社会開発調査部報告書

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ULAANBAATAR MUNICIPALITY
THE GOVERNMENT OF MONGOLIA

THE STUDY ON WATER SUPPLY SYSTEM IN ULAANBAATAR AND SURROUNDINGS

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

JUNE 1995

PACIFIC CONSULTANTS INTERNATIONAL
MITSUI MINERAL DEVELOPMENT ENGINEERING CO., LTD.

In this report, project costs are estimated based on December 1994 prices with an exchange rate of

US$ 1=Mongolian Tugrug 400 (US$ 1=Yen 100)

PREFACE

In response to a request from the Government of Mongolia, the Government of Japan decided to conduct the master plan and feasibility study on Water Supply System in Ulaanbaatar and Surroundings in Mongolia and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Mongolia a study team headed by Dr. Kiyoo Kawada, Pacific Consultants International (PCI) and composed of staff members of PCI and Mitsui Mineral Development Engineering Co., Ltd., three (3) times between May 1993 and March 1995.

The team held discussions with the officials concerned of the Government of Mongolia, 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 Mongolia for their close cooperation extended to the team.

June 1995

Kimio Fujita
President
Japan International Cooperation Agency

THE STUDY ON WATER SUPPLY SYSTEM
IN
ULAANBAATAR AND SURROUNDINGS

JUNE 1995

Mr. Kimio Fujita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Dear Sir,

We are pleased to submit the final report entitled "THE STUDY ON WATER SUPPLY SYSTEM IN ULAANBAATAR AND SURROUNDINGS". This report has been prepared by the Study Team in accordance with the contract signed between Japan International Cooperation Agency and Pacific Consultants International in association with Mitsui Mineral Development Engineering Co., Ltd.

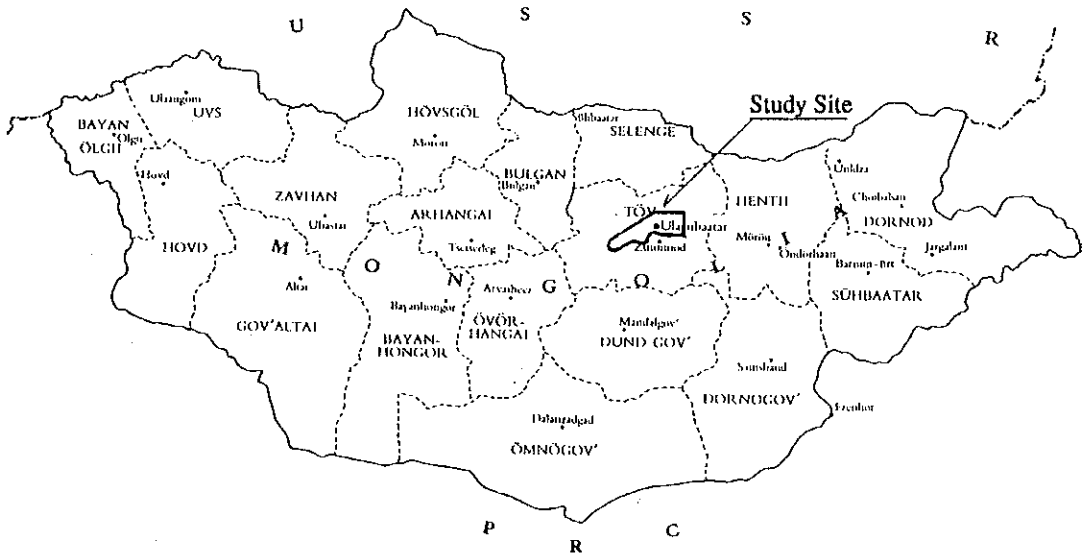
The report consists of Executive Summary, Main Report, and Supporting Report. Executive Summary summarizes the results of all studies. Main Report presents the results of the whole study including Master Plan for the water supply of Ulaanbaatar, Feasibility Study on groundwater development for a high priority project selected from the master plan study, and Emergency Rehabilitation Program for the existing water supply system. Supporting Report describes data and technical details of the entire study. In addition, Data Book and Drawings have been prepared and submitted herewith.

All members of the Study Team wish to express grateful acknowledgments to the personnel of your Agency, Advisory Committee, the Ministry of Foreign Affairs, the Ministry of Health and Welfare, the Embassy of Japan in Mongolia and JICA/JOCV office and also to officials and individuals of the Government of Mongolia for their assistance extended to the Study Team. The Study Team sincerely hopes that the results of the study will contribute to the improvement of the water supply condition and the social and economic development in Ulaanbaatar City.

Yours Faithfully,

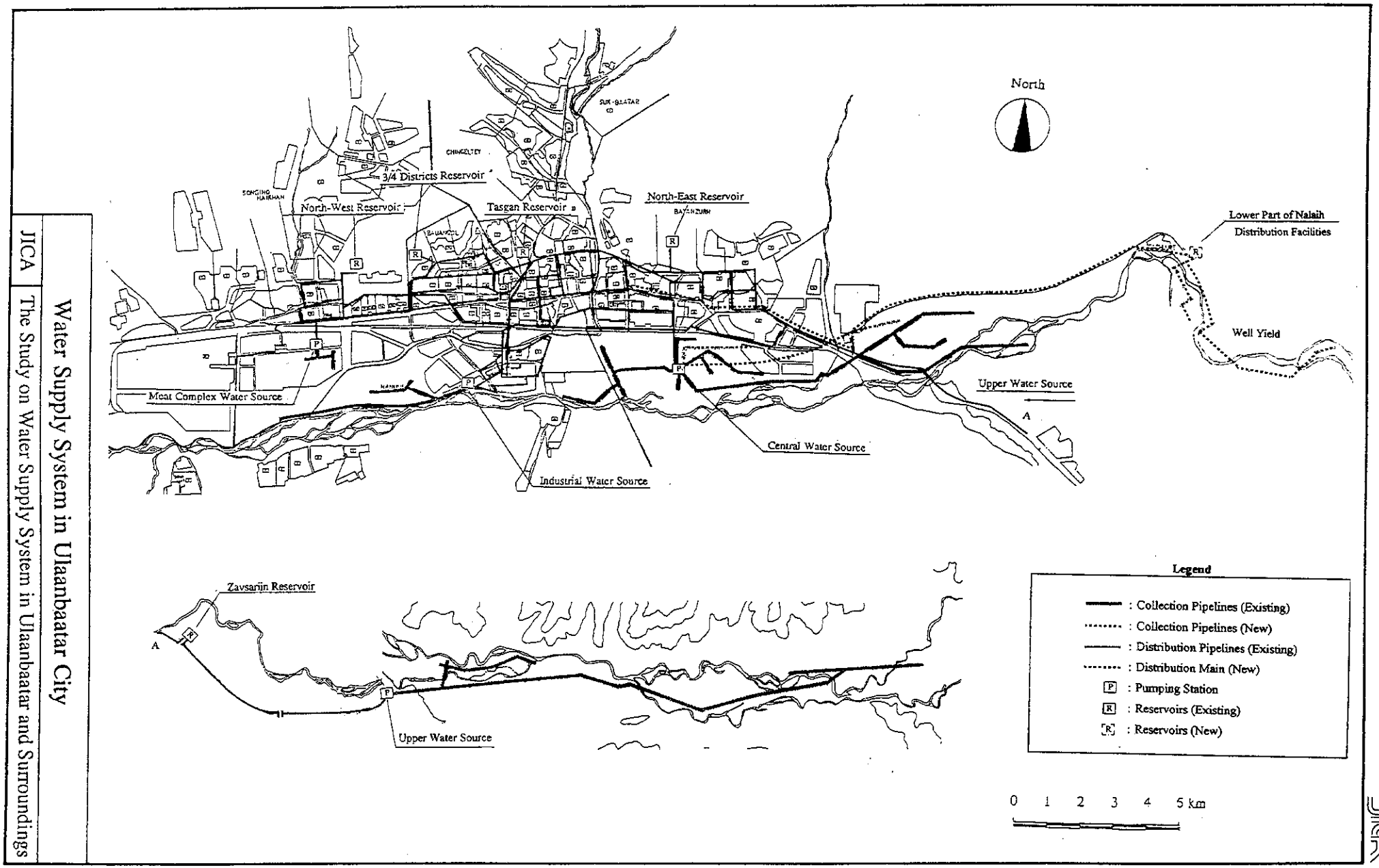
K. Kawada

Kiyoo Kawada
Team Leader



LOCATION MAP

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings


Water Supply System in Ulaanbaatar City
JICA
The Study on Water Supply System in Ulaanbaatar and Surroundings
North
3/4 Districts Reservoir
North-West Reservoir
Tasgan Reservoir
North-East Reservoir
Lower Part of Nalaih
Distribution Facilities
Well Yield
Upper Water Source
Meat Complex Water Source
Central Water Source
Industrial Water Source
Zavsariin Reservoir
Upper Water Source
Legend
: Collection Pipelines (Existing)
: Collection Pipelines (New)
: Distribution Pipelines (Existing)
: Distribution Main (New)
: Pumping Station
: Reservoirs (Existing)
: Reservoirs (New)
0 1 2 3 4 5 km
JICA

THE STUDY ON WATER SUPPLY SYSTEM IN ULAANBAATAR AND SURROUNDINGS

ABSTRACTS

1 Design Conditions

(1) Target year : 2010

(2) Future population : 932,000

(3) Population served and service area from Central Supply System in 2010

[Unit : Person]

Districts	Apartments	Ger	Total
Central City Area	450,774	330,335	781,109
Nalaih	9,005	26,777	35,782
Gachuurt	0	5,275	5,275
Total	459,779	362,387	822,166

Note: Central City Area is included six districts as follows;
Han-Uul, Bayanzurh, Suhbaatar, Chingeltei, Bayangol, Songinohairhan

(4) Unit water consumption : apartment dwellers 430 l/p/d, Ger dwellers 10 l/p/d.

(5) Future water demand : 285,700m^3/day

(6) Development capacity : 106,700m^3/day

2 Plan

First stage : 72,000m^3/day--expansion of Upper Water Source

Second stage : 114,300m^3/day--expansion of Central Water Source

Third stage : 41,400m^3/day--development of Lower Part of Nalaih

3 Design

(1) Expansion of Upper Water Source

Transmission facilities : flow meters, level meters (4 sets), and temperature meters, surge protection facilities, chlorinating equipment at the Zavsariin reservoir, telecommunication system at the Upper Water Source, Zavsariin reservoir, and North East reservoir.

(2) Expansion of Central Water Source

Required Intake Facilities of Central Water Source

Item	Number	Specification
Wells	14	30 m of depth, 1500m^3/day/well
Well Pump and others	14	submersible pumps
Remote Control System	1 Set	for pumps and motor valves
Pump Houses	14	made by brick (5m x 5m x H8m)
Collection Main Pipeline	10,500m	DCIP Ø 150 ~ 500 mm
Power Distribution Line	1 Set	

(3) Development of Lower Part of Nalaih (New Water Resource)

Required Intake Facilities of Lower Part of Nalaih

Item	Number	Specification
Wells	41	1,220 m^3/day/well
Well Pump and Others	41	submersible pumps
Remote Control System	1 Set	for pumps and motor valves
Pump Houses	41	made by brick (5m x 5m x H8m)
Collection main Pipeline	10,750 m	DCIP Ø 150~800 mm
Power Transmission Line	1 Set	
Power Distribution Line	1 Set	

Required Distribution Facilities of Lower Part of Nalaih

Item	Number	Specification
Distribution Reservoirs	2	6,900 m3 x 2 (Retention Time = 8 hr)
Chlorinating Equipment	1 Set	41,400 m3/day x 1.0 mg/l
Distribution Main	21,000 m	DCIP Ø 800mm
Electrical Equipment	1 Set	for pumps and motor valves
Buildings	1 Set	made by brick

4 Project Costs

Total Investment Costs (December 1994 Price) (Unit : US Dollar)

Work Item	1st Stage	2nd Stage	3rd Stage	Amount
1.Direct Construction Cost	1,148,270	8,371,390	46,827,930	56,347,590
2.Land Acquisition Cost	0	0	0	0
3.Engineering Cost	492,900	807,800	2,361,900	3,662,600
4.Administration Cost (3 % of 1)	34,448	251,142	1,404,840	1,690,430
5.Physical Contingency (10% of 1)	114,827	837,139	4,682,794	5,634,760
Total	1,790,445	10,267,471	55,277,464	67,335,380

Note 1) Exchange Rate : US$ 1.00 = Yen 100.0, US$ 1.00 = Tg. 400.0

5 Operation and Maintenance

Annual Operation and Maintenance Costs (Unit : US Dollar)

Item	1st Stage	2nd Stage	3rd Stage
Electric Consumption Cost	354,605	129,508	179,436
Chemical Consumption Cost	420	101	242
Personnel Cost	0	0	37,800
Repair Cost	11,483	83,714	468,279
Total	366,508	213,323	685,756

The equipment shall be periodically replaced at the end of its life span. The replacement cost is estimated to be US$56,347,590.

Replacement Cost (price of December 1994) (Unit US Dollar)

	1 st Stage	2 nd Stage	3 rd Stage	Total
Intake Facilities	0	8,371,390	19,762,150	28,133,540
Distribution Facilities	1,148,270	0	27,065,780	28,214,050
Total of Replacement Cost	1,148,270	8,371,390	46,827,930	56,347,590

6 Project Evaluation

(1) Economic Evaluation

Economic Internal Rate of Return (EIRR) of the project is estimated to be 3.5 %. The project would barely be considered fairly viable if we take the "basic human needs" nature of the project.

(2) Financial Evaluation

Financial Internal Rate of Return (FIRR) of the project is estimated to be 2.6 %. The Project is viable on the following unit water rate.

- for domestic users ; Tg.34/m^3
- for industry and others ; Tg.100/m^3

7 Emergency Rehabilitation Program

In order to solve the technical problems of existing water supply facilities, the following items are proposed for the Emergency Rehabilitation Program.

Item No.	Item	Component	Cost Estimate (Yen)
Item-1 :	Replacement of the existing intake pumps	: submersible pump 46 unites	675,738,000-
Item-2 :	Remote operation system for the above pumps	: 35 units	288,335,000-
Item-3 :	Replacement of the existing distribution pumps	: 10 units	649,510,000-
Item-4 :	Procurement of water tank lorries	: 7 units	127,644,000-
Item-5 :	Procurement of materials for wells construction	: casing pipes for 20 wells, 1 truck - mounted drilling machine	152,183,000-
Item-6 :	Remote operation system for existing intake pumps	: 98 units	365,034,000-
Item-7 :	Replacement of water meters at CTP	: 44 units (ø150mm)	21,817,000-
		Total = Yen	2,280,261,000-
		(= US$ 22,802,610-)	
		(Rate : US$ 1.00 = Yen 100.0)	

Table of Contents

List of Table and Figures

1. INTRODUCTION

The city of Ulaanbaatar, the capital of Mongolia, is the center of industry and commerce, has high concentration of population in the nation. Recently, water demand of the City has increased to a great extent. Water source is totally depending upon the groundwater withdrawn from alluvial aquifer, distributed in Tuul River basin, which is mainly located at the southern part of the City. A shortage of the water supply has been serious due to the decrepit water supply facilities. Especially, there is a tendency for the problem to appear in April and May because groundwater table is the lowest during this period of the year.

Ulaanbaatar Municipality has attempted to meet the water demand by constructing water supply systems and restricting high concentration of population and industry in the city. However, in spite of these countermeasures, provision of municipal water supply can be planned only up to the year of 1994. Reliable water supply is the strategy to develop the City. It is important to solve the existing water supply problem and to cope with the increasing future water demand of the City.

The Study was conducted by the Study Team of the Japan International Cooperation Agency (JICA) in cooperation with the Town Planning Department of Ulaanbaatar Municipality (TPD) and other related agencies from August 1993 to March 1995.

The objectives of the Study are :

1) to prepare an emergency rehabilitation program for the existing water supply system,
2) to prepare a master plan for the water supply of Ulaanbaatar with the target year of 2010,
3) to conduct a feasibility study on groundwater development for a high priority project selected through the master plan study, and
4) to prepare the proper advises on enhancing the management of water supply through strengthening the institution.

The Study area covers an area of about 8000 km^2 along Tuul River basin including Ulaanbaatar city and its surroundings (refer to Fig. 1).

2. PRESENT CONDITIONS

2.1 Socio-Economy

The present development plan of Ulaanbaatar City is yet to be implemented because of financial difficulties in the period of transfer from old economic system to new economic system.

The present area of Ulaanbaatar City (an area of about 135800 km^2) was set by the council of ministers in 1957, when the population was approximately 136,100. Ulaanbaatar makes only 0.001% of the country's territory, but its population equals to 26.8 % of the total.

(1) Population

Ulaanbaatar City had 24,200 people in 1939. Its population had rapidly grown at an average annual rate of 8.7%, having reached 294,400 in 1970. The population was 608,600 and the number of household was 132,000; that made the number of average members per household as 4.7 in 1994. The population density of the City was 4.5 heads per ha. The household numbers which occupied the apartment houses comprised 54.5%, and those in the 'Gers' did 45.5%.

Mongolia's population in 1994 is estimated to be 2.25 million with an average annual growth rate of 1.8% since 1990.

(2) Economy

When Mongolia transferring into market economy system and also after 1990 the economic condition have difficulties such as increasing of inflation rate and production capacity slowed down and the above conditions influenced on the economic condition of Ulaanbaatar City.

The intensity of concentration to the capital of population and accompanied economic activities in 1994 are as follows :

	(%)
Population	27
Industrial Production	47
Electricity	65.2
Transport (passengers)	53.2
Construction	42
Housing	50

Major Production Statistics (mil. Tg.*)

Item	1993	1994
Industry	2958.5	65238.8
Construction	399.6	6467.7
Communication	1048.8	4200.6
Retail Trade	14681.1	15548.2
Communal Service	2193.5	4435.9
Budget Income	5697.1	10024.6

* changes in price and exchange rate are reflected. Source : Ulaanbaatar Municipality

Budget of Ulaanbaatar Municipality (mil. Tg)

	1993	1994
INCOME	5697.1	10024.6
Income Tax	664.9	940.2
Corporate Tax	3558.4	5819.3
Commerce Tax	772.5	1546.1
Property Tax	135.4	166.9
Special Tax	177.5	154.9
Other Taxes, Fees	52.8	422.2
Non-Taxed Income	325.6	975
EXPENDITURE	4988.5	9177.9
Salary	1356.3	2428.5
Social Fund		314.2
Health Fund		100.8
Other Expenditure		4549.8
Subsidy		1270.4
Investment	290	498.3
Credit		15.9

Statistic Department of Ulaanbaatar Municipality

(3) Human Resources and Average Monthly Income

In 1992, the number of employees in private sector had increased 3.6 times from as much as the previous year reaching 34.5 thousand. Unemployment people, mostly young, amounted to 50.0 thousand in 1992. Average monthly salary of national enterprises was 8,000 Tugrugs as of July 1993.

(4) National Income (NI)

According to their trial calculation by means of the SNA , per capita GNP in 1989 was calculated at the order of 300 US dollars.

SNA : System of National Account of United Nation

2.2 Water Resources

2.2.1 Topography and Geology

The Study Area covers an area of about 8,000km^2 and is located in the south of Hentii Mountains along Tuul River, including Ulaanbaatar City. It is situated on about 1,350 meters above sea level and has about 250 millimeters of an average annual precipitation.
Hentii Mountains are the part of the world watershed between the Arctic and Pacific Ocean basin.

Tuul River is originated in the Hentii Mountains and flows generally from northeast to southwest with heavily and/or slightly meandering in the Study Area. A total length of the River is 819 km and a total catchment area is 50,400km^2. The catchment area of upper part from Ulaanbaatar (Zaisan bridge) is about 6,300km^2.

Geologically, the Study Area contains metamorphic, magmatic and clastic complexes of all geological ages. The surface of the mountain structures usually has Precambrian and Paleozoic Synclinorium, characterized to a significant extent by deformations and metamorphic changes. Mesozoic rocks and Cenozoic sediments cover the folded and faulted basement rocks. Small masses of granitic rocks occur at places (refer to Fig. 2).

2.2.2 Meteorology and Hydrology

Study area is characterized by the rainy season from June to August, of which rainfall shares about 74% of the annual rainfall (241mm). The humidity is high in winter, but low in rainy season of summer. The annual average temperature is calculated to be -2.1°C at Ulaanbaatar stations.

The average specific discharges are calculated to be 6.85 l/s/km^2 for Terelj Station and 4.51 l/s/km^2 for Ulaanbaatar Station. The recorded maximum daily mean discharges reach 721.0m^3/s and 338.0m^3/s, in Ulaanbaatar and Terelj Stations respectively, while the minimum discharges during the rainy season reach only 6.84m^3/s and 3.41m^3/s respectively. The average annual volume of runoff is calculated to be 903.1million m^3.

2.2.3 Hydrogeology

Cambrian-Precambrian rocks (R), Devonian rocks (D), Carboniferous rocks (C) and Mesozoic intrusive rocks (Gr.) are practically impermeable with low porosity and considered to be basement rocks from the hydrogeological point of view. But, fractured zones in the basement rocks have a possibility of aquifer. Quaternary deposits, which are considered to be the main water bearing formation, are distributed along Tuul River basin and its tributaries.

(1) Aquifer Types

There are two types of water bearing formations in the Study Area, namely fissure aquifer in the fractured zone of basement rocks, and alluvial aquifer in the Quaternary deposits.

Fissure Aquifer

14 of 62 previous exploration wells have been yielding the groundwater from the basement rocks more than five (5) liters/sec.(432m^3/day). 5 of the 14 wells produced more than ten (10) liters/sec.(864m^3/day).

Alluvial Aquifer

Alluvial aquifers along Tuul River are unconfined aquifers having the water table. The thickness of the Quaternary deposits tends to increase at the downstream. They have large groundwater potential.

(2) Aquifers in the Study Area

The important regions for the development of groundwater resources are as follows.

- Upper Part, which consists of Upper Water Source and the new water source of Lower Part of Nalaih.
- Central Part, which includes Central Water Source, Industrial Water Source, Meat Complex Water Source and Power Plant No.3 Water Source.
- Lower Part, which consists of Power Plant No.4 Water Source, and the new water sources of Lower Part of Power Plant and the downstream area.
- Buheg River
- North of Ulaanbaatar City : tributaries and valleys of Tuul River which are the principal and important fissure aquifer in the area.

(3) Groundwater Use of the Existing Water Sources

There are 133 production wells for the water supply system in Ulaanbaatar City. 30 wells, which do not belong to the Ulaanbaatar Municipality, are used for the factories and the power plants in the Study Area. The following table shows the description of these wells.

Water source	Number of Wells	Pumping rate (1,000 m^3/day)	Aquifer
Upper	39	24.0	Upper Part
Central	70	97.0	Central Part
Industrial	16	43.0	Central Part
Meat Complex	8	15.0	Central Part
Sub total	**133**	**179.0**	**USAG water sources**
Power Plant No.2	5	4.8	Central Part
Power Plant No.3	13	29.3	Central Part
Power Plant No.4	12	16.2	Lower Part
Sub total	**30**	**50.3**	**Other water sources**
Grand total	**163**	**229.3**	

(4) Fluctuation of the groundwater table

The fluctuation of groundwater table in an unconfined aquifer shows the change of water volume stored. A drawdown of groundwater table for these fifteen years(1978-1993) has not been progressing in Ulaanbaatar City area.

2.3 Water Supply

2.3.1 Water Supply System

Population in the City was 569,405 in the year of 1994 (data from TPD). Supply condition by USAG is given below.

- Total population in Ulaanbaatar City = 569,405 (25% of country's population)
- Served population in apartment buildings = 290,609 (51%)
- Served population in Ger Areas = 216,065 (38%)
- Not served population = 62,731 (11%)

(1) Outline of the System

The central water supply system is operated and managed by USAG (Water Facilities Exploitation Department of Ulaanbaatar Municipality). The USAG is responsible for supplying water up to the community heating center (hereinafter called "CTP") which is managed by the community company. The CTP distributes both cold and hot water by their own booster pumps to the apartment buildings. There are 51 CTP in the City.

In Ger Areas, there are 280 water vending centers (kiosks) for vending the drinking water to the dwellers. The USAG maintains water service stations (7 stations in the city) and tank lorries with a capacity of $5m^3$ that transport it to the kiosks. Ger dwellers buy the water at kiosks.

Many water supply facilities are superannuated and damaged due to the shortage of spare parts. The schematic flow chart of the public water supply system is shown in Fig.3.

(2) Supply Capacity

Total average supply capacity was 165,304m^3/day in last one year.

(3) Water Source

There are 133 production wells in four water sources which produce the groundwater of 179,000m^3/day in maximum.

(4) Facility

The outline of main water supply facilities are follows :

- transmission pipe lines ; a total length of 97,340m,
- storage reservoir ; 4 reservoir with a total capacity of 20,000m^3,
- distribution pump ; total 25 numbers
- supply reservoir ; 4 reservoir--North East, Tasgan, 3/4 District, North West with a total capacity of 42,000m^3
- distribution pipelines ; made by steel and cast iron, a total length of 200,340m
- service facilities for Ger Area ;

water service stations	--- 7 buildings
water vending centers (kiosk)	--- 280 buildings
tank lorries	--- 55 cars

2.3.2 Water Quality

(1) Existing Wells of USAG

Almost all items meet the standard for drinking water in Mongolia at each existing water sources.

And water quality of those water sources are considered usable for drinking water at present.

However, Mn, TDS, Alkali and Coliform in "Industrial Water Source" and "Meat Complex Water Source" show higher values than those in "Upper Water Source" or "Central Water Source". Considering future industrial growth, each of the above mentioned water sources is required to take measures against contamination.

(2) Private Wells in Ger Area

Some items of water quality in all wells does not meet the standard for drinking water in Mongolia sometimes. The residents do not use the water for drinking but use for washing, bathing and watering for plantation, etc.

(3) Test Wells

Almost all data meet the standard limits for drinking water in Mongolia, except the followings (refer to Fig. 4).

- The wells in which Mn slightly exceeds the standard limit for drinking water are A-2, B-1, B-3
- The well in which Fe slightly exceeds the standard limit for drinking water is A-2

(4) River Water Quality

The tendency of water quality in the lower stream is worse than that of upper stream. Mn, Cr, Fe, pH, and Coliform exceed the standard limit for drinking water in Mongolia.

(5) Drinking water

Tap water, water of water service stations (kiosks), and water supply stations clear the standard limits.

2.3.3 Population Served and Water Consumption

Present water balance of demand and supply is summarized below.

Water Consumption

Item	Capacity (Average) (m^3/day)	(%)
Actual Supply Capacity (Q)	165,304	100.0
Breakdown of Supply Capacity		
Apartment dwellers (q1)	122,056	73.8
Ger dwellers (q2)	1,600	1.0
Industrial factories (q3) *-1	11,452	6.9
Other consumers (q4) *-2	8,100	4.9
Loss (q5)	22,096	13.4

Note : *-1 ; recorded by water meters
*-2 ; including the supply water to unrecorded consumers

2.3.4 Institutional and Financial Aspects

(1) Organization and Management of USAG

- USAG is one of the Departments under the administration of the Municipality. However, it is an independent enterprise economically.
- USAG covers the water supply facilities up to CTP, Water Service, Supply Stations, and sewerage facilities in the Municipality.
- Planning and budgeting, operation and maintenance of the above facilities are the main tasks of USAG.
- The number of employees of USAG is 1,183 at present including the chairman.

(2) Balance Sheet of USAG

The balance sheet of USAG at the end of the year 1993 are shown in the following table.

Balance Sheet of USAG in 1993 (after tax) (unit : 1000Tg)

Item	Change	Credit	Item	Change	Debit
Basic fund	398,180	763,679	Bank loan	-954	5
Reserve fund	11,748	52,708	Reserve fund	3,799	4,877
Social fund	34,876	39,521	Social fund	22,361	52,664
Budget clear	16	16	Budget clear	76	381
Cash, bank	10,308	22,044	Misc. debts	10,825	12,616
Shares	-1,050	2,000	Shares	60,212	60,425
Outstanding	22,633	26,583	Advance	231	473
Other credit	1,098	1,410	Register fund	339,439	617,849
Advance	60,212	60,425	Dep.accumul	77,530	189,227
Material	2,552	9,027	Profit	44,517	65,868
Fuel	8,736	9,743			
Spare parts etc.	7,640	15,883			
Product unit	800	874			
Surplus reserve	216	473			
Omissions	79	0			
TOTAL	558,045	1,004,386	TOTAL	558,045	1,004,386

2.3.5 Technical Problems of the Existing Water Supply Facilities

Items 1) - 4) shall be implemented urgently. Items 5) - 9) shall be executed by the daily routine work of the USAG based on their own long term plan.

Problems to be Taken up by the Emergency Rehabilitation Program

1) Damage or deterioration of the existing intake pumps, distribution pumps and remote operation system for intake pumps.
2) Shortage in number of tank lorries.
3) Deterioration of the existing intake tube wells.
4) Lack and damage of water flow-rate measurement devices at CTP.

Problems to be Solved by the USAG in the Long Term Plan

5) Lack and damage of the water taps, and no installation of the water flow-rate measurement devices at apartment.
6) Wastage of water by domestic consumers.
7) Superannuated distribution pipelines.
8) Excessive energy consumption.
9) Lack of emergency power supply facilities, such as generators.

3. MASTER PLAN

3.1 Groundwater Potential

(1) Evaluation of Existing Water Source

Two out of existing four water sources have some potential for the additional development. Additional development volume of Central Water Source has been confirmed by the groundwater simulation from the view point of safe yield.

Potential of Existing Water Source (unit : m^3/day)

Water source	Total potential	Developed volume*	Undeveloped volume
Central Water Source	114,300	97,000	17,300
Upper Water Source	90,000	24,000	66,000

* a maximum supply capacity

(2) New Groundwater Resources

Alluvial Aquifer

Groundwater potential of the new groundwater resources is roughly estimated as follows.

Estimated Volume of New Groundwater Resources

	Lower Part of Nalaih	Buheg River	Lower Part of Power Plant	Downstream area *1
Area (km^2)	42.5	237.5	>50	>1,000
Thickness of alluvium (m)	15-20	20-40	40-60	50-100
Water table (Gl-m)	2.5	5.5	2-3	2-3
Thickness of aquifer (m)	12.5-17.5	14.5-34.5	about 40-60	about 50-100
Specific Yield *2	0.15	0.1	0.15-0.2	0.15-0.2
Volume (10^6 m^3)	102	586	>300	>1000

*1 : including Ulaan Hujiriin Bulan and Ulahiin Bulan

*2 : The ratio of the volume of water that will drain freely by gravity volume of the aquifer.

Lower Part of Nalaih may produce about 80,000 m^3/day of the groundwater.

Fissure Aquifer

Test wells constructed by JICA yield 903 m^3/day at Uliastai River, 2,164 m^3/day at Bayan Goliin, and 1,441 m^3/day at Selbe River (refer to Table 1). It is sufficient groundwater capacity for supplying to all Ger Areas in Ulaanbaatar. However, it is not available to develop on a large scale, because the potential is smaller than that of alluvial aquifer, and also it is difficult to determine the drilling sites without a detail geological investigation

3.2 Selection of the Priority Development Area of Groundwater

(1) Priority Development Area

Possible new groundwater resources are listed below.

Possible New Groundwater Resources

Location	Aquifer type	Distance *1 (km)	Hydro-geological condition	Groundwarer potential	Construc-tion cost	Running cost	Priority
Lower Part of Nalaih	alluvial	28 - 40	fairly good	medium	low	Low	1
Buheg River	alluvial	34 - 54	fairly good	big	high*2	medium	4
Lower Part of Power Plant	alluvial	34 - 55	fairly good	big	medium	medium	2
Ulaan Hujiriin Bulan	alluvial	55 - 122	fairly good	huge	high	high	6
Ulahiin Bulan	alluvial	122 - 147	fairly good	huge	high	high	7
North of ULBT							
Uliastai River	fissure	10 - 15	good	sufficient as	low	low	
Selbe River	fissure	5 - 10	good	for the local	low	low	3
Bayan goliin	fissure	18	good	water source	low	low	
Tahiltiin goliin	fissure	16 - 22	good		medium	medium	
Holiin River	fissure	10 - 15	good	ditto	medium	medium	5

*1 : Distance from the center of the City.
*2 : Water quality is unsuitable for drinking water.

Priority development area is determined at the **Lower Part of Nalaih** from the above mentioned hydrogeological and economical criteria.

(2) Environments

No damage is expected to the existing natural and social environments due to the construction of intake and transmission facilities at Lower Part of Nalaih.

Because intake facilities are installed in the riverbed at intervals of about 300m where nobody lives.

The stnucture to be settled on ground is only well houses.

The distribution main is installed underground in parallel with existing road.

3.3 Population and Water Demand Forecast

(1) Population Forecast

The future population in Ulaanbaatar City and its major distribution pattern are forecasted in the followings.

Population Forecast

		1985	1990	1995	2000	2005	2010
Mongolia (M)	million	1.91	2.19	2.50	2.84	3.20	3.59
	aagr*	2.76%	2.74%	2.68%	2.58%	2.43%	2.29%
Central System Area	'000		321	358	406	458	513
			55.8%	55%	55%	55%	55%
Ger Area	'000		254	293	332	375	420
			44.2%	45%	45%	45%	45%
Ulaanbaatar (U)	'000	503	575	650	738	833	932
U/M		26.3%	26.3%	26%	26%	26%	26%

* : an average annual growth rate

(2) Population Served and Service Area from Central Supply System in 2010

Population served is estimated to be 822,000 including apartment and Ger dwellers. Central city area, Nalaih and Gachuurt districts will be included the service area.

(3) Unit Water Consumption

Apartment dwellers : 430 l/p/d (including 10% of leakage of water)

Ger dwellers : 10 l/p/d

The present water consumption of apartment dwellers is 420 l/p/d which include 30% of leakage of water, and actual water consumption is 290 l/p/d. The leakage of water shall be gradually decreased. On the other hand, the water consumption will be gradually increased with the advance of living standard in future. The decrease of leaked water and increase of water consumption will be forecasted an offset each other, and water consumption is estimated 430 l/p/d in the year of 2010. In this case, the actual water consumption and the percentage of leakage of water will be estimated 390 l/p/d and 10% respectively. Besides, the urgent improvement of leakage of water is costly comparing with the water resources development. The leakage of water shall be gradually improved from the economical point of view.

The present water consumption of Ger dwellers is 7.4 l/p/d. This traditional life style does not required a rapid increase of water consumption. Accordingly, future water consumption is estimated 10 l/p/d.

(4) Future Water Demand

Total water demand in 2010 supplied from USAG is estimated as follows.

Water demand of industrial factories is determined in the cource of discussion with the Ministry of Infrastructure Development, because of no urban development plan which includes the policy of industrial development.

Water Demand in 2010 [Unit : m^3/day]

Item	Water Demand	Water Consumption in 1993
Apartment Dwellers	197,700	122,056
Ger Dwellers	3,600	1,600
Industrial Factories	42,500	11,452
Other Consumers	13,300	8,100
Loss (10 %)	28,600	22,096
Total	285,700	165,304

(5) Future Development Capacity

The existing production capacity in 1994 is estimated to be 179,000 m^3/day. The additional production capacity of 106,700m^3/day shall be developed in the year of 2010.

Future Development Capacity

	Item	Production Capacity (m^3/day)
A	Future Production Capacity	285,700
B	Exiting Production Capacity	179,000
	Central Water Source	max.97,000
	Industrial Water Source	max.43,000
	Meat Complex Water Source	max.15,000
	Upper Water Source	max 24,000
C	Future development capacity (=A-B)	106,700

3.4 Basic Concept for the Water Resources Development

(1) Future development capacity is available to be yielded by the groundwater without the development of surface water resource.

(2) Existing water sources, namely Upper Water Source and Central Water Source, have the capacity enough to spare for an additional development,besides, these water sources are located in near by the Ulaanbaatar City. Consequently, these water sources shall be utilized efficiently its remaining groundwater.

(3) Future development of the groundwater resources shall be planned at the Central Water Source and Upper Water Source in connection withLower Part of Nalaih.

4 FEASIBILITY STUDY

4.1 Design Conditions

Design conditions for the feasibility study on priority project are summarized below.

(1) Target year : 2010

(2) Future population : 932,000

(3) Population served and service area

Population Served and Service Area from Central Supply System in 2010

[Unit : Person]

Districts	Apartments	Ger	Total
Central City Area	450,774	330,335	781,109
Nalaih	9,005	26,777	35,782
Gachuurt	0	5,275	5,275
Total	459,779	362,387	822,166

Note: Central City Area is included six districts as follows;
Han-Uul, Bayanzurh, Suhbaatar, Chingeltei, Bayangol, Songinohairhan

(4) Future water demand : 285,700m^3/day

(5) Development capacity : 106,700m^3/day

(6) Water source and its potential :

- remaining volume of existing water source
  - Central Water Source ; 17,300m^3/day
  - Upper Water Source ; 66,000m^3/day
- priority new water source
  - Lower Part of Nalaih ; less than 80,000m^3/day

4.2 Selection of the Implementation Program

The comparative study was conducted for 4 cases including the expansion of the existing water source and the development of new water source. The following case is superior to other cases from the economical point of view.

72,000m^3/day----- expansion of Upper Water Source

114,300m^3/day----- expansion of Central Water Source

41,400m^3/day----- development of Lower Part of Nalaih

This implementation shall be divided into three stages as follows.

First stage : expansion of the Upper Water Source

Second stage : expansion of the Central Water Source

Third stage : development of the Lower Part of Nalaih

4.3 Plan of Water Supply Facilities

4.3.1 Expansion of Upper Water Source in the First Stage

(1) Intake facilities

The expansion of intake facilities is not necessary in this stage.

(2) Transmission facilities

The transmission pump is not necessary to construct in this stage. But the flow meter, level meter, and temperature meter shall be installed for the operation and maintenance. And also, the surge protection facilities is necessary to protect the water hammer. The transmission main from Pumping Station up to Zavsariin reservoir has the sufficient capacity (refer to Fig.5). However, the supply capacity of distribution pipeline from Zavsariin reservoir to the City area, not included in this Study, should be studied before implementation. An additional pipeline might be required if necessary after the study.

(3) Others

- Four (4) sets of water level meter shall be installed for the existing reservoirs of the Zavsariin reservoir and North East reservoir.
- Chlorinating equipment shall be installed at the Zavsariin reservoir.
- Telecommunication system shall be installed at the Upper Water Source, Zavsariin reservoir, and North East reservoir.
- Accessories equipment shall be installed to operate the Zavsariin reservoir.

4.3.2 Expansion of Central Water Source in the Second Stage

(1) Intake facilities

Required intake facilities are listed below. Remote control system is also required to control and operate the intake facilities (refer to Fig.6).

Required Intake Facilities of Central Water Source

Item	Number	Specification
Wells	14	30 m of depth, 1500m^3/day/well
Well Pump and Others	14	submersible pumps
Remote Control System	1 Set	for pumps and motor valves
Pump Houses	14	made by brick (5m x 5m x H8m)
Collection Main Pipeline	10,500m	DCIP Ø150 ~ 500 mm
Power Distribution Line	1 Set	

(2) Distribution facilities

It is not necessary to expand.

4.3.3 Development of Lower Part of Nalaih in the Third Stage

(1) Intake facilities

Required intake facilities are described below. Remote control system is also required to control and operate the intake facilities (refer to Fig. 7).

Required Intake Facilities of Lower Part of Nalaih

Item	Number	Specification
Wells	41	1,220 m^3/day/well depth of 20m (38 nos.) & 30m (3 nos.)
Well Pump and Others	41	submersible pumps
Remote Control System	1 Set	for pumps and motor valves
Pump Houses	41	made by brick (5m x 5m x H8m)
Collection Main Pipeline	10,750 m	DCIP Ø 150~800 mm
Power Transmission Line	1 Set	
Power Distribution Line	1 Set	

(2) Distribution facilities

- Distribution reservoir shall be planned near by the Gachuurt town.
- Chlorinating equipment shall be installed at the reservoir.
- Distribution main pipes shall be installed along the road.

Required Distribution Facilities of Lower Part of Nalaih

Item	Number	Specification
Distribution Reservoirs	2	6,900 m^3 x 2 (Retention Time = 8 hr)
Chlorinating Equipment	1 Set	41,400 m^3/day x 1.0 mg/l
Distribution Main	21,000 m	DCIP Ø 800mm
Electrical Equipment	1 Set	for pumps and motor valves
Buildings	1 Set	made by brick

The location of facilities is shown in Fig.7.

4.3.4 Land Acquisition

The intake, transmission and distribution facilities will be constructed in the government reserved land. The collection pipeline of each water source and distribution main of new water source will be installed parallel with the existing roads.

Hence, the construction of the above facilities will not require any land acquisition, although some procedure to get approval may be required.

4.3.5 Project Cost

The total investment costs amount to US Dollars 67,335,380 which includes the direct construction cost, engineering cost, administration cost, and physical contingency.

Foreign & Local Currency of Total Investment Costs (As of December 1994 Price)

(Unit : US Dollar)

No	Work Item	1 st Stage			2 nd Stage			3 rd Stage			Amount		
		Foreign C	Local C	Sub-Total	Foreign C	Local C	Sub-Total	Foreign C	Local C	Sub-Total	Foreign C	Local C	GrandTotal
1	Direct Construction Cost	1,042,020	106,250	1,148,270	6,312,860	2,058,530	8,371,390	34,792,680	12,035,250	46,827,930	42,147,560	14,200,030	56,347,590
-1	Upper Water Source	1,042,020	106,250	1,148,270	0	0	0	0	0	0	1,042,020	106,250	1,148,270
-2	Central Water Source	0	0	0	6,312,860	2,058,530	8,371,390	0	0	0	6,312,860	2,058,530	8,371,390
-3	Lower Part of Nalaih	0	0	0	0	0	0	34,792,680	12,035,250	46,827,930	34,792,680	12,035,250	46,827,930
2	Land Acquisition Cost	0	0	0	0	0	0	0	0	0	0	0	0
3	Engineering Cost	492,900	0	492,900	807,800	0	807,800	2,361,900	0	2,361,900	3,662,600	0	3,662,600
4	Administration Cost [3% of 1]	0	34,448	34,448	0	251,142	251,142	0	1,404,840	1,404,840	0	1,690,430	1,690,430
5	Physical Contingency [10% of 1]	104,202	10,625	114,827	631,286	205,853	837,139	3,479,268	1,203,526	4,682,794	4,214,756	1,420,004	5,634,760
	Total	1,639,122	151,323	1,790,445	7,751,946	2,515,525	10,267,471	40,633,848	14,643,616	55,277,464	50,024,916	17,310,464	67,335,380

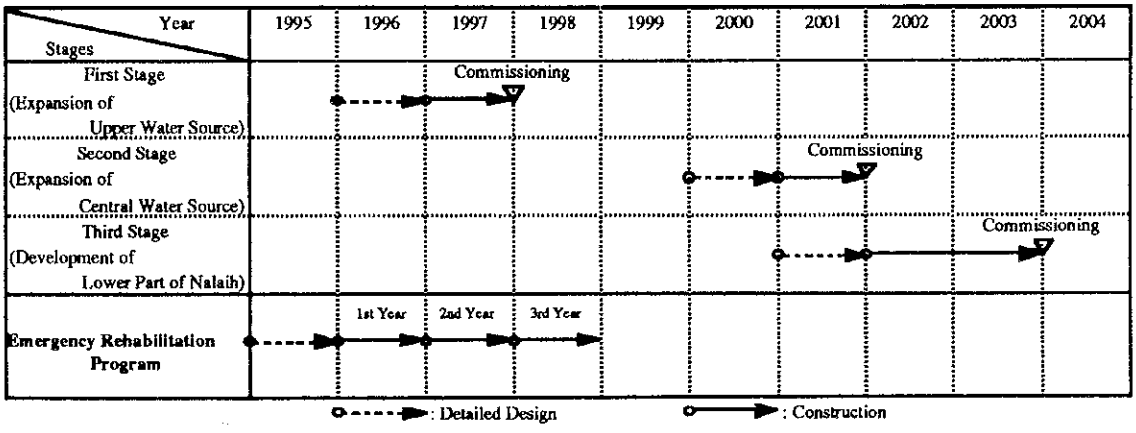
Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg. 400.0
2) Administration cost includes the direct cost and personnel expenses for land acquisition, design, and construction

4.4 Implementation Program

On the basis of this study, JICA Study Team proposes that first stage of this project shall be implemented in parallel with "Emergency Rehabilitation Program". It will be executed on three stages based on the future water demands by 2010 year as follows.

The future water demands by 2010 year and water supply capacity in each stage are shown in Fig. 8. This implementation schedule of "Emergency Rehabilitation Program" is studied assuming that rehabilitation is to be done by three years from 1996.

Implementatiion Schedule



4.5 Operation and Maintenance

(1) General

Daily operation and maintenance have been conducted by USAG. The expanded facilities of Upper Water Source and Central Water Source shall be managed by the existing organization in the USAG. On the other hand, the developed facilities in Lower part of Nalaih will be coped increasing the personnel.

(2) Operation and Maintenance (O/M) Costs

Annual O/M costs are estimated below.

Annual O/M Costs (Unit : US Dollar)

	Item	1st Stage	2nd Stage	3rd Stage
1	Electric Consumption Cost	354,605	129,508	179,436
2	Chemical Consumption Cost	420	101	242
3	Personnel Cost	0	0	37,800
4	Repair Cost	11,483	83,714	468,279
Total Annual O&M Cost		366,508	213,323	685,756

The equipment shall be periodically replaced at the end of its life span. The replacement cost is shown below.

Replacement Cost (price of December 1994) (Unit US Dollar)

	1 st Stage	2 nd Stage	3 rd Stage	Total
Intake Facilities	0	8,371,390	19,762,150	28,133,540
Distribution Facilities	1,148,270	0	27,065,780	28,214,050
Total of Replacement Cost	1,148,270	8,371,390	46,827,930	56,347,590
every 15 Years	386,640	1,628,000	4,039,460	6,054,100
every 20 Years	761,630	2,550,090	7,826,970	11,138,690
every 40 Years	0	4,193,300	34,961,500	39,154,800

Note The life span of equipment are as follows.
every 15 year : Intake wells, Intake Pumps.
every 20 Year : Other Equipments
every 40 Year : Pipe, Concrete Works, Buildings.

4.6 Project Evaluation

(1) Unit Water Rate

Present Water Tariff System

· Apartment dwellers : Tg.8/m^3 x 150 l/person/day, uniform tariff.

Water tariff in 1993 ; 4.7person /family x 0.15 m^3/person /day x 30days x Tg.8/m^3=Tg.169.2/family /month. Monthly earnings ; 8,000Tg.

Water tariff amounts to 2.1% of monthly earnings.

· Ger dwellers : Tg.400/m^3 and 600/m^3 , specific tariff.

Water tariff in 1993 ; 4.7person /family x 0.0074 m^3/person /day x 30days x Tg.400-600/m^3=Tg.420-630/family /month. Monthly earnings ; 8,000Tg.

Water tariff amounts to 5.3-7.9% of monthly earnings.

· Industry and others : Tg.39/m^3, specific tariff.

Future Water Tariff System

A unit water rate is set as follows:

- for domestic users ; Tg.34/m^3 (US$0.097 at an exchange rate of 350Tg./$ in 1993),

Average monthly earnings of both apartment and Ger dwellers have increased more than 10 times from 1989 to 1992 and 1.38 times from 1992 to 1993. It will be estimated to increase 40,000Tg. in 1998 at the same increasing rate of 1.38 times considering with the recent high infration rate.

Water tariff in 1998 ; 4.7persons/family x 0.43(0.01)m^3/person/day x 30days x Tg.34/m^3 =Tg.2,060(48)/family/month. Monthly earnings ; 40,000Tg.

Water tariff amounts to 5.1% of monthly earnings (water tariff of Ger dwellers amounts to 0.1% of monthly earnings). The weighted average of it is less than 2.6%. Considering a rapid growth of earnings in recent years in Mongolia, the percentage (5% of earnings) is forecasted to be decreasing in the year of implementation of the project.

- for industry and others ; Tg.100/m^3 (US$0.286)

The present water rate (Tg.39/m^3) for industry and others is too cheap to make this proposed project to be viable (EIRR=-0.01%).

(2) Economic Internal Rate of Return (EIRR)

EIRR of the project is estimated to be 3.5%. The project would barely be considered fairly viable if we take the "basic human needs" nature of the project and difficult economic situation in Mongolia into account.

As a source of finance, a long term loan allocated for building up of a social infra-structure would suit the purpose. Its terms and conditions are reasonable. An example is a loan provided by the OECF; its annual interest rate is 2.6 %, and lending period is 30 years with 10 year grace period.

(3) Financial Internal Rate of Return (FIRR)

FIRR of the project is estimated to be 2.6 %.

The project will be feasible by increasing the water rate as follows.

- for domestic users ; Tg. 34/m^3 (US$0.097 at an exchange rate of 350Tg./$ in 1993)
- for industry and others ; Tg. 100/m^3 (US$ 0.286)

5. RECOMMENDATION

(1) Immediate Implementation of the Proposed Projects

An immediate implementation of the proposed projects simultaneously with the Emergency Rehabilitation Program is necessary to meet the increasing water demand of Ulaanbaatar City.

Hence, it is recommended to commence the necessary financial procurement.

(2) Groundwater Potential

Groundwater resources are able to satisfy the water demand in 2010.

After 2010, groundwater resources of downstream of Tuul River are available to supply the large volume of water to the City, but these water resources are located far from the City and then the development cost of these water resources are estimated to be high. Consequently, the development of these water resources shall be examined on its economical merits comparing with the development of surface water.

(3) Surface Water

Surface water has the large potential, but development cost is estimated to be very high. It is unsuitable for the independent project of the water supply. The development of surface water shall be considered in connection with the flood mitigation, development of hydroelectric power generation, irrigation water, and industrial water from the economical point of view.

(4) Improvement of Water Tariff System

The Water Tariff System applied to the apartment dwellers should be changed from the present uniform tariff system (unit price x 150 l/person/day) to the water tariff system from the year of 2000 based on the actual consumption capacity by using the water meters.

(5) Measuring System of Supply Water

(i) Water meters shall be installed at the Pumping Stations, CTP, large consumers, and finally at each apartment. The actual usage capacity will be recognized and will be useful for the operation, maintenance, and tariff collection. It will also improve the people's consciousness of saving water.

(ii) The employment of economical lever for the economical use of the City Water Supply should consider the items below.

- USAG and CTP will be established measuring and monitoring system of water supply.

- Individual consumers have to uplift the saved water. It well be possible to achieve by changing from the present uniform tariff system to the water tariff system based on the actual consumption capacity by use of water meters.

(6) Measures Against the Contamination of Water Sources

(i) The measures against the contamination of water sources, especially in the Industrial Water Source and Meat Complex Water Source, should be taken urgently by restriction of a dumping waste, improving the treatment facilities of waste water, and improving the sewerage system.

(ii) From the results of this study, it is found that the water qualities of all existing water sources (Upper, Central, Industrial, Meat Complex) and of the proposed new water source (Lower Part of Nalaih) are suitable for drinking water in Mongolia.
The sanitary protection zones like enclosure by fence to prevent the water quality of new water source as well as the above existing water sources are also necessary.
From the above mentioned, pollution of above water sources due to the wastewater from the Nalaih District will be not caused.
However, as the development of new water source is started, the effects of wastewater from Nalaih District shall be studied.

(7) Restriction for the Groundwater Development
Groundwater is the limited natural resources that shall be endeavored to be sustainable development. The development of fissure aquifer in north of Ulaanbaatar shall be restricted without the permission of USAG and Mongolian government.

(8) Preservation of the Existing Water Source
Each production well in the Central Water Source shall be kept at the pumping rate of less than 1500m^3/day to protect the damage of wells and to preserve the groundwater resource.

(9) Improvement and Expansion of the Sewerage System
According to the expansion of water service area, the improvement and expansion of existing sewerage system will be required to prevent the contamination of Industrial Water Source and Meat Complex Water Source and also to improve the sanitation.

(10) Improvement of Water Supply System for Ger Area
For improving the system, the following steps are proposed.
- Installation of Public Hydrants
- Connecting the existing distribution pipelines to the kiosks

(11) Test Wells

(i) Test wells shall be used for the measurement of groundwater table to manage the groundwater resources and sustainable development.

A-1 to A-4 test wells except A-2 shall be considered to supply the water to Ger dwellers.

The water of A-2, B-1 and B-2 test wells will be able to use for drinking water if Mn and Fe are removed.

Water quality of test wells shall be studied based on the periodical analysis of the groundwater before utilization

(ii) If factories and other consumers require a new water source in future, a utilization of surface water, Lower Part of Power Plant and The Down Stream shall be studied to meet the purpose of the usage of the water.

APPENDIX

EMERGENCY REHABILITATION PROGRAM

In order to solve the technical problems of existing water supply facilities, the following items are proposed for the Emergency Rehabilitation Program.

Items of Emergency Rehabilitation Program

Item No.	Item	Component	Cost Estimate (Yen)
Item-1 :	Replacement of the existing intake pumps	: submersible pump 46 unites	675,738,000-
Item-2 :	Remote operation system for the above pumps	: 35 units	288,335,000-
Item-3 :	Replacement of the existing distribution pumps	: 10 units	649,510,000-
Item-4 :	Procurement of water tank lorries	: 7 units	127,644,000-
Item-5 :	Procurement of materials for wells construction	: casing pipes for 20 wells, 1 truck - mounted drilling machine	152,183,000-
Item-6 :	Remote operation system for existing intake pumps	: 98 units	365,034,000-
Item-7 :	Replacement of water meters at CTP	: 44 units (ø150mm)	21,817,000-
		Total = Yen	2,280,261,000-
		(= US$	22,802,610-)
		(Rate : US$ 1.00 = Yen 100.0)	

Implementation Schedule

Time	Item No. and Components	Investment Cost (Yen)
1st Year :	(Item-1) Replacement of the existing intake pumps (Item-4) Procurement of water tank lorries	Amount 803,382,000
2nd Year :	(Item-3) Replacement of the existing distribution pumps (Item-5) Procurement of materials for wells construction	Amount 801,693,000
3rd Year :	(Item-2) Remote operation system for new intake pumps (Item-6) Remote operation system for existing intake pumps (Item-7) Replacement of water meters at CTP	Amount 675,186,000
	(Total)	2,280,261,000

Table 1 The Results of the Test Well Drilling

Well No.	Location	Elevation	Coordinate X	Coordinate Y	Drilled Depth	Screen Depth from	Screen Depth to	Pumping Rate		S.W.L	P.W.L	Draw-down	Specific Capacity	Trans-missivity	Permeability Coefficient	Producing Laver	Depth to Bedrock	Remarks
		(m)	(Long.E)	(Lat.N)	Gl-(m)	Gl-(m)	Gl-(m)	(l/sec)	(m^3/day)	Gl-(m)	Gl-(m)	(m)	(m^3/day/m)	(m^2/day)	(cm/sec)		Gl-(m)	
A-1	Uliastai River	1442.50	107-03'22"	48-00'25"	183.5	84.0	177.5	10.5	903	12.4	58.75	46.35	19	23	(4.10×10^{-4})	Bedrock		
A-2	Selbe River	1431.50	106-54'20"	48-03'23"	201.8	102.8	196.3	0.6	52	11.8	82.05	70.25	1	<1	(4.61×10^{-6})	Bedrock		
A-3	Bayan Goliin	1374.60	106-42'48"	47-58'28"	200.3	95.5	123.0	25.0	2164	5.61	53.42	47.81	45	40	(6.52×10^{-4})	Bedrock	0	
						134.0	178.0											
						183.5	194.5											
A-4	Selbe River	1425.20	106-54'03"	48-03'02"	134.0	49.5	134.0	16.7	1441	3.48	52.22	48.74	30	31	(7.97×10^{-4})	Bedrock	18	
	Sub Total				719.6													
B-1	Buheg River	1305.50	106-45'00"	47-38'18"	50.0	22.5	39.0	3.9	337	(2.0)	11.53	13.53	25	35	2.46×10^{-3}	Alluvium	>50	Flowing well
B-2	Buheg River	1297.00	106-42'56"	47-39'45"	50.0	16.0	21.5	6.3	540	0.45	5.65	5.2	104	122	8.56×10^{-3}	of	>50	
						38.0	49.0									Buheg		
B-3	Buheg River	1230.50	106-35'02"	47-43'52"	65.0	22.0	33.0	22.0	1901	2.7	10.04	7.34	259	354	1.86×10^{-2}	River	>65	
						43.0	54.0											
	Sub Total				165.0													
C-1	Lower Area	1392.30	107-21'59"	47-48'52"	30.5	10.0	21.0	10.8	935	0.75	8.69	7.94	118	142	1.49×10^{-2}	Lower	21	
C-2	of Upper	1386.60	107-19'51"	47-49'10"	24.0	11.0	22.0	5.6	485	1.71	8.53	6.82	71	59	6.21×10^{-3}	Layer	20	
C-3	Water	1370.70	107-15'10"	47-50'52"	31.0	24.5	30.0	2.9	253	2.47	16.9	14.43	18	13	2.74×10^{-3}	of Alluvium	28	
C-4	Source	1331.70	107-09'55"	47-55'12"	22.3	9.1	14.6	4.4	382	1.08	7.23	6.15	62	91	1.91×10^{-2}	Tuul River	14	
C-5	Buheg	1226.60	106-35'20"	47-46'17"	30.0	13.5	24.5	8.5	734	5.47	26	20.53	36	37	3.89×10^{-3}		>30	
C-6	Lower Part	1204.50	106-30'36"	47-45'52"	32.0	13.5	30.0	25.0	2160	1.93	3.69	1.76	1227	873	6.12×10^{-2}	Alluvium of	>31	
C-7	of Power	1174.20	106-17'20"	47-43'35"	30.0	13.5	24.5	36.7	3168	1.8	3.37	1.57	2018	2410	2.54×10^{-1}	Tuul River	>30	
C-8	Plant	1173.00	106-18'10"	47-42'50"	30.0	16.0	27.0	4.4	382	1.2	8.06	6.86	56	50	5.26×10^{-3}		>30	
	Sub Total				229.8													
	Grand Total				1114.0													

S.W.L ; Static Water Level
P.W.L ; Pumping Water Level

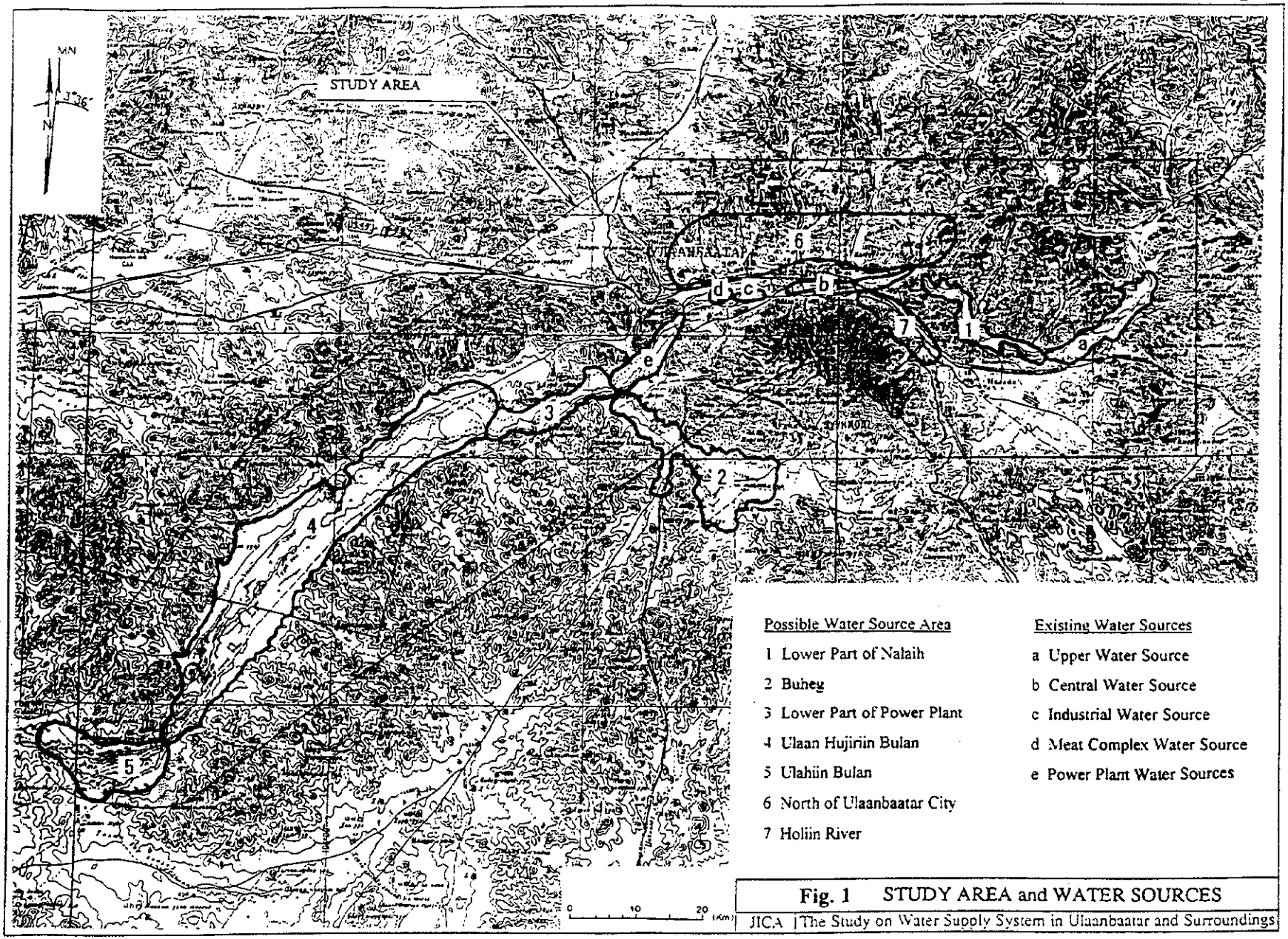
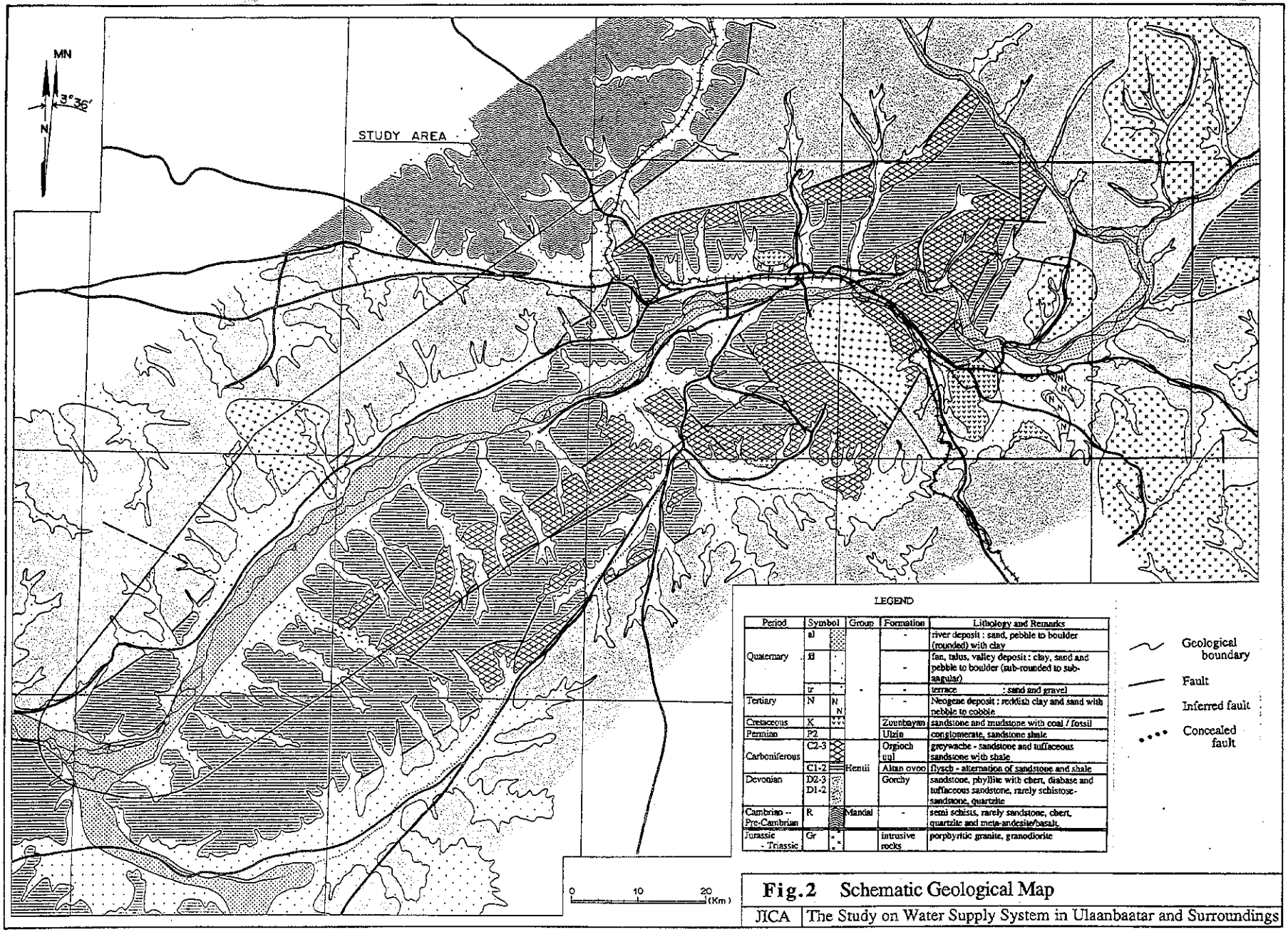


Fig. 1 STUDY AREA and WATER SOURCES

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings



LEGEND

Period	Symbol		Group	Formation	Lithology and Remarks
Quaternary	al		-	-	river deposit : sand, pebble to boulder (rounded) with clay
	fl			-	fan, talus, valley deposit : clay, sand and pebble to boulder (sub-rounded to sub-angular)
	tr			-	terrace : sand and gravel
Tertiary	N	N		-	Neogene deposit : reddish clay and sand with pebble to cobble
Cretaceous	K			Zuunbayan	sandstone and mudstone with coal / fossil
Permian	P2			Ulzii	conglomerate, sandstone shale
Carboniferous	C2-3		Henii	Orgioch uul	greywache - sandstone and tuffaceous sandstone with shale
	C1-2			Altan ovoo	flysch - alternation of sandstone and shale
Devonian	D2-3 D1-2			Gorchy	sandstone, phyllite with chert, diabase and tuffaceous sandstone, rarely schistose-sandstone, quartzite
Cambrian -- Pre-Cambrian	R		Mandal	-	semi schists, rarely sandstone, chert, quartzite and meta-andesite/basalt,
Jurassic - Triassic	Gr			intrusive rocks	porphyritic granite, granodiorite

- Geological boundary
- Fault
- Inferred fault
- Concealed fault

Fig.2 Schematic Geological Map

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

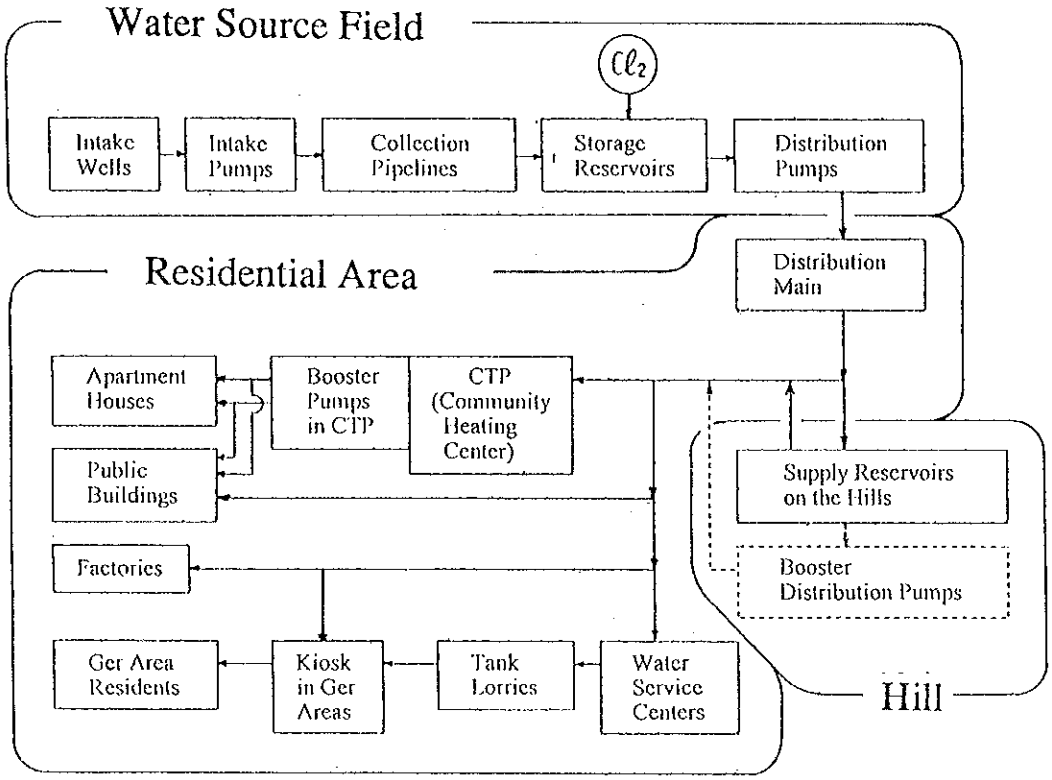


Fig. 3 Flow Chart of Water Supply System in Ulaanbaatar City

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

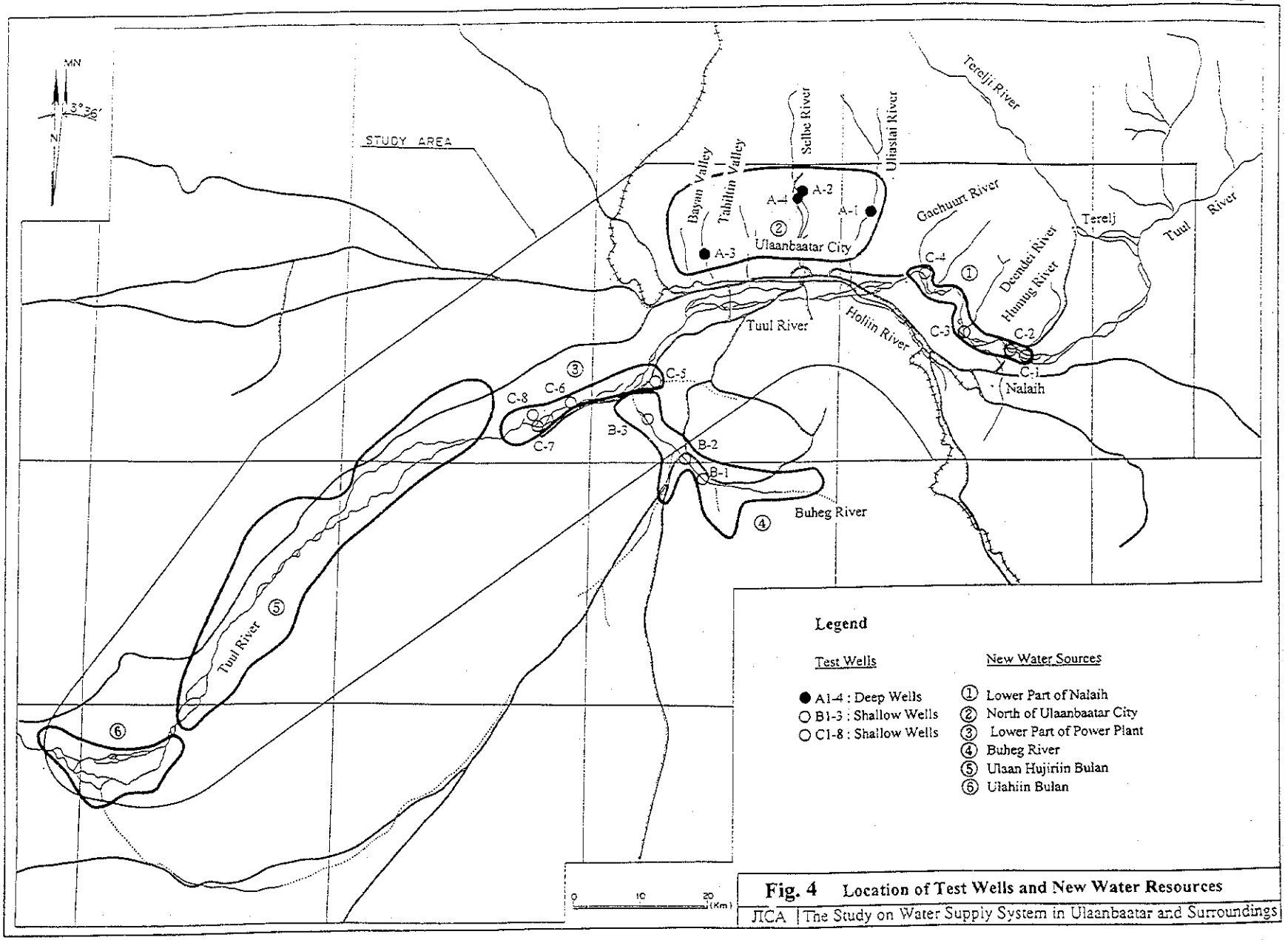


Fig. 4 Location of Test Wells and New Water Resources

JICA | The Study on Water Supply System in Ulaanbaatar and Surroundings

Fig. 5 Improvement of Pumping Station at Upper Water Source

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

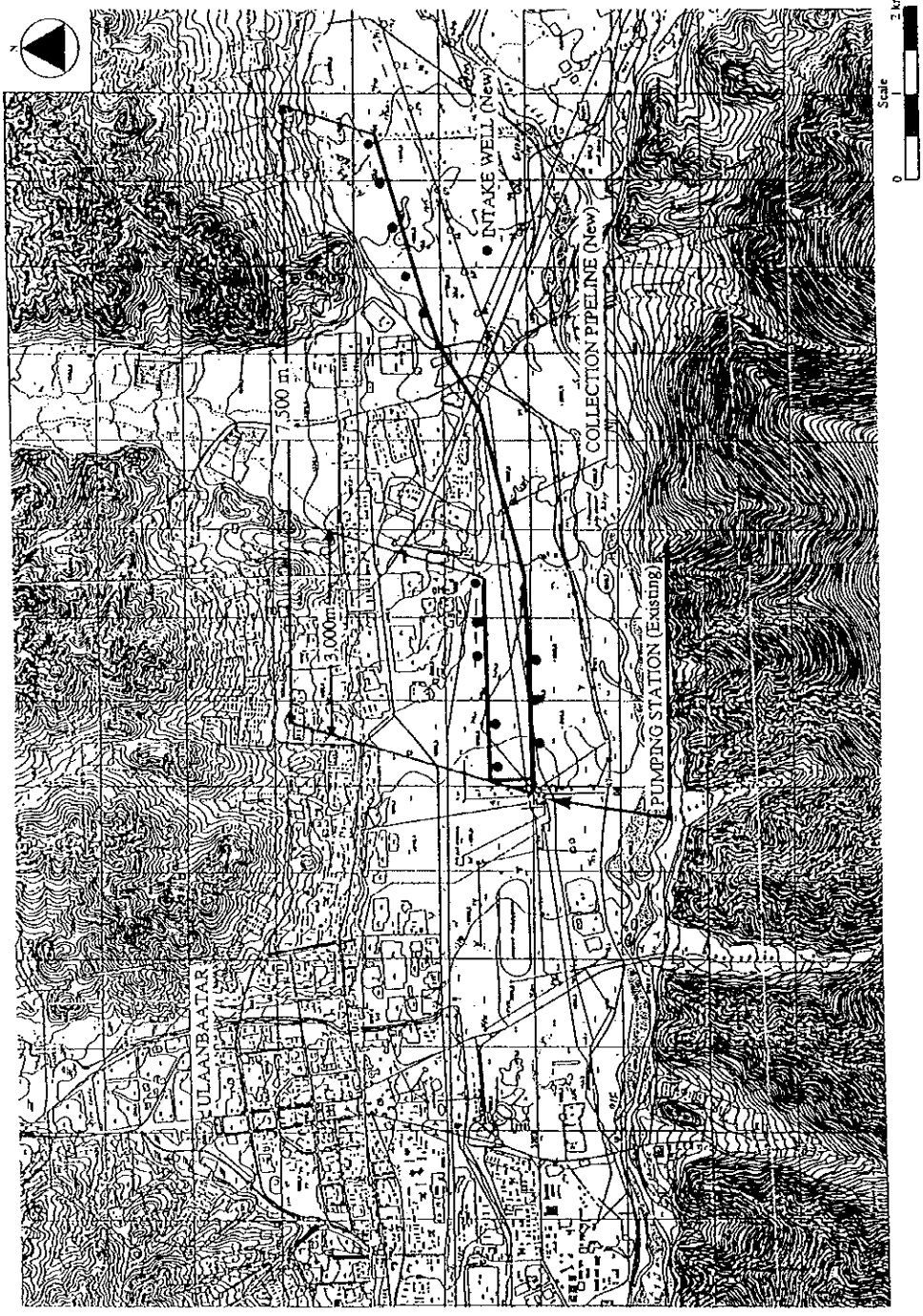


Fig.6 Expansion Facilities of Central Water Source	
JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

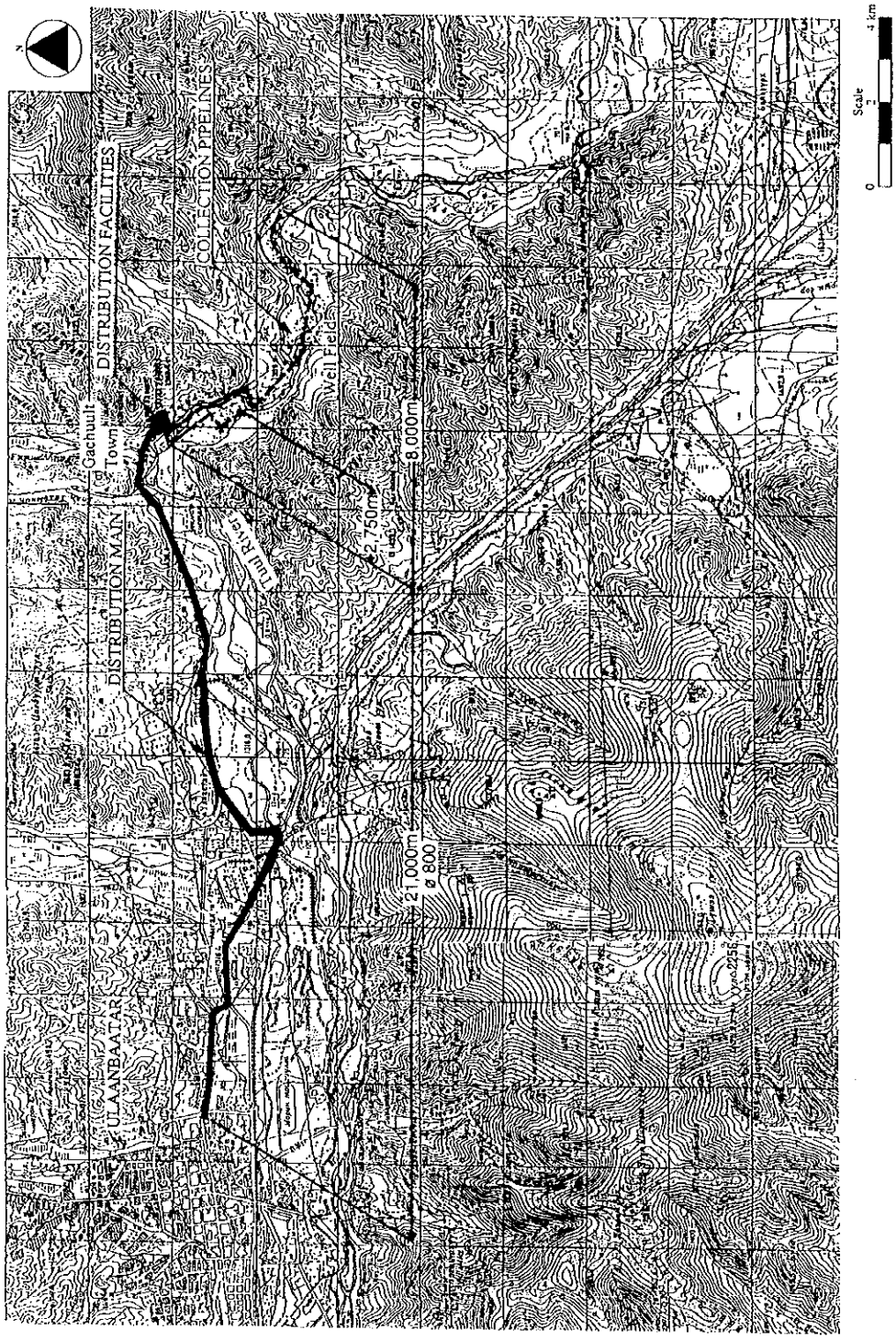


Fig. 7 Location of Lower Part of Nalaih

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings

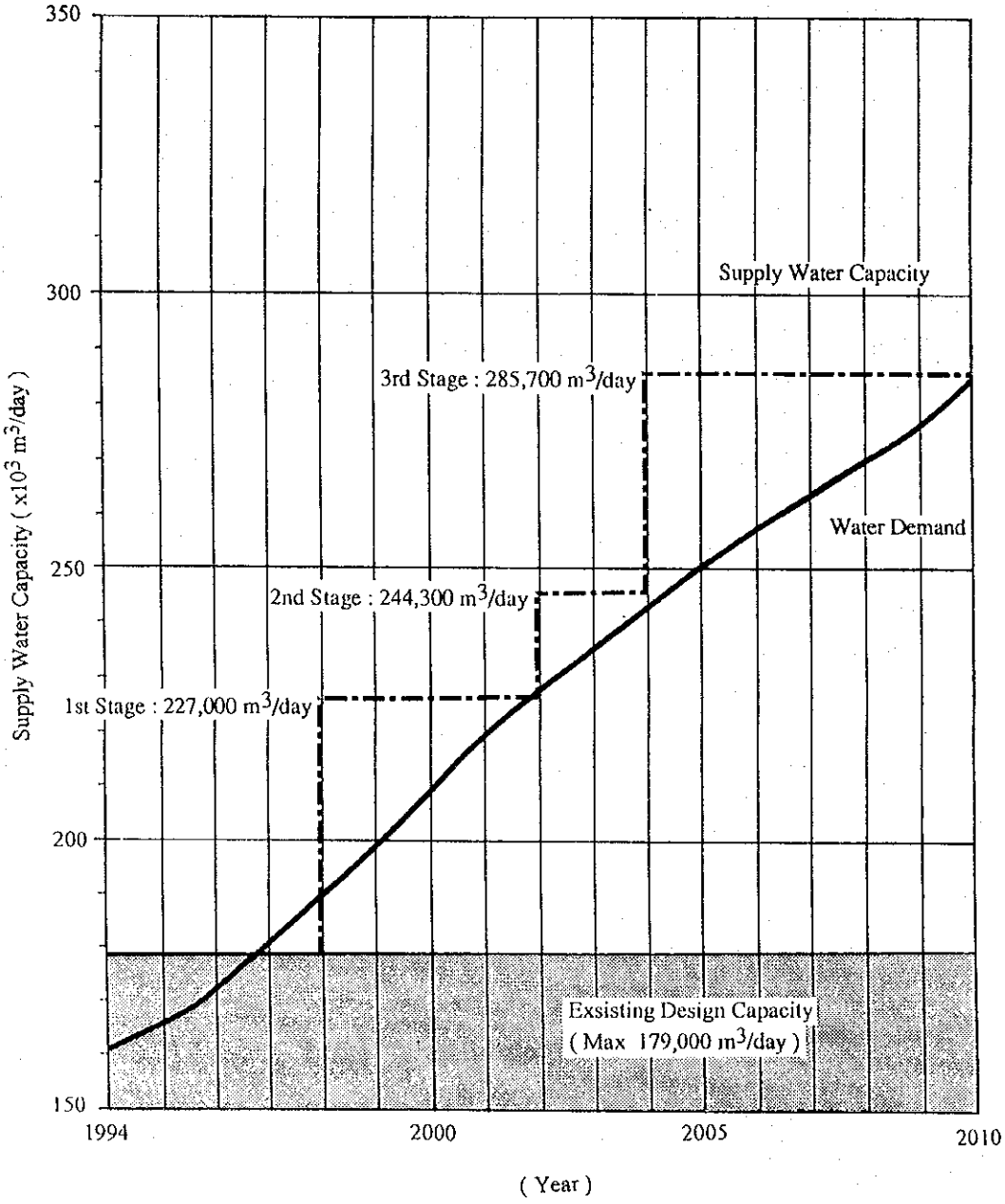


Fig. 8 Future Water Demand and Supply Water Capacity

JICA	The Study on Water Supply System in Ulaanbaatar and Surroundings