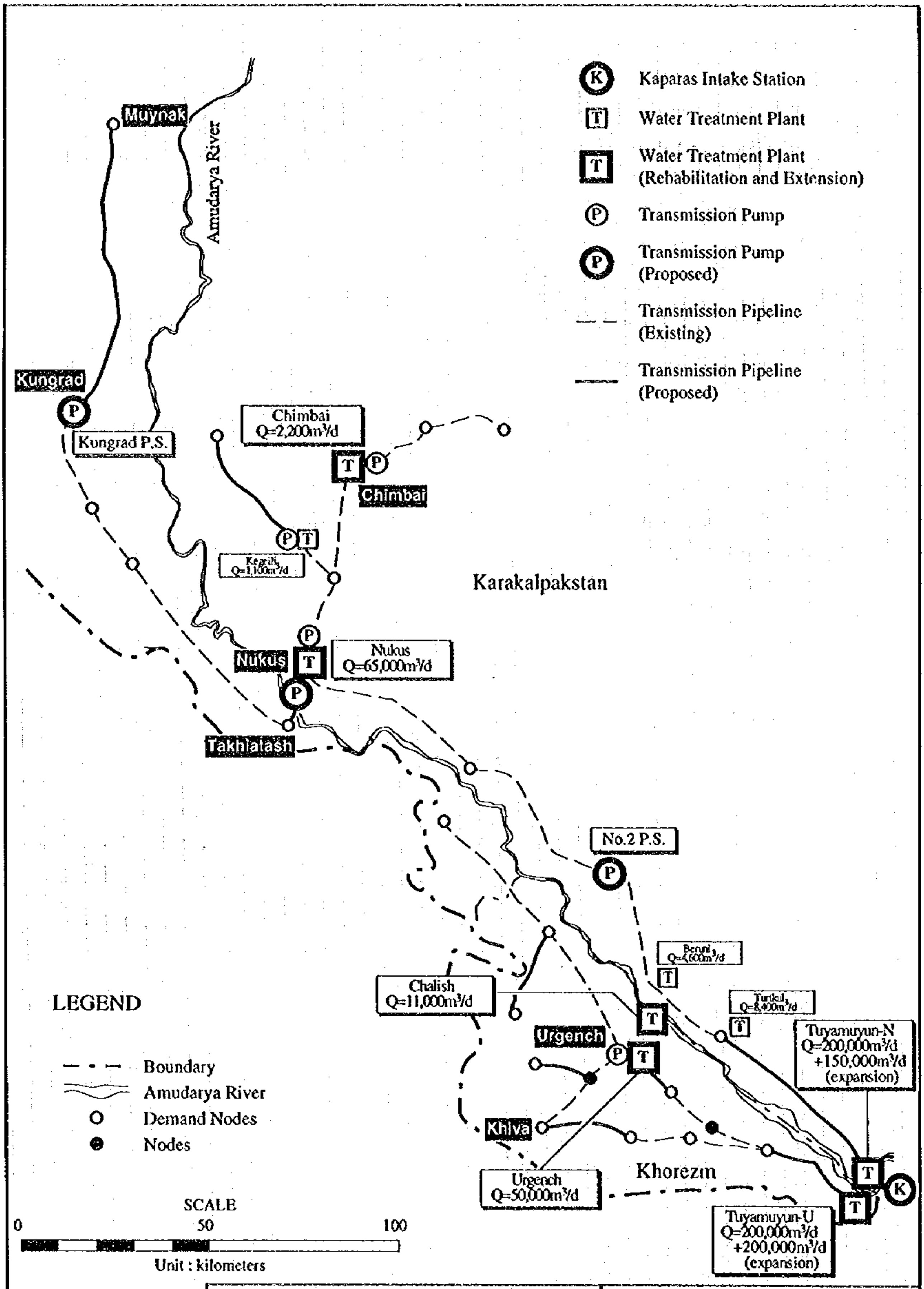
8. Project Assessment

The Economic Internal Rate of Return (EIRR) for the first priority project was 8.4%. If benefits that cannot be quantitatively assessed are taken into account, the feasibility for this project will be high. Results of financial analysis showed that the ROU government should give subsidies for covering the construction cost so that an adequate water tariff level is maintained and the project is implemented successfully. The water tariff for household consumers needs to be increased to a reasonable level (2% of the average household income).

9. Environmental Impact Assessment

Three activities were identified as the main environmental impacts, and the results of an assessment and relief measures to mitigate them are summarized below.

(1) Operation of the Kaparas reservoir (No eutrophication. Impact on the hydrosphere are negligible. Silting can be neglected. Problem of water rights was solved.)
(2) Operation of water treatment plants (Adequate disposal of sludge is necessary)
(3) Increase in the amount of sewage with the increase in served population (Development of sewage system is necessary.)



THE STUDY ON
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Fig. Proposed Water Supply Sys. in 2010

Fig. Implementation Schedule

Description \ Year		First Priority Project						Second Priority Project								Remarks
		0 1997	1 1998	2 1999	3 2000	4 2001	5 2002	6 2003	7 2004	8 2005	9 2006	10 2007	11 2008	12 2009	13 2010	
Loan Arrangement		▨					▨									
Preparation of Tender (Bids, Evaluations)		▨					▨									
1. Kaparas Raw Water Intake System																
1.1 Kaparas Intake Station	Q=750,000 m^3/d		■	■												
1.2 Raw Water Mains Pipeline																
1.2.1 Kaparas I.S. to T-N Existing Intake Station	D=1,400 L=10.7 km		■	■	■											
1.2.2 Kaparas I.S. to T-U Existing Intake Station	D=1,400 L= 1.0 km		■													
1.2.3 Kaparas I.S. to T-U Existing Intake Station	D=1,400 L= 9.0 km			■	■											
2. Tuyamuyun-Nukus Water Supply System																
2.1 Water Treatment Plant	Q=350,000 m^3/d															
2.1.1 Rehabilitation	Q=200,000 m^3/d									■	■					
2.1.2 Expansion	Q=150,000 m^3/d							■	■	■						
2.2 Transmission and Distribution Pumping Station																
2.2.1 No. 2 Booster Pumping Station	Q=234,410 m^3/d							■	■	■						
2.2.2 Nukus North Distribution Station	Q=122,950 m^3/d		■	■	■											
2.2.3 Kungrad Transmission and Distribution Station	Q= 42,130 m^3/d		■	■	■											
2.3 Transmission Pipeline																
2.3.1 W.T.P. - No. 1 Pumping Station	D=1,400 L= 63.0 km							■	■	■						
2.3.2 Nukus - Takhiatash L=21 km	D=1,200 L= 11.0 km		■													
2.3.3 Kungrad - Muynak (Q=3,870 m^3/d)	D=500 L= 96.5 km		■	■	■											
2.3.4 Kegeili - Bozatau	D=400 L= 50.0 km								■	■						
3. Tuyamuyun-Urgench Water Supply System																
3.1 Water Treatment Plant	Q=400,000 m^3/d															
3.1.1 Rehabilitation	Q=200,000 m^3/d									■	■					
3.1.2 Expansion	Q=200,000 m^3/d		■	■	■											
3.2 Transmission Pipeline																
3.2.1 W.T.P. - Khazarasp Pumping Station	D=1,200 L=27.0 km		■	■												
3.2.2 Khanki - Urgench	D=1,200 L=13.2 km					■										
3.2.3 Yangiaryk - Khiva	D=600 L=20.0 km				■											
3.2.4 S.P.1 - Koshkupyr	D=600 L=14.0 km						■									
3.2.5 Gurlen - Shavat	D=600 L=19.5 km			■												
4. VodoKanal Karakalpakstan																
4.1 Water Treatment Plant																
4.1.1 Nukus W.T.P (Rehabilitation)	Q= 65,000 m^3/d							■	■	■						
4.1.2 Chimbai W.T.P (Rehabilitation)	Q= 2,200 m^3/d							■								
4.1.3 Water Treatment Plant (Rehabilitation), 3Cities	Q= 14,000 m^3/d								■							
4.2 Distribution Network																
4.2.1 Replacement D=100～D=400	L=228.8 km		■	■	■	■	■	■	■	■	■	■	■	■	■	
4.2.2 Expansion D=100～D=400	L=119.6 km		■	■	■	■	■	■	■	■	■	■	■	■	■	
4.3 Metering System																
4.3.1 Meter Installation D=20	N=115,960 Pieces		■	■	■	■	■	■	■	■	■	■	■	■	■	
5. VodoKanal Khorezm																
5.1 Water Treatment Plant																
5.1.1 Urgench W.T.P (Rehabilitation)	Q= 50,000 m^3/d							■	■	■						
5.1.2 Chalish (Rehabilitation)	Q= 11,000 m^3/d							■								
5.2 Distribution Network																
5.2.1 Replacement D=100～D=400	L=170.3 km		■	■	■	■	■	■	■	■	■	■	■	■	■	
5.2.2 Expansion D=100～D=400	L= 71.5 km		■	■	■	■	■	■	■	■	■	■	■	■	■	
5.3 Metering System																
5.3.1 Meter Installation D=20	N=60,970 Pieces		■	■	■	■	■	■	■	■	■	■	■	■	■	

PART I BASIC PLAN

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PART I BASIC PLAN

PART I BASIC PLAN

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Aral Sea region of the Republic of Uzbekistan (hereafter called "ROU"), which is the Study Area, is located in the autonomous republic of Karakalpakstan (Karakalpakstan, ROK or KKP) and Khorezm Province (Khorezm or Kz), and in the downstream part of the Amu Darya river that flows into the Aral Sea.

The problems faced by the water supply system are degradation of quality of water at the sources due to polluted drainage from irrigated and agricultural land at the upstream end and the very low water tariffs because of which operation and maintenance of the supply system is inadequate. Particularly, the degradation in water quality has been reported to have caused serious damage to the health of the inhabitants in the Study Area.

In view of this background, the government of the ROU requested the Japanese government to carry out a study on the water supply project for the Six Cities mentioned below, and to recommend the necessary improving measures. On receipt of this request, the Japan International Cooperation Agency (JICA) dispatched a Study Team to start the Study.

1.2 Objectives of the Study

The Study was carried out in two stages: 1) Study for formulating the Basic Plan, and 2) Feasibility Study.

1) Formulation of the basic plan for improving the institution/management of the water supply service and the quality of water supplied to the Six Cities in the Aral Sea region
2) Implementation of a Feasibility Study for priority projects selected under the Basic Plan. Another objective is the transfer of technology to the counterparts through implementation of the Study.

1.3 Study Area

1) Karakalpakstan: Nukus, Chimbai, Kungrad, Muynak
2) Khorezm: Urgench, Khiva
3) Others: Tuyamuyun Hydro-unit, Tuyamuyun-Nukus (T-N) water treatment plant, Tuyamuyun-Urgench (T-U) water treatment plant, intake points for water supply to the Six Cities in the Study Area.

Fig. 1.1 Location Map of Cities and Regions in Karakalpakstan and Khorezm

CHAPTER 2 GENERAL CONDITIONS AND BACKGROUND OF THE STUDY

2.1 General Conditions of the Study Area

The ROU is located inland in Central Asia, with a mountain range stretching across the eastern part of the country, continued by the Pamir highland, the glaciers of which melt and give rise to the Syr Darya and the Amu Darya rivers flowing to the north-west across the Kyzylkum desert, steppes, and into the Aral Sea.

The Study Area of Karakalpakstan and Khorezm is situated to the extreme west of the ROU, along the coastal areas of the Aral Sea and at the downstream end of the Amu Darya river.

The Study Area has a continental climate. Summer is hot and dry; winter is very cold and the area has higher rainfall than in winter. The average temperature at Nukus is about 11 °C, and the average annual rainfall is about 170 mm.

2.2 Water Supply Diffusion Rate

The area, population and served population by centralized water supply system of the ROU and the Study Area are given below.

Table 2.1 Area, population, water supply diffusion rate in the ROU and the Study Area

Name of region	Area (thousand km^2)	Population (thousand)	Pop. Density (persons/km^2)	Water Supply Coverage Rate	
				Urban	Rural
ROU	447.4	21,718	48.5	84.6	60.0
Karakalpakstan	165.3	1,344	8.1	83.7	32.1
Khorezm	6.4	1,132	176.9	81.0	57.2

Source: Ministry of Public Utilities
Population (in 1993), Water supply coverage rate (in 1995)

2.3 Aral Sea Crisis

The former USSR converted the desert region at the midstream area of the Amu Darya river to a cotton cultivation land by large scale irrigation using the waters of the Amu Darya river. The result was that the inflow volume to the Aral Sea decreased steeply so that in 1989, the surface water area in the Aral Sea decreased to 60% of the original area, and the salt concentration rose to about 30,000 ppm. Furthermore, with the excessive use of agricultural chemicals such as defoliants and salt damage to the farmland, the surface water and the ground water at the downstream and midstream part of the Amu Darya river became polluted, and the health of the inhabitants drinking this polluted water at the downstream part was seriously affected.

2.4 Health Conditions in the Study Area

The direct causes of damage to health of the inhabitants in the Study Area have not been clear. Inadequate good-quality drinking water and lack of hygiene are considered to have had a major effect on the health of the inhabitants. The morbidity rate due to disease in the Study Area is high compared to the national average, and shows an increasing trend. The health conditions are given below.

- Kidney and liver disorders, arthritis, chronic bronchitis, typhoid and hepatitis has increased suddenly in the last 10 to 15 years.
- High maternal and infant mortality
- Increase rate of congenital disorder
- Morbidity rate is high for waterborne diseases, especially diarrhea diseases.
- Cases of acute respiratory diseases are many.
- Anemia

2.5 Related Water Supply Projects

2.5.1 ROU Water Supply Projects

(1) ROU water supply Master Plan (Karakalpakstan, Khorezm)

Since the quality of water in the mid and downstream reaches of the Amu Darya river has deteriorated, the ROU government formulated the Tuyamuyun Water Supply Master Plan, with the aim of ensuring new water sources. This plan envisages storage of water equivalent to a yearly demand in the Kaparas reservoir during summer when the quality of water in the Amu Darya river is good, treating this water at the Tuyamuyun water treatment plant, and supplying this water to Karakalpakstan and Khorezm. This plan currently delay because of the difficulties in procuring fund.

(2) Kungrad, Takhiatash and Khodzeili water supply plan

Urgench Transgas Company (gas production company) has been producing water for supply of drinking water to inhabitants of towns along gas pipelines and to public water works corporation (Vodokanal) located on the left bank of the Amu Darya river. This plan envisages supply of drinking water to inhabitants of towns along gas pipelines, particularly when supplying cooling water to compressors and pumps.

(3) Right Bank Collector Drain (RBCD) project

Contaminated water flows from many agricultural canals into the Amu Darya river and degrades the quality of water in the river. This project envisages collecting the drains before they flow into the river, thereby improving the quality of river water. The collector drain extends for 665 km, and the work is divided into three stages. The first stage of work is in progress, and one section has been completed.

2.5.2 Water Projects with the Assistance of International Organizations and Aid-giving Countries

(1) The World Bank has been investigating plans extending over various fields for environmental problems faced by the Aral Sea. Water supply plans in the JICA Study Area are also included in the plans.

(2) USAID has implemented a short-term drinking water improving project.

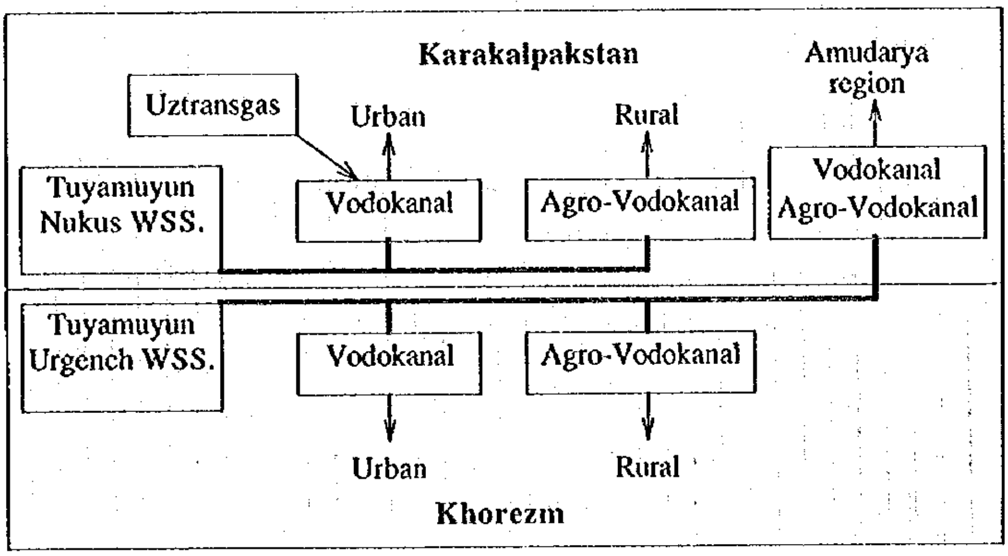
(3) The German Red Cross has constructed a reverse osmosis plant of capacity 100 m^3/hour at Takhtakupyr in Karakalpakstan in 1993.

CHAPTER 3 EXISTING WATER SUPPLY SYSTEM

3.1 Outline of Water Supply Systems in the Study Area

Public water works corporations in the Study Area include the urban water supply corporations (Vodokanal) for cities, and rural water supply corporations (Agro-Vodokanal) in the rural areas. Both Vodokanals purchase treated water from water treatment plans owned by themselves, and in addition, purchase treated water from the Tuyamuyun inter-regional water supply system, and supply the treated water to the inhabitants. Furthermore, the Vodokanal on the right bank of the Amu Darya river in Karakalpakstan, purchases water from the Urgench Transgas Company and supplies it to the cities on the right bank. The water supply systems in the Study Area are given below.

Fig. 3.1 Water Supply Systems in the Study Area



3.2 Existing Water Treatment Plants in the Study Area

The Study Area has the following water treatment facilities: flocculation-sedimentation water treatment plants, plain sedimentation water treatment plants, wells (artificial replenishment, ground water), electrodialysis and reverse osmosis systems, shallow wells and push-button pumps.

3.3 Tuyamuyun Inter-regional Water Supply System

3.3.1 Outline

Water supply and sewerage plants were formulated for cities and rural areas in both Karakalpakstan and Khorezm regions in 1986 with the target year taken as 2000. In these projects, the Tuyamuyun-Nukus (T-N) inter-regional water supply system and the Tuyamuyun-Urgench (T-U) inter-regional water supply system were planned for Karakalpakstan and Khorezm respectively with capacities mentioned below.

Total planned capacity of T-U water treatment plant: 577,000 m^3/day
Total planned capacity of T-N water treatment plant: 540,000 m^3/day

This project is scheduled to be implemented in three stages by the year 2000, but as of today, only the first stage has been completed; the project has been delayed considerably.

3.3.2 Kaparas Reservoir

The Kaparas reservoir has a planned effective storage capacity of 550 million m^3, and together with the Sultansanjar reservoir, Koshburak reservoir, and the Ruslovoye reservoir (the Amu Darya river bed reservoir), it forms the Tuyamuyun Hydro-unit. The plan formulated is for the Tuyamuyun water supply system to store water from the Amu Darya river in the Kaparas reservoir during July and September when the water quality and quantity are good, and use this stored water as the source of water supply for the whole year. Presently, the Kaparas intake station and the raw water main to the Tuyamuyun water treatment plants are under construction.(Fig. 3.2)

3.3.3 Tuyamuyun-Nukus (T-N) Water Supply System

(1) Water transmission area: Karakalpakstan

(2) Management: the Unit Repair and Maintenance of the T-N regional water pipelines under the RPA for Operation and Development of Regional Water Pipeline of the Ministry of Public Utilities (MPU)

(3) Outline of facilities:

1) Tuyamuyun-Nukus water treatment plant

Daily maximum supply capacity: 170,000 m^3/day

1. First stage pumping station
2. Coagulant feeding
3. First coagulo sedimentation (radial clarifier)
4. Second coagulant feeding
5. Second coagulo sedimentation (horizontal flow)
6. Rapid sand filter
7. Chlorination
8. Clear water reservoir
9. Transmission pump

2) T-N water transmission pipeline system (Fig. 3.3)

3.3.4 Tuyamuyun-Urgench (T-U) Water Supply System

(1) Water transmission area: Khorezm and Amu Darya region in Karakalpakstan

(2) Management: the Unit Repair and Maintenance of the T-U regional water pipelines under the RPA for Operation and Development of Regional Water Pipeline of the MPU

(3) Outline of facilities:

1) T-U water treatment plant
Maximum daily supply capacity: 200,000 m^3/day
The water treatment process is the same as that of T-N water treatment plant except for the rapid sand filtration and pump capacity.

2) T-U water transmission pipeline system (Fig. 3.3)

3.3.5 Progress of Tuyamuyun Water Supply System

The Kaparas reservoir and a part of transmission pipelines included in the first stage of the project, and half the planned capacity of the T-U and T-N water treatment plants were completed at the end of 1994, and are currently in operation. Many cities and rural areas are receiving water as a result of completion of this work. However, most of the facilities on the left bank of the Amu Darya river in the downstream areas are under construction, and water is still not being supplied.

The intake pumping station at Kaparas reservoir and the raw water main from there to the T-U water treatment plant are under construction. The work of laying raw water main from the intake pumping plant to the T-N water treatment plant has not yet started.

3.4 Outline of Water Supply Systems in the Six Cities of the Study Area

Name of City	Water supply facilities and supply status
Nukus	Although the planned supply capacity of existing water treatment plant is 100,000 m^3/day, the actual figure is 60,500 m^3/day. Treatment methods include natural sedimentation by feeding coagulant, rapid filtration and disinfection. The existing water treatment plant currently serves as a standby to the T-N water supply system.
Chimbai	Water supply has been through wells, but presently, supply of treated water from the T-N system has become possible, and Chimbai depends on this system for its entire supply of water. Only 6-9 wells operate for three hours a week because of maintenance of the facilities.
Kungrad	The water treatment plant of the public waterworks corporation produces 7,200 m^3 /day of treated water. The water source is Rafchan canal, and water is treated by natural sedimentation, filtration and disinfection by chlorination. In addition, it receives water from Uztransgas amounting to 16,000 m^3/day in summer and 9,000 m^3/day in winter.
Muynak	After natural sedimentation and disinfection by using bleaching powder, the water is supplied to the city. Water sources include the Cartabay canal which draws water from the Amu Darya river.
Urgench	The water supply capacity of the existing water treatment plant is 50,000 m^3/day. Treatment method includes coagulation-sedimentation, rapid sand filtration and disinfection by chlorination. It receives about 51,400 m^3/day from the T-U water supply system. In addition, 10,000 m^3/day of ground water can be used. The treated water received from the Urgench treatment plant and the T-U water supply system is supplied not only to Urgench city but also to Khiva, Karaul, and Koshkupyr areas.
Khiva	Water consumed in the city itself amounting to 21,200 m^3/day is received from Urgench.

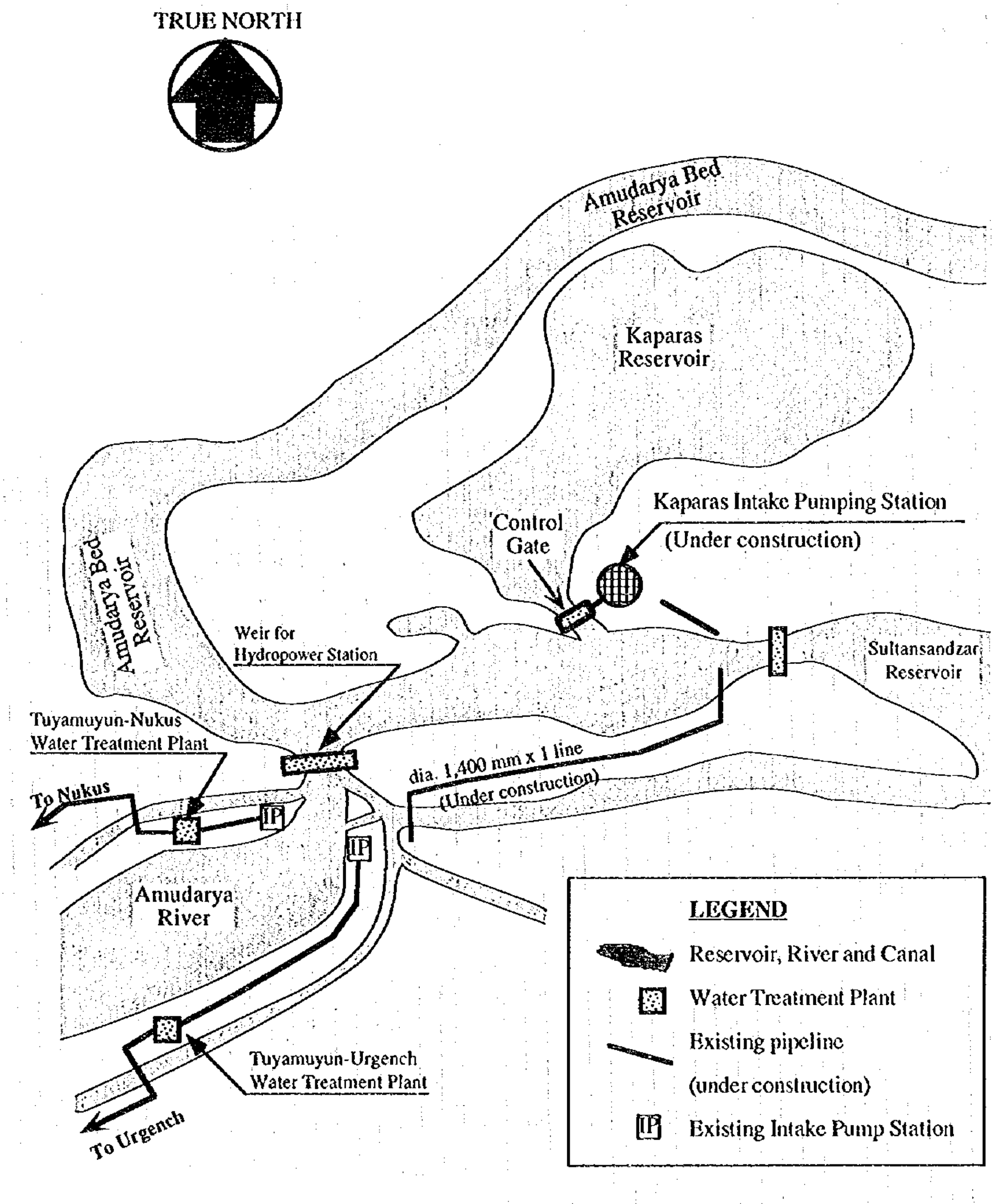


Fig. 3.2 Existing Kaparas Intake Facilities

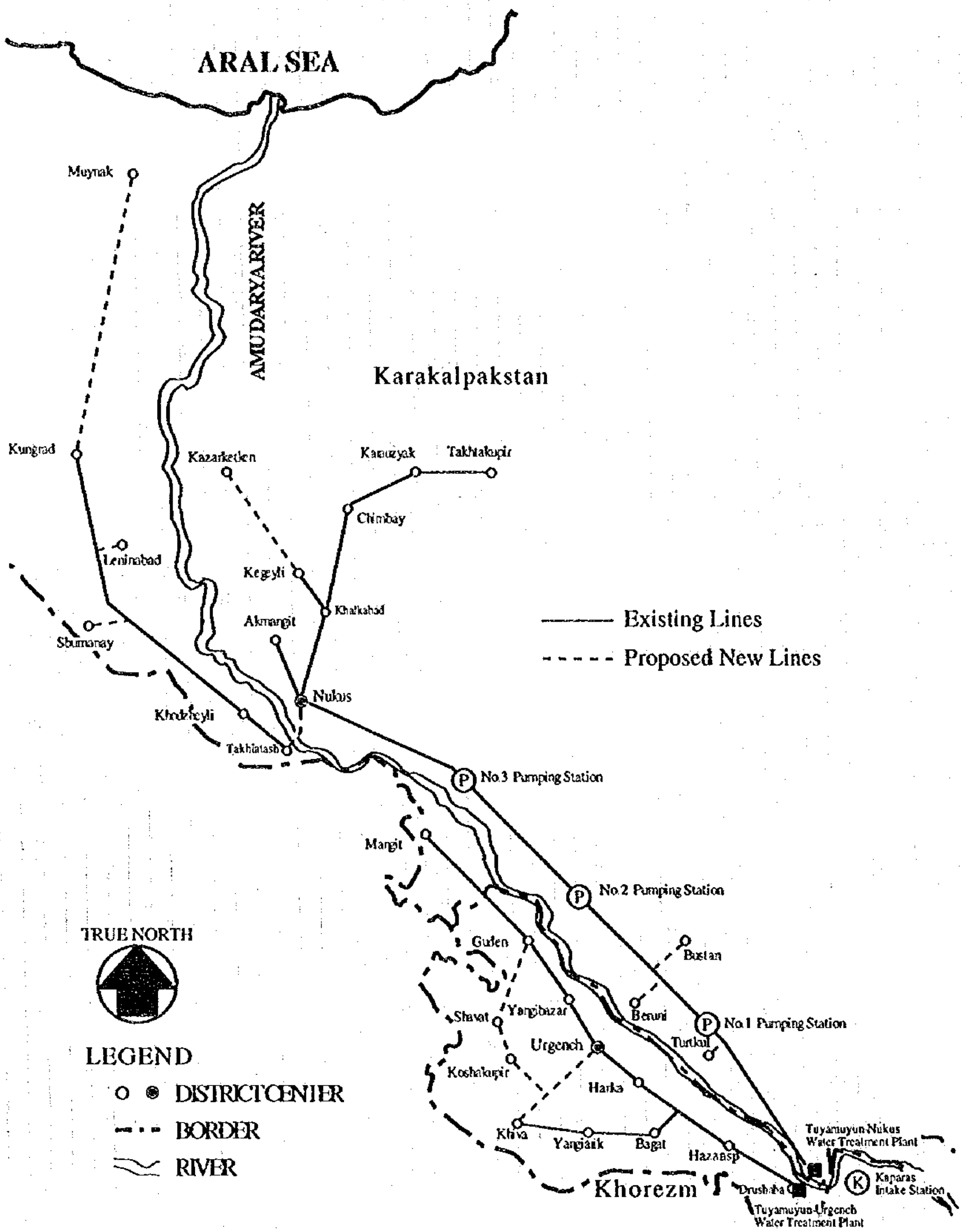


Fig. 3.3 Tuyamuyun Water Supply System

CHAPTER 4 WATER DEMAND AND SUPPLY PREDICTIONS

4.1 Basic Concept

The Tuyamuyun Water Supply Master Plan has been formulated with the target year as 2010 for Karakalpakstan and Khorezm by the ROU in 1986. According to this plan, construction of facilities are currently in progress, and about 60% of the water consumption of both areas is already being supplied by the Tuyamuyun water supply system. In the future, the water supply systems of the two areas are likely to be integrated with the Tuyamuyun water supply system.

Water demand are estimated by T-N water supply system and T-U water supply system, and by Agro-Vodokanal and Vodokanal separately. However, the JICA study for water demand are focused on the urban water supply because of the Study does not cover rural area. Water demand in the rural area was refereed to the study by the World Bank.

4.2 Population in Cities Covered by Water Supply

The total population and the population covered by water supply in cities in the Study Area are shown in the table below.

4.3 Water Consumption for Urban Area

4.3.1 Water Supply Records of Vodokanal

The type of water consumer is categorized into three groups as bellows:
Group (1) : The residents
Group (2) : Public institution, etc.
Group (3) : Industrial, Construction Enterprises, etc.

Records of water supplied to consumer groups by Vodokanal for 1995 are given in the table below.

Table 4.1 Total population and service population in the cities of Karakalpakstan (1994)

City, Town, Regional Center	Total Population	Service Population of Vodokanal		Except for Vodokanal	Total	
	thousand	thousand	%	thousand	thousand	%
Nukus	229.5	176.2	76.8	2.5	178.7	77.9
Beruni	44.6	31.8	71.4		31.8	71.4
Kungrad	33.2	24.8	74.6	6.0	30.8	92.7
Khodjeili	70.5	36.3	51.5	14.5	50.8	72.0
Takhiatash	49.3	45.2	91.8	2.3	47.5	96.4
Turtkul	44.8	33.7	75.3		33.7	75.3
Chimbai	31.8	25.1	78.8		25.1	78.8
Mangit	27.2	18.0	66.1		18.0	66.1
Kazanketken	3.6	3.3	91.0		3.3	91.0
Karauzyak	12.9	9.4	74.7		9.4	74.7
Kegeili	12.8	9.4	73.2		9.4	73.2
Kanlykol	9.0	7.4	82.7		7.4	82.7
Muynak	13.6	12.6	92.3		12.6	92.3
Akmangit	7.5	5.6	74.8		5.6	74.8
Takhtakupyr	16.8	10.7	63.8		10.7	63.8
Shumanai	12.5	8.8	70.6		8.8	70.6
Bustan	10.9	1.7	15.6		1.7	15.6
Altynkul	22.7	20.3	89.2		20.3	89.2
Khalkabad	10.9	6.5	59.7		6.5	59.7
total	663.7	486.8	73.3	25.3	512.1	77.2

Source: Vodokanal of Karakalpakstan

Table 4.2 Total population and service population in the cities of Khorezm (1994)

City, Town, Regional Center	Total Population	Service Population	
	thousand	thousand	%
Urgench	137.1	135.0	98.5
Khiva	45.4	44.0	96.9
Druzhba	14.9	14.1	94.6
Bagat	7.8	4.9	62.8
Gurlen	19.4	13.4	69.1
Koshkupyr	14.7	11.2	76.2
Urgench(Karaul)	14.5	12.8	88.3
Khazarasp	14.5	11.8	81.4
Khanka	28.7	21.4	74.6
Shavat	13.5	12.5	92.6
Yangiaryk	9.5	3.1	32.6
Yangibazar	5.2	2.4	46.2
Bustan	5.3	1.5	28.3
Total	330.5	288.1	87.2

Source: Vodokanal of Khorezm

Table 4.3 Water consumption records for urban water supply by Vodokanals Karakalpakstan and Khorezm

Year	Total Pop.	Served Population		Actual Delivered		Sold Water Quantity		1st group		2nd group		3rd group		Effectiveness
	ths.	ths.	%	mld	lcd	mld	lcd	mld	lcd	mld	lcd	mld	lcd	%
KKP	660	512.1	78	180.0	273	157.1	238	72.3	141	60.5	92	24.2	37	87.0
KZ	331	303.0	92	199.2	602	183.3	554	73.8	254	47.4	143	42.7	129	92.0

Source: Vodokanal of Nukus and Vodokanal of Urgench
mld: million liters per day: lcd: liters consumed per person per day
Efficiency = Purchased quantity + actually supplied quantity

In both areas, a large number of consumers do not have water meters. The water consumed by these consumers are calculated based on the Norm per capita consumption (Norm consumption). Therefore, the quantity of water purchased does not reflect the actual quantity of water consumed.

4.3.2 Water Consumption of Group (1)

The quantity of water consumed by the Group (1) was estimated by the method based on the Norm consumption because of no meters installed. The JICA Study Team estimated the actual per capita consumption (Meter consumption) by installing water meters. The Norm consumption, Meter consumption and the consumption in Japan are shown in the table below.

Table 4.4 Comparison of average per capita consumption

Consumer Type	Norm KKP	Norm Khorezm	Meter KKP	Japan in 1995
Living Use (unit : l/ca./day)				
Non-sewerage service				
A Street Hydrant(Stand Pipe)	41	50		
B Yard Hydrant & Tap	77	100	49	
C Room Tap	100	140	85	
D Room Taps, Toilet	150			135
E Internal Water pipe, Sink, Bath, Water Heater	177	230	90	125
F E + Toilet	227			130
Sewerage Service				
G Sink	117			
H Sink, Toilet	147			
I Sink, Bath/shower, Water heater	203			
J Internal Water pipe, Sink, Bath, Water Heater	233	250	91	165
K Internal Water pipe, Sink, Bath, Centralized WH	270(351)	350	169	
Non-Living Use				
Vehicle Washing (l/car/day)	19	17	-	33
Domestic Animals (l/head/day)	25 - 110	12	-	25 - 60
Garden irrigation (l/m²/day)	50	107	39	

Note: (351) : consumer using sewerage.
Per capita consumption in Japan is estimated from water consumption by facility.

The total water consumption by the Group (1) was estimated based on the Norm consumption and the Meter consumption and inventory data such as population. The summary of results for 1995 are shown in the table below.

Table 4.5 Estimated total water consumption for Group (1) by use (1995)

	Estimated from Norm consumption			Estimated from Meter consumption		
	Total consump.	Per capita consumption		Total consump.	Per capita consumption	
	mld	l/ca./day	%	mld	l/ca./day	%
Karakalpakstan						
Living	37.8	101	41.4	22.7	60.5	35.9
Garden	52.0	139	57.0	40.6	108	64.1
Others	1.4	4	1.6	-	-	
Total	91.2	244	100.0	63.3	168.5	100.0
Khorezm						
Living	50.2	176	44.7	25.5	89	40.6
Garden	58.8	206	52.3	37.2	130	59.4
Others	3.3	12	3.0	-	-	
Total	112.3	394	100.0	62.7	219	100.0

mld: million l/day

4.3.3 Water Consumption of Group (2) and Group (3)

Water tariff is collected from these consumers based on the consumed quantity according to water meters, or based on the consumption quantity negotiated between Vodokanals and consumer. The percentage consumption by the Meter reading and negotiation in 1995 was about 40% and 60% respectively. The water tariff for these group by the negotiation is generally greater than the tariff for actual quantity of water consumed, therefore, in recent years, consumers have been installing water meters at their own expense.

4.3.4 Leakage

The leakage rate for the Study Area was estimated as 30% by the JICA Study Team, based on the actual measured results of water distributed from the water treatment plant at Nukus.

4.3.5 Total Average Water Consumption by Consumer Group

Based on the results of the study mentioned above, the estimated results of average daily water consumption by consumer group and the average daily leakage quantity are given in the table below.

Table 4.6 Estimated water consumption by consumer group (1995)

(units: thousand m^3/day)

	Actual distributed water	1st group	2nd and 3rd group	Leakage
Karakalpakstan	180.0	63.3	62.7	54.0
Khorezm	199.2	62.7	76.7	59.8

Note: The estimated value from meter consumption quantity was used for the quantity of water consumed by Group (1).

4.3.6 Time Variation Coefficient for Water Consumed

From water distribution records of Vodokanals, the annual variation coefficient for monthly average water consumption for Karakalpakstan and Khorezm was in the range of 0.84 to 1.15.

The hourly variation coefficient was in the range of 0.66 to 1.44.

4.4 Future Water Demand Prediction

4.4.1 The Target Year

Target year for the Basic Water Supply Plan was Set as 2010.

4.4.2 Population Estimates

The values projected by the ROU were used for the population and water supply coverage rate in this Study.

Table 4.7 Total population, coverage rate and service population projected by the Uzbek Side

	1995			2000			2005			2010		
	T. pop	C.R	S. pop	T. pop	C.R	S. pop	T. pop	C.R	S. pop	T. pop	C.R	S. pop
	ths.	%	ths.	ths.	%	ths.	ths.	%	ths.	ths.	%	ths.
Karakalpakstan												
Urban	660.0	76	501.6	734.7	90	661.2	787.0	95	747.7	850.6	100	850.6
Rural	722.0	41	296.0	809.3	54	437.0	893.7	71	634.5	985.8	85	837.9
Total	1,382.0	58	797.6	1,544.0	71	1,098.2	1,680.7	82	1,382.2	1,809.4	93	1,688.5
Khorezm												
Urban	336.0	87	292.3	361.5	96	347.0	378.2	98	370.6	397.4	100	397.4
Rural	899.8	51	458.9	1,041.8	64	666.8	1,182.5	77	910.5	1,342.0	90	1,207.8
Total	1,235.8	61	751.2	1,403.3	72	1,013.8	1,560.7	82	1,281.1	1,739.4	92	1,605.2

T. pop: Total population, C.R: Coverage rate, S. pop: Service population
Source: State Committee on Forecasting and Statistics

4.4.3 Per capita consumption for the urban area

The future planned per capita consumption for Group (1) are estimated by living, garden watering and other use. The values projected by the ROU are used for the future planned per capita consumption for Group (2) and Group (3) in this Study. The target for reducing leakage rate is set at 15% in 2010 as below.

Table 4.8 Plan for reducing leakage ratio

	Units	1995	2000	2005	2010
Leakage rate	%	30	25	20	15

4.4.4 Summary of Per Capita Consumption

The summary of per capita consumption is given in the Table below.

Table 4.9 Planned per capita consumption

(unit: l/ca./day)

Consumer group		Region	1995	2000	2005	2010
1st group	Living	KKP	60	85	110	135
		Khorezm	89	108	127	147
	Garden watering	KKP	72	59	46	33
		Khorezm	87	71	56	40
	Others	KKP	1.1	1.1	1.1	1.1
		Khorezm	1.4	1.4	1.4	1.4
	Total	KKP	133.1	145.1	157.1	169.1
		Khorezm	177.4	180.4	183.4	188.4
2nd group		KKP	97	108	119	130
		Khorezm	137	140	144	147
3rd group		KKP	38	74	83	86
		Khorezm	122	164	197	226
Sub-total		KKP	268.1	327.1	359.1	385.1
		Khorezm	436.4	484.4	524.4	561.4
Leakage		KKP	115	144	113	82
		Khorezm	187	161	131	99
Total		KKP	383.1	471.1	472.1	467.1
		Khorezm	623.4	645.4	655.4	660.4

Note: Per capita consumption for garden watering is annual average, and is different from the seasonal average per capita consumption for the gardening season.
excluding consumption for Urgench Transgas and Sodany plant.

The per capita consumption is high compared to that of developed countries. This consumption should be reduced by a combination of efforts to reduce consumption by wastage by individual consumers, correct use of water, installation of water meters and appropriate water tariff system.

4.4.5 Per Capita Consumption in the Rural Areas

The study of water supply system in rural areas is not included in the study by the JICA Study Team. The per consumption proposed by the ROU and the World Bank for rural areas is as given in the table below. The values in the table give total water consumption including the water consumed by Groups (1), (2), and (3) and the leakage quantity.

Table 4.10 Per capita consumption in rural areas

(unit: l/ca./day)

	1995	2000	2010	2010
Karakalpakstan	180	88	125	168
Khorezm	183	114	150	150

Source: Uzbekistan Water Supply, Sanitation and Health, Interim Report, Binnie and Partners, etc., 1996

4.4.6 Time Variation in Water Demand

Considering the present values, the daily maximum variation coefficient is taken as 1.15.

4.4.7 Future Water Demand for Each Tuyamuyun System

Presently, the water supply systems for the two areas are divided into the T-N and the T-U water supply systems. The future water demand for each Tuyamuyun water supply system is given below. The water demand for the Amu Darya region in Karakalpakstan is included in the Tuyamuyun-Urgench water supply system in Khorezm.

Table 4.11 Summary of Future Water Demand for the Tuyamuyun System

(unit: thousand m³/day)

	1995		2000		2005		2010	
	Ave.	Max.	Ave.	Max.	Ave.	Max.	Ave.	Max.
Tuyamuyun-Nukus (T-N)								
urban	184.2	211.9	269.9	310.4	310.8	357.4	355.4	408.8
rural	49.2	56.6	34.1	39.2	68.8	79.2	122.1	140.4
total	233.4	268.5	304.0	349.6	379.6	436.6	477.5	549.2
Tuyamuyun-Urgench (T-U)								
urban	191.2	219.8	242.1	278.4	262.7	302.2	283.6	326.1
rural	88.2	101.4	80.1	92.1	146.9	169.0	200.9	231.1
total	279.4	321.2	322.2	370.5	409.6	471.2	484.5	557.2

Ave. : daily average water demand, Max.: daily maximum water demand
excluding the demand for Uztransgas and Sodany plant town, for which water is supplied from Uztransgas.

CHAPTER 5 WATER SOURCES AND WATER QUALITY

5.1 Water Sources in the Study Area

The water sources in the Study Area are the surface water of the main stream of the Amu Darya river, reservoirs, surface water of irrigation canals and ground water.

In this Study, the possibilities of using the three water sources mentioned below, as drinking water sources for the Study Area were studied.

- Surface water (main stream of the Amu Darya river)
- Ground water
- Kaparas reservoir

5.2 Water Quality and Water Quantity Characteristics of the Amu Darya River

5.2.1 Flow Characteristics of the Amu Darya River

1) Amu Darya river water usage
About 70% of the usable water of the Amu Darya river is used for irrigation. This water is fed by irrigation canals, and after use, the drain water returns to the river through drain channels called collectors.

2) Discharge characteristics of the main stream of the Amu Darya river
The flow decreases at the downstream end. Flow increases from April until the summer ends, when the snow melts, reaching a maximum in July. After the collapse of the Soviet Union, the Amu Darya river has become an international river flowing through different countries, therefore flow monitoring and control only by the ROU has become difficult.

3) Inflow and outflow of the Amu Darya river

The number of outflow canals from the Amu Darya river is 34 and that of inflow collectors to the Amu Darya river is 62. The flow amount ratio of total inflow to total outflow is about 6 %. A major part of the water that does not return to the river is irrigation water that steeps underground and evaporates, and flows into natural depressions.

5.2.2 Water Quality in Amu Darya River

Most of the flow of the Amu Darya river is used for irrigation purpose. The water led through irrigation canals has two main uses: for growing agricultural products and for washing off the salts precipitated in the farmlands. Accordingly, the collectors, which include highly-concentrated salts (mineralization) and agricultural chemicals, flow back to the river through collectors. The collectors are the main cause of degradation of quality of water in the Amu Darya river. There are many collectors and the mid-stream and downstream areas of the Amu Darya river, particularly at the Bukhara and Kashka Darya areas.

In the month of July, when the flow rate is maximum, the quality of water is good. In the month of March, when the flow rate is minimum, the quality of water degrades. Salt components such as mineralization and total hardness are the main indicators in the Study Area that is studied with most interest. The average concentration of mineralization in March to July for the years 1974 to 1994 is 1,277 mg/l and 675 mg/l respectively and the total hardness for the same months is 10.8 meq/l and 6.1 meq/l respectively.

5.3 Study on Potential Surface Drinking Water Source

The possibility of using the Amu Darya surface water as a drinking water source was investigated by studying the quantity and quality of the water at two points (Tuyamuyun and Sumanbay) representative of the Study Area.

Water quantity (mineralization) /quality models were created between Termez at the upstream end of the Amu Darya river and Sumanbay, near Nukus in the Study Area, and the concentration of mineralization was estimated every month.

The mineralization concentration of Amu Darya river was confirmed to comply with the water quality standards during three months (from June to August) at Tuyamuyun (Kaparas reservoir) and during two months (from July to August) at Sumanbay. To make use of surface water as drinking water under such water quality conditions, water should be stored during the months when good quality water is available. The quantity of water that can be stored at the Kaparas reservoir and the Sumanbay point was studied.

(1) Tuyamuyun (Kaparas reservoir)
The maximum storage quantity of 550 million m^3 in the Kaparas reservoir is about 6.7% of the 10-year probabilistic flow of the Amu Darya river, which is also extremely small compared to the outflow from the downstream canals. Therefor, the flow rate of the Amu Darya river can meet the maximum storage capacity as well as yearly water quantity required for drinking water of the Study Area.

(2) Sumanbay
The required water quantity as drinking water can be utilized at Sumanbay. However, Even if the flow rate of the Amu Darya river decreases in drought year, the appropriate quantity of water can be stored at the Sumanbay point, by efficiently control of the water distribution of upstream canals.

5.4 Study on the Kaparas Reservoir

5.4.1 Outline of the Kaparas Reservoir

The Kaparas reservoir belongs to the Tuyamuyun Hydro-unit used mainly for storing water for irrigation. This Hydro-unit consists of the Ruslovoye reservoir, the Sultansanjar reservoir, and the Koshburak reservoir in addition to the Kaparas reservoir. The Kaparas reservoir has been decided to be used as an intake source for the Tuyamuyun water supply system.

Presently, the Kaparas reservoir is being used mainly for irrigation together with the other three reservoirs, according to the schedule given below. It is also being used for hydraulic power based on this schedule.

- Store water in the Hydro-unit during the period from September to May.
- Discharge water from the reservoirs during the period from June to August.

In the future, when the Kaparas reservoir is used as a drinking water source, the reservoir should be managed as given below.

- Store the required quantity of water during the period from June to August when the quality of water is good; for the remaining period, use the reservoir as a drinking water source.

5.4.2 Water Rights

The government decision of the ROU has been made to use the Kaparas reservoir as a drinking water source for the inhabitants in the Aral Sea Region. The use of hydro-facilities used by Uzbekistan within the Turkmenistan territory, including the Kaparas reservoirs, has been agreed upon with the Republic of Turkmenistan.

5.4.3 Evaluation of Quality of Water in the Kaparas Reservoir

Based on the reservoir operating schedule required for storing drinking water, the quality of water in the Kaparas reservoir was evaluated. The results showed that the standard for concentration of mineralization was satisfied, but the standard for total hardness was not satisfied. There were no problems in other water quality characteristics. To improve further the quality of water in the Kaparas reservoir so that the standard for total hardness is satisfied, the measures stated below are necessary.

1) A water quality monitoring system and information control system should be established so that water can be stored when its quality is the best.
2) When storing water in the Kaparas reservoir, the flow of drain from the collector to the upstream part of the Amu Darya river should be stopped.

5.4.4 Studies on Volume Water to be Stored in the Kaparas Reservoir

An effective volume of 260 million m^3 (equivalent to a water level of 123 m) can be stored using the current operating method in a normal flow year for the Amu Darya river, based on the present operating schedule of the Tuyamuyun Hydro-unit used for irrigation water. This volume of water satisfies the annual water demand for the Karakalpakstan and Khorezm for the year 2010, mentioned in the Feasibility Study Report.

5.4.5 Proposal for Detailed Studies on the Kaparas Reservoir

Based on the study above, the Kaparas reservoir is judged to be suitable in principle, as a reservoir for drinking water and as a water supply source having good quality water and adequate volume. Detailed studies, however, on the following points need to be carried out.

1) Can the water level in a drought flow year and low flow year be raised to a level equivalent to the required volume of water to be stored?
2) The quality of water stored in the Kaparas reservoir needs to be studied in further detail. For this reason, a trial operation of one year should be included in the proposed operating schedule of the Kaparas reservoir.

5.5 Ground Water Sources

More than 60 sources of lens water were found in the period from 1960 to 1995 along the irrigation canals in the Study Area, but the quality of this water degraded with the drop in level of water, reduction in flow and increase of collector drain in the Amu Darya river. Artificial replenishment techniques were developed for ground water to counter this problem.

Comparatively low mineralization concentrations (1.5 to 5.0 g/l) and low total hardness (3 to 6 meq/l) of ground water exists in layers at depths of 350 to 450 m. This ground water is being desalted using desalting equipment (EKOS: capacity 50 m^3/day) and supplied as drinking water.

The mineralization concentration of ground water is constant throughout the year, and it does not satisfy the water quality standards. However, the mineralization concentration in seasons other than summer is lower than that of surface water sources.

In the Study Area, 40 locations in ROK and 25 locations in Khorezm have been discovered with lens ground water. In recent studies, ground water with capacities of 4,600 m^3/day in the northern zone and 21,400 m^3/day in the southern zone of ROK, and 39,800 m^3/day in Khorezm can used.

In the area of the Six Cities of the Study Area, the ground water sources of Urgench an Chimbai can be usable quantitatively and qualitatively as drinking water source.

5.6 Water Quality Standards

Two kinds of water quality standards are presently applicable for the quality of drinking water and surface water used for drinking purpose.

The water quality standards used for evaluating quality of water by the JICA Study Team and for this study are the water quality standards of the ROU. For water quality indicators for which no quality standards exist in the ROU, the quality standards of WHO or Japan were used for evaluation. The main water quality indicators in the ROU water quality standards are given below together with those used by the WHO and Japan.

Table 5.1 Major Water Quality Standards

Indicator	unit	Drinking Water	Row Water fro drinking source	WHO Guideline	Japan Standard
Quantity of B. Coli. (Colifom bacteria)	CFU	3/1 ml		0/100 ml	not to be detected
Total hardness	meq/l	7.0	7		3.75
Mineralization	mg/l	1000	1000	1000	500
Fe	mg/l	0.3	0.3		0.3
Mn	mg/l	0.1		0.5	0.05
Turbidity	mg/l	1.5	20	5 NTU	2
Residual Cl_2 (Free)	mg/l	0.3 - 0.5		5	approx. 1

5.7 Evaluation of Water Quality Analysis by the JICA Study Team

5.7.1 Outline of Water Quality Analysis

The JICA Study Team together with the Central Special Institution Agency for Analytical Control (GosSIAK) sampled surface water, ground water, treated water and supplied water once a month in the Study Area and carried out water quality analysis. The period of analysis was from March 1995 to February 1996. Supplementary analysis on mineralization, total hardness, heavy metals and agricultural chemicals was carried out until August 1996.

5.7.2 Evaluation of Results of Water Quality Analysis

The analyzed results were evaluated based on the water quality standards mentioned above.

(1) Evaluation of quality of surface water of the Amu Darya river

The quality of surface water of the Amu Darya river did not comply with the water quality standards with regard to turbidity, Fe, Mn, total hardness, mineralization, sulfates, chlorides, COD, and $KMnO_4$. Other quality indicators satisfied the water quality standards, or they posed no problems as the frequency and/or locations that does not comply with the Standard is considerable low. The concentration of agricultural chemicals was too small to cause any adverse effect on the drinking water.

(2) Evaluation of quality of treated and supplied water

From the quality indicators analyzed, sixteen indicators did not comply with the quality standards, but except for the quality indicators mentioned below, the others are not expected to pose major problems.

Turbidity, Fe, Mn, total hardness, mineralization, COD and $KMnO_4$

Measures to ensure that the quality indicators mentioned above satisfy the water quality standards are described below. Fe and Mn together with turbidity can be removed by appropriate coagulation-sedimentation. COD and $KMnO_4$, which show high values at Muynak and Kungrad indicate organic pollution. These organic substances can be removed by the activated carbon treatment or by appropriate coagulo-sedimentation to a certain extent. The first priority is to treat the water appropriately by coagulation-sedimentation. To reduce concentration of total hardness and mineralization, softening and desalting treatment are necessary, or using water by storing the good quality water of the Amu Darya river during summer when total hardness and mineralization are low is necessary.

(3) Evaluation of agricultural chemicals

Six quality indicators related to agricultural chemicals were detected, but only one sample taken in June at Kyzy-Ui, in the downstream end of the Amu Darya river exceeded the WHO guidelines (γ-BHC 2 g/l). Consequently, major problems are not anticipated. However, since such indicators were detected in the water, analysis and monitoring of agricultural chemicals should be continued.

CHAPTER 6 INSTITUTIONAL AND ORGANIZATIONAL ASPECTS

6.1 Global Trend in Water Supply Policies, Institution and Systems

Past experiences of global development efforts have shown that long-term success of the Water Supply and Sanitation Sector (WS&SS), which has been one of the most important sectors for development, was dependent on good planning, supportive policies, strong community participation, and adequate financing with emphasis stressed upon areas of community participation, policy dialogue, financing and management, training, institutional and human resources development. While a donor's role is to assist, the responsibility for development ultimately lies with the recipient nation. Partnership among donors, governments and NGOs help empower individuals and communities, and increase accountability of governmental and non-governmental institutions to the people they serve. The global trend in development and technical assistance is therefore to lay emphasis on institution strengthening and capability building of the authorities and agencies responsible for the Sector.

6.2 Basic Principles/Criteria for Service Delivery in the Water Supply Sector

To provide a satisfactory service efficiently and with the lowest possible and necessary financial, administrative and technical input at attractive prices, the water supply authorities, must essentially be supported with well set government policies and systems, legislation, strategic planning, funds and clearly defined institutional responsibilities. They need authority with reasonable flexibility to function effectively without being confronted with rigid civil and administrative rules and conditions. Appropriate inputs by all institutions responsible for sector governance, service delivery and service support at both national and local levels must be guaranteed besides maximum coordination and interaction among them.

Some basic principles/criteria required for better service delivery in the sector are;

1) <u>Accountability</u>

a) of the government for;

- national policy and strategic planning on water management and water supply,
- legislation and regulation development,
- planning and control of national water resources, and funding on their development, protection and conservation as well,

- planning and development of institutions and systems,
- planning , development and funding of national infrastructures,
- necessary sector support

b) of the regional/local governments for;

- implementing the government policies and plans
- planning and development of institutions and systems,
- planning, development and funding of local infrastructures,
- necessary sector support.

2) Financial Viability of all service delivery systems should be targeted by operating them on self-financing/commercial basis with gradual reduction in subsidies granted.
3) Sound Management of each individual institution in a cost conscious manner must be established.
4) Measurable Performance: Inputs and performance of functions by the institutions within the mandated authority and responsibilities must be measurable and accountable.

6.3 Goals and Objectives of the Water Supply Sector in the ROU

6.3.1 Overall Goals Set Out for Government Operations

To achieve the policy goal towards shifting to the market economy, the government of the ROU has established a series of specific objectives focusing on;

* formulation of systems for legislative and organizational aspects to facilitate administrative decentralization and increased level of public participation,
* promoting decentralization of executive-administrative functions of the government,
* reorganization and decentralization of ministries, central departments and public institutions in order to achieve efficiency and rationalization of functions,
* promoting privatization and increased participation of private sector in the appropriate sectors.

Accordingly, legislation has been enacted to establish in the provinces, districts and cities of the ROU posts of Khokims who will serve as heads of local representative and executive-administrative authorities. The ministries, state committees and central departments were reorganized and decentralized with delegation of authority to prevent/minimize duplication and overlapping of functions of different departments. Decentralized functional departments were subordinated to the respective Khokimiat.

Service or production departments were reorganized for them to operate as commercially oriented self supported enterprises.

6.3.2 Overall Goals Set Out in the Water Management Sector

Legislation has been formulated and being implemented on water management and water usage with the following objectives;

* regulation of water relations,
* rational use of water resources for the needs of population and national economy,
* protection of water resources against pollution, contamination and deterioration,
* prevention and elimination of harmful impact on the waters,
* improvement of conditions of water bodies/objects,
* protection of rights and responsibilities of enterprises, agencies and offices of farms and individuals as regards to water relations.

6.3.3 Overall Goals Set Out in the Public Water Supply Sector

Various resolutions have been passed and decrees, directives and guidelines have been issued identifying the following among the overall goals;

* Reorganization of the activities of the MPU of the ROU aimed at improvement in management of public utilities in the country, and staged conversion of public utility services on self supported basis,
* Establishing standards and legal basis for staged conversion of public utilities payment system towards a self-repayment system, but in line with the measures aimed at social protection of the population in the form of purposive subsidies for partial cover of public utility service expenses,
* Stage by stage reduction of state subsidies on the financing of public utilities expenses,
* Giving mandate to the Council of Ministers of the ROK, Khokimiats of the Provinces and Tashkent City to approve the consumption limits and tariff of public utilities within their respective territories,
* Gradual and complete shifting from the existing system whereby the population pay for water and sewerage services according to estimated water consumption rations, to a system of payment for actual consumption based on water meter readings.

* Taking measures to increase responsibility of the heads of public utility enterprises in order to ensure timely settlement of payments by consumers for services provided.

As evident from these goals, introduction of market economy policies has positively contributed the ROU to fall in line with the global trends in water sector development and service delivery. The changes and progress made towards achieving the goals in the water supply sector are encouraging in spite of the severe economic crisis the country faced soon after its independence, sudden shift in policies and logistical difficulties in the overall system in adjusting to the required changes etc. Such factors that influence the intended progress in the implementation of sector policies can not therefore be ignored in making future improvements through institutional and managerial strengthening, policy considerations etc.

6.4 Water Management and Water Supply Administration

Policies and norms on the management of interstate rivers are decided by the Interstate Coordinating Committee consisting of the relevant states. Amu Darya River maintenance, river flow management and distribution of water to concerned countries are executed by the Interstate Water Basin Department of Amu Darya River. In the ROU, legislation provides for protection, rational use and management of surface water and groundwater resources which are used for both urban and rural water supply. Overall responsibility for water management in the ROU lies with the Ministry of Melioration and Water Management while the State committee for Geological and Mineral Resources is responsible for the management of groundwater resources. Protection of the environment including the water sources is the responsibility of the SCNP.

The MPU and the MOA of the ROU are responsible respectively for urban public water supply and rural water supply. The responsibility of producing and supplying public water to the cities and urban centers lies mainly with "Vodokanal" enterprises managed under a Deputy Khokim in the 12 provinces (and Tashkent City) through the TCMA, or under the Deputy Minister, MPU of the ROK, and supervised by the MPU of the ROU. In the Study Area, local waterworks have their own water sources (groundwater or canals) and treatment facilities, but now depend largely on the bulk producers namely; the Department for Operation and Maintenance of Tuyamuyun-Urgench Inter-regional Water Pipeline (DOMIWP-T/N) and the Department for Operation and Maintenance of Tuyamuyun-Nukus Inter-regional Water Pipeline (DOMIWP-T/N), who treat and deliver Amu Darya water. Such DOMIWPs which supply bulk water to urban and rural population of two or more provinces are not included under the TCMAs, but report to the MPU of the ROU through the Republican Production Amalgamation for Development and Operation of Regional Water Pipelines (RPADORWP) that was set up to supervise these departments with a view to solve all problems arising from operation and development of regional water pipelines.

CHAPTER 7 FINANCIAL AND MANAGERIAL ASPECTS

7.1 General Trend

Water Supply Works was nationally prioritized among the public utility service by the Decree of the president of the ROU in 1990 "On the Improvement of Drinking Water and Natural Gas Supply for Rural Population of the ROU" Recently, infrastructure facilities and enterprises including water supply and sewerage was enlisted on the possible privatizing categories by the Decree of Supreme Council of the ROU in August, 1995.

There are three(3) organizations involved in public water supply in the study area as follows,

1) Vodokanals; Supply to urban district including regional centers, being managed by TCMA(Territorial Communal Services Maintenance Amalgamations) of the Khokimiats of the provinces and by MPU of the council of Ministers of the ROK.
2) Inter-Regional Water Pipelines;
   Supply to urban and rural districts of two or more provinces as DOMIWPs such as Tuyamuyun-Nukus and Tuyamuyun-Urgench water mains, being managed directly by the MPU of the ROU.
3) UzagroVodokanal ; Supply to Rural districts, being managed by the MOA of the ROU and the joint-stock investment "Obi-Hayat", and in the ROK by the council of Ministers.

7.2 Present Situation

7.2.1 Financial Support by the Government of Uzbekistan (GOU)

With the Decree NO.371 of July, 1993, the financial support of MPU of the GOU has been decreasing and transferring to local administrative bodies regarding some part of the capital construction and maintenance & operation of Vodokanals,.

The new administration policy of the GOU, has intended to realize "Staged Conversion of Public Utility Services on Self sufficient Basis" by the Resolution NO.54 by the staged reduction of the subsidies.

This resolution NO.54 can be said as a basic guideline for the improvement of the Public Utility Services.

7.2.2 Management System

Vodokanals are aiming "Self-sufficient" management under the administration of the Khokimiats of the provinces and the council of Ministers of the ROK who were assigned wide powers by law from MPU of the ROU.
Inter-regional Water Mains through RPA(Republican Production Amalgamation) under MPU of the ROU, it's management are far from self-repayment system with subsidies at present.

7.2.3 Accounting System

Basically "cash basis" instead of "accrual basis". As financial statement, principally, reports of "Income and Expenditure" annual and quarterly. B/S and I/L (Inventory list) still not habitual due to less diffusion of "double entry accounting system".

7.2.4 Financial Progress   Refer to Table 7.1 ~ 7.4 (Part I in Main Report)

Vodokanals, basically with favorable balance under less expenditures than forecasted due to shortage of supplies. This is not normal situations
Inter-regional Water Mains(DOMIWPs), with insufficient financial data and major expenditures supported by MPU, its financial improvement implies the paradox by the reduction of the Government subsidy and the increase of water revenue by raising tariff to be decided by the same Government.

7.2.5 Water Tariff System   (For Populations)

So far by norm consumption per capita. Tariff to be decided more flexibly with the Resolution NO.54.

(1) Basic Concept
"By water gauges, if not available, by the effective water consumption ration."

(2) Current Water Tariff System
Refer to Table 7.5 ~ 7.7 (Part I in Main Report)
Water Rate from DOMIWPs is key point for the tariffs of three groups of consumers.

(3) Billing & Collection System
Different system is adopted in case of consumers with and without water meters.

7.2.6 Management Analysis

Vodokanals: Due to shortage of funds, capital investment programs are delaying and by insufficient water services facing with difficulty of converting to complete self-supporting basis.

DOMIWPs:(Tuyamuyun Enterprises)

On the constant deficit valances from the beginning due to water producing cost approx. five times the water revenue.

Government's financial support being inevitable as ever under the present situation.

7.3 Consumer's Survey on Water Supply Services and Water Use

7.3.1 Method & Object of Survey :

1st Survey, Jun. 1995 (95 Household)
2nd Survey, Jun. 1996 (28 Household)

7.3.2 Summary of the Results

1)General Trend Refer to Table 7.11 (Part I in Main Report)
Observations from the 1st survey and 2nd survey
2)Characteristics by Area and Cities
3)Other Findings Refer to Table 7.12 (Part I in Main Report)
-water expense on Household Economy
-Data from testing water meters

7.4 Observation & Evaluation of the Water Supply Works

7.4.1 Securing of the Sufficient Budgetary Fund

Need to be financially supported for the capital construction of Vodokanals because of insufficient water revenues.

7.4.2 The Way to the Autonomous Enterprises

1) For Vodokanals, need, in principal, to have the water tariffs be raised properly and the support of the local budget if necessary.

2) Special financial sources of the GOU is to be considered for the flexible management.
3) DOMIWPs ; more hardness to realize autonomous management than Vodokanals.

7.4.3 Policy for Water Tariff

1) Special features of the ROU;
   a) Special low tariffs to Group-1 as a kind of social protection.
   b) Higher tariffs to Group-2 and 3 to cover the corresponding deficit of the budget.

7.4.4 Effective Water Volume (EWV) and Effective Water Ratio (EWR)

Production volume or Supply volume of Vodokanals has been calculated on estimation basis due to inadequate measuring system, the reason of the difference of EWR between KKP and KZ should be clarified.

7.4.5 Difficulty of the Procurement of Necessary Materials & Equipment

After the independence, Vodokanals and DOMIWPs have been facing constant problems of obtaining the supplies. Most urgent matters are the repairs (replacement) of the obsolete distribution networks.

7.5 Step for Improvement of Management & Finance

7.5.1 Need to raise AFW(accounted-for water) volume by Water Meters and to Collect the connection service charge

Necessary to receive some financial support for metering system and to collect some connection charges even by installments from the consumers.

7.5.2 Need to Establish Unified Accounting System and Management Through Figures

1) Unified Accounting System by common formats as "Accrued Basis" on the expenditures and revenues.
2) Double entry accounting system for financial report.
3) "Management through figures" on financial and accounting system and its opening to the public has close relation with the ideology of self-support system.

7.5.3 Need to Raise the Share of Expenditure on Water in the Household Economy

1) Too small share of water in the study area as an Average 0.31% in Jun., 1995, and 0.48% in Jun., 1996.

2) World trend in the developing countries : Ave. 2～4%

7.5.4 Water Tariff of DOMIWPs

1) Selling price of DOMIWPs cannot be raised simply with the reduction of government subsidies.
2) Max. affordability of the consumers should always be analyzed on such occasion.

7.6 Conditions to Self-sufficient Enterprises

7.6.1 Need to Formulate Solid Budget Plan

Stable water revenues depend on the metering system and staged increase of AFW volume within the medium-term.

7.6.2 Need to Grasp the Exact Receivable Amount and its Recovery

1) Annual percentage of the receivable amount is reportedly approx. 30%, which is higher than normal.
2) With the diffusion of the meter and increasing revenue share of group-1 by the raised tariff, collection ratio in total can be improved.

7.6.3 Need to Arrange Financial Souses for Vodokanals

1) Financial supports of the local government (Khokimiats) are scarcely possible due to lower income, and low productivity from the handicapped local conditions around Aral Sea Area.
2) Instead, the GOU(MPU) should reserve, the funding source for Vodokanals with vesting necessary powers and conditions.

7.6.4 The Future Options for Private Sector Involvement and Privatization

For the improvement of the economic effectiveness, parts of service and management for the operation and maintenance such as (1) inspection, repairing and replacement of water meters, (2) money collection, (3) Inspection, repairing and operation of the facilities can be entrusted to the subcontracted private enterprises or as an extended operational contract in a form of leasing and/or concession like many international examples except the responsibility for investment. Another way to introduce market principles is though privatization, transferring assets out of the public sector which is increasing rapidly in developing countries.

CHAPTER 8 WATER SUPPLY IMPROVEMENT PLAN

8.1 Conditions of Plan

A long-term plan for the water supply system with the objective of improving the quality of drinking water in the Study Area is formulated. The conditions and methods for planning the plan are given below.

(1) The target year is taken as 2010.
(2) For selecting the optimum water supply system, the optimum system in the Tuyamuyun inter-regional water supply system is studied first.
(3) Next, the improvement plan for Vodokanal regional water supply is formulated.
(4) For reducing the total hardness and mineralization of the water supply sources, the two methods below are studied.
   1) Store the volume of water that is equivalent to the annual water demand when the quality of water in the Amu Darya river is good, and purify the water by conventional treatment methods.
   2) Use the existing water supply sources, and use the desalting process in addition to the conventional treatment methods. Use reverse osmosis (RO) for desalting the water.
(5) Usable facilities are selected from the existing water treatment plants of Vodokanal after judging the quality of sources, treatment methods and status of facility and these facilities are used effectively.
(6) When studying the optimum system from the Tuyamuyun water supply system, the arrangement of existing water supply facilities, etc. are considered, and Karakalpakstan and Khorezm are divided into four blocks (Khorezm, KKPRight, KKPLeft, Muynak), and alternative plans are prepared.

8.2 Alternative Plans for Water Supply System (Alternatives)

(1) Description of Alternatives

Alternatives	Description
Alternative 1	All four blocks use the Kaparas reservoir as the source of water.
Alternative 2	Same as Alternative 1, except that only the Muynak block uses the reservoir as the water source, with water being treated by RO.
Alternative 3-1	Khorezm and KKPRight Blocks use the Kaparas reservoir as the source of water. KKPLeft and Muynak blocks use the existing water source in KKPLeft after RO treatment. The treated water is conveyed from KKPLeft to Muynak.
Alternative 3-2	Khorezm and KKPRight Blocks use the Kaparas reservoir as the source of water. KKPLeft and Muynak blocks use the new reservoir near Sumanbay as the source of

	water.
Alternative 4-1	Khorezm and KKPRight Block use the Kaparas reservoir as the source of water. KKPLeft and Muynak blocks each uso their own existing water sources after RO treatment.
Alternative 4-2	Khorezm and KKPRight Block use the Kaparas reservoir as the source of water. KKPLeft block uses the new reservoir near Sumanbay as the source of water. The Muynak block uses the existing source of water after RO treatment.

(2) First Screening of Alternatives

Alternatives 3-2 and 4-2, which envisage construction of a reservoir near Sumanbay in the KKPLeft Block are rejected because of such an reason for which appropriate area for the reservoir cannot be found.

(3) Comparison of Alternatives

The alternatives mentioned above were compared and studied with regard to the indicators below.

1) Costs (total construction cost, operation and maintenance (O&M) cost, Net present value of costs)

Table 8.1 Comparison of total construction costs (excluding shared facilities)

(Units: million US dollars)

Description	Alternative 1	Alternative 2	Alternative 3-1	Alternative 4-1
Construction Costs	409.0	382.1	456.5	404.8

Table 8.2 Comparison of annual operation and maintenance costs in 2010

(Units: million US$/year)

Description	Alternative 1	Alternative 2	Alternative 3-1	Alternative 4-1
O&M costs	23.7	23.1	20.1	19.6

Table 8.3 Comparison of net present value of total costs

(Units: million US dollars)

Discount rate (%)	Alternative 1	Alternative 2	Alternative 3-1	Alternative 4-1
10	441.4	418.1	437.0	399.4

2) Factors other than cost (level of difficulty of operation and maintenance, suitability of application technology, flexibility in the event of an emergency, convenience of consumers)

8.3 Selected Water Supply System

Based on the conditions below, Alternative 1 was selected as the optimum water supply system for the Study Area. (Table 8.7, Fig. 8.1 and Fig. 8.2)

1) There is no appreciable difference in the total current cost which includes total construction cost, and operation and maintenance cost for the Alternatives; therefore, comparison of costs for the Alternatives does not become a deciding factor in the selection.

2) Operation and maintenance of facilities are the easiest in Alternative 1. The water supply method of Alternative 1 is convenient for the consumer. Since the treated water from RO facilities will be supplied only for restricted applications that need drinking water, water supply means other than existing distribution networks are necessary. Accordingly, the method of supplying water to consumers through the RO facility in the KKP Left bank becomes extremely troublesome, and is also inconvenient for the consumers. For a comparatively large city, this sort of water supply method is not feasible in the long term.

3) A large number of facilities have already been completed for Alternative 1, and a part of the construction is in progress. For future construction, a part of the equipment and machinery has already been procured.

Alternative 1 has been selected, but this Alternative has a deficiency in that the response in the event of an emergency is difficult. It is dangerous to depend only on one water supply system for supply of water to the region between Tuyamuyun and Muynak extending for about 450 km. To solve this problem, water treatment plants in each area making use of its own water source should be kept as standby so that a good response is available in an emergency.

8.4 Inter-regional Water Supply System (Tuyamuyun Water Supply System)

8.4.1 Outline

The Tuyamuyun inter-regional water supply system sell treated water to the Vodokanals and Agro-Vodokanals through the transmission pipelines. Both these corporations then supply the purchased water as well as their own produced water to the inhabitants through their distribution networks. The T-N system and the T-U system, deliver water to Karakalpakstan and Khorezm respectively. The outline of the proposed Tuyamuyun water supply system is given below. (Fig. 8.1 and Fig, 8.2)

1) Water source: Kaparas reservoir
2) Treatment plant: Existing and expanded T-N water treatment plant and T-U water treatment plant
3) Transmission pipeline system: T-N transmission pipeline system and T-U transmission pipeline system

8.4.2 Projected Water Volume

(1) Maximum daily intake volume by water source

Table 8.4 Daily maximum intake water quantity in 2010

(Units: thousand m^3/day)

Covered area	Daily maximum supply capacity			Intake water quantity		
	total	Tuyamuyun	Local	total	Tuyamuyun	Local
T-Nukus	549.2	421.2	128	604.1	463.3	140.8
T-Urgench	557.2	437.2	120	612.9	480.9	132.0
total	1,106.4	858.4	248	1,217.0	944.2	272.8

(2) Required annual volume by water source

Table 8.5 Required annual storage volume by water source in 2010

(Units: million m^3/year)

Description	All water sources	Kaparas reservoir	Local water source	
			Karakalpakstan	Khorezm
Water quantity	387	300	45	42

including water quantity used in treatment plant

8.4.3 Planned Facilities

The main planned facilities are as given below (Table 8.7).

- Completion of Kaparas intake pumping station
- Laying of raw water main
- Improvement and expansion of Tuyamuyun water treatment plants
- Laying of transmission pipelines and transmission pumping station

8.5 Regional Water Supply System (Vodokanal)

Expansion, improvement and rehabilitation to facilities for regional water supply system are planned.

8.5.1 Water Treatment Plants

Treatment plants that perform proper treatment of water and well facilities with comparatively good quality water will be used effectively in the future also. Table 8.6 shows the planned capacities of treatment plants including effective use of the existing water treatment plant and their future expansions.

Table 8.6 Capacity of Water Treatment Plants Used and Expanded in Future

Vodokanal Agro Vodokanal	Design capacity	Distribution Capacity				Source of water	Type of treatment process
		Capacity operated at present	Capacity used in future	Capacity expanded in future	total		
Karakalpakstan							
1 Nukus (V.K)	65.0	60.0	60.0	30.0	90.0	canal	sedimentation & filtration
2 Turtkul (V.K)	8.4	8.4	8.4		8.4	ground water	
3 Beruni (V.K)	4.6	4.6	4.6		4.6	ground water	
4 Chimbai (V.K)	5.7	1.0	2.0		2.0	ground water	
5 Kegeili (V.K)	2.5	1.0	1.0		1.0	ground water	
6 Beruni (A.V)	-	8.0	8.0		8.0	ground water	
7 Turtkul (A.V)	-	14.0	14.0		14.0	ground water	
total		97.0	98.0	30.0	128.0		
Khorezm							
1 Urgench (V.K)	50.0	45.0	45.0	45.0	90.0	canal	sedimentation & filtration
2 Chalish (V.K)	-	10.0	10.0	20.0	30.0	ground water	
total	-	55.0	55.0	65.5	120.0		

8.5.2 Plan for Distribution Network

This plan envisages the renewal of old and corroded pipelines for reducing water leakage and laying of new pipelines for increasing the water supply area.

8.5.3 Water Meters

Presently, water meters have not been installed for consumers belonging to Group (1). Slightly less than 50% of the Group (2) and Group (3) consumers have installed water meters at their own expense. In the near future, water meters are likely to be installed for all the consumers of these groups. On the other hand, consumers of Group (1) are not likely to install water meters at their own expense. Accordingly, the Vodokanals shall install water meters for these consumers by making use of public funds.

8.6 Project Cost and Implementation Schedule

8.6.1 Construction Cost

Studies on the following conditions were carried out for estimation of construction cost.

1) Unit construction material cost
2) Labor charges
3) Construction machinery cost
4) Construction status

Besides, the costs for CIS, Europe, and Asian countries were taken as reference and the construction cost was estimated. The construction cost of the following facilities which are being constructed, was estimated considering that the parts of facilities whose constructions have been completed.

1) Kaparas intake plant
2) Raw water main (from Kaparas intake pumping station to T-U intake pumping station)
3) T-N water treatment plant (expansion)
4) T-U water treat plant (expansion)
5) Proposed pumping stations
6) Transmission pipelines

The machinery and equipment mentioned below and stored on site were procured in 1992 and approximately four years have elapsed. These machinery and equipment are also utilized in this plan. Inspection and repair charges were taken as 20% in case of new purchase of mechanical equipment, and 70% in case of new purchase of electrical equipment.

1) Mechanical and electrical equipment for Kaparas intake pumping station
2) Mechanical and electrical equipment for transmission pumping stations

8.6.2 Estimation of Construction Cost

(1) Estimation standards

1) The main imported materials and the countries from which materials are to be procured are listed below for estimating the cost.

a) Steel pipe	Russia, Ukraine
b) Ductile cast iron pipe	South Korea
c) Mechanical and electrical equipment	Japan
d) Water meters	Uzbekistan

2) Exchange rates

- 1 Uzbekistan sum = 0.025 US dollar
- 1 Uzbekistan sum = 2.75 Japanese yen
- 1 US dollar = 40 Uzbekistan sum
- 1 US dollar = 110 Japanese yen

The above rates are as of July 1996

3) Engineering expenses were assumed to be less than 10% of the construction cost.

4) Physical contingency was taken as 5% of the construction cost.

(2) Construction cost

The estimated result for the construction cost is 1,018.6 million US dollars. Table 8.7 shows the breakdown.

Table 8.7 Construction cost

(Units: million US dollars)

		Total	Phase I	Phase II	Phase III
1.Kaparas Intake Pumping Station	Q=1,000,000 m³/day	12.9	12.9		
2.Raw Water Mains	L=31.4 km	48.0	33.0		15.0
Sub-total		60.9	45.9		15.0
3.T-Nukus Water Treatment Plant	Q=500,000 m³/day	96.3	60.1		36.2
4.No.2, No.3 Transm. Pumping St.	Q=306,940 m³/day	19.0	9.5		9.5
5.Nukus North Distribution St.	Q=255,910 m³/day	10.8	10.8		
6.Kungrad Transmission St.	Q=55,020 m³/day	18.9	10.5		8.4
7.Transmission Pipeline	L=431.0 km	317.2	227.8		89.4
Sub-total		462.2	318.7		143.5
8.T-Urgench Water Treatment Plant	Q=500,000 m³/day	101.9	72.3		29.6
9.Khazarasp Pumping St.	Q=256,290 m³/day	12.1			12.1
10.Transmission Pipeline	L=403.7 km	55.2	51.5		3.7
Sub-total		169.2	123.8		45.4
11.Nukus Water Treatment Plant	Q=100,000 m³/day	28.3	17.7	10.6	
12.Chimbai Water Treatment Plant	Q=2,200 m³/day	1.6	1.6		
13.Water Treatment Plant, 3 cities	Q=14,000 m³/day	6.6	6.6		
14.Distribution Network	L=588.4 km	146.5	40.3	37.0	69.2
15.Meter Installation	N=141,760 pieces	12.5	3.3	2.7	6.5
Sub-total		195.5	69.5	50.3	75.7
16.Urgench Water Treatment Plant	Q=100,000 m³/day	31.7	19.7	12.0	
17.Chalish Water Treatment Plant	Q=100,000 m³/day	5.2	1.9	3.3	
18.Distribution Network	L=351.8 km	88.0	26.0	21.8	40.2
19.Meter Installation	N=66,250 pieces	5.9	1.6	1.3	3.0
Sub-total		130.8	49.2	38.4	43.2
Total		1,018.6	607.1	88.7	322.8

8.6.3 Operation and Maintenance (O&M) Cost

The O & M cost after implementation of the project was estimated with the conditions given below.

- Cost shall be estimated separately for four water supply systems- T-N, T-U, Vodokanal Karakalpakstan and Vodokanal Khorezm
- Cost shall be estimated based on the O & M cost for unit accounted-for water quantity.
- The increase in O & M cost per unit accounted for water quantity shall be estimated in the future as below.
  1) Kaparas intake pumping station (increase in electricity charges, decrease of coagulants)
  2) Transmission pumping stations (increase in electricity charges)
- Repair cost for new facilities shall be set at 0.5 % of total cost of facilities

The O & M cost per unit accounted-for water quantity after implementation of the project is given below.

Table 8.7 O & M cost per unit accounted-for water quantity after implementation of the project

	O & M cost after the Kaparas intake plant commences operation (sum/m³)	O & M cost for increase
Tuyamuyun water supply system		
T-N	4.143	Newly installed trunk line pumping plant + repair cost of new facilities
T-U	2.535	Repair cost of new facilities
Vodokanal water supply system		
Karakalpakstan	2.354	
Khorezm	1.122	

8.6.4 Project Implementation Schedule

The project implementation was divided into three stages given below so that the improvement in water quality, improvement in the supply and demand situation, stable supply of water and future demand are satisfied, and the objectives of preventing water leakage and increasing profits are achieved. (Fig. 8.2)

Stage 1 (1997 to 2000) Improvement in the water quality and expansion supply capacity

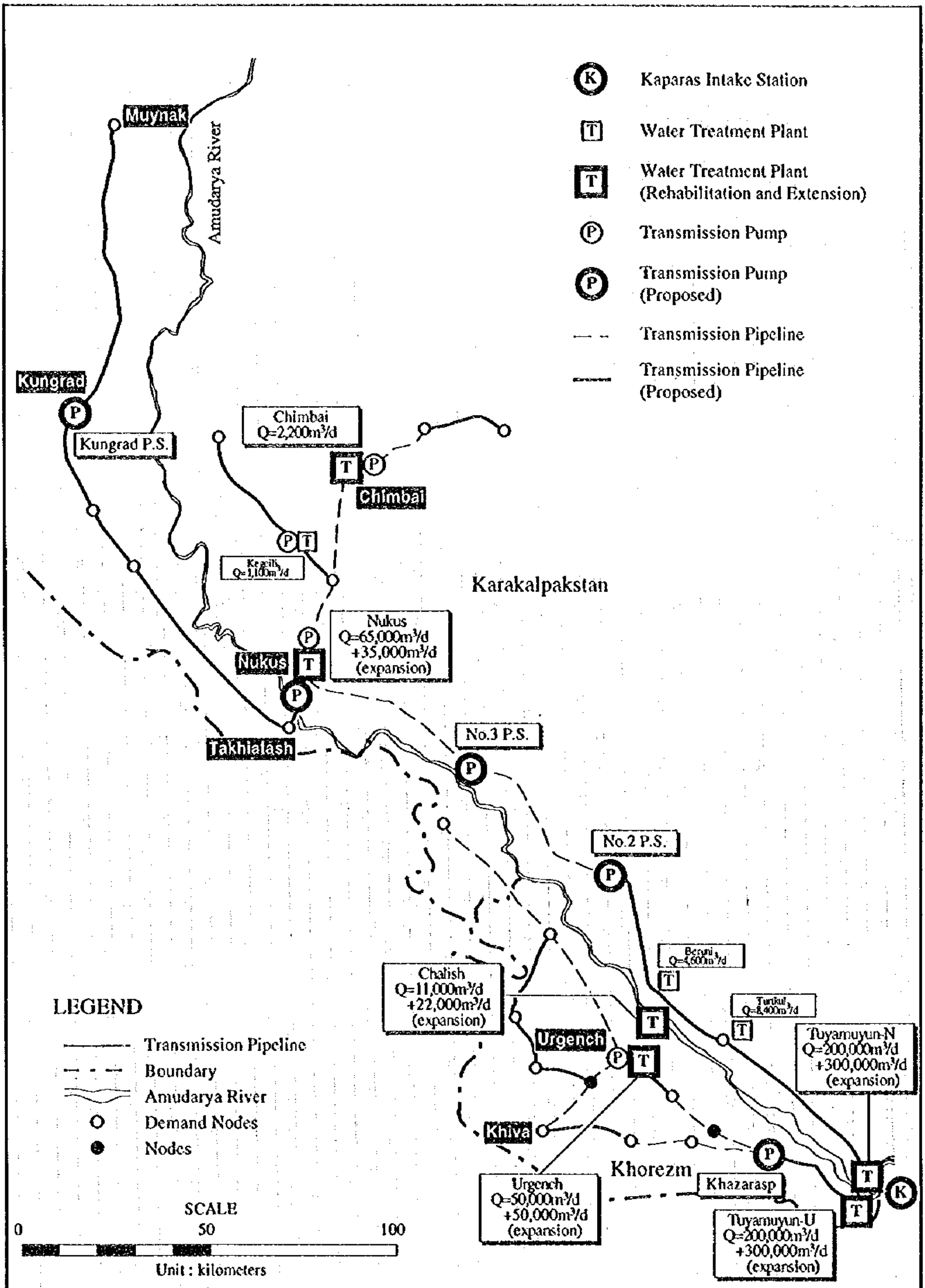
The Kaparas intake pumping station, raw water main, expansion and improvement for the both Tuyamuyun water treatment plants, improvement for water treatment plants of Vodokanals, expansion and replacement of distribution pipelines and installation of water meters to consumer

Stage 2 (2001 to 2003) stable water supply

Expansion of water treatment plants in Vodokanal, expansion and replacement of distribution pipelines and installation of water meters to consumer

Stage 3 (2004 to 2010), Satisfactory of the demand for the target year

Expansion of the second stage of Tuyamuyun system, Expansion of water treatment plants in Vodokanal, expansion and replacement of distribution pipelines and installation of water meters to consumer



THE STUDY ON WATER SUPPLY SYSTEM IN SIX CITIES OF THE ARAL SEA REGION IN UZBEKISTAN	Fig. 8.1 Proposed Water Supply Sys. in 2010
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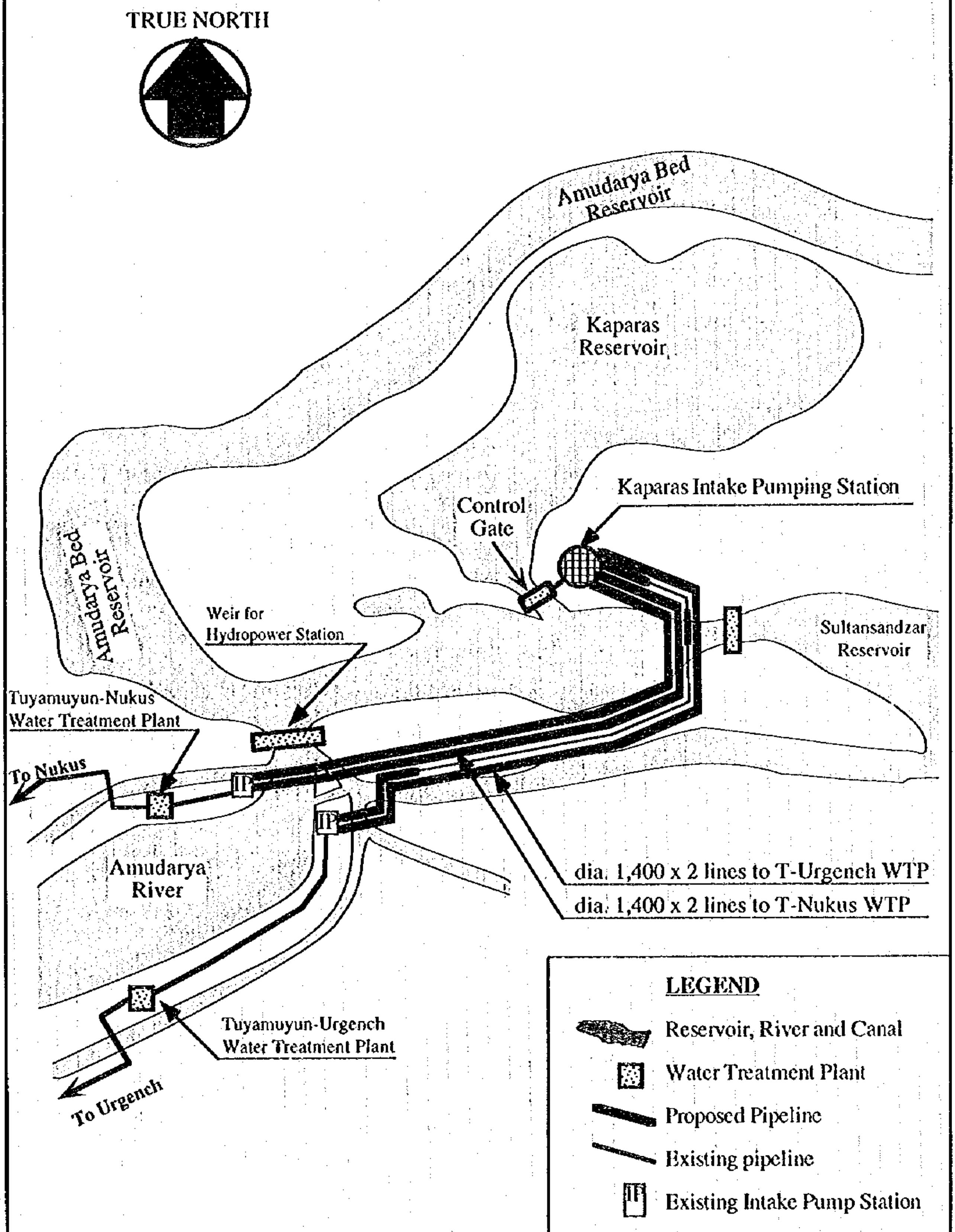

THE STUDY ON WATER SUPPLY SYSTEM IN SIX CITIES OF THE ARAL SEA REGION IN UZBEKISTAN

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Fig. 8.2

Proposed Kaparas Intake Facility

CHAPTER 9 PROJECT EVALUATION

9.1 Introduction

Based on the selected alternative of the basic plan as discussed in chapter 8 of Part 1, analysis should be made from the financial and economic view points for the total project under the assumed condition in relation to the four entities as follows.

(a)DOMIWP-T/N (referred to as T-N)
(b)DOMIWP-T-/U (referred to as T-U)
(c)Vodokanal-ROK (referred to as KKP)
(d)Vodokanal-KZ (referred to as KZ)

The four entities can be grouped as Group-A (T-N with KKP) and Group-B (T-U with KZ) in relation to the area they serve. Evaluation shall be done by Group and by entity, finally for the whole. The method of the analysis;

(1) Firstly, using the assumed group-wise water tariff of Vodokanal, water purchasing rate from DOMIWP shall be determined subject to the total balance of accounts being balanced during the project life under the given discount rate.

(2) Secondly by such obtained water selling price, financial viability of T-N and T-U is checked by calculation of FIRR.

Feasibility of the Basic Plan is then evaluated by the total average FIRR(Group-A plus Group-B).

The result of the analysis is discussed in Section 9.5 herein.

9.2 General Assumption for the Analysis

(a) Total Construction cost	: US$ 1,018,615 x 10^3
(b) Project life	: 30 Years
(c) Construction period	: 1998 ~ 2010 (Total)
(d) Base year for analysis	: 1998 (starting year of construction)
(e) Base of cost estimate	: 1996 prices (unescalated)
(f) Monetary unit	: US Dollar (US$)
(g) Rate of Exchange	: 1 US$ = 40 sum (as of July 1996)
(h) Water tariff	: Assumed as in Section 9.3

(i) O&M cost : Operation and maintenance cost is determined based on actual expenditure shown in the financial statement and assumed to be made up of two components; O&M cost except depreciation that depends on the volume of water sold (accounted-for water), and additional annual cost of replacement and maintenance of facilities and water meters. For details refer to Chapter 8 and Section 9.4 Part 1 of the Main Report.

(j) Discount rate : 7.5% per annual, as the rate currently offered by most international funding agencies.

9.3 Water Tariff

(1) The group-wise water tariff is assumed as follows.

Table 9.1 Assumed Tariff for Group (1)

	A)Current Ave.Tariff per m^3		B)Assumed Ave.Tariff per m^3		Ratio B/A
KKP	0.50sum	0.0125US$	2.10sum	0.0525US$	4.2
KZ	0.35sum	0.0087US$	1.47sum	0.0368US$	- 〃 -

Table 9.2 Assumed Tariff for Group (2) and 3

		A)Current Tariff per m^3	B)Assumed Tariff per m^3	Ratio B/A
KKP	Group2, and 3	9.64sum (US$0.241)	same as A)	1.0
KZ	Group 2(Ave.)	6.38sum (US$0.159)	- 〃 -	〃
	Group 3	7.90sum (US$0.198)	- 〃 -	〃

(2) Basis of the above assumptions

Group (1) :

Household water expenditure in the study area is much lower than those of other utility services. According to the world tendency in the developing countries, average water expenditure is between 2 ~ 5% of the family revenue. Average water expenditure of the households is 0.31% in Jan. 1995, and 0.48% in Jan. 1996 as shown in Table 7.15 of chapter 7 of Part 1. With the assumed 2% of family expenditure as a upper limit in the study area, assumed water tariff for Group (1) was obtained as shown in

Table 9.1 which is less than the affordability of consumers as in Section 7.3.2 (Part I in Main Report) and will be chargeable.

Group (2) and Group (3) :
The assumed tariff of Group (2) and Group (3) were determined as same with the current tariffs due to the fact that there are group of consumers who complains the tariff level and reluctant to close the agreement. Other consumers are even planning to secure own water sources other than Vodokanals because of expensive cost. It is considered that current tariffs may be almost equal level of the willingness-to -pay of the consumers. Thus, the relevant Ave. tariffs of Vodokanals are summed up below.

Table 9.3 Comparison of weighted Ave. Tariffs

	A)Current Ave.Tariff per m^3		B)Assumed Ave.Tariff per m^3		Ratio B/A
KKP	5.198sum	0.130US$	5.976sum	0.149US$	1.15
KZ	3.313sum	0.083US$	3.937sum	0.098US$	1.19

9.4 Operation and Maintenance Cost

Basic concept on the O&M cost of basic plan was discussed in section 8.6.3.
Assumed data of the O&M cost adopted in the analysis are summarized in Table 8.7.
The followings are some additional explanations.

(1) Basic O&M cost: unit cost per m^3 of AFW
For the starting year of the project, current unit cost by enterprise is adopted, varying depending on the AFW volume.
(2) Electricity and Chemicals
Cost of Both indicators are fluctuating with the progress of the construction, especially on the part of Tuyamuyun facilities. Changed unit cost are included in the basic cost stage by stage.
(3) Repairs
Upon the completion of each facilities such as WTP and Pumping stations in different stages, 0.5% of the relevant asset value of the facilities are added yearly to the repair cost.

As for water meters, replacement cost is assumed to be added as a part of repairs after ten (10) years on average from the installation.

9.5 Result of Financial Analysis and Observations

Calculation was made to obtain Financial Internal Rate of Return (FIRR) by the assumed condition as per Section 9.2 and by the water Tariff as per Section 9.3. As a principle, it is a requirement of "Financial Viability" to get revenue from the project enough to cover total investment cost. In this project, water tariff level was assumed at a lower side by the request of Uzbek side while the total investment costs remain huge even after the project has been reduced and rescheduled.

The followings are results and comments from these analysis.

(1) Case of 0% subsidies;
Financial analysis was made by the method discussed in Section 9.1. In both cases of Group-A and B, due to very short of revenue on Vodokanal side, none of the T-N nor T-U gain enough revenue to cover the corresponding cost, being unable to get FIRR. Conclusion is "NOT Feasible" at all.

(2) Case of 100% subsidies;
The construction cost can be off-set by the equivalent 100% subsidies. Min. requirement is whether or not the water revenue can cover the O&M cost within the project life.
By the manipulation of Ave. tariffs, both T-N and T-U will get the surplus balance during the project life. The problems are the fund source of such a huge amount of subsidies in terms of loan in the financial market and of the budgetary revenue of the GOU, including the stability of the entities.

9.6 Steps for the financial Improvement

(1) Need to reduce the investment cost, especially of the phase-1 which cost 60% of the total.
(2) Need to supply flexible subsidies of the GOU where it is necessary.
(3) Need to diversify the revenue source.
(4) Need to adopt the system of gradual increase of the tariff

9.7 Recommendation

Final decision should be taken by Uzbek side regarding the arrangement of special loan, the arrangement of the subsidies from the GOU, and setting-up the reasonable water tariff of the world average level as developing countries.

CHAPTER 10 INITIAL ENVIRONMENTAL EXAMINATION

In general, the environmental impact of a water supply project is considered to be very minimal, but as long as there is a possibility of an impact, environmental consideration (study) of the project is necessary. The Initial Environmental Evaluation (IEE) for the proposed water supply system in the chapter 8 is discussed here.

During the study, the environmental impacts of the project on the regional environment will be examined. Results of the examination will be evaluated, and if necessary, measures to prevent or mitigate environmental impacts will be framed. The Study needs IEE during the basic planning stage, and an Environmental Impact Assessment (EIA) at the feasibility study stage based on the results of the IEE.

Based on Environmental Guidelines prepared by the JICA Study Team, the IEE was implemented.

The environmental element matrix is utilized for the first screening of the IEE. All the environmental elements are screened with reference to each project activity.

From viewpoints of environmental elements, the following elements cannot be ignored during overall project activities and need to be examined at feasibility study further.

1) Noise and vibration
2) Landscape
3) Archaeological treasures

On the other hand, from the view point of the project activities, the following activities may have an impact on the environment and need to be examined at feasibility study further.

1) Operation of the Kaparas reservoir
2) Operation of the water treatment plant
3) Increase in sewerage water as the water supply system develops (Vodokanal system)

In addition, the following specific activities are to be considered:

1) Rehabilitation and replacement of existing facilities, and increase of solid waste.
2) Construction of pipelines that hinders traffic.

PART II FEASIBILITY STUDY

PART II FEASIBILITY STUDY

CHAPTER 1 SELECTED PROJECTS FOR FEASIBILITY STUDY

1.1 Introduction

The Basic Plan of the water supply system in the Study Area for improving drinking water quality, has been formulated as part I of this report. Following the Basic Plan, a feasibility study for the high priority projects was conducted as discussed in Part II of this report.

The target year for the Basic Plan is 2010. The target year for the feasibility study was set at the end of 2002, 5 years after the start of the project.

1.2 Preliminary Evaluation of the Project for Feasibility Study

The conclusions were arrived at that Basic Plan as a whole is not feasible or viable after financial evaluation of the project included in the Basic Plan.

Preliminary evaluation is conducted the project to be implemented by 2002 for feasibility study. The results summarized in Table 1.1.

Table 1.1 Preliminary Evaluation of the Project for Feasibility Study

Description	Evaluation
Possibility of financing	As of this stage, financing the project to the amount of US$ 607.1 million over a three-year period is impossible.
Financial Internal Rate of Return (FIRR)	FIRR can not be obtained. (minus figures)
Implementation schedule	Implementation of such a large-scale construction schedule within a period of only three years is impractical.

FIRR was calculated in principle using conditions of the project evaluation implemented in the Basic Plan.

As indicated by the above evaluation, the possibility of realization of the selected projects for the Feasibility Study is extremely low. Consequently, it is necessary to reschedule and cut down the project scale in order to enable the realization of the project. The method is described below.

1) Abandon the construction of approximately 111 km of pipeline (diameter 1,000

mm) between Takhiatash and Kungrad, and use the existing Urgench Transgas water supply pipeline.

2) Reschedule the expansion plan for water supply.

   Cut down the scale of the project. More specifically, postpone the implementation of projects included in the feasibility study that are to be implemented by 2002 in the Basic Plan, and implement them by 2010, the target year for the Basic Plan.

A feasibility study are carried out for this project (hereinafter called as "rescheduled project")

1.3 Water Demand and Supply of Rescheduled Project

As a result of rescheduling the project, the total capacity of water that can be supplied in 2010 is 828,000 m^3/day. The increase in the water supply capacity of the rescheduled project will be 325,000 m^3/day (T-N: 145,000 m^3/day; T-U: 180,000 m^3/day).

The rescheduled project cannot meet the water demand planned in the Basic Plan. The water demand was evaluated. Consequently, the water demand of rural area was reduced. Assuming that water consumption can be reduced by 15% which is expected through installation of water meters and proper arrangement of water tariff system, the water demands in 2010 for the rescheduled project are given in Table 1.2.

Table 1.2 Water Demand for the Rescheduled Project

(Unit : thousand m^3/day)

Description		1995	2000	2005	2010
Daily average water demand					
T-N	Urban	184.1	257.0	279.3	302.9
	Rural	49.2	34.2	43.7	55.2
	Total	233.3	291.2	323.0	358.1
T-U	Urban	191.0	229.9	236.6	241.1
	Rural	88.2	80.8	104.4	130.8
	Total	279.2	310.7	341.0	371.9
Daily maximum water demand					
T-N	Urban	211.7	295.5	321.3	348.3
	Rural	56.6	39.3	50.2	63.5
	Total	268.3	334.8	371.5	411.8
T-U	Urban	219.7	264.4	271.9	277.2
	Rural	101.4	92.9	119.9	150.4
	Total	321.1	357.3	391.8	427.6

1.4 Improvement in Drinking Water Quality

Presently, water treated by ordinary treatment process or by sedimentation process only, is not suitable for drinking because of the high concentration of contaminants of the raw water for drinking water.

According to the Basic Plan, Kaparas reservoir, where good quality water is to be stored during the flood season of Amudarya river, will be used as the water source. Consequently, the quality of drinking water will improve. Especially, improvement in the concentration of total hardness and mineralization by the Rescheduled Project in 2010 is anticipated as shown in the following table.

Table 1.3 Water Quality Improvement in 2010

	Total hardness(meq/l)	Mineralization (mg/l)
T-N system	6.7	733
T-U system	6.3	690

CHAPTER 2 ENGINEERING DESIGN

2.1 Design Conditions and Criteria

Some of the proposed facilities for the feasibility study have been already designed by the Uzbeki side in their own water supply master plans (the Uzbeki master plans), some are under construction, while the construction of some facilities has been suspended. Therefore, the design for this study has been conducted based on the design of existing facilities and plans.

The design criteria used for the water supply system and facilities are as follows:

1) Storage capacity of reservoir :	1.1 x 365 x daily average water demand
2) Intake pumping capacity :	1.1.x daily maximum water demand
3) Raw water main :	1.1 x daily maximum water demand
4) Water treatment plant :	1.1 (or 10/9) x daily maximum water demand
5) Transmission pipeline :	daily maximum water demand
6) Transmission pumping station :	daily maximum water demand
7) Distribution pipeline :	hourly daily maximum water demand
8) Distribution pumping station :	hourly maximum water demand

2.2 Summary of Proposed Water Supply System

Outline of the proposed water supply system and the major proposed facilities in 2010 are summarized in Table 2.1 and Fig. 2.1 - Fig. 2.2.

Table 2.1 Proposed Water Supply Facilities for the Rescheduled Project

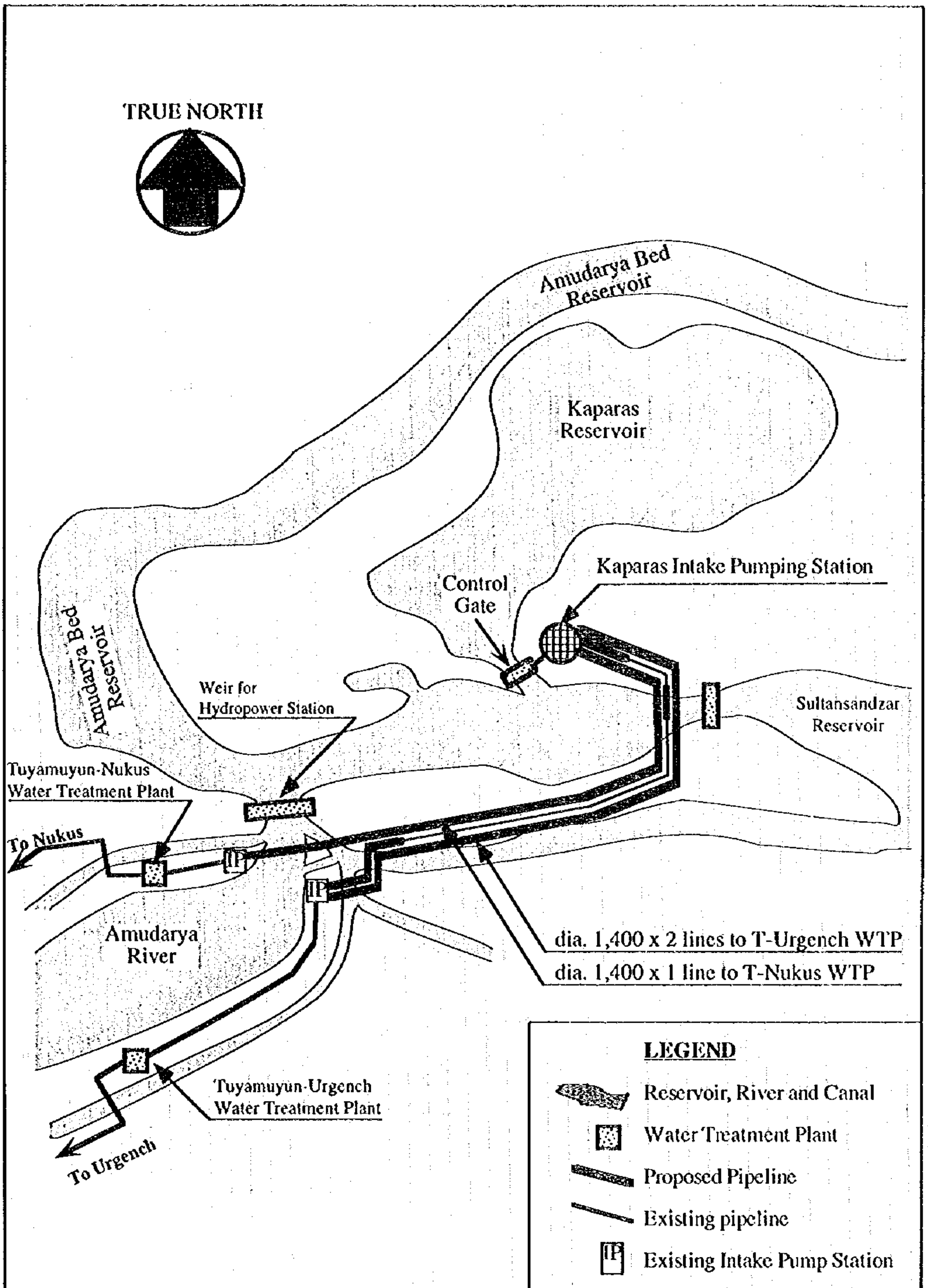
Work Item	Specification
1. Kaparas Raw Water Intake System	
1.1 Kaparas Intake Station	Q=750,000 m³/d
1.2 Raw Water Mains Pipeline	
1.2.1 Kaparas IPS to T-N Existing IPS	D=1,400 L= 10.7 km
1.2.2 Kaparas IPS to T-U Existing IPS	D=1,400 L= 1.0 km
1.2.3 Kaparas IPS to T-U Existing IPS	D=1,400 L= 9.0 km
2. T-N Water Supply System	
2.1 Water Treatment Plant	Q=350,000 m³/d
2.1.1 Rehabilitation	Q=200,000 m³/d
2.1.2 Expansion	Q=150,000 m³/d
2.2 Transmission and Distribution Pumping Station	
2.2.1 No. 2 Booster Pumping Station	Q= 234,410 m³/d
2.2.2 Nukus North Distribution Station	Q= 122,950 m³/d
2.2.3 Kungrad Transmission and Distribution Station	Q= 42,130 m³/d
2.3 Transmission Pipeline	
2.3.1 WTP - No. 1 Pumping Station	D=1,400 L= 63.0 km
2.3.2 Nukus - Takhiatash L=21 km	D=1,200 L= 11.0 km
2.3.3 Kungrad - Muynak (Q=8,870 m³/d)	D=500 L= 96.5 km
2.3.4 Kegeili - Bozatau	D=400 L= 50.0 km
3. T-U Water Supply System	
3.1 Water Treatment Plant	Q=400,000 m³/d
3.1.1 Rehabilitation	Q=200,000 m³/d
3.1.2 Expansion	Q=200,000 m³/d
3.2 Transmission Pipeline	
3.2.1 WTP - Khazarasp Pumping Station	D=1,200 L= 27.0 km
3.2.2 Khanki - Urgench	D=1,200 L= 13.2 km
3.2.3 Yangiaryk - Khiva	D=600 L= 20.0 km
3.2.4 S.P.1 - Koshkupyr	D=600 L= 14.0 km
3.2.5 Gurlen - Shavat	D=600 L= 19.5 km

IPS : Intake Pumping Station
WTP : Water Treatment Plant

Table 2.1 Proposed Water Supply Facilities for the Rescheduled Project (Continue)

Work Item	Specification
4. Vodokanal Karakalpakstan	
4.1 Water Treatment Plant	
4.1.1 Nukus WTP (Rehabilitation)	Q= 65,000 m^3/d
4.1.2 Chimbai WTP (Rehabilitation)	Q= 2,200 m^3/d
4.1.3 Water Treatment Plant (Rehabilitation) , 3 Cities	Q= 14,000 m^3/d
4.2 Distribution Network	
4.2.1 Replacement D=100 - D=400	L=228.8 km
4.2.2 Expansion D=100 - D=400	L=119.6 km
4.3 Metering System	
4.3.1 Meter Installation D=20	N=115,960 Pieces
5. Vodokanal Khorezm	
5.1 Water Treatment Plant	
5.1.1 Urgench WTP (Rehabilitation)	Q= 50,000 m^3/d
5.1.2 Chalish (Rehabilitation)	Q= 11,000 m^3/d
5.2 Distribution Network	
5.2.1 Replacement D=100 - D=400	L= 170.3 km
5.2.2 Expansion D=100 - D=400	L= 71.5 km
5.3 Metering System	
5.3.1 Meter Installation D=20	N=60,970 Pieces

IPS : Intake Pumping Station
WTP : Water Treatment Plant



THE STUDY ON WATER SUPPLY SYSTEM IN SIX CITIES OF THE ARAL SEA REGION IN UZBEKISTAN

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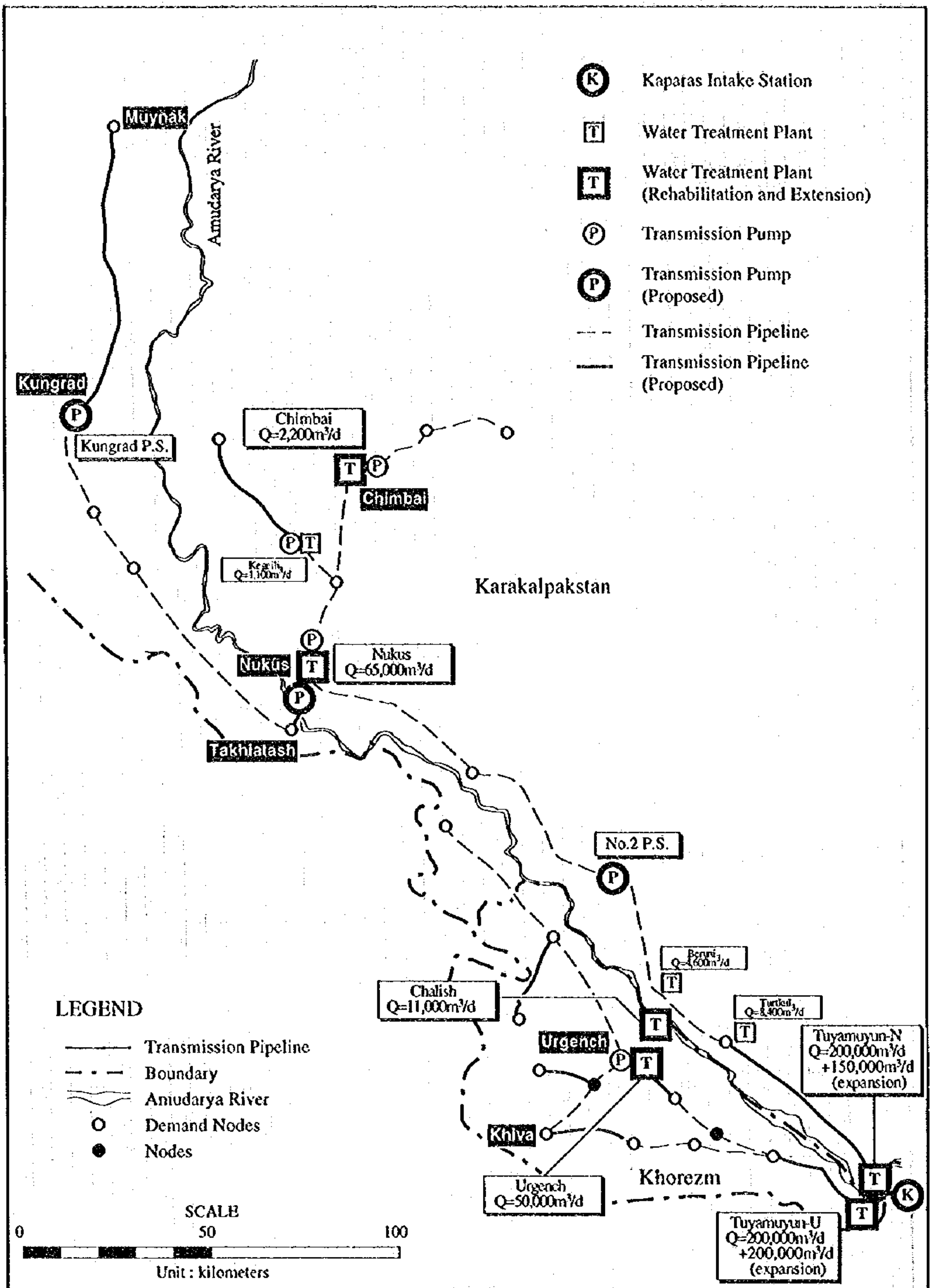
Fig. 2.1 Proposed Kaparas Intake Facility



THE STUDY ON
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Fig. 2.2
Proposed Water Supply Sys. in 2010

CHAPTER 3 SYSTEM OPERATION AND MAINTENANCE

3.1 Introduction

The focus of attention in this chapter will be on the points listed below, which will be important and necessary when the water supply plan is implemented based on the Basic Plan.

1) Integrated operation between water resources of the Tuyamuyun hydro-unit including Kaparas reservoir
2) Integrated operation of water supply systems of Tuyamuyun and Vodokanal systems
3) Response in an emergency of the water supply system
4) Leakage control measures

3.2 Integrated operation of water resources

When the Basic Plan is implemented, the Kaparas reservoir must be operated effectively taking into consideration the points mentioned below should be considered when framing the operation plan.

1) Coordination between related plans such as water supply plans, irrigation water plans and hydraulic power generation plans
2) Integrated operation plan of water source for the Tuyamuyun hydro unit including the Kaparas reservoir
3) Collection of water quality and water quantity data of the Amu Darya river, analysis of the data and predictions of water quality and quantity

Many related organizations are concerned with the operation of the Kaparas reservoir. To check the consistency of the plans of the various organizations, and to frame a rational and efficient water source operation plan, a new coordinating organization needs to be established. In addition, an organization that will actually implement the management and operation for the Kaparas reservoir must be established.

Water quality and water quantity models for the Amu Darya river including the Tuyamuyun Hydro-unit should be formed and the quality and quantity of the Ruslovoye (Amu Darya river bed) reservoir correctly predicted beforehand so that the operation plan for Kaparas reservoir can be framed.

In addition, a flexible response is necessary even for unpredictable conditions through the monitoring of the quality and quantity of water of Amu Darya river.

3.3 Integrated Operation of the Water Supply System

After the start of utilization of the Kaparas reservoir, the Kaparas reservoir and the Kaparas intake pumping station need to be jointly managed by the two Tuyamuyun systems. Therefore, a special organization for carrying out the overall management of the water supply systems in the two areas and for jointly managing these facilities will become necessary.

If the Tuyamuyun system that distributes treated water to the vast area has an accident, and the intake water, treated water or transmitted water is stopped, the entire system will be subjected to a major loss. Appropriate measures are necessary to prevent accidents and to minimize losses in the event of an accident. Among several countermeasures to accidents, it is more realistic to utilize existing facilities efficiently and prepare a manual in an emergency for responding promptly and appropriately to minimize losses.

3.4 Leakage Control Measures

In the Basic Plan in this report, the current leakage ratio was estimated as 30% by the JICA Study Team. Leakage ratio is to be brought down to 23 % in 2002, the target year of the feasibility study, and 15 % in 2010 in the Basic Plan. To achieve this target, it is necessary that Vodokanals takes more effective leakage control measures.