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JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ULAANBAATAR MUNICIPALITY
THE GOVERNMENT OF MONGOLIA

THE STUDY ON WATER SUPPLY SYSTEM IN ULAANBAATAR AND SURROUNDINGS

FINAL REPORT

VOLUME II

MAIN REPORT

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

SUMMARY

SUMMARY

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.

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.

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.

(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.

- 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. 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 the 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. 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.

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.

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

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

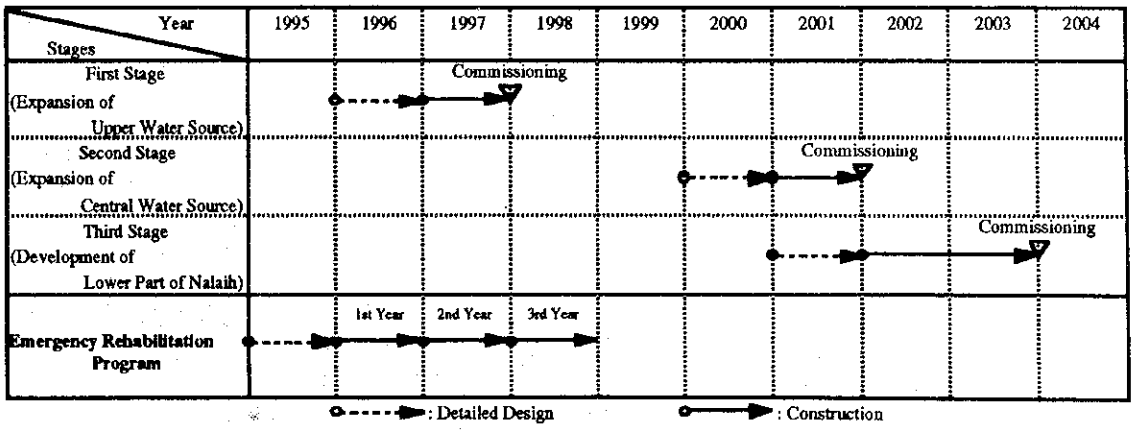
Note
1) Exchange Rate : US$ 1.00 = Yen 100.0 , US$ 1.00 = Tg. 400.0
2) Administration cost includes the direct cost and personnel expenses for land acquisition, design, and construction

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.

This implementation schedule of "Emergency Rehabilitation Program" is studied assuming that rehabilitation is to be done by three years from 1996.

Implementaiion 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 (Tg.8/m^3 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$ 20,729,640-) (Rate : US$ 1.00 = Yen 110.0)

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

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DRAWINGS

ABBREVIATION

bil.	billion
CIP	Cast Iron Pipe
COMECON	Council for Mutual Economic Aid
CTP	Community Heating Centers
DCIP	Ductile Cast Iron Pipe
EIU	Economist Intelligence Unit
IMF	International Monetary Fund
JICA	Japan International Cooperation Agency
mil.	million
MPR	Mongolia People's Republic
MPS	Material Product System
MCM	Million Cubic Meter
SNA	System of National Account of United Nation
SP	Steel Pipe
Tg.	Mongolian Tugrug
TPD	Town Planning Department of Ulaanbaatar Municipality
USAG	Water Facilities Exploitation Department of Ulaanbaatar Municipality
ULBT	Ulaanbaatar City
VLF	Very Low Frequency

CHAPTER 1 INTRODUCTION

1.1 Background of The Study

1.2 Objectives of The Study

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

The city of Ulaanbaatar, the capital of Mongolia, is also the center of industry and commerce, has relatively 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, the City has encountered with some trouble of the water supply from April to May because of the lowest groundwater table in the year.

Ulaanbaatar Municipality has attempted to meet the water demand by constructing water supply system 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 Government of Mongolia requested the technical assistance from the Japanese Government in the formulation of a master plan for the development of water supply system and a feasibility study of high priority project from the master plan. In response to the request of Mongolia, a preparatory study team visited Mongolia in March 1993 and agreed to conduct the Study on Water Supply System in Ulaanbaatar and Surroundings. The Scope of Work for the Study was signed on March 11, 1993.

1.2 OBJECTIVES OF THE STUDY

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 from the master plan study; and
(4) to prepare the proper advises on enhancing the management of water supply through institution building.

1.3 Study Area

1.4 Study Organization

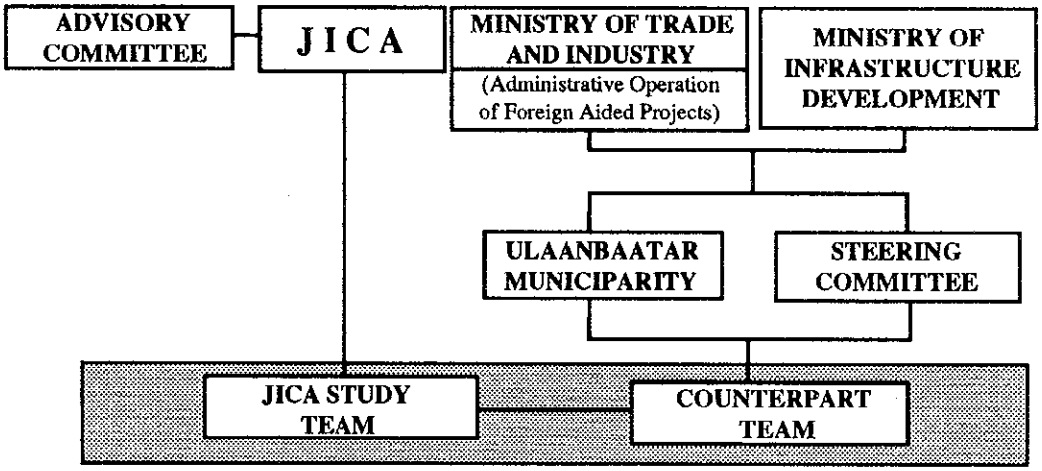
1.3 STUDY AREA

The Study area covers an area of about 8000 km^2 along Tuul River basin including Ulaanbaatar City and suburbs as shown in Fig. 1.1.1.

1.4 STUDY ORGANIZATION

1.4.1 General Organization

A general organization for the Study is described below.



1.4.2 Japanese Organization

The official agency of Japanese side to execute the Study is Japan International Cooperation Agency (hereinafter called "JICA"). JICA has organized an advisory committee to ensure the smooth and appropriate execution of the Study.

The JICA Study Team consists of fifteen members and Advisory Committee consists of two (2) members as shown below.

JICA STUDY TEAM

1	Team Leader	Dr. Kiyoo KAWADA
2	Hydrogeologist	Mr. Yuusuke OOSHIKA
3	Geologist	Mr. Teruo TAHARA
4	Hydrologist	Mr. Soichiro YUMOTO
5	Water Quality/Environment Specialist	Mr. Hajime MORI
6	Geophysical Survey Expert (A)	Dr. Kazushige WADA
7	Geophysical Survey Expert (B)	Mr. Kazuo UCHIDA
8	Groundwater Simulation Expert	Mr. Norifumi YAMAMOTO
9	Drilling Expert	Mr. Yuji KATABE
10	Water Supply Planner (Organization and Institution)	Mr. Terutoshi OZAWA
11	Water Supply Facility Designer/Cost Estimator (Intake Facilities)	Mr. Takashi SUZUKI
12	Water Supply Facility Designer/Cost Estimator (Transmission Facilities)	Mr. Hideki YAMAZAKI
13	Operation and Maintenance Specialist	Mr. Hiroaki MIYAKOSHI
14	Socio Economist	Mr. Fumiaki ONODA
15	Coordinator	Mr. Takashi HOSHINO

JICA ADVISORY COMMITTEE

1	Former Chairman	Dr. Yuuzi MARUO	JICA
2	Present Chairman	Mr. Hayao ADACHI	JICA
3	Member	Mr. Masaki ITOH	The Institute of Public Health

1.4.3 Mongolian Organization

Ulaanbaatar Municipality acted as the counterpart agency to the JICA Study Team and provided the Study Team with the necessary counterpart staff. The municipality also organized the committees consisting of the officials of the municipality and the other related agencies to control the operation of the Study.

Counterparts from the Mongolian side conducted the Study together with the members of JICA Study Team. Good relationship and cooperation between JICA Study Team and counterparts have made good results, overcoming the obstacles of language.

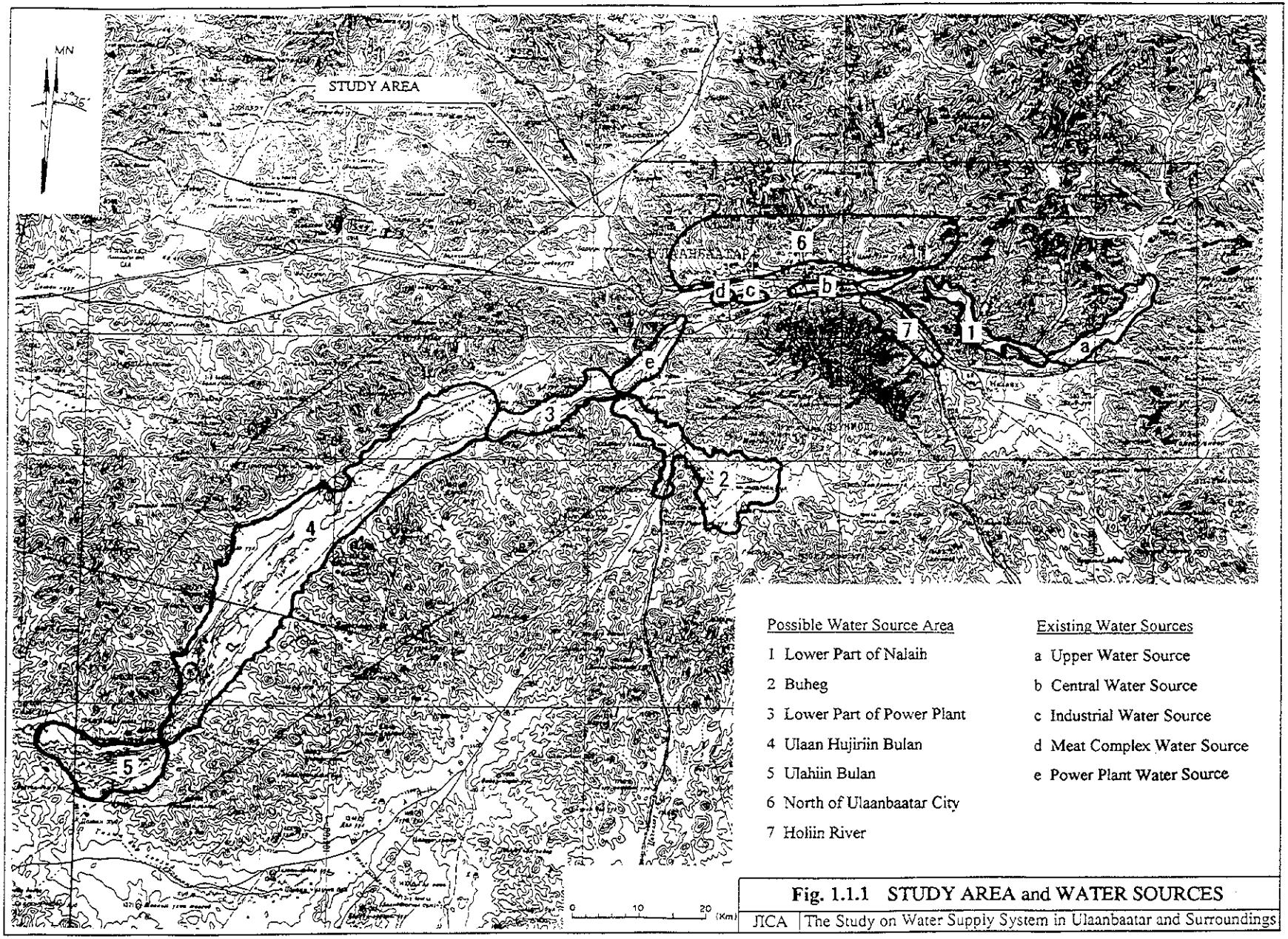
Steering Committee set up on September 17, 1993 and Mongolian counterparts are shown below.

MONGOLIAN STEERING COMMITTEE

1.	Deputy Chairman	Mr. D. Biambaa	Deputy Mayor, General Manager of Ulaanbaatar Municipality
2.	Secretary	Mr. B. Altangerel	Coordinator, "Water" Programme
3.	Members		
	(1)	Mr. O. Chuluun	General Director, Dept., Ministry of Energy, Geology and Mining
	(2)	Mr. Kh. Ganbaatar	General Director, Industrial and Foreign Investment Dept., Minsitry of Trade and Industry
	(3)	Mr. T. Adiyasuren	Head, Science, Monitoring and Cooperation Dept., Ministry of Environment
	(4)	Mr. S. Khurelbaatar	General Director, Asian and African Dept., Ministry of External Relations
	(5)	Mr. J. Khurelsukh	Consultant to State Board of National Development
	(6)	Dr. J. Sanjaajamts	Director, State Dept. of Geodesy and Cartography
	(7)	Mr. N. Saijaa	Head, Hygienic and Infection Research Control Dept.
	(8)	Mr. G. Bold	Chief of Division Housing and Town Planning Dept.
	(9)	Mr. Ts. Perenleimaa	Officer
4.	Coordinator	Mr. Ts. Ulambayar	Officer

MONGOLIAN COUNTERPART

1.	Team Leader	Mr. G. Bold
2.	Hydrogeologist	Mr. C. Ganbold US OYU Co.,Ltd.
3.	Geologist	Mr. B. Banzragch GGEC, 11th party, Senior geologist
4.	Hydrologist	Mr. Dashdeleg
5.	Drilling Expert	Mr. G.Sharav GGEC, 11th party, Chief
6.	Groundwater Simulation Expert	Dr. G. Lkhanaasuren Section Chief, Institute of Geology and Mineral Resources
7.	Water Facility Designer Group Chief	Mr. Enkhabat Deputy head, Town Planning Department
8.	Water Source and Pipeline Maintenance Expert	Mr. N. Nyamdavchimbaa Engineer, USAG
9.	Economist	Mrs. Z. Altantseseg Economist, USAG



Possible Water Source Area

1 Lower Part of Nalaih
2 Buheg
3 Lower Part of Power Plant
4 Ulaan Hujiriin Bulan
5 Ulahiin Bulan
6 North of Ulaanbaatar City
7 Holiin River

Existing Water Sources

a Upper Water Source
b Central Water Source
c Industrial Water Source
d Meat Complex Water Source
e Power Plant Water Source

Fig. 1.1.1 STUDY AREA and WATER SOURCES

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

1.5 Report

1.5 REPORT

The study report are prepared as follows :

Main Report,
Supporting Reports,
Data Book,
Executive Summary Report, and
Drawings.

The main report presents the summarized results of the whole study. It mainly consists of four part :

1) a description of the background information for the present social and natural conditions of Mongolia and Ulaanbaatar (chapter 1 and 2),
2) a description of the master plan study for the long term development plan (chapter 3),
3) a description of the feasibility study for the priority project (chapter 4), and
4) an emergency rehabilitation program (Appendix).

The supporting reports describe the details of the same contents presented in the main report. It consists of three part as mentioned below.

Groundwater including geology
Meteorology and hydrology
Water supply system including water quality

The summary report presents an executive summary of the whole study.

The data book contains a basic data and information used in the study.

The drawings contain the hydrogeological maps.

CHAPTER 2 PRESENT CONDITIONS

2.1 Socio-Economy

CHAPTER 2 PRESENT CONDITIONS

2.1 SOCIO-ECONOMY

2.1.1 General

The present development plan, (called General Plan) of Ulaanbaatar City is yet to be implemented because of on-going restructuring of economic and its ensuing political system. On one hand, basic laws concerning the right of land ownership are under preparation by a committee for parliament debates and on the other hand, the municipality is trying to settle its administrative boundary with Tuv Aimag, the surrounding central province, with an intention to increase its area. The municipality and Tuv Aimag's administration have recently reached an accord over the mutual boundary after a long and serious negotiations over lands along the boundary. The new area of the national capital would become about 3.7 times as big as the present one (about 1,400 km^2). A gist of the proposal is given in 2.1.3.

2.1.2 National Conditions

(1) Population

An estimate of Mongolia's population in 1993 is 2.20 million with an average annual growth rate of 2.2 % since 1988.

Population

		1989	1990	1991	1992	1993
Population	(mil.)	2.04	2.10	2.15	2.18	2.20
aagr*	(%)	2.2	2.5	2.7	1.4	1.1

*average annual growth rate Source: EIU Country Report 3Q 1994

(2) National Income (NI)

In Mongolia, Material Product System (MPS) had been used to calculate the NI like other socialist countries. The government has been switching the accounting system into the System of National Account of United Nation (SNA) which all the member countries of the IMF use. According to their trial calculation by means of the SNA, per capita GNP in 1989 was about 300 US dollars.

National Income

		1989	1990	1991	1992*	1993*
Net Material Product	mil Tg	8,646	8,328	15,140	n/a	n/a
Real Produced NI Growth	%	9.7	-3.8	-14.2	-7.6	-15.0
Consumer Price Inflation	%	–	–	130	126	69**

* estimate, ** June '94 Source : EIU Country Report 2Q '93 & 3Q '94

(3) Origins and Components of Net Material Product (NMP)

Industrial production which includes mining had never reached its target, 35 % of the total NMP in 1991. It has grown by 2.8% in the first half of 1994. Agro-pastoral sector comprised around 20 % (though it fluctuates as it depends on favorable climates), and commerce sector has been reaching almost 30 % with privatization.

Value of imports was about twice that of export in 1990. Engineering goods comprised some 30 % of the total import; fuels, minerals and metals a little less than 30 %, and consumer goods 20 %. Principal exports, on the other hand, are minerals and metals (50 %), and consumer goods (20 %). This discrepancy of values of exports and imports was quickly narrowed in 1991 and 1992. Imports from free-market zone were reduced to nearly a half in the two consecutive years, and were found to be only 10 % more than that of exports. (Here, transactions among non-convertible area, mainly between the ex-USSR, is excluded, which comprised nearly 80 % of the total transaction.)

Origins and Components of Net Material Products (%)

ORIGINS	1989	1990	1991	COMPONENTS	1990
Industry	33.8	35.0	36.0	Consumption : private	73.0
Agro-pasturage	19.2	20.2	20.7	public	25.9
Construction	7.1	5.8	5.5	Investment	29.0
Transport	10.5	8.4	7.2	Exports:	28.5
Commerce	28.7	27.6	28.4	Imports	-56.4
TOTAL	100.0	100.0	100.0	TOTAL	100.0

Source : EIU Country Report 2Q '93 & 3Q '94

(4) Current Account and Government Finance

Efforts of the Government brought down the deficit in the current account in years of 1992 and 1993. External Debt are from ex-COMECON countries, about 99 % of which is from ex-USSR. In the end of 1992 the balance was equivalent to about 1.5 billion Dollars. Exchange rate, as of September 2,1994 was Tg. 399.8 per dollar at free market rate.

Current Account and External Debt

		1988	1989	1990	1991	1992*
Current Account	mil$	- 951	1,240	- 644	- 111	- 46
External Debt	$	12.3	14.2	14.6	ca15	ca15

*estimate Source: EIU Country Report 3Q '94

National Finance (mil Tg.)

	1985	1986	1987	1988	1990*
Transaction Tax	3,559	3,895	4,171	4,321	6,895
Profit Tax	1,634	1,602	1,684	1,851	
Income Tax	42	40	46	49	50
Others	506	360	541	526	430
Total Revenue	5,741	5,897	6,442	6,747	7,375
National Economy	2,485	2,307	2,864	3,065	3,484
Socio-Culture	2,159	2,346	2,420	2,609	2,989
Others	1,057	1,223	1,125	1,071	902
Total Expenditure	5,701	5,876	6,409	6,745	7,375

* budget Source : Gov. publications

(5) Human Resources

Mongolia is a country with a long heritage and full of youth. Numbers of those under the age of twenty comprise 55.1 % of the total population in 1989. Household numbers were 428,800 in the same year, which makes the number of average household member to be 4.8.

Urban migration with the improvement in education makes an unbalanced situation in the supply and demand of labour force. The proportion of urban population has increased from 26.8% in the year 1989 to present 57.1%. As a result, short of supply in agro-pastoral and construction sectors, and the rising level of unemployment in Ulaanbaatar are the major problem observed. Sector-wise composition of employment is given below.

Employment Composition by Sector

		1985	1988	1989
Total labour force	(thousand)	561.6	616.2	633.2
Industry	(%)	18.6	19.1	18.9
Agro-Pasture	(%)	33.8	30.2	29.4
Others	(%)	21.4	22.8	23.0
Material Production Sector	(%)	73.8	72.1	71.3
Non-Material Production	(%)	26.2	27.9	28.7
TOTAL	(%)	100.0	100.0	100.0

Source: Gov. publications

Total number of labour force were 1,029,000 in 1990, and woman labour force comprised 45.5 % according to the information provided by the World Resources Institute.

Unemployment reached 73,600 in July 1994. Some 93,000 families are living below the poverty level.

(6) The Ninth National Economic Development Plan (1991-1995)

A revised plan in a formal appearance is not officially circulated. A tentative program without fixed target was announced at the first cabinet meeting after the election held in

1992. Targets of the plan would be placed under discussion in the coming parliament session.

Figures' non-availability notwithstanding, the direction is quite clear under free market economic system. Improvement in efficiency in every sectors with safety nets for socio-economically handicapped people, especially during the transition phase. Electrification policy of 'Ger' housing area is given priority with reference to our study perspective.

(7) Water and Environment

Annual internal renewable water resources, their withdrawal situation, water supply, sewerage situation, and carbon dioxide emission are given below

Water Related Statistics

	Total	per Capita	Remarks
Renewable Water Resources	24.6 km^3	11,050 m^3	in 1990
Withdrawal	0.55 km^3	272 m^3	in1987:*

Drinking water service

	Urban	Rural	Remarks
Drinking water service	78 %	50 %	in 1988
Sanitation Service	100 %	43 %	in 1988

Emission of carbon dioxide in 1989

From solid material	7,694	(Unit : 1000 tons)
Liquid material	2,308	
Cement material	297	
Total	10,303	(4.84 ton per capita)

Source: "World Resource 92-93", World Resource Institute, Oxford Univ. Press.

* In 1987, annual withdrawals amounted to ca. 2 % of annual internal renewable water resources. The water use consists of three major categories in 1987; domestic use 11 %, industrial use 27 %, and agro-pastoral use 62 %.

2.1.3 Socio-Economy of Ulaanbaatar

(1) Introduction

The necessity of creating a new city planning in the capital area with ample space big enough for securing actual plan's maneuverability was given in the introductory note of the proposal. The details are described below.

1) The new constitution and the law on administration, territorial units and their management (1992) require a restructuring of Ulaanbaatar area administration.
The present area (an area of about 1,400 km^2) was set by the council of ministers in 1957, when the population was approximately 170,000. The territories of Gachuurt, Jargalant, Baganuur and Bagakhangai (administrative units belonging to the Ulaanbaatar Municipality) are still under jurisdiction of Tuv Aimag. Ulaanbaatar makes only 0.001 % of the country's territory and 1.7 % of Tuv Aimag's. However, the population of the City is 26.8 % of the total.

2) The on-going economic and political changes lead to new issues in land holding right and related problems which should be solved through law institutions and restructuring the whole economic system of the City.
At the same time, recent years have seen a quick increase in cattle number in the City area, reaching 206,000. It requires over 180,000 hectares of grazing land and over 60,000 tones of hay. More citizens and enterprises apply for land for cattle breeding and agricultural cultivation.

3) The over-strained density of industrial enterprises and population in the City has affected an ecological balance of the surrounding area and also its comprehensive socio-economic development.
Some areas, suitable for land-cultivation and cattle-breeding to provide the City with food products, are restricted by hygienic zone of drinking water basin, national park zone of the Bogd Mountain and prohibited area around the biological factories and the poultry farms.

4) The future expansion of the City is no longer affected by public transportation routes, because a number of car owners have been sharply rising. Thus, the City planning is aiming at establishing and developing the satellite or suburb towns which are self-sufficient in transportation and engineering supply network.
Urgency is keenly felt from the concise expression. According to the new capital district area plan, the number of Duureg (district) has increased from six(6) to twelve(12). Some of the previous districts would enlarge their areas, one would be resolved into new ones. Two have changed their names. The municipality has been

kept one detached district of coal mines under its administration, and the new one would have another of a former military base in addition. The names of new districts are given below.

Name of New Duureg (Districts) and Their Areas in 1994 (1,000ha)

	Central area			Suburbs area	
1	Han-Uul	48.2	7.	Bagahangai *	61.0
2.	Bayanzurh	136.2	8.	Baganuur *	63.0
3.	Chingeltei	8.6	9.	Nalaih	73.2
4.	Sukhbaatar	21.8			
5.	Bayangol	2.9			
6.	Songinohairha	114.0			
	Sub total	331.7		Sub total	197.2
				TOTAL	528.9

* : detached district

(2) Population

1) 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) The administration system of micro district in the central areas is of importance for water supply service. Once under the jurisdiction of Ministry of Community Service, all the facilities of public utility and its supporting activities within each micro-district were maintained by the ministry. Now each micro-district has a community service company instead. Every micro-district has its own community heating center (CTP) for cold and hot water supply in all season.

(3) Socio-Economy

1) General

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
Constrution	42
Housing	50

2) Economic Activity

The production statistics of major sectors in the city area are shown below.

Major Production Statistics (mil.Tg*)

	1993	1994
Industry	2,958.5	65,238.8
Construction	399.6	6,467.7
Communication	1,048.8	4,200.6
Retail Trade	14,681.1	15,548.2
Communal Service	2,193.5	4,435.9
Budget Income	5,697.1	10,024.6

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

At present, most part of coal produced within the municipality have been brought from Baganuur mine located in Baganuur detached district. In 1992, 96.8 % of coal was produced in Baganuur mine; it was 85 % of planned target production volume. Mining operations are carried out on open-pit mines. The product is of a soft coal variety, containing sulfur and relatively much water, which is one of the major cause of frequent break downs of the system at the No. 4 power station. 74.2 % of Baganuur coal went to three power stations in 1992. 14.4 % of the total coal demand of the city was met by coal from other provinces, mostly from Sharin Gol mine.

Industry areas are allocated in several places in the city. In the context of water supply and sewage scheme, livestock industry within the city area is clearly demarcated from other industries' water use with a few exceptions. Most big scale industries are concentrated in southwest and west (including Tolgoi) parts of the City. There are four (4) power stations in Ulaanbaatar, out of which three are in commission. No. 4 is the biggest. Types and location of the industries are given below.

Industries by Types and Location

	SouthWest	West	East	Central	Total
Food	4	5	4	1	14
Fiber (clothe)	7	1	0	3	11
Leather (boots)	11	0	0	0	11
Machine Tool(Elec)	7	0	0	0	7
Machine Repair shop	11	4	5	0	20
Construction,					
Timber, Furniture	14	3	1	1	19
Others	6	8	2	3	19
TOTAL	60	21	12	8	101

Source: "Study on Water Supply in Ulaanbaatar", Technical Export, 1979.

3) Recent Trend in Housing Industry and Public Transport

In the year of the 355th anniversary of the city, new construction of flats for 1,400 families is being planned. After privatization, contractors are either Mongolian or Mongolian-Soviet companies.

Public transport in the city consists of bus and trolley bus services. 56 % of 603 buses and trolley buses owned by three public transport agencies were in operation in 1993. Total number of passengers in 1992 were about 200 million and operating ratio was 400 % when the standard bus fare (SBF) was Tg.10 in Oct.1993. The SBF has increased sharply by 200 % to Tg. 30 (US$ 0.072) since July 1994.

4) Municipal Budget

Organization

In the municipal office, mayor is supported by four deputy mayors. The divisions of planning, housing, water supply and sewerage, heating come under the second deputy-mayor.

Budget

Income and expenditure structure of the municipality is given in the following table. In these high inflation years trend cannot be analyzed by itself. The budget had been healthy at first glance as the amount of expenditure were always within that of income.

Budget of Ulaanbaatar Municipality (mil Tg)

	1993	1994
INCOME	5,697.1	10,024.6
Income tax	664.9	940.2
Corporate tax	3,558.4	5,819.3
Commerce tax	772.5	1,546.1
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	4,988.5	9,177.9
Salary	1,356.3	2,428.5
Social fund		314.2
Health fund		100.8
Other expenditure		4,549.8
Subsidy		1,270.4
Investment	290	498.3
Credit		15.9

Source : Statistic Department of Ulaanbaatar Municipality

5) 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. Unimployment people, mostly young, amounted to 50.0 thousand in 1992. Average monthly salary of national enterprises was 8,000 Tg. as of July 1993.

Reference : The Tuul Basin, the suburbs of the central city areas

(1) Upper Stream

In some of the water shed areas of tributaries as well as the river beds of the main stream, beach forests with some birches in them, and patches of larch forest at a little higher up areas are found. In the national park area, calls of bucks are frequently heard. Yet, while people have been coming in with cattle, shrub cutting for grasslands and hay making have been increasing. Trees have been cut for housing material and fuel woods in winter.

In the grasslands, "tarbags", a rodent family, are abundant. They carry pest; epidemic of pest erupts on and off in such settlements up-stream as Terelj.

Hunters on jeep or motorcycle are sometimes seen on the grasslands. If the number increases, we may foresee the area would be trumped excessively by treads like the national parks in Kenya where tourist cars are allowed to crisscross.

Various levels of land degradation are seen at the sites of winter camp of cattle in the tributaries of the Tuul.

On the gentler slopes, mechanical farming of wheat are seen. Contour binding are not observed.

Nalaih coal mine is being closed down. Its operation method is of deep mining, and the depth has reached 300 meters. There is only one small heap of coal waste at the site, though. The rest seemed to have been back-stowed on the course of mining operation.

(2) Lower Stream

Some of the river beds are kept as conservation areas. Some areas are even called 'hangai' for its natural beauty. As a township located along the river, it is a responsibility in the part of Ulaanbaatar municipality to bring back used water as nearer as possible to the quality before its use. Improvement of sewage facilities are therefore indispensable along with that of drinking water, especially in "Industrial" areas.

2.2 Natural Conditions

2.2 NATURAL CONDITIONS

2.2.1 Topography and Geology

(1) General Description

Mongolia is a mountainous country. Basically, its topography consists of mountains, hummocks and high denudation plains, forming three major regional stages on its surface. Mountains are found mainly in the northern and western regions, and denudation plains in the southeast. Hillocks, equally distributed on its entire territory, are highly developed in the desert.

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 is about 6,300km^2. It flows approximately east to west from near Nalaih to Ulaanbaatar. The River joins Orhon River that is one of the main tributary of the Selenge River which pours into the Baikal Lake.

Hentii Mountains are the part of the world watershed between the Arctic and Pacific Ocean basins and the closed drainage basin of Central Asia. The highest point in this mountain systems is the Asralt Hairhan peak with an altitude of 2,751m above sea level. A characteristic feature of the topography of Hentii Mountains is the intermontane tectonic depression, which is extended and broad in its southwest where the Study Area is located. In the central part of ridges, innumerable traces of ancient graciation in the form of moraine, cirque and gracial lakes are found.

Tectonically, Mongolia basically comes under the Ural-Mongolian Paleozoic fold belt, and only a portion of it belongs to the Mediterranean - Central Asiatic branch of Tethys. The geological structure of Mongolia contains seven unit of folded zones as described below (refer to Fig. 2.2.1).

I. Mongolian Altai Folded Zone,
II. North Mongolian Folded Zone,
III. Mongol Pre-baigalian Folded Zone,
IV. Central Mongolian Folded Zone,
V. South Mongolian Folded Zone,
VI. South Gobian Folded Zone,
VII. Inner Mongolian Folded Zone.

Geologically, Mongolia contains metamorphic, magmatic and clastic complexes of all geological ages. The surface of the mountain structures usually has Precambrian and

Paleozoic geosynclinal complexes, characterized to a significant extent by deformations and metamorphic changes. In intermountane hollows and on a considerable part of Govi, Mesozoic and Cenozoic rocks cover the folded and faulted foundations.

The Study Area belongs to Mongol Pre-baigarian folded zone that is divided into three sub-folded zones, arranging from northwest to southeast, as mentioned below.

i North Hentii folded zone	:	Mandal Series of the Riphean System.
ii Hentii Variscan folded zone	:	Hentii Series
iii South Hentii Caledonian folded zone	:	-

Small masses of granitic rocks occur at places. Its intrusion has had contact metamorphic effect on the surrounding rocks. Most of the original rocks are assumed to have been pelite, psammyte of the middle to upper Paleozoic.

(2) Topography in the Study Area

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. Ulaanbaatar is situated on about 1,350 meters of the average height and about 250 millimeters of average annual precipitation. Besides, city is surrounded by the hill and/or mountains.

The Study Area is classified into five (5) topographical regions as the followings (refer to Fig. 2.2.2).

Mountain 1 region
Mountain 2 region
Hilly region
Undulated region
Lowland region (fluvial region)

1) Mountain 1 region
It is widely spread in the eastern part of the Study Area and on the right bank of Tuul River in the western part. A slope gradient of this area is over 35 degrees. It is mainly characterized by the exposure of Devonian rocks and granites.

2) Mountain 2 region
It is widely spread on the left bank of Tuul River in the western part of the Study Area with a slope gradient of 10 to 35 degrees. It is mainly characterized by the exposure of Carboniferous rocks.

3) Hilly region

It is distributed along the tributaries ,valleys, and mountain foots faced to Tuul River with a slope gradient of 3 to 10 degrees. It is mainly characterized by the distribution of Cretaceous rocks, Neogene sediments, and talus deposit. This region is gradually changed into the undulated region.

4) Undulated region

It is distributed along the both sides of Tuul River and it's tributaries and high above 2 to 5 meters compared with a recent River as if a terrace. It is mainly characterized by the distribution of fan and valley deposits. A slope gradient of this region is under 3 degrees.

5) Lowland (fluvial region)

It is spread in Tuul River and it's tributaries. There are many swamps here and there in this region. Recent river deposit is mainly distributed in this region.

(3) Stratigraphy in the Study Area

Geology around the Study Area mainly consists of Cambrian, Devonian, Carboniferous rocks, and which are intruded by granitic rocks in Jurassic to Triassic period and covered locally by the Cretaceous rocks, Tertiary, and Quaternary deposits. Devonian and Carboniferous rocks organize the Hentii series. These rocks are generally distributed in the direction of northeast to southwest parallel to the River (refer to Fig. 2.2.3). All the rocks are unconformable to each other and complexly folded and faulted. The Mandal series is distributed outside of the Devonian and Carboniferous rocks. Granitic rocks cause a contact metamorphism to the Devonian and Carboniferous rocks which are changed to biotite hornfels faces.

Summarized Geology in and around the Study Area

Era	Period	Thickness (m)	Group	Formation	Lithology and Remarks
Cenozoic	Quaternary	5-110		-	river deposit: sand, pebble to boulder (rounded) with clay
		5- 40		-	fan, talus, valley deposit: clay, sand and pebble to boulder (sub rounded to sub angular)
		6- 21		-	terrace : sand and gravel
	Tertiary	10-100		-	Neogene deposit: reddish clay and sand with pebble to cobble
Mesozoic	Cretaceous	72-350		Zuunbayan	sandstone and mudstone with coal / fossil
Palaeozoic	Permian	300-350		Ulzin	conglomerate, sandstone shale
	Carboniferous	1200-1500 C_{2-3}	Hentii	Orgioch uul	greywache: sandstone and tuffaceous sandstone with shale
		2500-3000 C_{1-2}		Altan ovoo	flysch: alternation of sandstone and shale
	Devonian	1500-1900 D_{2-3}		Gorchy	sandstone with shale, chert, diabase and tuffaceous sandstone
		1500-2000 D_{1-2}			sandstone, slate, phyllite with reddish chert, rarely schistose sandstone, quartzite
Proterozoic	Cambrian – Precambrian	3400	Mandal		semi schists, rarely sandstone, chert, quartzite and meta andesite/basalt.
Mesozoic	Jurassic - Triassic	-		intrusive rocks	porphyritic granite, granodiorite

1) Precambrian to Cambrian rocks

The rocks are represented by Mandal series (R3-E1 mn) and distributed on North Hentii Folded belt and Iroo's fracture to Ulaanbaatar Variss Geosyncline in the southern side and Har Horin's uplift in the western side. These are composed of various kind of metamorphic rocks and divided into three (3) as the followings.

Lower formation
Middle formation
Upper formation

2) Devonian rocks

Devonian rocks represented by Gorchy formation (Dgr), are spreading in a big territory along the southern Hentii Mountain range. These rocks are composed of the complex layers of green colored and fine grained sandstone, siliceous shale with radiolarian chert. Occasionally, there are some layers and lenses of agglomerate, volcanic materials (diabase etc.), tuff and crystalline limestone. Gorchy formation is divided into two formation (D1-2, D2-3) in the territory of Tuul River's left bank and Shohoin Tsagaan Bulag.

3) Carboniferous rocks

Carboniferous rocks consist of Altan ovoo (C1-2) in the lower to middle Carboniferous period and Orgioch uul formation (C2-3) in the middle to upper Carboniferous period.

Altan ovoo formation (C1-2)

This is distributed in the Tuul River valley near the Ulaanbaatar area.

This formation is originated in the flysch which are alternated of sandstone and shale, and rarely interbeded with basic to intermediate tuffs and lens of conglomerate.

Fault is inferred between this formation and Devonian rocks. Flora and fauna fossils of the lower Carboniferous period were found in this rock (V.A. Amantov, 1961).

Orgioch uul formation (C2-3)

This formation is originated in the greywache which is mainly composed of bad-sorted sandstone in the bottom and top, and with rarely interbeded of sandstone and shale in the middle part. This formation is expected to be middle to upper Carboniferous rock from the stratigraphycal point of view.

4) Permian rocks

Ulzin formation (P2 ul) in the upper Permian period is locally distributed in Deendei valley as a block-wedge from Hadat valley to Baga Deendei along the left bank of Deendei valley. It has northeast to southwest strike with nearly vertical dip of 80 to 85 degrees. This is unconformably lying on lower-middle Carboniferous formation (C1-2) and bordering by a fault with the middle-upper Devonian formation (D2-3).

This formation is composed of conglomerate in the northeastern and southwestern part, and sandstone and shale without conglomerate in the central part.

The age was determined as a upper Permian by the *Cordaite sp* of fauna fossil, accompanied with the properties of lithology and stratigraphy.

5) Cretaceous rocks (K)

Cretaceous rocks are represented by Zuunbayan Formation in lower Cretaceous period.

It is locally distributed in Nalaih depression, Tolgoit hill, Hamba hill and Buheg River, and composed of sandstone and mudstone with coal. This formation has monocline structure with north east strike and southern dip of 15-20 degree. These sedimentary rocks are weak in diagenesis and not well consolidated. The thickness of this formation is 72 to 86 meters, and locally 350 to 500 meters in Nalaih depression.

The age of this formation was determined as lower Cretaceous by some flora and fauna (insects) fossils.

6) Neogene deposits (N)

These deposits are distributed in and around of Nalaih and Ulaanbaatar depression and some part of Holiin River.

It consist of unconsolidated reddish to yellowish clay, sand, and pebble to cobble with rarely conglomerate. It is expected to be old talus and fan deposit in Neogene period.

The thickness of these deposits are from several meters to 10 meters. According to a geophysical data, it is expected to be 60-80 meters in the Ulaanbaatar depression.

The age was determined by fauna analysis as Pliocene epoch of Tertiary period.

7) Quaternary deposits

Quaternary deposits are widely distributed along Tuul River, its tributaries, and intermontane valleys. It is mainly composed of terrace deposit, fan deposit, talus deposit, and recent river deposit. The age is ranging from lower Pleistocene to upper Holocene.

Quaternary deposits in the Ulaanbaatar area have been studied in connection with the project of urban developments and water supply developments. There are many data of seismic studies and boreholes to investigate the engineering geology, hydrogeology, and construction material.

Terrace deposits

It is expected to be distributed along Tuul River covered by the fan and talus deposits. Terrace plain is divided into three (3). It is reported that the age of 1st terrace is Pleistocene epoch, and 2nd/3rd are Holocene. Three quarry sites for construction materials such as sand and gravel are developed in 1st terrace deposit.

Fan deposits

It is distributed near the mouth of river and tributaries along Tuul River. It is composed of clay, sand, and pebble to cobble that are subrounded to subangular with intermediate sorted. This deposit is gradually changing from talus deposit and valley deposit around tributaries.

Talus deposits

Talus deposit is distributed at the mountain foot and composed of clay, sand, and pebble to boulder that are angular to subangular with bad sorting.

Recent river deposits

It is distributed in Tuul River and large tributaries and composed of clay, sand, and pebble to boulder that are angular to subangular with well sorted. Swamps composed of clay with sand and gravel, are formed here and there in the River and large tributaries.

(4) Lineament

According to the interpretation of Landsat images, NE direction of lineaments are dominant in the Study Area and secondary NNW direction. Lineaments are clear in the northeast part, but indistinct in the southwest part of the Study Area. This may be reflected by the topographical deference in the Study Area where the intermontane tectonic depression of Hentii Mountains elevation is found.

Almost lineaments correspond with faults and fractured zones which are expected to be fissure aquifer. Faults and fractured zones in the basement rocks may be pervious in itself, and/or these may form the impervious zones which control the groundwater flow.

(5) Electrical Prospecting

The electrical prospectings were conducted at 136 sites by JICA Study Team.

A map of basement depth is presented in Fig. 2.2.4. Based upon the electrical prospecting incorporated with the previous electrical prospecting, possible alluvial aquifers are recommended below..

Alluvial aquifer

1) Buheg Area (St.96 and 97)
2) Confluence of Tuul River and Buheg River (St.63, 64 and 78)
3) Lower stream of Uliastai River (St.18 and 19)
4) Upper Water Source Areas (St.41, and St.114 through 118)
5) Debris fan deposit area in Ulaan Hujiriin Bulan (St.63 and 64)
6) Boundary area of Ulaan Hujiriin Bulan and Lower Part of Power Plant (St.69 and 72)

(6) Very Low Frequency (VLF) Prospecting

VLF prospectings were conducted at 45 sites in the north of Ulaanbaatar City and Holiin River by JICA Study Team.

On the basis of the VLF and electrical prospecting, possible fissure aquifers are recommended below.

Fissure aquifer (Fractured zone)

1) Selbe River (VLF profile 12)
2) Holiin River (VLF profiles 37 and 38)
3) Bayan Goliin Valley (St.53 and VLF profile 3)
4) Uliastai River (St.18, 20 and 22)
5) Tahiltiin Goliin Valley (St.56 through St.59)

(7) Selection of Possible Groundwater Resources Area

As the result of interpretation of Landsat images, electrical prospecting, VLF prospecting, and geological survey, alluvial deposit and fractured zone in the basement rocks are expected to be good aquifer.

Alluvial Deposit

Recent river, fan, and valley deposit are mainly composed of sand and gravel with a high groundwater table and a high permeability, moreover they have large capacity of groundwater basin with sufficient recharge from the large catchment area and river discharge.

Fractured zone

Fractured zones in the basement rocks are distributed here and there in the Study Area. Fractured zones consist of fault breccia and fault clay that may be pervious in itself and /or they may form the impervious zones which control the groundwater flow. Especially, area of North of Ulaanbaatar City (ULBT) is located in good condition as for the groundwater resources.

From the geological point of view, possible groundwater resource areas are listed below. These areas shall be discussed in detail from the hydrogeological and economical points of view in the later chapter.

Possible Groundwater Resource Area

Location	Aquifer type	Geological Characteristics	Distance*1 (km)	Depth (m)	Width*2 (Km)	Length*2 (Km)
Upper Source	alluvial	sand, gravel, clay	40-54	5-36	1-3	14
Lower part of Nalaih	alluvial	sand, gravel, clay	28-40	20-30	1-2	12
Buheg River	alluvial	sand, gravel, clay	34-54	40-130	2-10	20
Lower part of Power Plant	alluvial	sand, gravel, clay	34-55	30-130	2-4	21
Ulaan Hujiriin Bulan	alluvial	sand, gravel, clay	55-122	50-130	10-12	67
Ulahiin Bulan	alluvial	sand, gravel, clay	122-147	>50 ?	6-8	25
North of ULBT						
Uliastai	fissure, alluvial	fractured zone. sand, gravel	10-15	169-202	(< 0.5) 1-2	(30)
Selbe	fissure	fractured zone	5-10	30-353	(< 0.5)	(14)
Bayan goliin	fissure. alluvial	fractured zone, sand, gravel	18	32-206	(< 0.5) 1-1.5	(20)
Tahiltiin goliin	fissure	fractured zone	16-22	25-72	(< 0.5)	
Holiin River	fissure	fractured zone	10-15	50-173	(< 0.5)	(31)

*1 : Distance from the Water Supply Department
*2 : ( ) width and Length of fractured zone

2.2.2 Test Well Construction

(1) Drillings

15 test wells were constructed for the Study with a total depth of 1114.4 meters.

These wells can be divided into three(3) types, namely Type A, B and C. Type A wells are located in the north of Ulaanbaatar City to explore the fissure aquifers. Type B wells are located in the alluvial plain of Buheg River. Type C wells are located in the alluvial plain of Tuul River. Fig. 2.2.5 shows the locations of the wells. Type A and B wells were constructed by the rotary method. Type C wells except C-5 were constructed by the percussion method. C-5 well was constructed using a rotary machine.

Six (6) water level recorders were installed in the test wells of A-4, B-2, C-2, C-4, C-5 and C-7.

The specifications of each type are as follows. Specifications of some well are changed due to the geological condition.

Designed specifications of test wells are stated below.

Type A	
Depth	200 meters
Borehole diameter	12.5 inches
Casing program	8 inches casing and screen pipes
Type B	
Depth	50 meters
Borehole diameter	14 inches
Casing program	10 inches casing and screen pipes
Type C	
Depth	30 meters
Borehole diameter	14 inches
Casing program	10 inches casing and screen pipes

The results of test well drilling and pumping test are shown in Table 2.2.1.

Geological sampling of cuttings and geophysical loggings for all fifteen (15) wells were conducted to investigate the geological and hydrogeological condition on the possible new groundwater resources areas. Drilling logs are shown in Supporting Report I.

(2) Pumping Test

Two type of pumping tests, namely Step Drawdown Test and Constant Discharge Test, were conducted at the all drillholes. In general, the step drawdown test consists of seven(7) stages and the duration of pumping at each stage was two hours. Twenty four (24) hours constant discharge test followed it after the recovering of water level. The results are shown below.

Hydrogeological constant

Drilling number	Pumping Rate		Static water level	Pumping water level	Drawdown	Specific capacity	Trans-missivity	Permeability coefficient
	(liter/sec)	(m3/day)	(G.L.- m)	(G.L.- m)	(m)	(m^3/day/m)	(m^2/day)	(cm/sec)
No. A-1	10.5	907	12.4	58.75	46.35	20	23	(4.1×10^{-4})
No. A-2	0.6	52	11.8	82.05	70.25	1	<1	(4.61×10^{-6})
No. A-3	25	2160	5.61	53.42	47.81	45	40	(6.52×10^{-4})
No. A-4	16.7	1443	3.48	52.22	48.74	30	31	(7.97×10^{-4})
No. B-1	3.9	337	- 2.00	11.53	13.53	25	35	2.46×10^{-3}
No. B-2	6.3	544	0.45	5.64	5.19	105	122	8.56×10^{-3}
No. B-3	22	1901	2.70	10.04	7.34	259	354	1.86×10^{-2}
No. C-1	10.8	933	0.75	8.69	7.94	118	142	1.49×10^{-2}
No. C-2	5.6	484	1.71	8.53	6.82	71	59	6.21×10^{-3}
No. C-3	2.9	251	2.47	16.90	14.43	17	13	2.74×10^{-3}
No. C-4	4.4	380	1.08	7.23	6.15	62	91	1.91×10^{-2}
No. C-5	8.5	734	5.47	26.00	20.53	36	37	3.89×10^{-3}
No. C-6	25	2160	1.93	3.69	1.76	1227	873	6.12×10^{-2}
No. C-7	36.7	3171	1.80	3.37	1.57	2020	2410	2.54×10^{-1}
No. C-8	4.4	380	1.20	8.06	6.86	55	50	5.26×10^{-3}

2.2.3 Meteorology and Hydrology

(1) Meteorology

The climate of the Mongolia is predetermined by the geographical location, relief structure and altitude above sea level. It varies widely from Desert in southern part called Govi to Subarctic along the boundary with Russian territory. Upper Tuul River Basin is located in the Steppe zone which lays west to east along the country's territory.

The meteorological characteristics of Upper Tuul River Basin is characterized by the rainy season from June to August, of which rainfall shares about 74% of the annual rainfall. The average annual rainfall of Ulaanbaatar and Terelj stations are calculated to be 243.1mm and 402.5mm respectively. The rainfall in the other months is less than 50mm. The average temperature in the basin varies from a minimum of -24.2°C in January to the maximum of 16.7°C in July in Ulaanbaatar Station. The average annual temperature is calculated to be -2.1°C, while at Terelj -3.8°C. The humidity is high in winter, but low in rainy season of summer. The annual average humidity is calculated to be 69% and 79% in Ulaanbaatar and Terelj stations respectively. The climate in Ulaanbaatar, Terelj, Tahilt and Ih Surguuli stations is illustrated in Fig. 2.2.6, and summarized in Table 2.2.2.

(2) Hydrology

1) Upper Tuul River Basin

Selenge River of which length is measured to be about 2,120km flows the northern part of Mongolia northward to Baikal Lake. Tuul River belongs to Orhon River system which is one of the major tributaries of Selenge River. The total length and the catchment area of Tuul River are measured to be about 819km and 50,400km^2, respectively. The river gradient in the upstream reach of Tuul River is as steep as 1/100, and gradually become milder to 1/5,000 near the confluence with Orhon River. Ulaanbaatar City is located in the middle reach of the River, about 650km far from Orhon River. There are two(2) major tributaries in Tuul River Basin; Haruuh River and Terelj River.

Tuul River system is located in the high mountain range that reaches the altitude over 2,000m. The vegetation of basin, therefore, varies from place to place depending on its altitude. Foothill zones along the rivers are considered low land which is covered mainly by the shallow root grass suitable for grazing cattle such as sheep, cows, horses and goats. The other higher mountain areas of which altitude is considered to be above the range between 1,400m and 1,800m are covered by forests consisting of a kind of cedar and beech, but such forest area expands only in northern side of the range due to difference of climate.

Upper Tuul River Basin is defined as the drainage area of Tuul River upstream of Tavantolgoi, of which catchment area is measured to be 7,312km^2. As shown in Fig. 2.2.7, Upper Tuul River Basin consists of the following four (4) sub-basins.

- Terelj River Basin of which catchment area is measured to be 1,339km^2
- Upper Tuul River Sub-basin upstream of the confluence of Terelj River of which catchment area is measured to be 2,740km^2
- Middle Tuul River Sub-basin of the reach from Zaisan bridge to the confluence with Terelj River of which catchment area is measured to be 2,221km^2
- Lower Tuul River Sub-basin of the reach from Tavantolgoi to Zaisan Bridge of which catchment area is measured to be 1,012km^2

2) Precipitation

Fig. 2.2.8 shows the variation of annual precipitation and surface runoff observed in Ulaanbaatar Station from 1936 to 1993 for the precipitation and 1946 to 1993 for the surface runoff together with those 5-year moving average values. The annual precipitation varies year by year with a range between 61mm in 1972 and 400mm in 1967. The 5-year average values indicate that the drought occurs with a cycle from 10 to 15 years and it continues for about 10 years once it starts. The surface runoff volume also seems to vary with the similar pattern to precipitation. The trend shown in the figure suggests that the precipitation seems to be decreasing these five (5) years since 1988 and this decreasing tendency may continue some years in the future toward drought years of cycle.

The probable annual precipitation is worked out for various return periods with the Iwai Method as stated below.

Return Period	Probable Precipitation (mm)	
	Exceeding	Non-exceeding
2-year	233.8	233.8
5-year	308.7	177.1
10-year	356.9	153.2
20-year	402.4	135.9
100-year	503.9	108.5
1000-year	648.4	84.3

The precipitation of 1993 measured to be 271.9mm is considered those observed in ordinary years, since its occurrence is calculated to be about 33% and 67% for non-exceeding and exceeding conditions, respectively.

3) Runoff

The average annual discharges are calculated to be 8.36m^3/s and 28.41m^3/s for Terelj and Ulaanbaatar Stations, respectively. 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 discharge reaches a peak in July or August, and the most flood discharges are recorded in these two (2) months. The river flow at Terelj Station is frozen at the end of December or the beginning of January, while that at Ulaanbaatar is frozen in January normally. After winter season the frozen river flow is melted and in March or May the flow starts gradually increasing its discharge toward the rainy season from July to August.

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 903.1 million m^3.

The probable flood discharge is calculated for Ulaanbaatar Station employing Iwai Method as stated below.

(Unit: m^3/sec)

Return Period	Proposed Dam Site (Gachuurt)
500-year	2,241
200-year	1,855
100-year	1,587
50-year	1,338
20-year	1,037
10-year	826
5-year	627

The monthly drought discharge is calculated, for the proposed dam site (Determined by former Soviet Union) at Gachuurt as summarized below.

Monthly Drought Discharge at Gachuurt (Unit: m^3/sec)

Items	Month												
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
2-year	0.02	0.02	0.34	5.46	27.11	39.87	69.41	71.61	45.25	14.23	3.59	0.42	23.11
5-year	0.01	0.01	0.18	2.81	13.92	20.47	35.64	36.77	23.23	7.31	1.84	0.22	11.87
10-year	0.00	0.00	0.07	1.11	5.52	8.12	14.14	14.59	9.22	2.90	0.73	0.09	4.71

2.2.4 Hydrogeology

Definition of Aquifer Type

Fissure Aquifer is defined as the aquifer of fractured zone in the basement rocks and Alluvial Aquifer as the aquifer of sand and gravel layer of Quaternary deposits.

(1) General

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 the basement rocks from the hydrogeological point of view.

Cretaceous rocks locally cover the basement rocks. Neogene and Quaternary deposits are distributed along Tuul River basin and its tributaries.

Basement rocks

According to the existing data and this investigation, basement rocks are basically impermeable, but there are some pervious zones due to fractures. The results of satellite image interpretation and geophysical prospecting suggest the existence of these fractured zone.

More than fifty(50) drillings were constructed for a subject of these basement rocks by Mongolian side. Yields of the exploration wells ranged widely due to probable underlying structure. Maximum one was 18 liters/sec.(1555 m^3/day) and the specific capacity was 518 m^3/day/m. The fissure aquifer may be fit for local water supply.

Cretaceous rocks (K)

Cretaceous rocks composed of sandstone and mudstone with coal are distributed in Nalaih area, the north hill of Ulaanbaatar City area, and Buheg River. The data of existing drillholes show that groundwater potential of this rocks is not satisfactory. The maximum yield was 6.7 liters/sec. (579m^3/day) and the specific capacity was 33m^3/day/m. The TDS (Total Dissolved Solid) of groundwater in this area ranged from 0.4 to 0.9 g/liter, higher than the value in other areas.

Groundwater in Cretaceous rocks has not sufficient potential and it is not suitable for drinking water.

Neogene deposits (N)

Neogene deposits are locally distributed in the north bank of Tuul River and some parts of the Holiin River. It consists of reddish clay and sand with gravel. It is reported that the maximum yield of Neogene deposits was 15 liters/sec. (1458m^3/day) and the specific capacity was 240m^3/day/m, while other wells in Neogene deposits area yield from 0.2 to 3.7 liters/sec.(17 to 320m^3/day).

Quaternary deposits (Q)

Quaternary deposits in the Study Area are classified as follows.

Recent river deposit
Fan deposit
Talus deposit
Terrace deposit

The deposits are most interesting from a viewpoint of groundwater development. The deposits, which mainly consist of gravel, sand, and clay, are widely distributed along Tuul River and have a thickness of over 100 meters in the maximum. The maximum yield of the exploration wells in the Study Area was 78.8 liters/sec.(7092m^3/day).

The production wells of the existing four(4) water sources, namely Upper Water Source, Central Water Source, Industrial Water Source, and Meat Complex Water Source, have been withdrawing the groundwater from the river deposits distributed in Tuul River.

(2) Aquifer Types

There are two types of water-bearing formations in the Study Area, one is fractured zones in the basement rocks, namely fissure aquifer, and another is sand and gravel layer of Quaternary deposits, namely alluvial aquifer.

Fissure Aquifer

According to the existing data, 14 of 62 exploration wells have been yielding the groundwater more than 5 liters/sec.(432m^3/day). The screen pipes of these wells are installed in the basement rocks. 5 of 14 wells produced more than 10 liters/sec (864m^3/day). These productive wells are distributed at random reflecting the irregularity of subsurface geological and hydrogeological structure.

Alluvial Aquifer

Quaternary deposits distributed along Tuul River and its tributaries are unconfined aquifers having the water table. The results of previous exploration boreholes show that the depth to the basement rocks ranges from 5 meters at Huandei and Deendei River to more than 90 meters at the downstream of Tuul River. The thickness of the Quaternary deposits tends to increase at the downstream. In Buheg, the depth to the basement rocks varies from 34 to 70 meters.

The map of the basement depth which is presented as the result of the electrical prospecting by JICA Study Team indicates the general tendency of the area (refer to Fig. 2.2.4).

Alluvial deposits can be divided into two layers, upper and lower. The upper layer is Late Quaternary to Recent deposits. The lower layer is Middle to Late Quaternary deposits. The screen pipes of the production wells in the four(4) water sources and exploration

boreholes were installed through these two layers mostly. The production wells of the Fourth Power Plant, the screen pipes were installed in the lower layer only, yield 30 liters/sec.(2600m^3/day) per one well.

(3) Aquifers in the Study Area

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

- Upper Part (of Ulaanbaatar), which consists of Upper Water Source and new water resource 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 (of Ulaanbaatar), which consists of Power Plant No.4 Water Source, proposed new water resource of Lower Part of Power Plant and the downstream area.
- Buheg River
- North of Ulaanbaatar : tributaries and valleys of Tuul River which are the principal and important fissure aquifer in the area.

1) Upper Part

The alluvium of this area consists of sand and gravel with clay, and the thickness ranges from 14 to 36 meters. The width of this alluvium ranges from 0.8 kilometers at near Terelj Bridge to 2.5 kilometers at Uublan. The alluvium can be divided into the two layers of upper layer and lower layer. The upper layer is more permeable than the lower layer. The screen pipes of previous exploration wells were installed through two layers. Consequently each layer's permeability coefficient has not been estimated. Most of exploration wells have been used as production wells of Upper Water Source.

The permeability coefficient ranges from 5.56×10^{-3} cm/sec to 1.02×10^{-1} cm/sec with an average of 4.8×10^{-2} cm/sec. Specific capacity ranges from 74 to 1606 m^3/day/m.

Hydrogeological Constant of Upper Water Source

No. on Map	Exploration Well No.	Permeability Coefficient		Length of Screen (m)		Specific Capacity	Calculated Transmissivity
		m/day	cm/sec	from	to	m^3/day/m	m^2/day
35	1	54.4	6.30×10^{-2}	4	28	1192	1306
36	2	84.2	9.75×10^{-2}	3	26	1606	1937
38	4	88	1.02×10^{-1}	4	23	1439	1672
40	6	42.4	4.91×10^{-2}	6	32	949	1102
44	10	15.2	1.76×10^{-2}	6	36	415	456
45	11	4.8	5.56×10^{-3}	6	28	74	106
46	12	14.2	1.64×10^{-2}	5	25	98	284
47	13	28.3	3.28×10^{-2}	6	31	545	708
	Ave.	41.44	4.80×10^{-2}				
	Min.	4.80	5.56×10^{-3}				
	Max.	88	1.02×10^{-1}				

The specific yield can be estimated 0.15

Alluvial deposit in Upper Water Source area are thicker than that of Lower Part of Nalaih. The depth of production wells in Upper Water Source are from 24 (Well No.12) to 40 meters (Well No.29).

Lower Port of Nalaih (proposed new water resource)

Four(4) test wells, C-1,2,3 and 4, were constructed in the Lower Part of Nalaih. The thickness of aquifer in Lower Part of Nalaih is estimated from 15 meters (downstream) to 20 meters (upstream). The permeability coefficient of the lower layer ranges from 6.21×10^{-3} to 1.49×10^{-2} cm/sec with an average of 1.07×10^{-2} cm/sec. The permeability coefficient of the upper layer is expected nearly same as the value of Upper Water Source because of the similar geological conditions. Consequently, the transmissivity of this area is estimated to be around 520 m^2/day or more.

2) Central Part

The area extends from Gachuurt to Songino. The alluvium of this area consists of sand and gravel with clay. The alluvium is divided into two layers as upper and lower. The depth of upper layer ranges from 10 to 20 meters and the lower layer ranges from 10 to 30 meters or more thick in places. The width of this alluvium ranges from 1 kilometer in Gachuurt to 4 kilometers in Songinoblan.

Specific yield of the upper layer was estimated 0.2. Specific yield of lower layer was estimated 0.15. Permeability coefficient of the upper layer varies from 1.22×10^{-1} cm/sec to 2.85×10^{-1} cm/sec with an average of 1.79×10^{-1} cm/sec. Permeability coefficients of the lower layer varies from 2.63×10^{-2} cm/sec to 6.71×10^{-2} cm/sec with an average of 4.48×10^{-2} cm/sec.

There are 94 production wells managed by USAG in the Central Water Source, Industrial Water Source and Meat Complex Water Source.

22 wells have been constructed in the eastern area of Central Water Source. Specific capacity varies from 199 m3/day/m to 2359 m^3/day/m with an average of 830 m^3/day/m.

34 wells have been constructed in the middle area of Central Water Source. Specific capacity varies from 441 to 3888 m3/day/m and an average of 1506 m^3/day/m.

14 wells have been constructed in the western area of Central Water Source. Specific capacity varies from 240 to 1503 m^3/day/m with an average of 824 m^3/day/m.

10 production wells in the Industrial Water Source and Meat Complex Water Source are working in summer and additional 14 wells in winter usually. The estimated pumping rate per well ranges from 1,250 m3/day (July. 94) to 3,450 m^3/day (April. 94).

3) Lower Part

This area is composed of Power Plant No.4 Water Source, Lower Part of Power Plant and the downstream area. The thickness of this alluvium is estimated from 20 to 64 meters or more. The aquifer of downstream tends to be thick comparing with the upper stream. The width of this alluvium ranges from 1 kilometers near Altanbulag Bridge to 5 kilometers in the downstream area.

34 exploration wells were conducted in the previous studies. Yield of these wells ranges from 630 to 6800 m^3/day with an average of 4542 m^3/day (2639 m^3/day per one meter of drawdown). Permeability coefficient varies from $1.34x10^{-2}$ cm/sec to $1.61x10^{-1}$ cm/sec with an average of $7.53x10^{-2}$ cm/sec.

For Power Plant No.4 Water Source, 12 production wells have been constructed in Songino Valley. These wells were designed the depth of 63 meters and the discharge of 2520 m^3/day. The actual withdrawing volume was an average of 501,100 m^3 per month or 16,400 m^3/day in 1993.

Three (3) test wells, C-6,7, and 8, were constructed by JICA Study Team in the area. The depths of wells were 30-32 meters and none of them encountered the basement rocks. Yields were 2160 m^3/day (C-6), 3168 m^3/day (C-7) and 382 m^3/day (C-8). Hydrogological constants are shown below.

Hydrogeological Constants of Lower Part of Power Plant

Well No.	Specific capacity (m^3/day/m)	Transmissivity (m^2/day)	Permeability coefficient (cm/sec)
C-6	1227	873	$6.12x10^{-2}$
C-7	2018	2410	$2.54x10^{-1}$
C-8	56	50	$5.26x10^{-3}$

C-8 was located somewhat far from the main stream of Tuul River.

4) Buheg River

It is 20-30 kilometers far from Ulaanbaatar City. Its catchment area is about 1,621 km^2. Groundwater has been developed and used in Zoonmod, the capital city of Tuv aimag, located in the northeastern part of Buheg watershed. The aquifer in the downstream of the capital is not developed on a large scale except near the junction of Buheg and Tuul River where the groundwater is utilized for farm.

Four (4) test wells, B-1,2,3 and C-5, were constructed by JICA Study Team in the downstream of Buheg River. The thickness of alluvium is more than 65 meters. Yields range from 3.9 liters/sec (B-1) to 22 liters/sec (B-3). Hydrogeological constants of this aquifer are shown below.

Hydrogeological Constants of Buheg River

Well No.	Specific Capacity (m^3/day/m)	Transmissivity (m^2/day)	Permeability Coefficient (cm/sec)
B-1	25	35	$2.46x10^{-3}$
B-2	104	122	$8.56x10^{-3}$
B-3	259	354	$1.86x10^{-2}$
C-5	36	37	$3.89x10^{-3}$

According to the previous exploration wells, the specific capacities of the alluvial aquifer ranged from 31 to 562 m^3/day /m.

B-1 was a flowing well. One of previous exploration wells was also a flowing well. Multiple water-transmitting layers may exist within the alluvial aquifer.

The specific yield of the aquifer is expected to be 0.1, considering the geological and hydrogeological condition of alluvial deposits.

5) North of Ulaanbaatar City

There are some tributaries of Tuul River in the North of Ulaanbaatar City. The principal tributaries are Bayan Goliin, Selbe and Uliastai. The maximum width is 2 kilometers or more. The thickness of alluvium is 8-40 meters in places. Eight(8) exploration wells in Bayan Goliin, 26 exploration wells in Selbe River and nine(9) exploration wells in Uliastai River have been inventoried. Summarized hydrologic data of the alluvium and the basement rocks are as follows.

Source	Number of wells	Pumping rate (liters/sec)		Specific capacity (m3/day/m)	
		Range	Average	Range	Average
Alluvium of Uliastai	2	2-3	2.5	52-115	83.5
Alluvium of Selbe	8	1-9	4.5	5-202	73.4
Alluvium of Bayan Goliin	3	1-31	13.3	18-362	168
Basement rocks of Uliastai	7	0.5-5	2	2-21	13.4
Basement rocks of Selbe	17	0.1-11.7	2.7	1-115	25.6
Basement rocks of Bayan Goliin	4	2-18	9.2	35-518	328

Four (4) test wells, A-1 ~ A-4, were constructed by JICA Study Team in the area. All test wells were drilled into basement rocks up to the depth of 134-200 meters and sealed off the unconsolidated layer with blank casing pipe. Hydrogeological properties are as follows.

Hydrogeological Constants of fissure Aquifer of JICA Wells

Well No.	Location	Pumping rate	Specific capacity	Transmissivity	Permeability coefficient *
		liters/sec (m^3/day)	m^3/day/m	m^2/day	cm/sec
A-1	Uliastai	10.5 (903)	19	23	($4.10x10^{-4}$)
A-2	Selbe	0.6 (52)	1	<1	($4.61x10^{-6}$)
A-3	Bayan Goliin	25.0 (2164)	45	40	($6.52x10^{-4}$)
A-4	Selbe	16.7 (1441)	30	31	($7.97x10^{-4}$)

*)Permeability Coefficient were calculated based on the geologic logs obtained.

Each well location was determined by the results of electrical prospecting and VLF prospecting. The results of the test wells showed that these geophysical prospecting was useful to decide the location of a production well even though it is not perfect. A-1,3 and 4 may be utilized for supplying water to local area. However it is difficult to develop on a large scale

(4) 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 source
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	
Grand total	163	229.3	

The groundwater of the Central Area has been developed and withdrawn more than 200,000m^3/day. Fig. 2.2.9 shows the locations of the production wells in the Central part.

(5) Groundwater Table of Existing Water Source

Fluctuations of groundwater table are caused by various factors, some are the artificial and others are the changes of natural conditions. Most of the natural conditions are seasonal or daily variations such as precipitation, evapotranspiration, water level of a river and atmospheric pressure. The artificial conditions are, for example, pumping rate from wells, irrigation, construction works in subsurface.

Fluctuations of groundwater table in an unconfined aquifer follow the change of water volume in the aquifer. In other words, a decline in groundwater table means a reduction of water volume in an unconfined aquifer. Therefore continuous measurement of water level is important for the sustainable groundwater development and groundwater management. A groundwater flow model also requires the records of groundwater table fluctuations in the aquifer.

Groundwater level measurement has been conducted by Mongolian side from 1978 to 1993 year. The results are shown in Fig.2.2.10.

JICA Study Team conducted the groundwater level measurement at the selected thirty six (36) wells on September 1993, April and September 1994. The results are shown in Fig. 2.2.11.

JICA Study Team installed Four(4) sets of groundwater level recorders at the following wells.

Upper Water Source	Well No.19(19/347)
Central Water Source	Well No.69(19a)
Central Water Source	Well No.15(15)
Meat Complex Water Source	Well No.1(1)

The results for the last one year are shown in Fig. 2.2.12. The water levels in the four wells fluctuated 2-5 meters. The highest groundwater levels occurred in August and the lowest water levels occurred at the end of March or the beginning of April. From June to September, the aquifer is recharged by rainfall and the surface runoff resulting from the rain. From October, the water levels decrease gradually. In 1993, Tuul River froze completely toward the end of December, after that the water levels had fallen successively to the lowest levels. After the frozen river started melting in March, the water levels increased steadily from April. In April and May, the aquifer is recharged by the river discharge resulting from melting of the snow in the upper reaches. Fig. 2.2.12 indicates that the time of river runoff started after winter is important to recover a water level in the aquifer.

Fluctuation of a groundwater table

The fluctuation of the groundwater table in an unconfined aquifer shows the change of water volume stored. The volume of water stored in the aquifer has an annual cycle. In winter, rainfall and Tuul River recharge lesser to the aquifer, and the groundwater volume decrease. After winter the groundwater volume of the aquifer recovers resulting from starting to be recharged by rainfall and river discharge. The data of long-term groundwater table fluctuation do not show a tendency to decrease in a volume of water stored for the present. The annual rainfall and the river discharge rather affect the stored water volume in the aquifer. It means that an withdrawing volume of groundwater should be controlled depending on the seasonal variation of rainfall and river discharge.

A drawdown of the groundwater table for these fifteen years(1978-1993) has not been progressing in Ulaanbaatar City area.