3 MASTER PLAN STUDY

3. MASTER PLAN STUDY

3.1 BASIC CONCEPTS FOR THE MASTER PLAN

Water supply development shall be established on the basis of the following basic concepts.

(1) Existing Kharzat water source shall be expanded under the plan of groundwater preservation such as groundwater table and water quality monitoring.
(2) Water supply development for ger district shall be given priority.
(3) Recommended unit water consumption for apartment dwellers is 150 liter / capita / day. It should be raised step by step under the improvement work of leakage from water taps and toilet instruments.
(4) Unit water consumption for ger dwellers is recommended to be 40 liter / capita / day that is the recommended volume of Ministry of Health.
(5) Water demand of institutions and industries shall be projected on the basis of economic (3-4%) and industrial growth rate (4-5%) respectively.
(6) Water loss from pipes shall be decreased step by step with the improvement work of water supply facilities.
(7) It is important to promote the people's awareness of saving water. This is as equally important as developing the water source or improving the water supply facilities.
(8) Water tariff system shall be changed with the installation of water meter.
(9) The self-operation system of Altai Public Service Department (APSD) shall be established on the basis of water tariff and operation and maintenance cost.

3.2 WATER RESOURCES

3.2.1 Evaluation of Groundwater Resources

Groundwater resources in and around the Altai City are listed below and its location is shown in Figure 3.1.

Kharzat water resources shall be given priority for the water resources development from the viewpoints of the potential, water quality, and economy as follows.

Examination for Groundwater Resources

Water resources	Aquifer type	Dis-tance* (km)	Altitude (m)	Potential	Water quality	Hardness ($mgCaCO_3/l$)	Const-ruction cost	Run-ning cost	Priority
Kharzat	Alluvial	4-6	2,180	big	good	225	low	low	1
Olon Nuur	Alluvial	8-9	2,190	big	good	256	low	medium	2
Skhyn Hooloy	Quarter-nary	8-10	2,050	medium	bad		medium	high	-
Khadaason	fissure	6-7	2150	small	edium	363	medium	high	-
NE of Altai	fissure	2-3	2120	medium	bad	1875	low	medium	-
Tsgaantoghoy	Alluvial	98	1890	big	good	406	high	high	-
Tyshir	Alluvial	45	1700	big	good	-	high	high	-

* : distance from the governor's office (elevation is 2170 meters)

(1) Kharzat

Kharzat groundwater resources located near the city has been utilized for the domestic and industrial water. It has sufficient potential for the use of water supply and its water quality is better than the other water resources.

(2) Olon Nuur

It is located at the upstream of Kharzat water resources. It is expected that its groundwater potential is sufficient for the water supply of Altai City and its water quality is slightly worse than Kharzat water but not as bad as the others.

(3) Sukhyn Khooloy

It is located at the north of Altai City and about 10 kilometers far from the city. It is reported that water quality of this water is bad. The groundwater potential is not big comparing with Kharzat and Olon Nuur.

(4) Khadaasan

Kadaasan water resources of fissure aquifer is located at the northwest of Altai City, and about 6 to 7 kilometers far from the city with an altitude of 2150 meters. Its potential is suitable for local water supply. Water quality of this fissure water is not so bad with a hardness of about 362.5 (mg $CaCO_3$/liter), Magnesium content of about 73 (mg/liter).

(5) NE of Altai

This water resources of fissure aquifer is located at the northeastern edge of Altai City,

and about 2 kilometers far from the city with an altitude of 2120 meters. Its potential is estimated about 1000 m^3/day. Water quality of this fissure water is not suitable for the source of potable water with a hardness of about 1,875 (mg $CaCO_3$/liter), Magnesium of about 402 (mg/liter).

(6) Tsagaantokhoy

This water resources of Alluvial aquifer was investigated by the Mongolian side. They found a flowing well (artesian well) and it proved to be a good water resource with satisfactory water quality. But, Tsagaantokhoy is located far away from Altai City with a distance of about 98km and its elevation is 280 meters lower than Altai City. These are significant disadvantages from the viewpoints of procurement cost of materials, construction cost, and running cost of electricity and maintenance.

(7) Tayshir

This water resource of Alluvial aquifer is supposed to be a good water resource with an available water quality. But, it is also located far away from the Altai City with a distance of about 45 kilometers and its elevation is 450 meters lower than that of Altai City. These are significant disadvantages in the same manner as Tsagaantokhoy water resource.

3.2.2 Groundwater Potential of Kharzat Groundwater Resources

(1) Groundwater Storage

Based on the Isopach map of the aquifer, the volume of groundwater storage can be roughly calculated as follows.

	The area of the aquifer			
A thickness	0	10	20	(meters)
The area	26.5	11.1	2.5	(km^2)

The volume of the whole aquifer is estimated by the following simplified expression;

$26.5 \times 10^6 \times 5 + (11.1+2.5) \times 10^6 \times 10 = 268.5 \times 10^6$ (m^3)

Effective porosity of the aquifer material is estimated at 0.1 to 0.15;

Then, the groundwater volume stored is ;

$268.5 \times 10^6 \times (0.1 \text{ to } 0.15) = 26.9 \times 10^6 \text{ to } 40.3 \times 10^6 (m^3)$

(2) Recharge Volume

The average annual recharge volume to an aquifer can be quantified by considering the infiltration rate of precipitation. The recharge volume to Kharzat aquifer is estimated below.

Recharge Volume to Aquifer

Area	Catchment area	Precipitation	> 8mm/d in a year	Recharged precipitation	Recharged volume
Kharzat	about 70km^2	181.6 mm	34 mm	14% of total or 25.4mm/year	4,870m^3/d or 1,778,000 m^3/year

The area of Kharzat is about 70 km^2. The annual average precipitation is reported at 181.6 mm. About 64 % of precipitation concentrate during rainy season from June to August. The result of the continuous water level observation indicates that rainfall affects water level if it is over eight millimeters per day (8mm/day). It probably means that rainfall of seven millimeters or less flow out from ground surface.

In 1998, the total of rainfall that is over eight millimeters per day was 34.4 mm. The value is 25 % of the total rainfall in the rainy season (137.4mm in 1998) that has 64 % of annual precipitation in an average of about 40 years. Therefore, 16 %, or 0.64 multiplied by 0.25, of annual precipitation is the roughly estimated recharge to underground. Two percent of precipitation is considered to become inter flow. Consequently, 14 % of annual precipitation, or 25.4 mm, recharge to the aquifer. The estimated total recharge volume becomes 1,778,000 m^3/year, or 4,870 m^3/day in Kharzat area.

(3) Groundwater Potential

Groundwater potential, in other words, is an available volume of groundwater. Groundwater can be utilized within the storage and recharge volume under proper groundwater preservation measures of groundwater table and water quality measurement.

The following simple equation is representing flow through an aquifer;

$$\text{Total potential} = (\text{Storage volume} + \text{recharge volume}) - (\text{utilization} + \underset{\textit{discharge}}{\text{baseflow}})$$

The groundwater development potential in an area will be evaluated on the basis of the storage of the aquifer and the natural recharge to the aquifer.

In the Kharzat area, the estimated recharge volume is 4,870 m^3/day. The present yield (utilized volume) from the aquifer is 960 m^3/day in average and 1,150 m^3/day in maximum.
Therefore, more than 3,000 m^3/day may be safe yield for water supply.

Potential of Groundwater Resources of Kharzat (unit: m^3/day)

Water source	Total potential	Utilized volume	Safe yield
Kharzat	4,870	1,150	> 3,000

(4) Development Program

When the development is implemented, it should be avoided that a large amount of water is pumped up from only one production well. It may cause the local reduction of water level and the deterioration of water quality. The continuous monitoring of water level and quality in the area is recommended even if a number of production wells are constructed to obtain water.

Kharzat aquifer has the sufficient groundwater potential in summer season because of sufficient recharge volume from precipitation.
No recharge is expected in winter season from November to the middle of April. But, its aquifer has a large storage of groundwater (26,900,000m^3), and this stored groundwater can be used in winter season without any significant effects on the environment. Groundwater potential recovers from the middle of April every year because of the increase of groundwater table.

3.2.3 Optimum Pumping Yield of Kharzat Water Source

There are four production wells in Kharzat and two of them have been operating at present. The maximum total pumping volume is about 1,150 m^3/day. The discharge rate is 575 m^3/day from one well, which is close to the volume originally planned by the Mongolian side (see table 2.9.1). It seems to be an appropriate operation and pumping yield.

When considering an optimum pumping yield, the drawdown in a well should be kept

under six meters (ideally four meters) considering the aquifer thickness of 10 to 20 meters.
But, actual pumping rate and pumping water level have not been recorded at any of Kharzat production wells. So the water level monitoring is essential for the proper groundwater management in future.
Therefore a proper water level measurement system should be urgently established.

The optimum pumping yield for a well in Kharzat is examined with Theis non-equilibrium equation on the basis of the following assumed figures;

1) Transmissivity is 360 m^2/day that is the mean value in the area.
2) Storage coefficient of the aquifer that is 0.005 of unconfined with semi-confined

The above-assumed figures can be applied to the present condition first as follows.
When the annual average of the pumping rate of a well is 480 m^3/day, the drawdown in a cased well with an inside diameter of 0.2 m is calculated at 2.39 meter after the pumping duration of 365 days. The interference drawdown caused by another pumping well that is 100 meters away is calculated at 0.92 m for the same duration. The total drawdown in the well is the sum of the two figures; 3.31 m.

While actual water levels in the intake wells are unknown, the figure can be considered reasonable compared with the original planned figures of 4m. These planned figures were likely determined by the pumping test conducted when the well was constructed in 1979, 1986, and 1995, though the detailed data were not obtained during the Study. The isopach map shows that the thickness of Kharzat aquifer is 10 to 20 meters or more. If the actual present drawdown is more than the estimated drawdown, it possibly means that the well performance has been deteriorated by some factors. For example, when a pump operates continuously for a long period, the filter zone of the well may be plugged by fine particles and it causes loss of well efficiency. Almost 20 years have passed since the construction of the wells in Kharzat.

3.3 POPULATION AND WATER DEMAND FORECAST

3.3.1 Socio-Economic Framework

(1) Objective

The objective of formulating a Socio-economic framework is to provide some of the

basic conditions for water demand forecast. Water demand in Altai City is to be estimated for the year of 2005 and 2015 on the basis of the projected population and economic growth rates set as the Socio-economic Framework.

(2) Economic Growth

The following economic growth targets for Altai City were set.

Economic Growth Targets (%/year)

	1996-2005	2005-2015
Whole economy	3.0	4.0
Industry	4.0	5.0

The period until the year 2005 is regarded as a transitional period from a centrally planned to a market economy. The period since 2005 is characterized by a higher level of market oriented operations. The period until 2005 could be characterized also by a high level of dependence on the central government for the development activities, both public and private. As for the other regions in Mongolia, Gobi-Alai would have to depend on the central government for funding various projects. A whole mechanism of development in Mongolia would be that the advanced areas in Mongolia such as Ulaanbaatar and border towns accelerate economic growth, leading to an increase in tax revenue for the central government. The central government can channel part of the collected revenue to regions in the form of subsidy or loans with favorable conditions. It is important that the fund, thus, provided be used for investment objective as much as possible rather than consumption purpose. Once initial momentum for further growth is gained, it would become easier for regions to expand development activities on their own. This would take place more in the period from 2005 to 2015 in areas like Gobi-Altai with location disadvantages and underdeveloped infrastructure.

Various efforts by the Mongolian government is aimed at accelerating economic growth through development of various hard and soft infrastructure. The mechanism such as above would likely take place with continued efforts by the government. Based on these considerations, the economic growth rates set for Altai City as presented above are to be applied as the Socio-economic framework.

(3) Population Forecast

The population in Altai City is projected in the following two steps.

- projection of total population in Altai City for 2005 and 2015
- projection of population by district and settlement pattern, ger or apartment, for 2005 and 2015

The result is summarized as follows and presented in Table3.1 and Table3.2.

Projected Population in Altai City

Year	Ger	Apartment	Total
1997	14,516	3,245	17,761
2005	15,357	3,433	18,790
2015	17,131	3,830	20,961

The total population in Altai City is projected by estimating the natural growth and social change, migration of the population. First, population change by natural factor, birth and death, are estimated until 2015. Secondly, the number of labor force to be generated in Alai City is estimated. Those people becoming 16 years are all assumed to enter into the labor market in Altai City. Part of this age group that continues to higher school is assumed to be cancelled out by those entering into the labor market from the higher level schools. The number of jobs available in Altai City is estimated based on the number of jobs in 1997 and annual growth rates of 3% per year until 2005 and 4% per year between 2005 and 2015.

The balance between the number of new labor force and available jobs results in out-migration or in-migration of labor force from and into Altai City. As the summarized result in Table 3.1 (1) shows, the labor force will keep flowing out of the city until 2009, but from 2010 labor force will start coming in from outside the city along with economic growth of Altai City. The population change by social factor is estimated by multiplying the dependency ratio by the labor force out-migrating or in-migrating. The total population in Altai City is, thus, estimated by adding the population change by the social factor to the population based on natural change. A detail of the applied assumptions are presented in the notes attached to Table 3.1 (2).

Table 3.2 shows a distribution of the total population into each district by settlement pattern, ger or apartment. The population in 1997 in each district and by settlement pattern was estimated by applying the distribution proportions of the households, for which data were collected at the Altai City Mayor's office. The distribution in 2005 and 2015 is made applying the same proportions as those in 1997. It is judged that

there will be no significant investment on apartment construction at such a magnitude as to change the distribution proportion between ger and apartment dwellings.

3.3.2 Population Served and Service Area in 2015

The whole population of 20,961 shall be served and whole area of ger and apartment shall be covered by the water supply service in the year of 2015.

(1) Ger Area

For ger area, enough public taps or water kiosks which will deliver domestic water by pipe shall be installed. The service level to the ger area will be greatly improved and about 17,131 dwellers will be able to get more water timely.

The service ratio for the water demand projection will be raised up to 100% starting from the recent year. Unit water demand for the ger dwellers is also considered to increase up to 40 litter/c/d from the current 8.6 litter/ capita/ day in the year of 2015. This value is recommended by Ministry of Health.

(2) Apartment Area

The coverage for the apartment dwellers should be maintained at the current level of 100%. Whole apartment dwellers of 3,830 will have access to the tap water in the year of 2015. Unit water demand is calculated to be 150 litter/capita/day in 2015.

(3) Service Condition for Institution and Industry

Service condition for the institution and industry should be considered on the basis of economic growth rate of 3 % in 1998 to 2005 and 4 % in 2006 to 2015 and industrial growth rate of 4 % in 1998 to 2005 and 5 % in 2006 to 2015 respectively.

3.3.3 Water Demand Forecast

Based on the assumptions discussed in the previous paragraphs, the water demand projection until the year of 2015 shall be made for each category of apartment, ger, institution, and industry. The result is presented in the following table.

The current total water demand for Altai City is calculated by adding the loss volume of pipeline to the sum of the present water demands for the above four categories. The

loss rate is estimated to be about 30% of daily consumption, which will be improved step-wise with the completion of water supply facility constructions in the year of 2005 and 2015. The target is set at 25% in 2005 and 20% in 2015.

The yearly projected demand is calculated in the same manner as mentioned above. The projected water demand for Altai City for the year of 2005 is 1,140 m^3/day and 1,500 m^3/day for the year of 2015. The result is summarized below to show the general trend of water demand increase.

Water Demand Forecast

	Category	Popula-tion (persons)	Served Raito (%)	Unit Demand in max (l/c/d)	Water Demand (m^3/d) mean.	max.	Remarks
1997 - 1998	Apartment	3,245	100	150	487	487	
	Ger	14,516	62 (100)	8.6 (5.2)	41	78	
	Institution	(31)	-	-	136	229	0n the basis of 1998 data
	Industry	(3)	-	-	9	14	ditto
	Loss	-	-	-	287	324	As 30% of Total
	Total	17,761			**960**	**1,150**	Actual measurement data
2005	Apartment	3,433	100	150	515	515	
	Ger	15,357	100	20	163	307	mean=max x (41/78)=0.53Max
	Institution	(38)	-	-	167	282	Annual 3% in Growth Rate.
	Industry	(4)	-	-	12	19	Annual 4% in Growth Rate.
	Loss	-			283	377	As 25% of Total
	Total	18,790			**1,140**	**1,500**	
2015	Apartment	3,830	100	150	575	575	
	Ger	17,131	100	40	363	685	mean=max x (41/78)=0.53Max
	Institution	(56)			248	417	Annual 4% in Growth Rate.
	Industry	(7)			20	31	Annual 5% in Growth Rate.
	Loss	-			294	432	As 20% of Total
	Total	20,960			**1,500**	**2,140**	

3.4 DEVELOPMENT PLAN

3.4.1 Design Condition

Design conditions for the establishment of water supply services are recommended as follows.

Item	1997	2005 (FS)	2015 (MP)
Population	17,760	18,790	20,960
Service ratio (%)			
Apartment dwellers	100	100	100
Ger dwellers	60-100	100	100
Unit water demand (l/c/day)			
Apartment dwellers	150	150	150
Ger dwellers	8.6	20	40
Water supply method*			
Apartment area	Pipeline / tap		
Ger area	Pipeline / kiosk 1000 - 1500 residents / 1 kiosk within 250m radius / 1 kiosk		
Growth rate of water demand (%/year)		1998 - 2005	2006 - 2015
Institution	-	3	4
Industry	-	4	5
Effective distribution ratio (%)	70	75	80
Dairy maximum water demand (m^3/day)	1,150	1,500	2,140
Hourly maximum water demand (m^3/hour)	65	133	205

* : Distribution area will be divided into four: Central Area, ger area G-1, G-2 and G-3 shown in Figure 3.2

3.4.2 Water Resources Development

(1) Development Capacity for Water Resources

Future maximum water demand is estimated to be 2,140 m^3/day in the year of 2015. On the other hand, the existing production capacity in 1997 is 1,150 m^3/day in maximum. Therefore 990 m^3/day more shall be developed in the year of 2015.

Development Capacity in 2015 (Unit : m^3/day)

	Item	Production capacity
A	Future production demand in maximum	2,140
B	Existing production capacity in maximum	1,150
C	Future development capacity (=A-B)	990

Existing water source of Kharzat has the sufficient capacity for an additional development to cope with the future water demand in 2015. It is located near Altai city with a distance of about 3.4 kilometers and its remaining groundwater potential can be utilized efficiently under the groundwater preservation management.

(2) Development Plan for Kharzat Water Source

The four production wells in Kharzat were planned to pump up 600-800 m^3/day with a drawdown of 4-6 meters. According to the collected data, specific capacity of Kharzat aquifer ranges from 104 to 432 m^3/day/m. Based on the relation of specific capacity to transmissivity, it is estimated that the value of transmissivity ranges from 157 to 565 m^3/day/m.

The optimum pumping yield for a well is examined with Theis non-equilibrium equation as discussed in section 3.2.3.

When developing a water resource in an area, the following points should be kept in mind.

Avoid excessive drawdown of water in wells by regulating the pumping rate.
If the target discharge can not be achieved with the regulated pumping rate, the number of wells should be increased. In that case, the arrangement of wells must be appropriate in a way that they won't cause interference with each other.

This means that the optimum developing condition for Kharzat aquifer can be simulated by changing the number of wells, their discharge and distance to each other. The table below shows the estimated drawdown in a well located in the center of the well field when it is surrounded by one to four wells respectively. The table also shows the projected water demand in 2005 and 2015. The conditions for the calculations are,

① the pumping duration is 3650 days

② the wells with the inside diameter of 0.2m are located in a straight line and the one in the center is focused on.

③ the wells are operated simultaneously with the same pumping rate.

④ the distance between the two wells are fixed at 100m.

When the wells are operated, the drawdown should be kept around six meters (ideally four meters) while satisfying the projected water demand.

At present there are four intake wells including one that is under repair. The table indicates that the operation of three wells is sufficient for water demand in 2005. Therefore, one well can be used as a spare one.
In 2015, if the pumping wells are operated attentively with a water level monitoring, four wells will be adequate for the water demand. But, these four well are deteriorating. Consequently, these four existing wells shall be reconstructed before 2015 and it is recommended that a spare well will be constructed anew.

	Year	1997-98	2005	2015	*2015max*1*
	Water demand (average)	960	1140	1500 (m^3/day)	*2,140 (m^3/day)*
Number of wells					
2	Pumping rate a well (m^3/day)	480x2	570x2	750x2	*1070x2*
	Drawdown (Pumping)	-2.63 m	-3.12 m	-4.11 m	*-5.87 m*
	Drawdown (Interference)	-1.17 m	-1.38 m	-1.82 m	*-2.60 m*
	Total drawdown in a well	-3.80 m	-4.50 m	-5.93 m	*-8.47 m*
3	Pumping rate a well (m^3/day)		380x3	500x3	*714x3*
	Drawdown (Pumping)		-2.08 m	-2.74 m	*-3.91 m*
	Drawdown (Interference)		-0.92x2 m	-1.21x2 m	*-1.73x2 m*
	Total drawdown in a well		-3.92 m	-5.16 m	*-7.37 m*
4	Pumping rate a well (m^3/day)			375x4	*535x4*
	Drawdown (Pumping)			-2.06m	*-2.93m*
	Drawdown (Interference)			-(0.91x2+0.79)m	*-(1.30x2+1.03)m*
	Total drawdown in a well			-4.67 m	*-6.56 m*
5	Pumping rate a well (m^3/day)			300x5	*428x5*
	Drawdown (Pumping)			-1.64 m	*-2.35m*
	Drawdown (Interference)			- (0.73-0.64)x2m	*-(1.04+0.91)x2m*
	Total drawdown in a well			-4.38 m	*-6.25 m*

Well location; every 100 m on a straight line

*1 : as a reference

3.4.3 Development Plan of Water Supply Facilities

(1) Development Alternative

There are some ways to develop the water supply facilities to cope with the water demand in 2015. The following table shows three comparative distribution methods to be selected as a suitable development plan for the Feasibility Study.

Development Alternative

Case	Summary of the system	Distribution facilities
1	Dual pumping system to divide the service area into low and high ground level areas (Figure 3.2)	Pump: 1.3m³/min x 35m x 18kw x 3 unites 0.9m³/min x 55m x 18kw x 2 unites Pipe: dia. 150mm~200mm x 9.3 Km Others
2	Direct pumping system to overall service area. (Figure 3.3)	Pump: 1.8m³/min x 55m x 30kw x 3 unites Pipe: dia. 150 ~ 200 x 9.4 Km Others
3	Gravity distribution system to low ground level area with distribution to high ground level ger area by pump (Figure 3.4)	Pump: 1.5m³/min x 65m x 30kw x 2 unites Reservoir: 500m³ x 2 ponds Pipe: dia. 150mm ~ 250mm x 11.0Km Others

The suitable development plan shall be selected from the viewpoints of technical aspect, environmental impact, economic aspect, and financial aspect.
As the result of the following examination, Case 3 shall be given priority as the development alternative for the development of water supply facilities.

Examination of Each Case

Case	Technical	Environ-mental	Construct - ion cost	O/M cost	Financial	Priority
1	Medium	Small	Low	Medium	Medium	2
2	Difficult	Small	Low	High	Medium	3
3	Easy	Small	Low	Low	Low	1

(2) Optimum Development Plan

The development of water supply facilities shall proceed in the following order.

① Reconstruction of 4 existing production wells
② Replacement of 4 submersible pumps with control system
③ 2 sets of water level meter shall be installed at the reservoir to control the

withdrawing volume from intake wells.

④ Procurement of 3 water wagons for supplying water to the ger area

⑤ Procurement of water cart for ger dwellers to transport water from kiosk to their home

⑥ Installation of distribution pipe for supplying water to ger area of G-1, G-2 and G-3

⑦ Construction of kiosks in at gel area of G-1 to G3

⑧ Construction of one new well in the south east part of Kharzat

⑨ Installation of transmission pipe from the new well to existing reservoirs

⑩ Construction of new reservoirs

⑪ Installation of new pump station to transmit the domestic water to new reservoir for water distribution to gel area of G-1

Required Facilities for the Development of Water Supply in 2015

Measures	Facilities
Improvement of existing facilities	1, reconstruction of 4 wells 2, replacement of submersible motor pump with control system : 0.42m^3/min x 60m x 4 unites
Construction of new facilities	1, water level indicator system for reservoir : 2sets 2, procurement of water wagon : 3 cars 3, procurement of water cart : 2792 (households) sets 4, distribution pipe for ger area G-1, G-2, G-3: dia.150mm ~ 250mm x 11.0 km lines 5, construction of water kiosk : G-1; 6 places, G-2; 3 places, G-3; 5 places 6, construction of one production well 7, installation of transmission pipe : dia.200mm x 3.5km x 2lines 8, construction of new reservoir : 500m^3 x 2 ponds 9, installation of new pump station: 1.5m^3/min x 65m x 2units

Intake Facilities

The existing intake wells, submersible motor pumps, and collection pipes have the sufficient capacity for the present water demand. But, two of the four production wells constructed in 1979 have deteriorated and they shall be reconstructed as soon as possible. Another two wells were constructed in 1986 and 1995. These wells may become deteriorated by 2015, and they should also be reconstructed in 2015.

Submersible motor pumps may become also deteriorated by 2015 and they shall be replaced with new pumps.

The control system of pump is also necessary to automatically manage the withdrawing volume of groundwater in the night or in the case of low consumption of water. This system should be a simple one to avoid mechanical trouble.

One production well shall be constructed in the southeast part of Kharzat water source to cope with the water demand in 2015.

Transmission Facilities

Raw water transmission pipe (made of steel) from the production well to the reservoir shall be also replaced with a new steel pipe because of the deterioration and the lack of transmission capacity for future water demand.
The transmission pipe shall be also installed from the production wells to the existing reservoirs.

Distribution Facilities

Proposed water distribution network is shown in Figure 3.4. Two sets of water level meter shall be installed at the reservoirs to control the withdrawing volume from the intake wells. They should be connected to the intake wells with transmission cable to communicate the information of water level.

There are four water wagons which transport water to ger area at present, but the number is not enough for 2005. Distribution pipe shall be installed along with water kiosks for gel area G-1, G-2 and G-3 which can be supplied with water from the existing pump station and three water wagons. These wagons are procured to strengthen water transportation capacity of the existing wagons to gel area G-1 where the will be no pipeline in 2005. All ger area will be covered by water kiosks in 2015.

Water cart shall be procured for ger dwellers to transport water from the delivery points of water wagon or kiosk to their houses.

Distribution pipes for all ger area of G-1 to G-3 are necessary to be installed in 2015.

New reservoir shall be constructed at the southwest of G-1 ger area so that water can be supplied to the lower part of Altai City by gravity. It will help decrease the distribution energy.
A new pump station shall be installed to transmit the domestic water to new reservoir for water distribution to gel area of G-1.

3.5 OPERATION AND MAINTENANCE PLAN

In order to make a future plan for the operation and maintenance of water supply system, Altai Public Service Department (APSD) shall comply with the basic concept of water supply development.

The self operation system should be applied to APSD that will make APSD independent both financially and legally. It is also important to make people aware that the user of the water supply system should pay water tariff in proportion to the amount of benefit they get.

3.5.1 Institutional Strengthening

(1) Introduction of Appropriate Water Tariff

It has been made clear by JICA Study Team that the people of the service area can afford a rise in the water tariff, if sufficient and safe water is supplied. Consequently, water tariff shall be determined on the basis of financial aspect of water supply operation and management.

(2) Establishment of Meter System

If water meters are to be installed to every consumer and if meter system is to succeed, it will be necessary institutionally to obligate every user to maintain the proper functioning of the meter. On the side of APSD, it will be necessary to conduct the inspection of meters and collection of water tariff.

(3) Reduction of Leakage

The causes of leakage should be identified and proper measures should be taken toward the alleviation of leakage. People shall have the awareness of saving water to reduce leakage from taps and valve of toilet. In addition to these, APSD shall improve the superannuated distribution pipes to reduce leakage from the pipelines.

(4) Introduction of Strict Financial Management

All the above mentioned items have one common objective of improving the financial status of APSD toward self-financing. The revenue of APSD has been higher than its

expenditure. However APSD still depends on central government in the case of expansion and reconstruction of facilities. This investment cost should be paid by APSD in order to achieve the self-operation.

For strict financial management of APSD, the three steps cycle of "plan, do, see" should be introduced.

Plan

Before the start of particular financial year, the annual financial plan should be prepared and formulation of the expenditure and revenue should be done. Such a budget will be ultimately distributed over 12 months.

Do

APSD's activities such as the implementation of investment project, the production and distribution of water, and the collection of water tariff should be done based on the carefully drawn up budget.

See

APSD's actual activities should be recorded monthly to be, compared with the budget ones. Finally the annual comparison of accomplishments and budget should be done and the difference between them should be analyzed.

(5) Organization

Increase of staff related to water tariff collection should be necessary if meter system starts. Also the staff in administrative section should be increased to procure and to control various equipment.

If the pipeline network expands to the ger area, wastewater generation from ger area also will increase. In this case enforcement of sewerage section may be necessary.

3.5.2 Legal Strengthening

The following legal issues should be considered in order to accomplish the self operation,.

(1) Establishment of standard for industrial products

If meter system is introduced, many spare parts such as taps, valves, pipes, water

meters will be in need. However the market of Altai City is so small that APSD will not be able to procure the spare parts with reasonable price and quality. If the nationwide standard of spare parts is established, it may attract manufacturers which provide spare parts to many water supply agencies across the nation.

(2) Independence from Altai Municipality

The nationwide law under which a local government can approve the independence of water supply agency may be necessary.

3.5.3 Training System

Operation and Maintenance (O/M) manuals for mechanical and electrical equipment should be prepared. Training of employee for O/M will also be required.

3.5.4 Hygiene Education Plan

Measure to contamination of drinking water

Other than technical improvement of water quality test, it is important to make the resident of ger area know that the responsibility of water quality lies on the residents once the water has been delivered to the ger area. It is recommended for Social Health Center to conduct often a microbiological test on stock water in ger so that they can monitor the hygienic situation in ger area. It should be noted that the water analysis is to monitor the condition of drinking water not to measure true risk of the people. Therefore, it is encouraged to promote the understanding on the role of water analysis a swell as exchanging information between APSD and Social Health Center.

In order to increase the hygiene practice among the residents in Altai City, the following approaches are recommended.

(1) Increase of Awareness on Hygiene Practice and Water Consumption

Target group:	All the residents in Altai City
Media:	Local radio and TV
Expected outcome:	All the residents of Altai City apply the knowledge of hygienic practice to their daily life.
Implementation body:	Gobi-Altai Social Health Center / Governors' office

Media and communication are undertaken by the Governors' office. TV station with

10 staffers provides its local broadcasting service for three hours every Monday evening and radio broadcasting for 30 minutes every Monday morning. The number of TV sets and radio sets are quite large with a prevalence ratio of 1 to 25 for TV and 1 to 24 for radio respectively. Meanwhile, the Social Health Center holds education methodology specialist in its institution. If all resources above are utilized for common purpose, they will bring substantial impact. It is more preferable to conduct a series of broadcasting program on hygiene practice including sanitation and waste management.

(2) Proper Management of Stock Water and Water Consumption

Target group:	Residents in ger area
Media / Promoter:	Health Volunteer
Expected outcome:	The risk of water-borne and water-washed disease will be lowered through the proper management and use of stock water and increase of water consumption.

Recently health volunteers were appointed as promoter of community health along with the National Community Health Program. They are also expected to identify the problems to be addressed for hygiene and sanitation in their living community. With the technical support from the health promotion section of Social Health Center, the group takes a role of health promoters in front line. In the hygiene education program within the Study, they were involved in the production process of educational material and trainer's training. The Social Health Center also experienced program implementation and was capable of handling the program.

(3) Water and Health

Target group:	School children
Media:	School class
Expected outcome:	The basic knowledge on hygiene will be put into practice in their life.

Primary and middle schools are not included for bases for health education including hygiene practice. In fact, national health education program is being prepared for schools with the joint cooperation of Ministry of Education and Ministry of Health and Social Service. However, a textbook for health education is not available yet and those textbooks / posters are usually prepared by the national health education center of Ministry of Health. The hygiene education component within the study provided the chance of developing educational materials at local setting through encouraging participation process. The process and program planning can be applied to not only

future program but also other relevant programs.

3.6 MONITORING PLAN

3.6.1 Groundwater

Groundwater shall be utilized sustainably for the public and the economic activity because of its advantage such as the availability of its source near the consumer, good water quality, and easiness of intake comparing with surface water. The overall restriction of groundwater utilization is not appropriate without any scientific investigation.

According to the existing data, groundwater quantity may be sufficient for the future water demand in Altai city. But, groundwater, especially shallow groundwater is easy to be polluted. For the time being, it shall be focused on the preservation for water quality.

The following steps shall be taken to establish the program for groundwater management and groundwater preservation.

(1) Institutional Strengthening

One of the problems is that no organization has the responsibility of synthesizing the existing data. A scientific organization for research and development shall be established to synthesize and analyze the existing dispersed data from the geological and hydrogeological points of view. "Department of Strategy planning, Unified policy in Ministry of Agriculture and Industry " may be the most suitable for it.

(2) Investigation

It shall be clarified the present condition of groundwater basin structure, aquifer structure, recharge volume, groundwater quality, and groundwater utilization as follows.

- The volume of groundwater basin. This means the storage capacity of groundwater.
- The essential element of hydrogeological parameters of permeability, transmissivity, storativity, specific storage, specific yield, and so on.
- The external element of precipitation, river discharge, and so on. Those are utilized to estimate the recharge volume to groundwater.

- Groundwater quality. This is important to estimate an available volume of groundwater and the cost of purification for groundwater.

(3) Making Inventory and Database

All existing data shall be investigated and an inventory and a database should be established. Inventory of production well and monitoring observation well has to describe location in coordinate system, screen position, the result of pumping test (pumping rate, permeability, specific capacity) and water quality, geological condition and the constructed year.

(4) Preliminary Examination

JICA Study Team made an examination of the groundwater potential and established the development plan on the basis of groundwater potential, national development plan, and regional development plan.

The following items shall be continued in order to establish the groundwater management.

(5) Monitoring

Monitoring shall be continued at the existing station and some of the test wells of JICA as follows.

Existing meteorological station and observation wells
B5 : Kharzat water resources of Alluvial aquifer
B6 : Olon Nool water resources of Alluvial aquifer
A3 : Khadaasan water resources of fissure aquifer
A4 : NE of Altai city water resources of fissure aquifer

The following items shall be measured and investigated.

Groundwater table

The actual storage volume of unconfined groundwater is represented by the groundwater table that can be used for the estimation of stored or remaining volume of groundwater and to judge the safe pumping yield. If the groundwater table has a tendency to lower, its cause shall be clarified. There are many causes such as the seasonal fluctuation or long-term fluctuation, reduction of precipitation and river

discharge (decrease of recharge volume), excess utilization of groundwater, and deterioration of pumping equipment.

Hydrological and meteorological data

Hydrological and meteorological factors affect the fluctuation of recharge volume. Groundwater balance shall be considered on the balance of utilizing volume of groundwater and recharging volume from precipitation, and surface water. The fluctuation of groundwater table shall be considered in connection with hydrological and meteorological data.

Groundwater quality

The change of groundwater quality is important to estimate the available volume of groundwater and to find the source or site of pollution.

Regarding shallow groundwater, measures shall be taken to prevent a polluted water inflow from the surface to aquifer.

Groundwater utilization

Groundwater utilization pattern was not clear in the study area. It is one of the important elements to assess the groundwater balance and remaining volume for the development.

(6) Establishment of the Groundwater Management and Preservation Plan

- The water balance shall be simulated from the monitoring data of at least five (5) years.
- The groundwater potential and recharge volume shall be projected.
- The groundwater utilization plan shall be established on the basis of estimated hydrogeological condition, national development plan, and regional development plan.

(7) Opening Information

All database and information shall be opened to the public and other user to improve the awareness for saving water, preservation of the environment, and sustainable development in order to set across the idea that groundwater is limited natural resources.

Consequently, groundwater shall be managed and preserved by not only the government but also the public and user. Otherwise, it cannot be controlled the irregular development of groundwater and pollution.

3.6.2 Water Supply Facilities

The monitoring of water supply facilities is required for the appropriate operation and maintenance as follows:

- water quality of raw water and distributed water,
- residual chlorine at the water tap of the end of pipeline,
- distributed water pressure at pumping station, and
- supplied water pressure at the end of pipelines.

3.7 COST ESTIMATION

The total investment cost for the proposed development plan is estimated at US dollars 3,031,060 which includes the construction cost, land acquisition cost, engineering cost, and physical contingency as shown below.

Investment Cost

Unit : US Dollar

Work Item	Nos	Amount	Year 2000-2005	Year 2006-2015
A. Direct Construction Cost		1,916,876	630,108	1,286,768
		1,274,733 | 642,143	382,466 | 247,642	892,267 | 394,501
(1) Intake facility				
-Reconstruction of existing well	4 Wells	263,078	197,308	65,770
		230,547 | 32,531	172,910 | 24,398	57,637 | 8,133
-New production well	1Wells	65,770		65,770
		57,637 | 8,132		57,637 | 8,133
(2) Transmission facility				
-New pipe-line (φ200 x 2line)	3.5Km	311,500	0	311,500
		245,000 | 66,500	0 | 0	245,000 | 66,500
(3) Distribution facility				
-Water level indicator				
① Electrode	2 Sets	6,694	6,694	0
		6,586 | 108	6,586 | 108	0 | 0
② Transmit Cable	1 Lot	47,805	47,805	0
		40,659 | 7,146	40,659 | 7,146	0 | 0
-Water wagon	3 Cars	52,800	52,800	0
		50,400 | 2,400	50,400 | 2,400	0 | 0
-Water cart	2792 Sets	92,136	92,136	0
		0 | 92,136	0 | 92,136	0 | 0
-Water kiosk	14 Unit	71,484	51,060	20,424
		0 | 71,484	0 | 51,060	0 | 20,424
-Reservoir	2 Ponds	78,140	0	78,140
		0 | 78,140	0 | 0	0 | 78,140
-Pipe-line (φ150~250)	11Km			
① G-1 Area	(3.6Km)	192,700	38,540	154,160
		128,260 | 64,440	25,652 | 12,888	102,608 | 51,552
② G-2 Area	(1.3Km)	67,500	51,975	15,525
		40,500 | 27,000	31,185 | 20,790	9,315 | 6,210
③ G-3 Area	(3.7Km)	184,500	91,790	92,710
		110,700 | 73,800	55,074 | 36,716	55,626 | 37,084
④ Central Area	(3.4Km)	186,520	0	186,520
		121,160 | 65,360	0 | 0	121,160 | 65,360
-Pump Station (Including Pump)	1 St.	206,297	0	206,297
	-	157,714 | 48,583	0 | 0	157,714 | 48,583
-Chlorinating equipment	Unit	53,250	0	53,250
		53,250 | 0	0 | 0	53,250 | 0
-Water level indicator	Set	36,702	0	36,702
		32,320 | 4,382	0 | 0	32,320 | 4,382
B. Land Acquisition Cost	-	0	0	0
C. Construction Cost (A X 1.25)	-	2,396,095	787,635	1,608,460
D. Design & Supervision (C X0.1)	-	239,610	78,764	160,846
-Detailed Design (C x 0.05)	-	119,805	39,382	80,423
-Supervision (C x 0.05)	-	119,805	39,382	80,423
E. Physical Contingency {(C+D) X 0.15)}	-	395,356	129,960	265,396
Total (C+D+E)	-	3,031,061	996,359	2,034,702

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

2) ① ② ③ ① Total ② Foreign Portion ③ Local Portion

3.8 IMPLEMENTATION PROGRAM

The existing water supply facilities of production wells, raw water transmission pipe, and distribution pump have sufficient capacity to cope with the water demand in 2005. However, some of them are deteriorated and there is not enough number of water wagon. Therefore, water will by in short supply by 2005.
The present water supply facilities don't have sufficient capacity to cope with the water demand in 2015.

In consideration of the above fact, this project was designed to improve the existing water supply facilities at first and expand the water resources and the water supply facilities after that. Consequently, the improvement and expansion of water resources and water supply facilities shall proceed step by step on the basis of implementation schedule shown in the following figure.

Implementation Schedule

Work Item	Nos	Year (2000-2015)															
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
(1) Intake facility																	
·Reconstruction of existing well (Including submersible pump)	4 Wells			■	■				■								
·New construction of production well (Including submersible pump)	1Wells									■							
(2) Transmission facility																	
·New pipe-line (Φ200 x 2line)	3.5Kms								■	■							
(3) Distribution facility																	
·Water level indicator	2 Sets			■													
·Water wagon	3 Cars		■														
·Water cart	2,792 Sets		■														
·Water kiosk	14 Units				■	■					■						
①G-1 area	(6)				(2) ■■■						(4) ■■■						
②G-2 area	(3)				(3) ■■■												
③G-3 area	(5)					(5) ■■■											
·Reservoir	2 Ponds										■						
·Pipe-line (Φ150~250)	11Kms				■	■				■	■	■	■	■	■		
①G-1 area (Φ150~200)	(3.6)				(0.7) ■■■					(2.9) ■■■							
②G-2 area (Φ150)	(1.3)				(1.0) ■■■										(0.3) ■■■		
③G-3 area (Φ150)	(3.7)					(1.8) ■■■								(1.2) ■■■	(0.7) ■■■		
④Central area (Φ150~250)	(3.4)										(2.0) ■■■	(0.8) ■■■	(0.6) ■■■				
·Pump Station (Including Pump)	1 St.									■	■						
·Chlorination equipment	1 Unit										■						
·Water level indicator	1 Set										■						

■■■ breakdown

3.9 IMPROVEMENT PLAN FOR SANITATION

For the central area it is required to improve the existing sewer and waste water treatment capacity to cope with the increase of water after water supply facilities are expanded in 2005 and 2015.

On the other hand, much more waste water from ger dwellers will be discharged to the ground after the improvement of water supply system to ger area. There is not any facilities to collect and treat the waste water, in ger area. Consequently, it is also required to install personal or community treatment facilities to prevent contamination of soil, groundwater, and the environmental in ger area until the establishment of collection sewer system in the area.

The following sanitary zones should be established to protect the sources of drinking water:

I - (100 m) strictly prohibited zone.
prohibit the setting up of any sources of possible pollution in the I-zone
II - (300 m) zone under protection.
III - (1,000 m) monitoring zone.

Bacteriological and chemical analyses should be carried out in these zones.

3.10 EVALUATION FOR THE MASTER PLAN

3.10.1 Economic Analysis

(1) Objective

An economic analysis was carried out to confirm the contribution of the master plan from the viewpoint of a national economy. Economic feasibility is confirmed by a cost –benefit analysis, deriving economic internal rate of return (EIRR), benefit-cost ratio (B/C) and net present value (NPV).

(2) Conditions and Assumptions

The economic evaluation for this project was carried out based on the following assumptions.

a. Costs and benefits are estimated on the basis of the data as of November 1998. The costs and benefits are expressed in constant terms, taking no account of inflation.
b. A period of the economic analysis is determined based on an assumed life of the pipelines at 25 years.
c. The costs include investment cost, operation and maintenance cost and replacement cost. The estimated costs are used with no adjustment, since a standard conversion factor was derived at close to 1.0. The estimated costs are as follows.

Category	Cost (thousand U.S. dollar)	Remarks
Investment cost	3,031	in total
Operation and maintenance cost	82	per year in 2015 and thereafter
Replacement cost	1,593	in total

d. Table 3.3 shows the assumptions of the benefit estimate. Economic benefit by domestic water supply is estimated by the concept of willingness-to-pay for water, based on the prevailing water charges and the surveyed willingness-to-pay of the consumers. Domestic water demand is divided into the minimum requirement portion and the portion of the water as a commercial commodity. The minimum requirement portion is the amount of water needed for people to maintain minimum level of life. The commercial commodity portion corresponds to the

amount of water beyond the minimum requirement. The water use in this category can be adjusted depending on price, income and other factors in the same way as ordinary commercial commodities. The following are the used values and the estimated economic benefit.

Economic Benefit by Domestic Water Supply

Item	Unit	Minimum requirement	Commercial commodity
Value of water	Tg/m³	1,875	67
	$/m³	2.11	0.08
Net water use in 2015			
Apartment	l/c/d	20	130
Ger	l/c/d	20	1.2
Population in 2015			
Apartment	No.	3,830	
Ger	No.	17,131	
Economic benefit in 2015 and thereafter	10^3 $/year	322	15

The values of water for the minimum requirement portion was estimated based on the prevailing water charge at Tg 1,250 per m³ applied to ger water supply and on an additional 50% as the willingness-to-pay of water users. The 50% addition was determined based on the result of the Social Survey conducted in June 1997. The value of water for the commercial commodity portion was estimated based on the water charge for apartment dwellers, judging that apartment water use has a high commercial commodity element. The present per capita monthly water charge at Tg 250 for apartment residents was converted to per amount charge assuming a water consumption at 150 l/c/d. An additional willingness-to-pay beyond the present charge level is estimated to be 20%.

Future Economic benefit of industrial and institutional water supply is estimated by extrapolation using the following values.

P : Present revenue in water sale
W : Additional willingness to pay for water of industries and institutions
G : Annual Growth rate (%)
Y : Period (number of years)

$$\text{Economic benefit} = (P + W)x(1 + G/100)^Y$$

With the annual growth rate of 3.5% and 4.5% until 2005 and 2015 respectively. The following economic benefits are derived.

2005 : $ 112 thousand per year
2015 and thereafter : $ 174 thousand per year

(3) Result

The following table presents the derived EIRRs, B/C ratios and NPVs of the master plan.

Result of Economic Evaluation of Mater Plan

Case	EIRR (%)	B/C	NPV (10^3)
Standard	14.5	1.23	591
Cost 10% up	12.4	1.12	339
Benefit 10% down	12.2	1.11	280
Cost 10% up plus benefit 10% Down	10.3	1.01	29

The EIRR for the standard case was derived at 14.5% indicating high economic return of the master plan, compared with an opportunity cost of capital or cut-off EIRR at 10%. Even in the worst case of cost 10% up plus benefit 10% down, an EIRR is beyond 10% cut-off rate. Table 3.4 shows the costs and benefits of the master plan.

3.10.2 Financial Analysis

(1) Objective

The objectives of a financial analysis are :

- to derive appropriate water charges from the viewpoints of cost recovery and affordability, and
- to assess financial viability of the Mater Plan by deriving a financial internal rate of return (FIRR) based on the derived water charges.

(2) Conditions and Assumptions

Cost Recovery Aspect

a. The water charges are derived in constant term, taking account of no inflation. The actual charges to be levied should be adjusted along with inflation rates.

b. Water charges for cost recovery are estimated for three cases : recovery of operation and maintenance cost (OM cost), recovery of OM cost plus local currency portion of the investment and replacement costs and finally recovery of OM cost plus the total investment and replacement costs including both local and foreign currency portions.

c. Water charges are derived separately for the ger area where the water is delivered by water wagons and the central area where a pipe water supply service is provided to apartment dwellers, industries and institutions. The proposed master plan aims at the water supply by kiosks connected with pipes in the ger area, whereas the central area will continue receiving water through the pipes. The investment cost and replacement cost per cubic meter of water, thus, would be different in the two areas and this difference should be reflected in water charge. The costs of the facilities used commonly for the ger and central areas are allocated by water demand. The allocated investment costs are as follows.

Allocation Proportions and Allocated Investment Cost in Ger and Apartment Areas

Item	Unit	2015	
		Ger	Central Area
Allocation proportions of common facilities	%	30	70
Investment cost (LC)	$ thousand	641	375
Total Investment cost	$ thousand	1,554	1,477

a. Water charges are derived by dividing the annual cost by annual amount of water used. The investment cost and replacement cost are annualized by applying a 25 year period and a discount rate of 3% assumed as the cost for procuring fund.

b. The replacement costs appear 10 to 40 years after the installation, depending on the type of facility. To take into account the time value, the replacement costs are discounted to the year 2000 applying a discount rate at 3%. Allocation of the replacement cost for common facilities is made in proportion to the investment costs for the ger area and the central area. The total replacement cost discounted to 2000 is estimated to be $ 222 thousand for the ger area and $ 861 thousand for the central area.

c. The operation and maintenance cost (OM cost) estimated is allocated to the ger area and the central area by the proportion of the investment cost. The allocated OM costs are estimated to be $38 thousand per year for the ger area and $18 thousand per year for the central area in the year 2015 and thereafter.

d. The water charges for cost recovery is presented in Table 3.5 and summarized below.

Water Charges for Cost Recovery

Item	2015	
	Ger	Central Area
(in $/m³)		
OM cost recovery	0.32	0.13
OM cost plus investment cost (LC) Recovery	0.66	0.22
OM cost plus total investment cost Recovery	1.18	0.48
(in Tg/m³)		
OM cost recovery	283	116
OM cost plus investment cost (LC) Recovery	586	192
OM cost plus total investment cost Recovery	1,058	431

* LC : local currency

Big differences are observed between the water charges for the ger area and the central area. This would be the reflection of the following factors.

- Lower water consumption rate estimated for the ger area
- High proportion of sunk cost for the central area
- A large service area for the ger area leading to lower efficiency in investment

Affordability Aspect

a. The water charges estimated for cost recovery are checked from the viewpoint of affordability for water consumers. Table 3.6 shows the result of the affordability analysis. The proportion of expenditure on water is compared with the income of water users. It is assumed that the expenditure on water within 5% of income is the maximum affordable level for water users. The midpoint per capita income of the population of less than Tg 10,000 per month per person, that is Tg 5,000 or $ 5.6 per month per person, is used as the criterion. The proportion of this lowest income group is 80% of the ger population and 40% of the apartment population in 1998.

b. The per capita income level is assumed to grow with economic growth and population growth at the rates set in the Socio-Economic Framework. The estimated growth rates of per capita income are 2.3 % per year until 2005 and 2.9% per year between 2005 and 2015. The mid-point per capita income is estimated to grow as follows.

1998 : $ 5.6/month
2005 : $ 6.6/month
2015 : $ 8.8/month

c. Expenditure on water is estimated based on the water charges for the three cases

of cost recovery. The amounts of water use are 21.2 l/c/d for the ger residents and 150 l/c/d for the apartment residents in 2015.

d. To calculate the expenditures on water under the three cases of cost recovery water charges were compared with the projected income in 2015. The following proportions were derived.

Proportions of Expenditure on Water to Income for three proposed cases

(Unit : %)

Area	1998	2015
(Case 1 : OM cost recovery)		
Ger	3.5	2.3
Apartment	5.0	6.7
(Case 2 : OM/Investment (LC) recovery)		
Ger	3.5	4.8
Apartment	5.0	11.1
(Case 3 : OM/Total investment recovery)		
Ger	3.5	8.6
Apartment	5.0	25.1

* LC : local currency

(3) Proposed Water Charges

In the case of OM cost recovery water charges (Case 1), affordability problem occurs for the apartment residents with the proportion at 6.7%. The expenditure on water becomes 5.0 % of the income for the apartment dwellers in 2015 if the water charge is reduced to Tg 86 per m^3. For the Case 2, the problem in affordability appears for the apartment residents. In Case 3, the cost recovery water charges are too high both for ger and apartment residents. Considering these, the water charges for OM cost recovery were proposed to be applied with the adjustment mentioned above. The following are the proposed water charges as of 2015 based on these considerations.

Proposed Water Charges for Domestic Water

(Unit : Tg/m^3)

	Existing	2015
Ger	1,250	283
Apartment	56	86

The water charge for industries and institutions is proposed to remain at the present level at Tg 900 per m^3 in constant term. The fact that the organizations have been paying the existing water charge indicates that they are able to afford it.

The water charges proposed here are indicative ones. At the stage of actual adoption

of the proposed water charges, the water charges to be levied should be determined in due consideration of the following factors.

1) Installation of water meters for apartment residents to realize charging by water use amount

2) Cost
   - Inflation
   - Indirect cost for APSD

3) Demand/income
   - Actual water consumption rate in relation to water charge
   - Actual household income and affordability limit

4) Step-wise water tariff
   - Consideration for the poorest segment of the population
   - Introduction of a penalizing step tariff system, by which a higher charge is levied beyond certain amount of water use

5) Review of cross-subsidy by industrial and institutional water consumers for reducing water tariff disparity between ger and apartment water users

(4) Financial Internal Rate of Return

The financial internal rate of return (FIRR) of the master plan was estimated under the proposed water charges as shown in Table 3.7. The FIRR for the master plan is negative. It would be necessary for the government to subsidize the investment cost and replacement cost for implementing the master plan.

3.10.3 Social Evaluation

Proposed project on water supply system mainly focused on the improvement of water supply in the ger area by increasing chances of water availability. Although the residents of ger area cited yard connection as a preferable choice, it is not technically feasible. As mentioned in social analysis, no negative impact on the proposed project is recognized in terms of religion and social custom, acquisition of land for the project, and water seller etc.

3.10.4 Analysis for the Beneficiaries

While the higher income group of non-piped households approved 161% of increase, the lower income group of non-piped households approved 80% of increase from the current tariff level. As indicated in the result of the household survey, the lower income group of non-piped household consume less volume of water per day per person than the higher income group. Since the water used by the higher income group is still insufficient, it is recommended that exemption system of water charge for lower income group - unemployed and single female headed households should be revised periodically in corresponding to local poverty assessment.

The proposed program for water supply system, which plans the installation of kiosk type water delivery points in the ger area, will facilitate the availability of water in terms of time. This also will lead to the increasing in the water consumption for non-piped households. The frequent supply of water will reduce the habit of stocking water and bring about less opportunity of contamination.

However, 20% of non-piped households will not gain the very benefit of kiosk type of water supply since a fixed single kiosk is designed to cover radius of 250m. It is recommended that the water supply department promote a water cart into wide use.

3.10.5 Initial Environmental Examination (IEE)

(1) General

In Mongolia, IEE is regarded as the General Environmental Screening Process. For this project, it was carried out on May 22, 1998 by State Senior Inspector, Policy and Coordination Department of the Ministry of Nature and the Environment.

The conclusion of the General Environmental Screening Process is as follows.

"Basing upon the General Environmental Screening Process carried out in conformity with the Mongolian Law on Environmental Impact Assessment approved by the Parliament of Mongolia, dated January 22, 1998, for the Groundwater Development of Altai City in Gobi-Altai, it is necessary to carry out a Detailed Environmental Assessment".
As a result of this screening, "Scope of Actions" was drawn up. It is briefed in the following paragraphs.

(2) Scope of Actions

The main points of Scope of Actions are as follows.

a) The following items should be carried out to study and to be concluded by a specialized organization.
   - Water
   - Soil
   - Flora and Fauna
   - Historical and Cultural Monuments

b) To work out an environmental plan of action and environmental monitoring program.

c) To submit to the Ministry for Nature and Environment the detailed environmental impact assessment statement carried out in conformity with the Law on Environmental Impact Assessment.

3.11 SELECTION OF THE PRIORITY PROJECT

Considering the above mentioned criteria such as groundwater potential, water demand, and economy, the priority project of the water supply development recommends improvement of the existing water supply facilities of production wells, transmission pipes, distribution pump. It is also recommended to procure water wagon and water cart and to construct the main distribution pipe and kiosk for some ger area. These shall be examined in an implementation design in the feasibility study.

Table 3.1(1) Population Projected for Altai City

Year	Population change by natural factor					Population change by social factor						Total Population (rounded)
	Population by natural change (a)	Total birth (b)	Infant mortality (c)	Total death (d)	Natural increment of population (e)	Number of labor force required to achieve economic growth (f)	Additional labor force requirement (g)	Labor force to be added by Altai population (h)	Balance in labor force (i)	Labor force out-migrating from Altai City (j)	Population out-migrating from Altai City (k)	(l)
1997	17,761	282	15	112	-	6,890	-	-	-	-	-	17,760
1998	17,916	285	15	113	155	7,097	207	426	219	110	285	17,630
1999	18,073	287	15	114	157	7,310	213	426	213	107	277	17,800
2000	18,231	290	15	115	158	7,529	219	426	207	103	269	17,960
2001	18,391	276	12	110	160	7,755	226	426	200	100	260	18,130
2002	18,545	278	13	111	154	7,987	233	426	194	97	252	18,290
2003	18,699	280	13	112	154	8,227	240	426	187	93	242	18,460
2004	18,854	283	13	113	155	8,474	247	426	179	90	233	18,620
2005	19,011	285	13	114	157	8,728	254	426	172	86	224	18,790
2006	19,169	288	12	115	158	9,077	349	585	236	118	307	18,860
2007	19,330	290	12	116	161	9,440	363	706	343	172	446	18,880
2008	19,492	292	12	117	162	9,818	378	550	172	86	224	19,270
2009	19,655	295	12	118	163	10,211	393	661	268	134	349	19,310
2010	19,820	297	12	119	165	10,619	408	379	-30	-15	-39	19,860
2011	19,986	300	11	120	166	11,044	425	256	-169	-84	-220	20,210
2012	20,155	302	11	121	169	11,486	442	387	-55	-27	-71	20,230
2013	20,325	305	11	122	170	11,945	459	253	-206	-103	-268	20,590
2014	20,497	307	11	123	172	12,423	478	267	-211	-105	-274	20,770
2015	20,670	310	11	124	173	12,920	497	270	-227	-113	-295	20,960

Table 3.1(2) Assumptions for the Projection of Altai City's Population

(a) $(\text{Population by natural change})_n = (\text{Population})_{n-1} + (\text{Natural increment of population})_n$

(b) Total birth = Population by natural change (a)/1,000 * crude birth rate

Crude birth rate (per 1,000 population) :

1995-2000 :	15.9 (average of 1996 (18.1) and 1997 (13.7))
2001-2015 :	15.0 (assumed)

(c) Infant Mortality = Number of birth * infant mortality rate

Infant mortality rates are assumed as follows.

52.73 per 1,000 live births for 1996-2000
45.00 per 1,000 live births for 2001-2005
40.00 per 1,000 live births for 2006-2010
35.00 per 1,000 live births for 2011-2015

(d) Total death = Population by natural change * crude death rate

Crude death rate (per 1,000 population) :

1995-2000 :	6.3 (average of 1996 (5.9) and 1997 (6.6))
2001-2015 :	6.0 (assumed)

(e) $(\text{Natural increment of population})_n = (\text{total birth})_{n-1} - (\text{infant mortality})_{n-1} - (\text{total death})_{n-1}$

(f) Labor force in 1997 is estimated as follows.

Labor resource :	9,300
Unemployment :	2,410
Labor force :	6,890

Labor force requirement since 1997 is assumed to growth at the same rats as the economic growth rates as follows.

3.0% per year for 1996 - 2005 period
4.0% per year for 2005 - 2015 period

(g) $(\text{Additional labor force requirement})_n = (\text{Labor force})_n - (\text{Labor force})_{n-1}$

(h) Data were obtained regarding the population by age strata in 1995. These data are adjusted to 1997 applying the same proportions for each age stratum. The number of population to become 16 years of age in each year are all counted as entering into the labor market. The proportion that continues on to upper level school is assumed to be cancelled out by those entering into the labor market from the upper level schools.
It is assumed that all those surviving the infant age (up to 12 months of age) reach 16 years of age.

(i) (Balance in labor force) = labor force added by Altai population(h) - labor force requirement(g)

(j) For the labor force unable to find a job in Altai City, the ratio of out-migration from Altai City and the unemployed labor force staying in Altai City are assumed as follows. Negative values indicate in-migration of labor force into Altai city.

Out-migration :	50%
Unemployment :	50%

(k) Total population to migrate out of or into Altai City is estimated by the following formula.

Migrating population = migrating labor force * dependency ratio

Dependency ratio is derived as total population divided by working labor force as follows.

Population 1997	17,761
Labor force 199	6,890
Dependency rati	2.6

(l) Total population = Population by natural change (a) - Out-migrating population (k)

Table 3.2 Projected Population of Altai City by District and Dwelling Pattern

Item	Household		Population		
	Number	(%)	1997	2005	2015
District I					
Ger	680	21.6	3,709	3,924	4,377
Apartment	204	6.5	1,357	1,435	1,601
District II					
Ger	631	20.0	3,442	3,642	4,063
Apartment	0	0.0	0	0	0
District III					
Ger	809	25.7	4,413	4,669	5,208
Apartment	0	0.0	0	0	0
District IV					
Ger	541	17.2	2,951	3,122	3,483
Apartment	284	9.0	1,888	1,998	2,229
Total					
Ger	2,661	84.5	14,516	15,357	17,131
Apartment	488	15.5	3,245	3,433	3,830
Total	3,149	100.0	17,761	18,790	20,960

(1) Population in 1997 by district and dwelling pattern is estimated based on the total population in 1997 and distribution proportions of households in 1997.
(2) Population in ger area includes those living in private houses built in ger areas.
(3) It is assumed that distribution of population among districts and area remains constant in the future.
(4) Figuires may no add up to total due to rounding.

(Number of Household Members in 1997)

	Population	Household	Household member
Ger	14,516	2,661	5.5
Apartment	3,245	488	6.6
Total	17,761	3,149	5.6

Table 3.3 Assumptions and Results of Economic Benefit Estimate

(Domestic water)

	Unit	Minimum requiremen	Commercial element	Total	
1. Value of water					
Base	Tg/m^3	1,250	56 *		
Additional WTP	%	50%	20%		
Total WTP	Tg/m^3	1,875	67		
	Tg/$	890	890	-	(December 1998)
	$/$m^3$	2.11	0.08	-	

* present amount paid by apartment dwellers :
(Tg 250/person/month)/(150 lcd/(1,000l/m^3)*30days)

2. Unaccounted-for-water (UAFW)		
1997	30%	
2005	25%	
2015	20%	

3. Amount of water supplied/used (1) Amount supplied (UAFW included (2) Amount used (UAFW excluded)	Unit	Minimum requiremen	Commercial element	Total
(2005)				
Apartment	lcd	10.6	139.4	150.0
Ger	lcd	10.6	0.0	10.6
(2015)				
Apartment	lcd	20.0	130.0	150.0
Ger	lcd	20.0	1.2	21.2
4. Population				
(2005)				
Apartment	no.	-	-	3,433
Ger	no.	-	-	15,357
Total	no.	-	-	18,790
(2015)				
Apartment	no.	-	-	3,830
Ger	no.	-	-	17,131
Total	no.	-	-	20,961

5. Annual total benefit (2005)	Unit	Minimum requiremen	Commercial element	Total
Apartment	$/year	27,982	13,189	41,171
Ger	$/year	125,175	0	125,175
Total	$/year	153,157	13,189	166,346
(2015)				
Apartment	$/year	58,902	13,722	72,624
Ger	$/year	263,461	567	264,028
Total	$/year	322,364	14,288	336,652

(Industrial and institutional water)

1. Present tariff	900	Tg/m^3
2. Present revenue	63,139	thousand Tg in 1997 (indication of WTP)
	890	Tg/$
	71	thousand US$
3. Coefficient for additional WTP	20	%
4. Total WTP	85	thousand US$
5. Annual growth		
1998-2005	3.5%	per year
2005-2015	4.5%	per year
6. Annual benefit		
2005	112	thousand US$ per year
2015	174	thousand US$ per year

Table 3.4 Economic Evaluation of Master Plan

EIRR = 14.5%

(Unit : $)

No.	Year	Cost				Benefit			Balance
		Invest-ment	OM	Replace-ment	Total	Domestic	Industrial & instiutrional	Total	
1	2000	10,418	44,113	0	54,531	0	0	0	-54,531
2	2001	232,134	48,710	0	280,844	1,739	1,172	2,911	-277,933
3	2002	293,869	52,245	0	346,114	40,495	27,290	67,785	-278,329
4	2003	282,859	48,108	0	330,967	89,557	60,353	149,911	-181,056
5	2004	177,080	52,433	0	229,513	136,782	92,178	228,960	-553
6	2005	0	55,967	0	55,967	166,346	112,101	278,447	222,480
7	2006	15,922	56,498	0	72,420	166,346	112,586	278,932	206,512
8	2007	363,232	57,028	0	420,260	167,679	112,586	280,265	-139,995
9	2008	640,667	60,324	0	700,991	198,081	123,653	321,734	-379,257
10	2009	723,078	66,268	0	789,346	251,706	143,171	394,877	-394,469
11	2010	69,980	75,083	0	145,063	312,228	165,200	477,428	332,365
12	2011	54,952	76,724	0	131,676	318,085	167,332	485,417	353,741
13	2012	93,311	77,564	0	170,875	322,685	169,006	491,691	320,816
14	2013	73,560	79,390	0	152,950	330,495	171,849	502,344	349,394
15	2014	0	81,080	0	81,080	336,652	174,090	510,742	429,662
16	2015	0	82,161	0	82,161	336,652	174,090	510,742	428,581
17	2016	0	82,161	0	82,161	336,652	174,090	510,742	428,581
18	2017	0	82,161	0	82,161	336,652	174,090	510,742	428,581
19	2018	0	82,161	0	82,161	336,652	174,090	510,742	428,581
20	2019	0	82,161	404,081	486,242	336,652	174,090	510,742	24,500
21	2020	0	82,161	66,562	148,723	336,652	174,090	510,742	362,019
22	2021	0	82,161	0	82,161	336,652	174,090	510,742	428,581
23	2022	0	82,161	0	82,161	336,652	174,090	510,742	428,581
24	2023	0	82,161	0	82,161	336,652	174,090	510,742	428,581
25	2024	0	82,161	0	82,161	336,652	174,090	510,742	428,581
26	2025	0	82,161	408,440	490,601	336,652	174,090	510,742	20,141
27	2026	0	82,161	0	82,161	336,652	174,090	510,742	428,581
28	2027	0	82,161	0	82,161	336,652	174,090	510,742	428,581
29	2028	0	82,161	0	82,161	336,652	174,090	510,742	428,581
30	2029	0	82,161	0	82,161	336,652	174,090	510,742	428,581
31	2030	0	82,161	243,664	325,825	336,652	174,090	510,742	184,917
32	2031	0	82,161	66,562	148,723	336,652	174,090	510,742	362,019
33	2032	0	82,161	0	82,161	336,652	174,090	510,742	428,581
34	2033	0	82,161	0	82,161	336,652	174,090	510,742	428,581
35	2034	0	82,161	0	82,161	336,652	174,090	510,742	428,581
36	2035	0	82,161	404,081	486,242	336,652	174,090	510,742	24,500
37	2036	0	82,161	0	82,161	336,652	174,090	510,742	428,581
38	2037	0	82,161	0	82,161	336,652	174,090	510,742	428,581
39	2038	0	82,161	0	82,161	336,652	174,090	510,742	428,581
	Total	3,031,062	2,821,238	1,593,390	7,445,690	10,581,876	5,636,640	16,218,515	8,772,825

Sensitivity Analysis

Case	EIRR (%)	B/C	B-C ($)
Standard	14.5%	1.23	590,800
Cost 10% up	12.4%	1.12	339,377
Benefit 10% down	12.2%	1.11	280,297
Cost 10% up plus benefit 10% dow	10.3%	1.01	28,875

Table 3.5 Water Charges for Cost Recovery by Ger and Central Area

Item	Unit	2005		2015	
		Ger	Central area	Ger	Central area
1. Costs					
OM	thousand $/year	38	18	42	40
Investment cost (LC)	thousand $	351	41	641	375
Replacement Cost (LC)	thousand $	83	10	145	85
Total investment cost	thousand $	674	322	1,554	1,477
Total replacement cost	thousand $	169	81	442	420
LC investment cost annulaized	thousand $/year	20	2	37	22
LC replacement cost annualized	thousand $/year	5	1	8	5
Total investment cost annulaized	thousand $/year	39	19	89	85
Total replacement cost annulaized	thousand $/year	10	5	25	24
2. Amount of water used					
Daily mean	m^3/day	163	694	363	843
Annual mean	m^3/year	59,495	253,310	132,495	307,695
3. Water charge					
(in $)					
OM cost recovery	$/$m^3$	0.64	0.07	0.32	0.13
OM and LC investment/replacement costs recovery	$/$m^3$	1.06	0.08	0.66	0.22
OM and total investment/replacement costs recovery	$/$m^3$	1.45	0.16	1.18	0.48
(in Tg)					
OM cost recovery	Tg/m^3	566	64	283	116
OM and LC investment/replacement costs recovery	Tg/m^3	939	74	586	192
OM and total investment/replacement costs recovery	Tg/m^3	1,291	145	1,053	431

Table 3.6 Proportion of Expenditure on Water to Per Capita Monthly Income by Income Strata

(Under the revised water tariff for OM cost recovery)

Income strata (Tg/month /capita	Propor-tion (%)	Mid-point income (Tg/month/ apita in 199	($/month/capita) 1998	2005	2015	Expenditure on water ($/month/capita) 1998	2005	2015	Proportion to Income (%) 1998	2005	2015
(Ger)											
0	9.5	-	-	-	-	0.19	0.20	0.20	-	-	-
1-4,999	36.8	2,500	2.8	3.3	4.4	0.19	0.20	0.20	6.9	6.2	4.6
5,000 - 9,999	33.3	7,500	8.4	9.9	13.2	0.19	0.20	0.20	2.3	2.1	1.5
1 - 9,999	*79.6*	*5,000*	*5.6*	*6.6*	*8.8*	*0.19*	*0.20*	*0.20*	*3.5*	*3.1*	*2.3*
10,000 - 14,999	12.7	12,500	14.0	16.5	21.9	0.19	0.20	0.20	1.4	1.2	0.9
15,000 - 19,999	5.3	17,500	19.7	23.1	30.7	0.19	0.20	0.20	1.0	0.9	0.7
20,000 - 24,999	1.1	22,500	25.3	29.6	39.5	0.19	0.20	0.20	0.8	0.7	0.5
25,000 - 29,999	0.5	27,500	30.9	36.2	48.2	0.19	0.20	0.20	0.6	0.6	0.4
30,000 - 35,000	0.4	32,500	36.5	42.8	57.0	0.19	0.20	0.20	0.5	0.5	0.4
35,000 - 39,999	0.5	37,500	42.1	49.4	65.8	0.19	0.20	0.20	0.5	0.4	0.3
40,000 -	0	-	-			-	-	-	-		
(Apartment)											
0	5.6	-	-	-	-	0.28	0.32	0.59	-	-	-
1-4,999	18	2,500	2.8	3.3	4.4	0.28	0.32	0.59	10.0	9.6	13.3
5,000 - 9,999	16.1	7,500	8.4	9.9	13.2	0.28	0.32	0.59	3.3	3.2	4.4
1 - 9,999	*39.7*	*5,000*	*5.6*	*6.6*	*8.8*	*0.28*	*0.32*	*0.59*	*5.0*	*4.8*	*6.7*
10,000 - 14,999	30.4	12,500	14.0	16.5	21.9	0.28	0.32	0.59	2.0	1.9	2.7
15,000 - 19,999	11.8	17,500	19.7	23.1	30.7	0.28	0.32	0.59	1.4	1.4	1.9
20,000 - 24,999	13.7	22,500	25.3	29.6	39.5	0.28	0.32	0.59	1.1	1.1	1.5
25,000 - 29,999	2.5	27,500	30.9	36.2	48.2	0.28	0.32	0.59	0.9	0.9	1.2
30,000 - 35,000	1.9	32,500	36.5	42.8	57.0	0.28	0.32	0.59	0.8	0.7	1.0
35,000 - 39,999	0	37,500	42.1	49.4	65.8	0.28	0.32	0.59	0.7	0.6	0.9
40,000 -	0	-	-	-	-	-	-	-	-	-	-

Note :

(1) Exchange rate : 890 Tg/US$ (average rate in December 1998)

(2) Growth of personal income is estimated based on the economic growth rates and population growth rates assumed in the Socio-Economic Framework.

	-2005	2005-2015
Economic growth (%/year)	3.0	4.0
Population growth (%/year)	0.7	1.1
Per capita incomegrowth (%/year)	2.3	2.9

(3) Expenditure on water

		1998	2005	2015
(Ger)				
Water consumption rate	lcd	4.6	10.6	21.2
Water charge	$/m^3	1.40	0.64	0.32
Expenditure on water	$/month/capi	0.19	0.20	0.20
(Apartment)				
Water consumpriton rate	lcd	150.0	150.0	150.0
Water charge	$/m^3	0.06	0.07	0.13
Expenditure on water	$/month/capi	0.28	0.32	0.59

Table 3.7 Financial Internal Rate of Return of Master Plan (Under the revised water tariff for OM cost recovery)

FIRR = -1.2% (Unit : $)

Year	Cost				Revenue			Balance
	Invest-ment	OM	Replace-ment	Total	Domestic	Industrial & instituriona	Total	
2000	10,418	44,113	0	54,531	0	0	0	-54,531
2001	232,134	48,710	0	280,844	536	977	1,513	-279,331
2002	293,869	52,245	0	346,114	12,489	22,741	35,230	-310,884
2003	282,859	48,108	0	330,967	27,620	50,294	77,914	-253,053
2004	177,080	52,433	0	229,513	42,184	76,815	118,999	-110,514
2005	0	55,967	0	55,967	51,302	93,418	144,720	88,753
2006	15,922	56,498	0	72,420	51,302	93,418	144,720	72,300
2007	363,232	57,028	0	420,260	51,391	93,822	145,213	-275,047
2008	640,667	60,324	0	700,991	53,416	103,044	156,460	-544,531
2009	723,078	66,268	0	789,346	56,989	119,309	176,298	-613,048
2010	69,980	75,083	0	145,063	61,022	137,667	198,688	53,625
2011	54,952	76,724	0	131,676	61,412	139,443	200,855	69,179
2012	93,311	77,564	0	170,875	61,718	140,839	202,557	31,682
2013	73,560	79,390	0	152,950	62,239	143,207	205,446	52,496
2014	0	81,080	0	81,080	62,649	145,075	207,724	126,644
2015	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2016	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2017	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2018	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2019	0	82,161	404,081	486,242	62,649	145,075	207,724	-278,518
2020	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2021	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2022	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2023	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2024	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2025	0	82,161	408,440	490,601	62,649	145,075	207,724	-282,877
2026	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2027	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2028	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2029	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2030	0	82,161	243,665	325,826	62,649	145,075	207,724	-118,102
2031	0	82,161	66,562	148,723	62,649	145,075	207,724	59,001
2032	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2033	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2034	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2035	0	82,161	404,081	486,242	62,649	145,075	207,724	-278,518
2036	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2037	0	82,161	0	82,161	62,649	145,075	207,724	125,563
2038	0	82,161	0	82,161	62,649	145,075	207,724	125,563
Total	3,031,062	2,903,399	1,526,829	7,461,290	2,159,847	4,841,870	7,001,717	-459,573

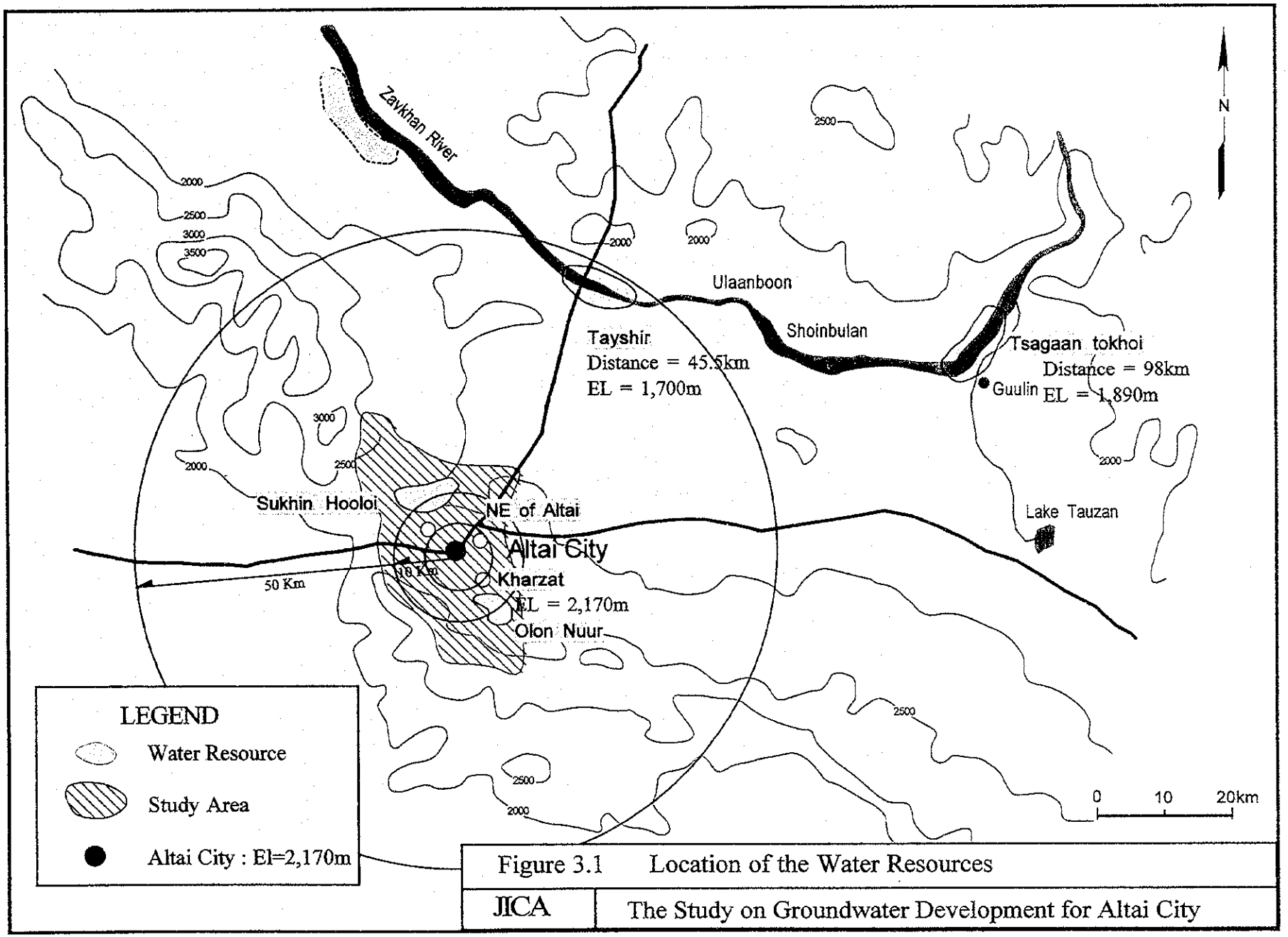

Figure 3.1 Location of the Water Resources

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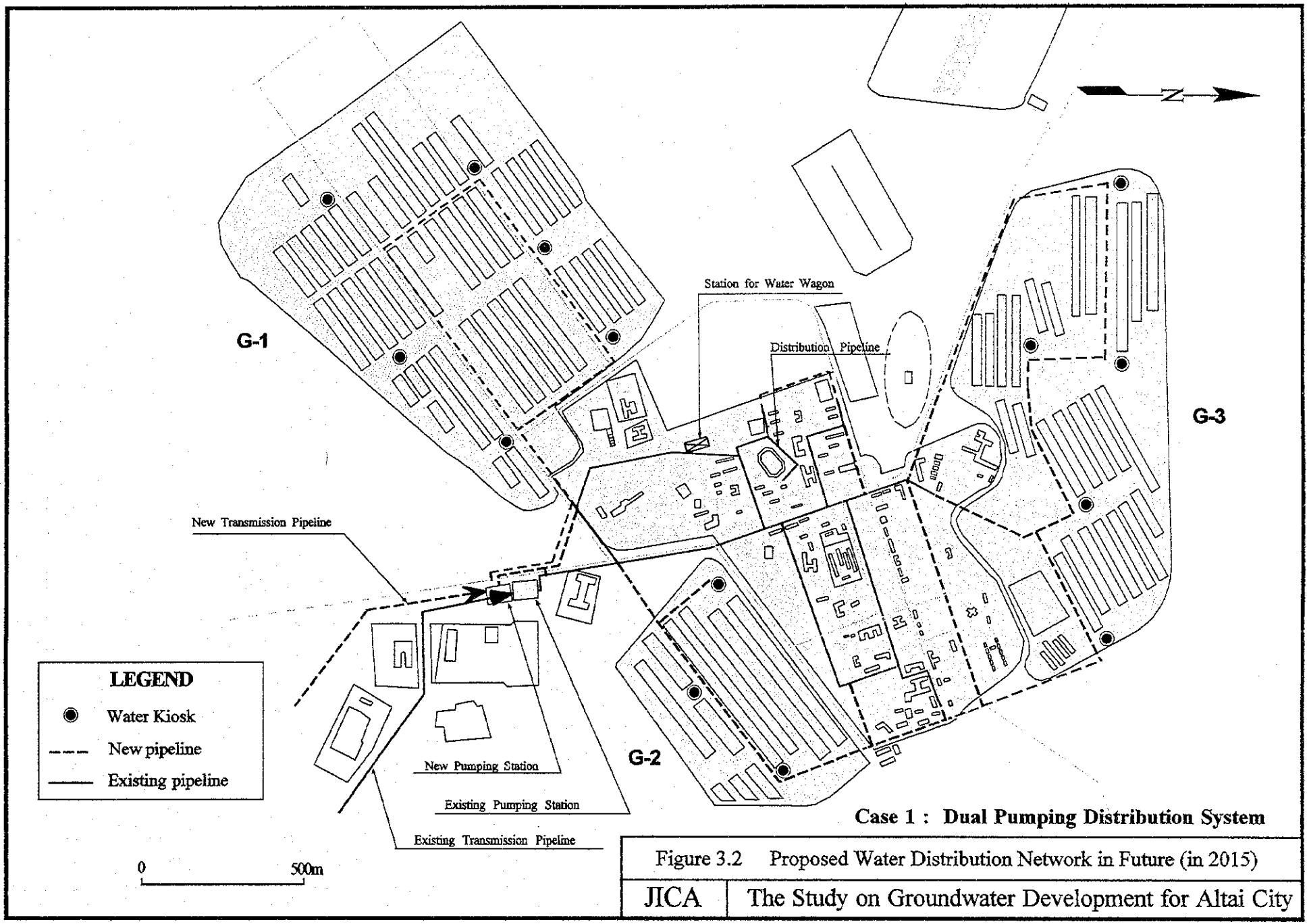

Figure 3.2 Proposed Water Distribution Network in Future (in 2015)

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main

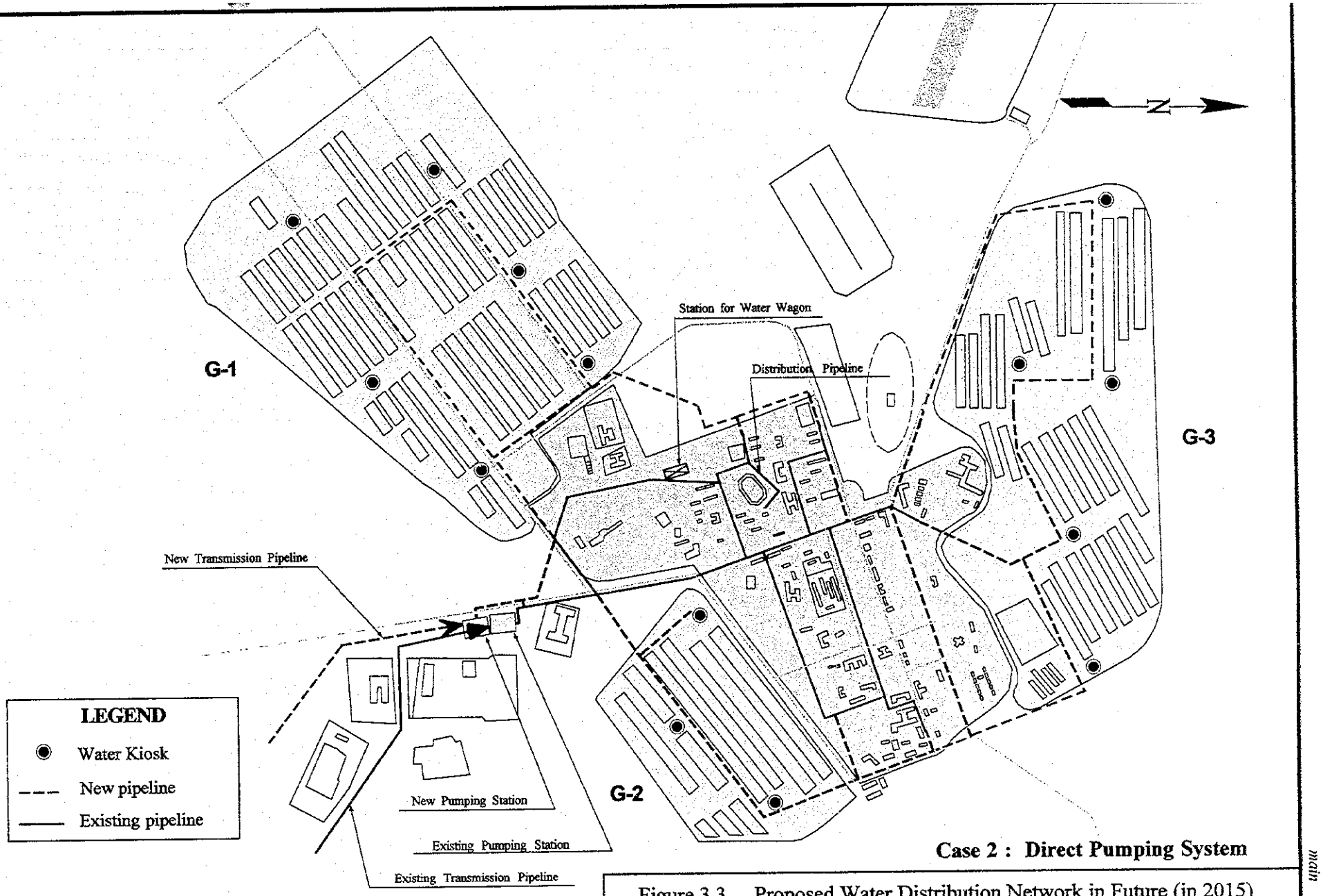

Figure 3.3 Proposed Water Distribution Network in Future (in 2015)

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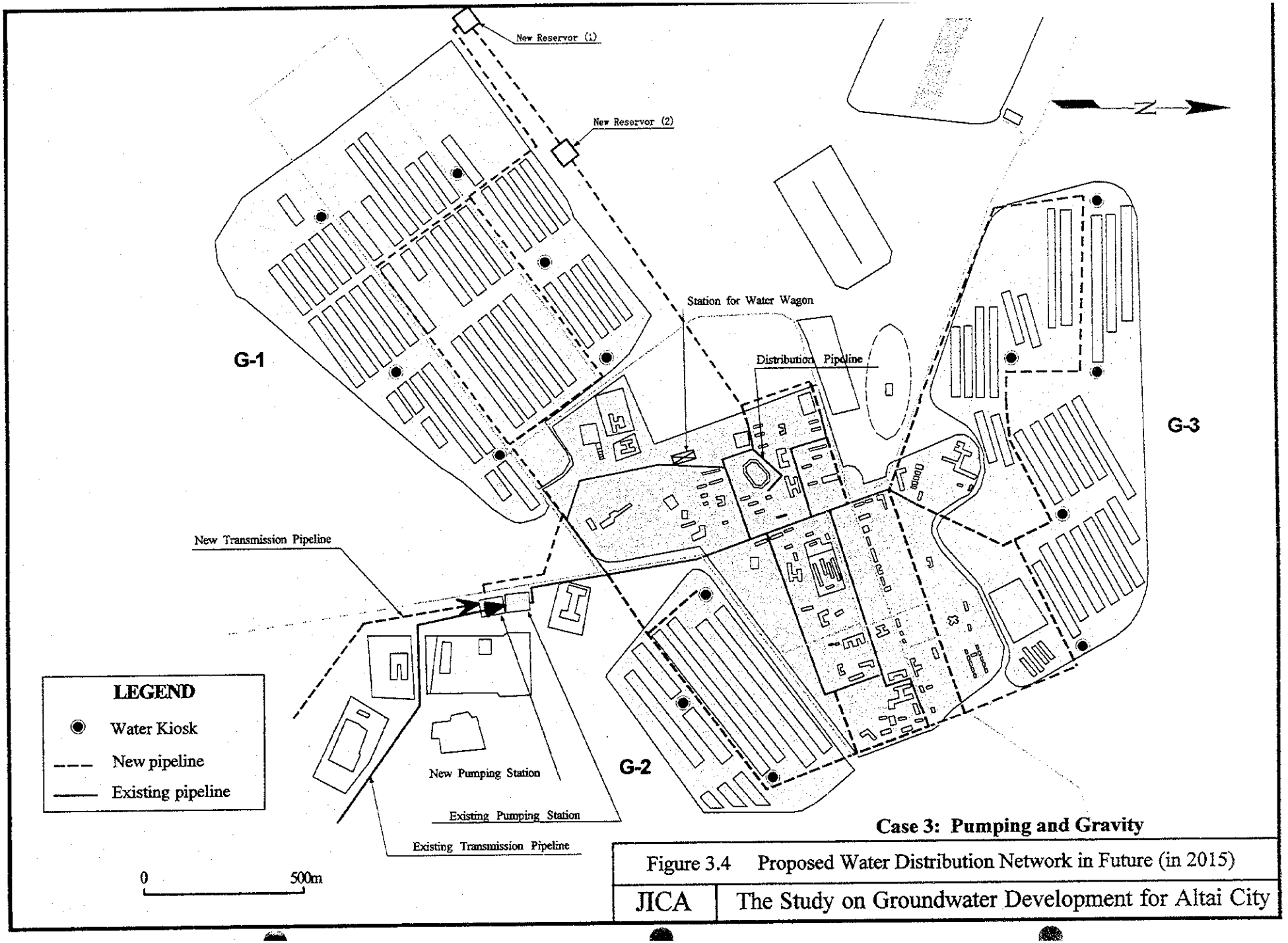

Figure 3.4 Proposed Water Distribution Network in Future (in 2015)

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main

4 FEASIBILITY STUDY

4. FEASIBILITY STUDY

4.1 DESIGN CONDITION

Design conditions for the feasibility study on priority project are summarized below. Details are described in the supporting report.

(1) Target year	:	2005
(2) Future population in 2005	:	18,790
(3) Population served	:	18,790 (apartment; 3,433, ger; 15,357)
(4) Service area	:	whole apartment and ger area shown in Figure 4.1
(5) Future water demand in 2005	:	1,500 m^3/day in maximum
(6) Additional development capacity	:	350 m^3/day in maximum
(7) Water source and its potential	:	Kharzat, more than 3,000 m^3/day

4.2 WATER RESOURCES AND WATER SUPPLY DEVELOPMENT

4.2.1 General

In Kharzat water source, there are four production wells. Two of them have been utilized and have supplied water about 960 m^3/day in average and 1,150 m^3/day in maximum in October 1998. This water resource can be expanded to yield about 1,500 m^3/day in maximum in 2005.

It was found that a large amount of water (34 to 38 m^3/hour) is constantly distributed during the night. It is supposed to be leakage from the pipe, water taps and toilet instruments. A control system is needed to minimize unnecessary supply volume and distribution pressure by switch and valve operation.

The development of water supply facilities shall proceed as follows.

① Reconstruction of three existing intake wells
② Replacement of three submersible pumps of intake wells
③ Two sets of water level meter shall be installed at the reservoir to control the withdrawing volume from intake wells.
④ Procurement of water wagon for strengthening water supply to the ger area

⑤ Procurement of water cart, for ger dwellers to transport water from kiosk or public tap to their houses.

⑥ Installation of distribution pipe for supplying water to ger area of G-2 and G-3 and lower part of G-1.

Required facilities to increase the capacity of water supply

Measures	Facilities
Improvement of existing facilities	1, reconstruction of 3 wells (total 4 wells; one is spare) 2, replacement of submersible motor pump with control system : 0.42m^3/min x 60m x 3 unites (total 4 pumps; one is spare)
Construction of new facilities	1, water level indicator system for reservoir : 2sets 2, procurement of water wagon ; 5m^3 x 3 cars 3, procurement of water cart : 2792 (households) sets 4, distribution pipe for ger area G-2, G-3, and a part of G-1 : dia.150-200mm x 3.9km 5, water kiosk : 2 in G-1, 3 in G-2, 5 in G-3

4.2.2 Intake Facilities

Intake wells, submersible motor pumps, and collection pipes have sufficient capacity for the present water demand. But, two of the four production wells constructed in 1979 are deteriorated and another one well constructed in 1986 is damaged. Therefore these wells shall be reconstructed. The well constructed in 1995 is not necessary to be replaced in this stage.

Submersible motor pumps may be also deteriorated by 2005 and they shall be replaced with new pumps. The control system of the pumps is also necessary to manage the withdrawing volume of groundwater in the night or in the case of low consumption of water.

4.2.3 Distribution Facilities

Two sets of water level meter (detector) shall be installed at the reservoir to control the withdrawing volume from intake wells.

There are four water wagons which transport water to ger area at present, but there will not be enough cars in 2005. Three water wagons are necessary to be procured by 2005.

Water cart shall be procured for ger dwellers to transport water from the point where

they can get water to their houses.

In this stage, it is necessary to extend the distribution pipelines to ger area G-1, G-2 and G-3 which can be supplied with water by existing distribution pump system according to a plan of phased implementation up to 2015. Ten water kiosks shall be also constructed for the ger areas. Location of proposed extension pipeline and water kiosks for ger areas are shown in Figure 4.1.

4.2.4 Land Acquisition

Land will be required for the construction of the facilities without monetary compensation.

4.3 OPERATION AND MAINTENANCE PLAN

(1) Institutional Strengthening

Daily operation and maintenance have been conducted by APSD. The expanded and developed water supply facilities shall be also managed by strengthened organization and institution of APSD. The following items shall be put into practice to strengthen maintenance and operation system of APSD.

- Introduction of appropriate water tariff
- Implementation of meter measuring system
- Reduction of water leakage
- Introduction of strict financial management
- Establishment of functional organization

(2) Establishment of Related Law for the Water Supply Service

Design and operation criteria shall be established to ensure the structural and hygienic safety of the water supply facilities.
Regulation of water supply service shall be also established to provide the rational service for consumer.

(3) Improvement of Data Arrangement

Daily or monthly operation data of water consumption, electric power consumption, chemical dosage and other necessary data shall be arranged systematically and checked well under the strengthened organization. These data is inevitable to maintain water supply facilities and to make the development plan of water supply facilities.

(4) Training System

There are 45 employees including director in APSD. They have been working for long period in the same section, and learning skills of operation and maintenance through daily work.
It means that they do not have so much experience with skilled work in other sections. Therefore appropriate training system is necessary to make them master the comprehensive operation and maintenance technique regardless of their field of expartize.

(5) Hygiene Education Plan

Measure against contamination of drinking water

Other than technical improvement of water quality test, it is important to make the residents of ger area know that the responsibility of water quality lies on the residents once the water has been delivered. It is recommended for Social Health Center to conduct often a microbiological test on stock water in ger so that they can monitor the hygienic situation in ger area. It should be noted that water analysis is to monitor the condition of drinking water but not to measure true risk of the people. Therefore, it is encouraged to promote the understanding on the role of water analysis as well as exchanging information between Water Supply Organization and Social Health Center.

In order to increase the hygiene practice among the residents in Altai City, the following approaches are recommended.

Increase of awareness on hygiene practice and water consumption

Target group:	All the residents in Altai City
Media:	Local radio and TV
Expected outcome:	The all residents of Altai City apply the knowledge of hygienic practice to their daily life.

Implementation body: Gobi-Altai Social Health Center / Governors' office

Proper management of stock water and water consumption

Target group:	Residents in ger area
Media/Promoter:	Health Volunteer
Expected outcome:	The risk of water-borne and water-washed disease will be lowered through the proper management and use of stock water and increase of water consumption.

Water and health

Target group:	School childredn
Media:	School Class
Expected outcome:	The basic knowledge on hygiene will be put into practice in their life.

4.4 MONITORING PLAN

Monitoring of water sources and water supply facilities shall be conducted continuously as follows.

For water sources

- groundwater level,
- hydrological and meteorological data,
- groundwater quality, and
- groundwater utilization.

For water supply facilities

- water quality of raw water and distributed water,
- residual chlorine at the water tap of the end of pipeline,
- distributed water pressure at pumping station, and
- supplied water pressure at the end of pipelines.

4.5 COST ESTIMATION

The total investment cost by the year of 2005 amounts to US dollars 996,359 which includes the direct construction cost, overhead cost, land acquisition cost, engineering (design & supervision) cost, and physical contingency. Its break down is shown below.

Investment Cost until the Year of 2005

(Unit : US Dollar)

Work Item	Nos	Total Cost (2000~2005)	
A. Direct Construction Cost	-	630,108	
		382,466	247,642
(1) Intake facility		197,308	
·Reconstruction of existing well	3 Wells	197,308	
		172,910	24,398
(2) Distribution facility		432,800	
·Water level indicator			
① Electrode	2 Sets	6,694	
		6,586	108
② Transmit Cable	1 Lot	47,805	
		40,659	7,146
·Water wagon	3 Cars	52,800	
		50,400	2,400
·Water cart	2792 Sets	92,136	
		0	92,136
·Water kiosk	10 Unit	51,060	
		0	51,060
·Pipe-line (Φ 150~250)	3.9 Km		
① G-1 Area	(1.0Km)	38,540	
		25,652	12,888
② G-2 Area	(1.0Km)	51,975	
		31,185	20,790
③ G-3 Area	(1.9Km)	91,790	
		55,074	36,716
B. Land Acquisition Cost	-	0	
C. Construction Cost (A X 1.25)	-	787,635	
D. Design & Supervision (C X0.1)	-	78,764	
·Detailed Design (C x 0.05)	-	39,382	
·Supervision (C x 0.05)	-	39,382	
E. Physical Contingency {(C+D) X 0.15	-	129,960	
Total (C+D+E)	-	996,359	

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00 = Tg 890

2) ① ② ③ ① Total ② Foreign Portion ③ Local Portion

4.6 IMPLEMENTATION SCHEDULE

On the basis of this study, implementation schedule on priority project is proposed as shown below.

Implementation Schedule

Work Item	Nos	Year (2000-2005)					
		2000	2001	2002	2003	2004	2005
(1) Intake facility							
・Reconstruction of existing well (Including submersible pump)	3 Wells			■	■		
(2) Distribution facility							
・Water level indicator	2 Sets			■			
・Water wagon	3 Cars		■				
・Water cart	2,792 Sets		■				
・Water kiosk	10 Units				■	■	
①G-1 area	(2)				(2)		
②G-2 area	(3)				(3)		
③G-3 area	(5)					(5)	
・Pipe-line (Φ150～250)	3.9 Kms				■	■	
①G-1 area (Φ150～200)	(1.0)				(1.0)		
②G-2 area (Φ150)	(1.0)				(1.0)		
③G-3 area (Φ150)	(1.9)					(1.9)	

4.7 DISBURSEMENT PLAN

According to implementation schedule, the proposed disbursement of the project is shown as follows.

Disbursment Plan

(Unit : US Dollar)

Work Item	Nos	Year 2000 - 2005						Total Cost
		2000	2001	2002	2003	2004	2005	(2000~2005)
A. Direct Construction Cost	-		144,936	186,038	181,815	117,320		630,108
			50,400 | 94,536	162,519 | 23,520	114,474 | 67,341	55,074 | 62,246	0 | 0	382,466 | 247,642
(1) Intake facility								197,308
·Reconstruction of existing well	3 Wells			131,539	65,770			197,308
				115,274 | 16,265	57,637 | 8,133			172,910 | 24,398
(2) Distribution facility								432,800
·Water level indicator								
① Electrode	2 Sets			6,694				6,694
				6,586 | 108				6,586 | 108
② Transmit Cable	1 Lot			47,805				47,805
				40,659 | 7,146				40,659 | 7,146
·Water wagon	3 Cars		52,800					52,800
			50,400 | 2,400					50,400 | 2,400
·Water cart	2792 Sets		92,136					92,136
			0 | 92,136					0 | 92,136
·Water kiosk	10 Unit				25,530	25,530		51,060
					0 | 25,530	0 | 25,530		0 | 51,060
·Reservoir	2 Ponds							0
								0 | 0
·Pipe-line (Φ150~250)	3.9 Km							
① G-1 Area	(1.0Km)				38,540			38,540
					25,652 | 12,888			25,652 | 12,888
② G-2 Area	(1.0Km)				51,975			51,975
					31,185 | 20,790			31,185 | 20,790
③ G-3 Area	(1.9Km)					91,790		91,790
						55,074 | 36,716		55,074 | 36,716
B. Land Acquisition Cost	-	0	0	0	0	0	0	0
C. Construction Cost (A X 1.25)	-	0	181,170	232,547	227,268	146,650	0	787,635
D. Design & Supervision (C X0.1)	-	9,059	20,686	22,991	18,696	7,333	0	78,764
·Detailed Design (C x 0.05)	-	9,059	11,627	11,363	7,333	0	0	39,382
·Surpervision (C x 0.05)	-		9,059	11,627	11,363	7,333	0	39,382
E. Physical Contingency {(C+D) X 0.15)}	-	1,359	30,278	38,331	36,895	23,097	0	129,960
Total (C+D+E)	-	10,418	232,134	293,869	282,859	177,080	0	996,359

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

2) ① ② ③ ① Total ② Foreign Portion ③ Local Portion

4.8 OPERATION AND MAINTENACE COST

(1) General

Daily operation and maintenance have been conducted by APSD. The improved facilities shall be also managed by the existing organization of APSD, which naturally requires some expense.

(2) Operation and Maintenance Cost

Annual Operation and Maintenance (O/M) consist of the following items:

① Electric consumption
② Chemical consumption
③ Labor cost
④ Repairing cost
⑤ Replacement cost

The annual average O/M costs after the completion of each construction works without replacement cost (as of 1998) are estimated below.

Annual Operation and Maintenance Cost

Item	Unit	Year (2000-2005)						Total
		2000	2001	2002	2003	2004	2005	
Daily Mean Demand	m3/day	1,011	1,037	1,063	1,089	1,114	1,140	
Hourly Maximum Demand	m3/h	86.4	95.6	104.9	114.1	123.3	132.5	
1. Electric Power Cost (US$0.126/KwH)	US$/Year	32,600	37,173	37,699	31,213	31,558	31,917	202,160
・Electric Consumption	KwH/Year	258,727	295,022	299,198	247,726	250,463	253,310	
①Intake Pump (Existing)	KwH/Year	162,367	166,542	170,718				
②Intake Pump (Reconst. & New)	KwH/Year				119,246	121,983	124,830	
③Distribution Pump (Existing)	KwH/Year	96,360	128,480	128,480	128,480	128,480	128,480	
④Distribution Pump (New)	KwH/Year							
2. Chemical Cost (US$0.34/Kg)	US$/Year	916	939	963	987	1,009	1,033	5,847
・Chemical (Cl_2) Consumption	Kg/Year	2,693.81	2,763.09	2,832.36	2,901.64	2,968.25	3,037.53	
3. Personnel Cost	US$/Year	10,598	10,598	11,771	11,771	13,456	15,141	73,335
4. Repair Cost (1% of Const.-Cost)	Lot	0	0	1,812	4,137	6,410	7,876	20,235
Total Annual M & O Cost	US$/Year	44,113	48,710	52,245	48,108	52,433	55,967	301,576

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00 = Tg 890

The equipment shall be periodically replaced at the end of its life span. The detail replacement cost are shown in the following table.

Replacement Cost

Unit : US Dollar

No	Work Item	Unit	Life Span	Year (2000-2005)						Total
				2000	2001	2002	2003	2004	2005	
1	Intake facility (Exist. & New)					164,423	82,212			246,635
	・Well	Year	15			30,660	15,330			45,990
	・Pump house	Year	40			6,710	3,355			10,065
	・Intake pump	Year	15			116,531	58,266			174,798
	・Collection pipe	Year	25			10,522	5,261			15,783
2	Distribution facility	Year			181,170	68,124	145,056	146,650		541,000
	・Water level indicator	Year	15			68,124				68,124
	・Water wagon	Year	10		66,000					66,000
	・Water cart	Year	15		115,170					115,170
	・Water kiosk	Year	40				31,913	31,913		63,826
	・Pipe-line (Φ150~250)	Year	25				113,143	114,738		227,881
3	Total of Replacement Cost	-	-		181,170	232,547	227,268	146,650		787,635
	Every 10 Years				66,000					66,000
	Every 15 Years				115,170	215,315	73,596			404,081
	Every 25 Years					10,522	118,404	114,738		243,664
	Every 40 Years					6,710	35,268	31,913		73,890

Note 1) Exchange Rate : US$ 1.00 = Yen 117.5 US$ 1.00= Tg 890

4.9 IMPROVEMENT PLAN FOR SANITATION

It is required to improve the existing sewer and waste water treatment capacity in the central area to cope with the increase of waste water after water supply facilities are expanded in 2005 and 2015.

At the same time, much more waste water from ger dwellers will be discharged to the ground after the improvement of water supply system. However, there is not any facilities to collect and treat the waste water in the ger area. Consequently, it is also required to install personal or community treatment facilities to prevent contamination of soil, groundwater, and the environment in ger area until the establishment of collection sewer system connected to the central treatment plant.

The following sanitary zones should be established to protect the sources of domestic water:

I - (100 m) strictly prohibited zone.
prohibit setting up of any sources of possible pollution in the I-zone

II - (300 m) zone under protection.

III - (1,000 m) monitoring zone.

It should be carried out bacteriological and chemical analyses in these zones.