CHAPTER 4 CURRENT SITUATION

4.1 Natural Condition

4.1.1 Topography, Geology and Hydrogeology

(1) Topography

Topo-map of 1:100,000 scale near around Mendefera is shown as Figure 4.1.1 (made by USSR in 1977). As shown in the Figure, Mendefera situates on the corridor-like narrow plateau in NNW-SSE direction (referred as Mendefera plateau). Both sides of the corridor are quite steep cliffs dissected by the Mereb on eastern side and by the tributaries of Oblow River on western side. Ground surface on the plateau is very gently undulated and several remaining hills are scattered here and there. Most of those hills, excepting vary small ones, have flat top and rather steep slopes surrounding. Villages in this area are existing on these hills, in most of the cases.

A minor tributary of the Mereb, named Mai Takhala, flows down to SSE along almost center of the corridor. While, the main flow of the Mereb forms vast flat plain at the east of the Mendefera plateau. Several small streams join into the tributary on the plateau. Among them, major two streams are Mai Chiare and Mai Aron. The former is flowing in the eastern part of the plateau and joins to the tributary at 3.5km SSE of Mendefera, and the later is flowing in the central part of the corridor joining to Mai Takhala at about 2km west of the town. Elevation of the central part of the town is around 2,010m.

(2) Geology

The plateau-forming Tertiary basalts, of which the thickness might be several 100m, are exposed over a wide range in this area, as shown in Figure 4.1.2, Geological Map of the area. Precambrian basement exposes only in the flood plain of the main Mereb, far northwest of Mendefera. Thin alluvial sediments of about 2 – 6m thick occur along the said several streams' flood plains on the plateau and in the river route of the Oblow.

According to the lithological log of BH-6 (code number in the Inventory, drilled by Sector Study on National Water Resources and Irrigation Potential), the weathered basalts occur up to a depth of 35m and the unconsolidated tuff up to a depth of 61m. Aquifer zone is recognized at depths of 13m in the heavily weathered basalts and at 37m, a composite of weathered tuff. Long-term yield test of the borehole was unlikely to exceed 0.2 lit/sec due to low transmissivity and the shallowness of inflow layers.

As per the lithology of borehole BH-10 (BH No.2 under the mentioned Sector Study, at southern outside of Figure 4.1.1), the lateritic sediments accumulate up to a depth of 19m. The volcanic succession of the weathered basalts, tuffs and clay accumulates up to a depth of about 69m, and the massive basalts over the depth of 69m. The volcanic succession at this borehole proved to be non-productive.

(3) Hydrogeology

Hydrogeological situation of Mendefera site was arranged and presented as Hydrogeological Map, attached in the Report (Appendix-C).

Figure 4.1.1 Topographic Map -Mendefera-

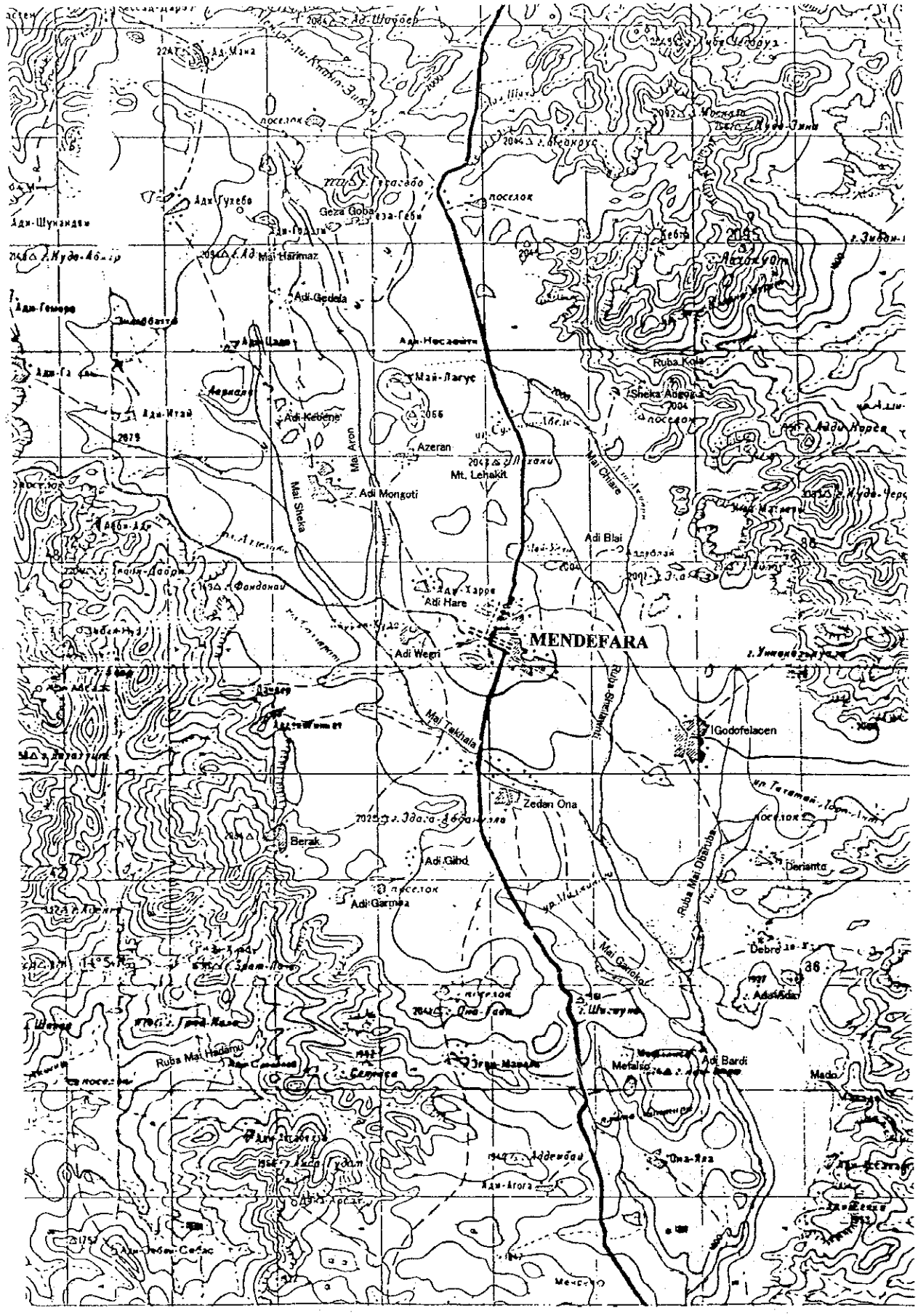
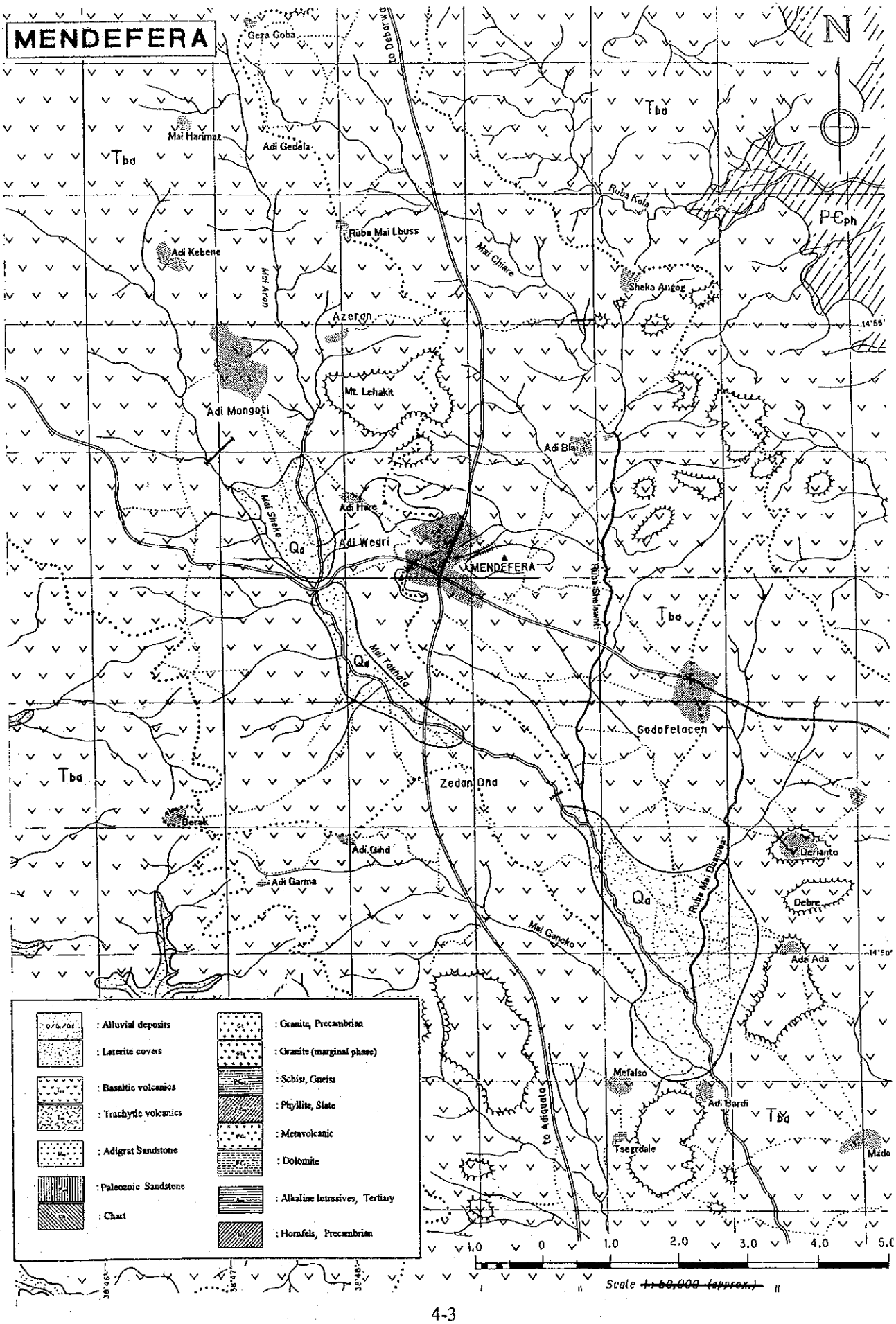


Figure 4.1.2 Geological Map



Most of the area, the Mendefera plateau in other word, is a catchment area of Mai Takhala. Since the configuration of the plateau surface is concave in general, the watersheds of the catchment run along both edges of the plateau, in almost parallel each other. Further, the total catchment of Mai Takhala can be divided into two major sub-basins: Mai Takhala and Mai Chiare sub-basins.

Almost all of the area, excepting northwest hedge of the area, is underlain by Tertiary basalts. That means, a major aquifer in the area is to be a fissure aquifer type of basaltic volcanics, classified into c-i, associated with aquiclude consisted of fresh basalts. Alluvial deposits along Mai Takhala are usually less developed, so that there is no alluvial aquifer (d-i) but combined aquifer with basaltic aquifer, shown as d-i/c-i. While, alluvial deposits in the main Mereb or the Oblow basins are possibly forming an alluvial aquifer.

Fissured aquifer in basaltic volcanics is reported to have moderate permeability and high productivity. In fact, BH-4 and BH-5, those are current water resources of Mendefera water supply, showed 6.0 and 2.0 lit/sec of yields respectively, at the pumping test immediately after the drilling. However, Test Well MEN-1 drilled under the Study showed only 2.0 lit/sec of yield and MEN-2 yielded less than 1.0 lit/sec of water. These facts, and general property of the basaltic volcanics, suggest that groundwater is easily contained in the fissures or tuffacious parts in the layer but these aquiferous zones exist locally and are hardly continuous for wide area. That means in the same time, a siting for well drilling is rather difficult.

4.1.2 Meteorology and Hydrology

(1) Meteorology

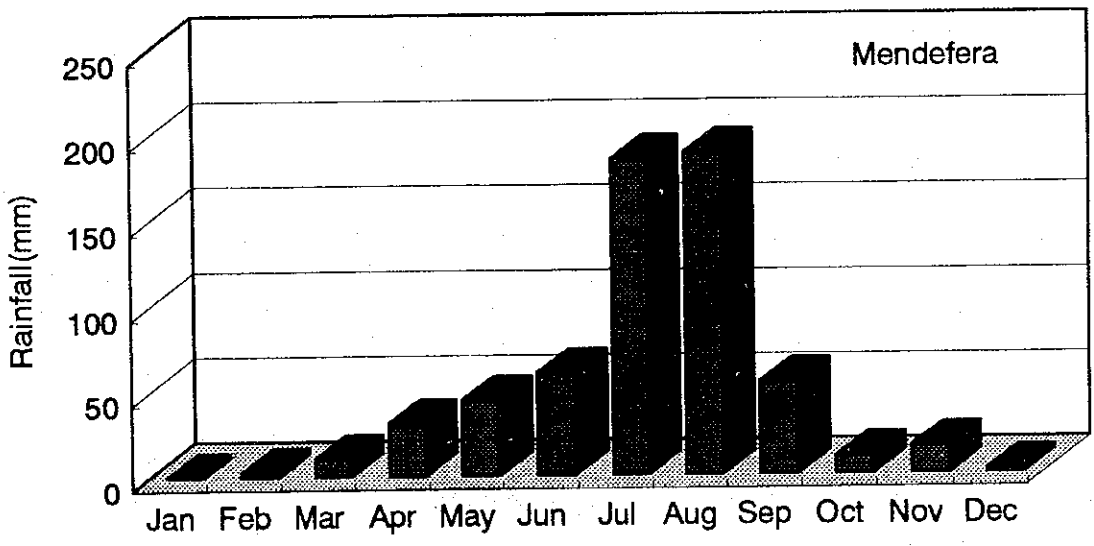
There is a first class meteorological station (MOA) in this regional headquarter. An average monthly temperature varies from 15 to 21°C. An evaporation varies between 5 to 7.5mm/day, and an annual rainfall is about 612mm. Most of them occur in the months of July and August, about 186mm and 190mm of monthly rainfall, respectively. In October of 1997、unusual rainfall was recorded in this sub-region as in the other sub-regions. The monthly total was found as 209mm, historical records show that the highest rainfall in October was only 55.0mm (1931). Monthly averages of meteorological data are presented in Table 4.1.1 and monthly rainfall pattern is presented in Figure 4.1.3.

Table 4.1.1 Meteorological Data

Month	Temperature (°C)	R.H. (%)	Windspeed (m/sec)	Pan Evapo. (mm/day)	Sunshine (hr/day)	Rainfall (mm)
Jan	16.3	75	1.5	5.4	10.8	0.5
Feb	17.3	68	1.6	6.7	10.4	3.3
Mar	20.7	59	1.7	7.0	10.7	10.9
Apr	19.2	70	1.8	7.5	11.1	31.3
May	19.3	65	2.0	6.0	12.3	44.8
Jun	19.1	64	1.9	5.4	11.2	60.5
Jul	15.5	98	1.8	5.6	8.8	185.8
Aug	15.4	95	1.8	4.6	7.2	189.9
Sep	17.1	78	1.7	5.1	9.7	54.6
Oct	16.9	86	2.1	6.3	11.4	10.7
Nov	16.3	89	1.4	5.5	10.6	16.4
Dec	15.6	83	1.3	5.5	10.7	2.8
					Total	**611.5**

Data source: Sector Study Report (ref. FAO), MOA and WRD

Figure 4.1.3 Monthly Rainfall Pattern



(2) Hydrology

Although there are some streams running in and around the town such as Mai Takhala, Mai Aron, Mai Chiare, but none of them has a constant flow. They only facilitate local drainage during the rainy season. There are about 14 micro dams in this sub-region and a list of them is presented in Table 4.1.2. Among them, Kilowlie dam constructed on Mai Chiare is used for the partial fulfillment of town's water supply. The other prominent dams are Zeban Una, Dander-Ghenet, Egri-Mekel, Mai Aron and Adi-Mongoti. They are mainly used for irrigation and livestocks. As in other areas, the dams are suffering severely from sedimentation problem. Especially, Adi Mongoti Dam has lost its capacity almost completely.

During the field visit it was reported that all of those, except Mai Aron Dam, dry up if there is not enough rainfall in the rainy season.

Table 4.1.2 List of Existing Micro Dams

Sl. No.	Village Name	Const. Year	Agency	Capacity (cum)	Remarks
1	Adi Mongoti	1985	MoA	1,000,000	H.S.
2	Mai-Aron	1985	MoA	715,000	RGC
3	Derco	1985	MoA	242,000	RGC
4	Kilowelie	1986	Cath. Sec.	550,000	Silted
5	Zeban-Una	1986	LWF	400,000	Silted
6	Taakia	1987	MoA	80,000	Silted
7	Geza-Gobo	1988	MoA	135,000	RGC
8	Kudo-Felsi	1988	MoA	62,620	H.S.
9	Adi Hezbai	1988	MoA	60,000	Silted
10	Adi Angua	1988	MoA	200,000	H.S.
11	Egri Mekel	1988	LWF	350,000	H.S.
12	Dander Ghenet	1989	MoA	100,000	H.S.
13	Haser Ablo	1992	MoA	250,000	Silted
14	Adi Abisa	1992	MoA	1,139,000	Silted

Source: MoA
LWF: Lutherian World Fund, RGC: Relatively good condition, H.S: Highly silted

4.1.3 Hydrogeological Investigation and Groundwater Monitoring

(1) Hydrogeological investigation

To identify the water resources available for each target township, to evaluate the potential of those water resources, and to obtain basic data needed to formulate a water resources development plan, a series of hydrogeological surveys were conducted. To minimize the survey period and to maximize the outputs of the survey, the hydrogeological survey must be conducted systematically, from the wider area to the local; extensive to intensive; and general to special. Thus, the hydrogeological surveys in this Study flew as follows:

1) Regional geological study:

To grasp the geological conditions/structures of the area and to select the following geophysical prospecting site(s), through a review of existing data/information, aerial-photo interpretation, and an actual field reconnaissance survey.

2) Geophysical prospecting:

To analyze the resistivity structure of the ground and interpret the geological/hydrogeological relations, to select the most suitable drilling point for test or observation well(s), through VLF-EM, horizontal geoelectric sounding (HS), and/or vertical geoelectric sounding (VES).

3) Test well drilling:

To obtain exact geological/hydrogeological information of the site and to know the aquifer potential through well drilling, borehole logging, pumping test, and water quality analysis. Further, to get data on time-series groundwater level fluctuations through setting automatic water level recorders into the wells.

4) Total analysis:

To analyze the geological and hydrogeological conditions of the target areas, to identify the available and suitable water resources, and to evaluate their resource potential for long-term development, through comprehensive analysis, examination and consideration of the results of the above mentioned field surveys.

The details and results of each investigation work were already reported as "Field Investigation Report", as a separated volume of the Interim Report, and quite roughly but the work volumes and results of them are summarized and presented in Appendix-C, excepting the parts explained in the following clauses.

(2) Groundwater monitoring

After completion of the Test/Observation Well drillings, an automatic water level recorder was installed in MEN-2, 3, and 4. The measurement was commenced on March 7. It is still continued but the records until June 11 were withdrawn and analyzed (the records are attached in Appendix). The groundwater monitoring period since early March to middle June corresponds to the end of dry season through the beginning of rainy season. That means, the water level comes down to the lowest level in a year and starts recovering, as a general tendency. Nevertheless, the water level recorded was quite steady, fluctuating within only 1.0cm range throughout the record. It suggests the water level around 5.0m below ground level is the lowest water level in a year, and the yearly fluctuating is not so much because of the vast extension and storativity of the aquifer. In any rate, it is too early to make a conclusion on the groundwater hydrograph and aquifer condition. One year of continuous monitoring shall be required to make severe examination on groundwater hydrograph.

(3) Recharging effect of surface dam

For the purpose to examine the recharging effect of a surface dam, two Observation Wells were drilled at just downstream of the Kilowlie Dam, and the groundwater monitoring has been carried out through an automatic water level detector as mentioned above. A staff gauge was set in the reservoir near the western end of the embankment, for the same purpose. And during the Study period, water level of the reservoir was measured periodically. The measurement is still continued by the counterpart agency, and the records till the middle June are shown in Appendix.

Although it is still early to make any comment on the study, but the data collected so far (only three months) suggest the groundwater level at the downstream of the dam (MEN-3 and 4) has almost no relation with the water level of the dam. Further, the water level fluctuations of these Observation Wells have also no relation, no same tendency. The facts suggest, the dam has no recharging effect or ever recharged groundwater but clogged already by silting, and the aquifer in this area is not continuous. In any rate, the study shall be continued by the counterpart agency, at least one hydrological year.

4.1.4 Water Resources

(1) Existing water resources

Many boreholes and dug wells exist along Mai Chiare and Mai Takhala. All of existing wells, both boreholes and dug-wells, were checked and arranged into Well Inventory associated with their location map. These are attached in Appendix-C, and only a copy of the location map is presented here as Figure

4.1.4. As the Inventory said, and as shown in the figure, there are 13 wells in total, 3 of dug-wells and 10 of boreholes.

Current public water sources of the town are those three of dug-wells and two boreholes of BH-4 and BH-5. Among those three of dug-wells, two wells are located at the downstream of Kilowlie Dam, and another situates at the downstream of Mai Aron Dam. Groundwater in those wells are utilized through water tankers and by manpower directly. While, the boreholes are used as water sources of pipe-born water supply system of Mendefera, installed submergible pump.

Besides those water sources, one borehole (BH-7) is out of use now, one is dry (BH-11), and most of others are capped (unknown reason). Only BH-8 equipped with a hand-pump is still on work now.

(2) Test wells

Both Test Wells and Observation Wells were drilled in Mendefera. The locations of them are shown in Figure 4.1.4, together with existing wells. Hereafter, the results of Test Well drilling, those are expected as new water sources, are roughly explained.

MEN-1

0 – 0.5m	Top soil, dark brown.
0.5 – 63.0m	Basalt, alternation with hard fresh rock and weathered crack rich phases, crack rich at 16-22m and 28-32m spans, heavily weathered from 48 to 51m, black.
63.0 – 71.0m	Pyroclastic, unconsolidated and gravelly, brown to reddish brown.
71.0 – 79.0m	Basalt, upper 3m span weathered and crack rich, lowest 3m span fresh and very hard, black.

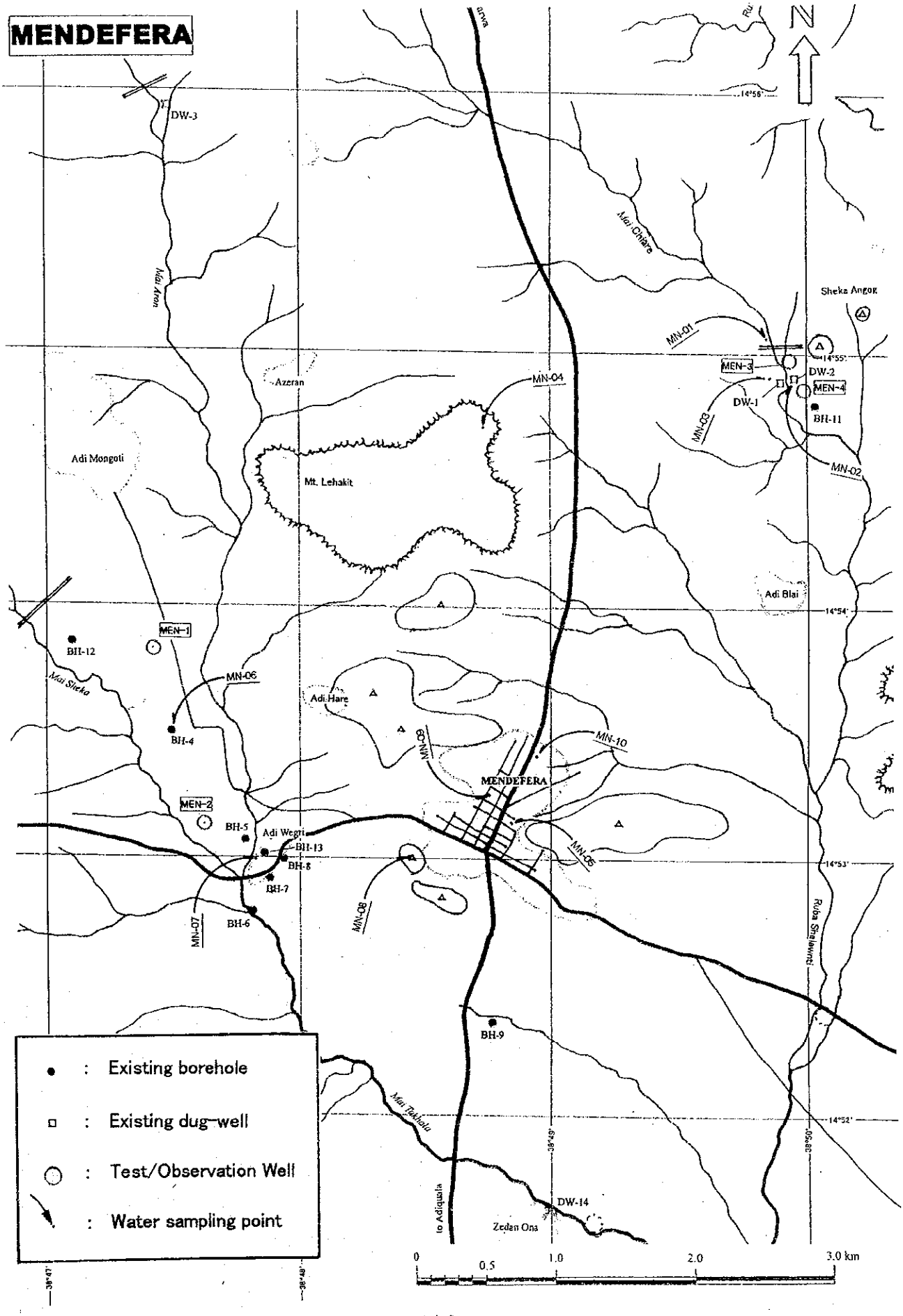
MEN-2

0 – 4.0m	Top soil, black.
4.0 – 33.0m	Basalt, mostly fresh excepting uppermost 2m, slightly weathered and crack rich from 10 to 16m, black to brownish black.
33.0 – 38.0m	Tuff, weathered into sticky clay like phase, brown.
38.0 – 70.0m	Basalt, mostly fresh and hard, intercalating thin tuff at around 62m depth, very hard at the lowest 3m, black.

In MEM-1, groundwater was detected at 6m in depth. Then, the yield increased at 28m and slightly but increased at 48m, both of them were crack rich weathered zones. Finally, the yield increased to almost double (total around 2.2 lit/sec), through drilling the pyroclastic from the depth of 63 to 71m. Screens were set at three spans of 16-22m, 28-34m and 43-73m. Based on the result of step draw-down test by 1, 2, 3, 4 and 5 lit/sec of step pumping rates, a constant discharge test at the pumping rate of 2.0 lit/sec was carried out for 48 hours, followed by 25 hours of recovery test. The results are presented in Appendix-C. Transmissivity obtained through the test was quite low as 2.5 m^2/day.

In MEM-2, groundwater was obtained at 16m and 62m in depth, however, the yield of both crack rich zones were only 0.1 lit/sec, total 0.2 lit/sec by simple air-lift measurement. Thus, the following pumping test was omitted.

Figure 4.1.4 Location Map of Water Resources



4.1.5 Water Quality

In order to know the water quality of current water supply system, samples from ten points were collected, and their physical, chemical and bacteriological qualities were analyzed in the laboratory of WRD. The samples include the main source of water, vicinity of the main source, dug-well, public fountain, house connections, etc. The location of the sampling points is presented in Figure 4.1.4, together with all water sources.

It was reported that the water quality of this sub-region is generally good. However, the results of the analyses show that two samples (MN-06 and MN-08) were found as hard-water group and one sample (MN-01) was found with high iron concentration. Moreover, four samples were found contaminated with *faecal coliform bacteria*. However, this contamination may have occurred due to the inflow of rain water from surrounding areas into the sample source at/or just before the time of sample collection. The results of the analysis are presented as Table 4.1.3, and arranged as Piper Diagram as shown below (Figure 4.1.5).

Figure 4.1.5 Water Quality of Mendefera Area

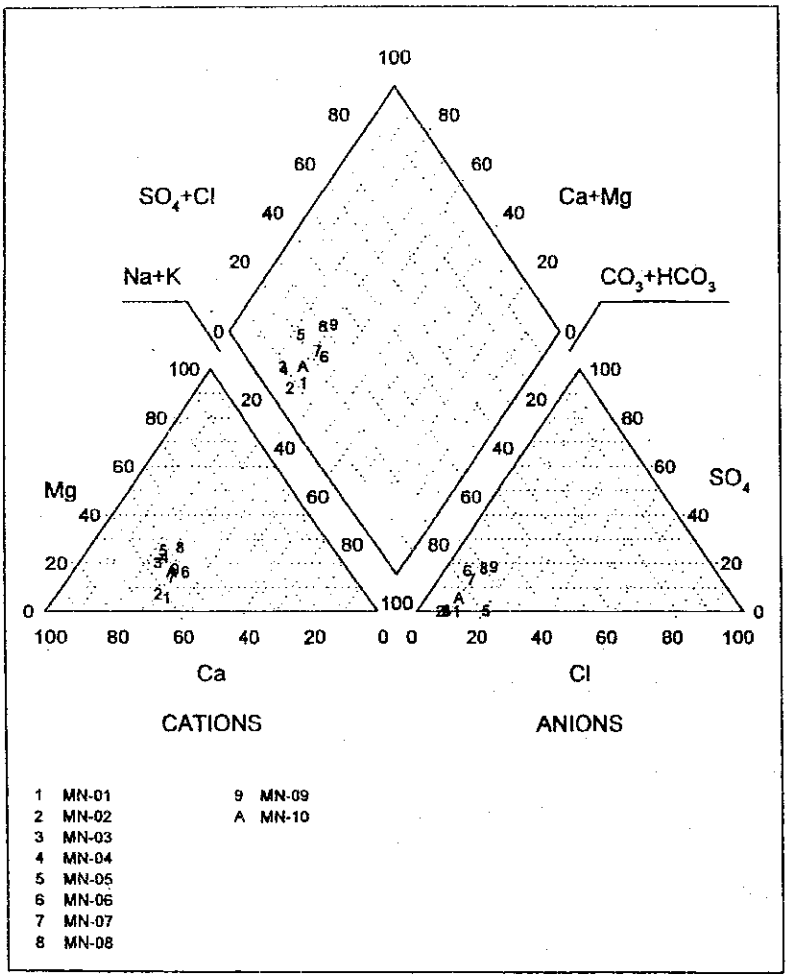


Table 4.1.3. Water Quality in Mendefera

I.Physical Quality

Date Sampled 30/09/97

Date Analysed 01/10/97

II. Bacteriological Quality

T.C.B = Total Coliform Bacteria

F.C.B = Faecal Coliform Bacteria

Well	Description	EC	pH	Temp	Odor	Taste	Turb.	Color	T.C.B	F.C.B	Remarks
Ident		us/cm		°c			TU		count/100ml,35°c	count/100ml,44.5°c	
MN-01	Dam, Kilowlie	152	7.5	23.0	agreeable	disagree	150	muddy	4	0	Safe
MN-02	HDW, Kilowlie, not concrete	577	6.9	27.9	agreeable	agreeable	<5	clear	0	28	contaminated
MN-03	Underground reservoir, Kilowlie	403	7.2	23.0	agreeable	agreeable	<5	clear	8	0	Safe
MN-04	Main Reservoir, 500 cum	377	7.2	28.1	agreeable	agreeable	<5	clear	2	26	contaminated
MN-05	Public tap	560	7.2	22.5	agreeable	agreeable	<5	clear	2	20	contaminated
MN-06	BH, Sub.Pump, Adimongoti	1091	7.1	25.6	agreeable	agreeable	<5	clear	0	0	Safe
MN-07	Underground Reservoir at Konel	977	7.2	25.5	agreeable	agreeable	<5	clear	5	0	Safe
MN-08	Reservoir at Forto	1044	7.1	23.0	agreeable	agreeable	<5	clear	2	0	Safe
MN-09	Consumer's Tap	458	7.3	26.7	agreeable	agreeable	<5	clear	0	many	contaminated
MN-10	HDW, Private, Alimuth	622	7.0	24.2	agreeable	agreeable	<5	clear	5	0	Safe

III.Chemical Quality

Date Sampled 01/10/97

Date Analysed 14/10/97

Well	Description	Ca	Mg	Na	K	Fe	Mn	HCO3	SO4	Cl	NO3	N-NH3	NO2	F	Hard.
Ident		mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	*G.d.h
MN-01	Dam, Kilowlie	17	1	9	3.0	0.41	0.0	73	0	6	0.0	0.77	0.04	0.01	2.7
MN-02	HDW, Kilowlie, not concrete	72	5	39	2.2	0.01	0.0	305	0	14	30.1	0.45	0.05	0.27	11.2
MN-03	Underground reservoir, Kilowlie	46	10	21	2.2	0.09	0.0	200	0	12	6.2	0.35	0.02	0.00	8.7
MN-04	Main Reservoir, 500 cum	43	11	22	1.8	0.02	0.1	212	1	12	1.4	0.05	0.02	0.25	8.6
MN-05	Public tap	58	17	26	2.2	0.03	0.1	256	1	40	6.2	0.10	0.01	0.26	12.0
MN-06	BH, Sub.Pump, Adimongoti	105	21	78	10.1	0.01	0.0	464	80	26	11.5	0.51	0.03	0.10	19.6
MN-07	Underground Reservoir at Konel	90	14	55	5.7	0.21	0.0	393	53	30	42.5	0.43	0.01	0.21	13.0
MN-08	Reservoir at Forto	95	33	64	2.2	0.01	0.0	405	80	40	20.8	0.54	0.01	0.22	20.9
MN-09	Consumer's Tap	104	21	68	2.6	0.01	0.0	437	95	56	18.2	0.71	0.07	0.24	19.3
MN-10	HDW, Private, Alimuth	65	12	40	1.8	0.00	0.1	290	15	20	19.5	0.16	0.04	0.27	11.8

* G.d.h= German degree of hardness, 1G.d.h= 17.9 mg/l hardness as CaCO3

* Note: HDW = Hand dug well

4.2 Socioeconomic, Water Supply and Sanitation Condition

4.2.1 Socio-economy and Gender Issue

(1) History and population

The Italians established Mendefera for their military garrison in the early 1930's. Presently, because of its central location, it has become the capital city of Debub Region and as such it is a booming town with a lot construction going on for government offices, hotels and all kinds of establishments. With the completion of the master plan of the town and the subsequent allocation of plots of land for dwellings and businesses, the already inadequate town utilities will be over-stretched.

The current population figure of Mendefera is 20,371 comprising of 46.6% males and 53.4% females. Adequate data on age structure does not exist, but it is fair to assume that it will not be any different from the other towns where there is a large dependent population. In terms of ethnic composition, 98.2% are of Tigrigna ethnic group while that of Saho is 1.2% and few Tigre ethnic group. An estimated 74.1% of the inhabitants profess Christianity while Moslems account for 23.4%.

According to the information provided from the town administration, the perceived occupational classification of the residents looks as follows: 6.3% civil servants, 6.5% traders, 36.7% unemployed, 4.7% daily workers, 44.2% students, 1.1% farmers and 0.5% pensioners. There are big and relatively well to do traders and shop-owners as well as small ones who live in the surrounding villages. Mendefera town administration currently has in its list 773 licensed micro and small-scale enterprises classified into manufacturing (23); trade and distribution (531); hotels, restaurants, tea rooms, etc. (92); service establishments (51); local drinks brewers (75); and others (2). Most of these are one person establishments. There is market every day but Saturday is the big market day when many sellers and buyers come from far away places. In the town, there are 41 regions administration, sub zoba and line ministry offices as well as 10 non-government offices.

Mendefera has the largest concentration of students and schools of all the seven towns under study. There are altogether 22 schools (3 kindergartens, 14 primary, 4 junior and 1 senior secondary school) enrolling a total of 15,120 students with 123 teachers. The percentage distribution of enrollment in the different levels of education amounts to 1.8%, 67.6%, 13.7% and 16.8% respectively.

(2) Social and gender issues: Analysis of the result of the survey

a) Household characteristics

The average household size for the town of Mendefera is 5.5. Female headed households comprise about 39%. In terms of ethnic composition, the great majority are from the Tigrigna ethnic group who profess the Christian faith. There are about 9% ethnic groups that are classified as others and according to administrative sources, they are non-Eritreans. Within the Tigrigna population, 30% are Muslims and the rest Christians (Appendix A, Table 4.1).

b) Occupation

In this town, the major source of employment for heads of household is commerce (31%) followed by daily laborers (17%) and Government (15%). When male and female heads of households are

looked separately, female headed households' main source of employment is commerce (34%), followed by daily laborers (20%). About 21% of the households responded that they are unemployed of which women constitute (36%). For men the major sources of employment are in commerce, Government and daily labor. According to the respondents, agriculture is virtually not a major source of employment for the residents of Mendefera (Appendix A, Table 4.2).

c) Agriculture and land

Only 7% of the households of this town own livestock, and another small (3%) own agricultural land. As compared to the residents of Debarwa, Mendefera residents own six chickens per household (Appendix A, Table 4.3).

The average income of a typical household in Mendefera is Nfa 774 per month. Females earn almost half of that of males. Those engaged in animal husbandry earn an average income of Nfa 1336 per month, followed by those who are engaged in commerce, others and Government. The category of other occupation is the third highest earner to household income and is believed to include activities like private quarrying and non-formal sector activities. The reported earning of the unemployed (Nfa 588) is also quite high as compared to, say to, one of the major employers like agriculture which is a low of Nfa 492. When income is compared with ethnic and religion background, one finds that Christians earn higher income than their Muslim brothers (Appendix A, Table 4.4).

d) Household income and expenditure

The composition of the town's households by income group and the percentage share of expenditure on some basic items of household expenditures is presented in Appendix A, Table 4.5. About 11% of the households are reportedly earning less than Nfa 299 per month. The majority of the households (37%) earn between Nfa 600 – 999, those who earn Nfa 300 – 599 (29%) are also quite numerous. Overall, those who are over the income bracket of Nfa 600-999 are about 60% a percentage quite high compared to the estimated per capita GDP. Looking at the expenditure column of the table reveals that 40% the income of households is spent on food and beverages, followed by electricity and energy (13%). The fact that almost equal amount of expenditure is allocated for clothes and footwear, and travel/culture is somewhat puzzling because one expects an increase in the allocation of expenses for the former item. The share of water in the expenditure schedule is even much smaller than that of Debarwa.

e) Household level of education

With regards to the education status of the households, there is a reported 100% student attendance of school age children of households and a 63% literacy rate. The educational status of the head of households reveal that 51% have completed six years of schooling (primary level), 15% completed eight years of schooling (junior secondary level) and 16% senior secondary school. This rather high percentage may be the result of the abnormal situation in the prior years. That is, those who had missed schooling in the early years of independence could have attended classes even if they were over-aged. Those who attended some sort of non-formal education are 13%. College education and above account for 6% (Appendix A, Table 4.6).

f) Women's status and participation in communal activities

Table 4.7 of Appendix A, shows percentage of women's and girls' daily activity in the sample

households. All women in Mendefera are engaged in housekeeping. The major source of employment of women is in commerce (19%), followed by daily labor. Very few women are engaged in Government and tending livestock. Looking at girls' activities, 55% of young girls attend school, 35% of who also assist in housekeeping. Only 3% are engaged in commerce.

Sessions on sanitation, childcare, and water use are the major events participated by the women in the sampled group. Among the women folk there is active participation in most educational sessions. Those who participated in water use and family planning sessions are only 37% and 29% respectively, an aspect that requires the attention of the concerned officials in view of the importance of such sessions to the welfare of women. Of the interviewed households, almost none reported that they attend literacy sessions (Appendix A, Table 4.8).

In Mendefera, there seems to be a very high participation (84%) of sampled households in some sort of community organizations. The clear majority of them (88%) are members of national organizations like the Peoples' Front for Democracy and Justice (PFDJ) and National Union of Eritrean Women (NUEW). Another 71% are members of traditional socio-cultural organizations like (Ekub - traditional savings association, Maheber - traditional social welfare organization, etc.). Virtually, no participation in management of communal water points, communal toilets and cottage industry is reported (Appendix A, Table 4.9).

If we examine the participation of adult women in communal activities, such as, those enumerated in Appendix A, Table 4.10, 33% of the women do not participate in any of the listed ones. On the other hand, 55% of them participate in one kind of meeting or the other and another 33% in soil and water conservation activities and a small percentage of 3% in road building. To the extent that road building and soil and water conservation activities are not voluntary activities, but are part of the national cash-for-work programs, it is difficult to categorize these activities as communal activities. Again Appendix A, Table 4.10 confirms the earlier assertion that there is no participation in voluntary communal water point or communal toilet management. Despite the fact that it is reported that a very sizeable of them participate in sanitation and water education sessions, actual participation in sanitation and communal water point related activities is nil.

The survey result shows that women's participation in formal or national organizations/group is quite high. However, their participation in traditional organizations such ekub and mahber is minimal, suggesting that such traditional organizations are dominated by men.

g) Problems of Mendefera residents

Shortage of income (55%) seems to be the major source of households' response to the type of problem they face, and it is more pronounced on women rather than men. The next ranked problem is shortage of water, where 23% of the males are affected as opposed to 14% of thew women. The third highest problem is lack of sanitation. Most respondents seem to be satisfied with the health and school services provided in the town (Appendix A, Table 4.11).

Ranking of the first three households' problems related with the existing water supply facility show that distance to water source is first followed by poor quality of water and high water tariff. They also reported that water is not adequate, there is long queuing and of deteriorating water facilities. Even though the first complaint is distance from water source, none of the households reported that hired labor for fetching water is a problem (Appendix A, Table 4.12).

h) Affordability

Of the sampled households, those group whose income is less than Nfa 299, can afford to pay up to Nfa 10-14 per month for water. Within this income group, only 6% responded that they could afford to pay less than Nfa 5 per month and another 5% Nfa 5-9 per month. A total percentage of all income groups (49%), except the less than Nfa 299 income group, can afford to pay between Nfa 10-14 (Appendix A, Table 4.14).

Unlike the residents of Mendefera, the interviewed households in Mendefera whose income is less than Nfa 299 said that they can afford to pay up to Nfa 4-6 per month for community toilet. A total of the income group Nfa 300-599 (10%), 1000-1499 (10%) and above responded that they can afford Nfa 4-6 and Nfa 10-14 respectively. Of the income group of Nfa 300-599, 19% responded that they can afford to pay from Nfa 2-3, and another 10% said they could afford between Nfa 4-6 each month. Looking down at the column of Appendix A, Table 4.15, one observes that 32% of all income groups responded that they can afford to pay up to Nfa 10-14 per month. Another 26% and 23% said they could afford Nfa 2-3 and 4-6 each month respectively every month. It seems therefore, that overall, the residents of Mendefera are more willing and can afford to pay for community toilets when compared to the Debarwa residents.

i) Communal water points

The respondents of the sample households of the town that travel less than 90m to the nearest communal water point account for only 36% which, is quite a distance compared to the previous town we have seen. In fact, an equal percentage travel a distance of 200-399m to the nearest communal water point, suggesting the need for more communal water point facilities or yard/house connections, if women and the girl child are to be saved from the burden of wasting time in fetching water. Analysing the gender role in fetching for water, it seems that men have nothing to do with it: it is equally shared between the adult women and girls who each reportedly travel almost 15 times per week to fetch for water. A large percentage of the respondents (64%) reported that they are not satisfied with the existing communal water point. When asked about their preference, 64% of them prefer yard connection. A small fraction (14%) responded that they can do with communal water point (Appendix A, Table 4.16).

4.2.2 Water Supply Conditions

The main mode of water services of Mendefera are: (1) private connection, (2) communal water points and (3) water tanker. The domestic consumers by private water connections are 11% of the population. The rest of the population either use public water points or water tanker supply. According to the socio-economic survey conducted house to house and derived from average volume of water consumed, frequency of fetching water and household size the average water consumption by house connection, yard connection and communal water tank is 24, 15 and 10 liters per capita per day (Appendix E, Table 4.2). The amount of water supplied by water tanker at present is about 5000 m^3 per month.

The consumption rate of private domestic customers is increasing at a higher rate. The percentage increase in 1996 and 1997 was 68% and 18% respectively. In a situation were water supply is scarce and distribution is uneven, reselling of water by private tap owners is inevitable. The total amount of water consumed by all modes of supplies as shown in the table has increased annually from 1995 by 44% and from 1996 by 11% (Appendix E, Table 4.1).

About 36% of the communal water point users and all public well users travel 200-400m distance to fetch water (Appendix E, Table 4.3). Among the communal water point users 64% expressed their dissatisfaction with the service. With regard to their preferences, about 21% of those report they prefer and afford house connection and 64% yard connection.

At present there is no community organization which mange the communal water points. Currently the communal water points are managed by the WSS. However, about 50% of the households are favoring community based management for communal water points.

In spite of the capital constraint The Mendefera Town administration has undertaken interim measures regarding the improvement of water supply facilities for the last three to four years. For instance, in 1996 when the well dried up, the Municipality was forced to drill another well. New house connections are given permit for house connections, without restriction wherever the main and secondary pipeline networks are existing. Moreover, the Town administration encourage the new house builders to construct cisterns for rain water harvesting.

Proportion of water supply by pipes and by water vender is estimated nearly 47 percent and 53 percent respectively. Five communal water points and 650 house connections are connected to the distribution pipes. Outlines of water supply system of the town is illustrated in Figure 4.2.1.

As shown in the figure, water of two main sources is transmitted to the town. One is surface water from a dam (Kilowlie dam) located in the northern part of and approximately 4.2 km far from the municipality and the other is underground water from two boreholes located at a western part of and from 1.3 to 2.0 km far from the municipality.

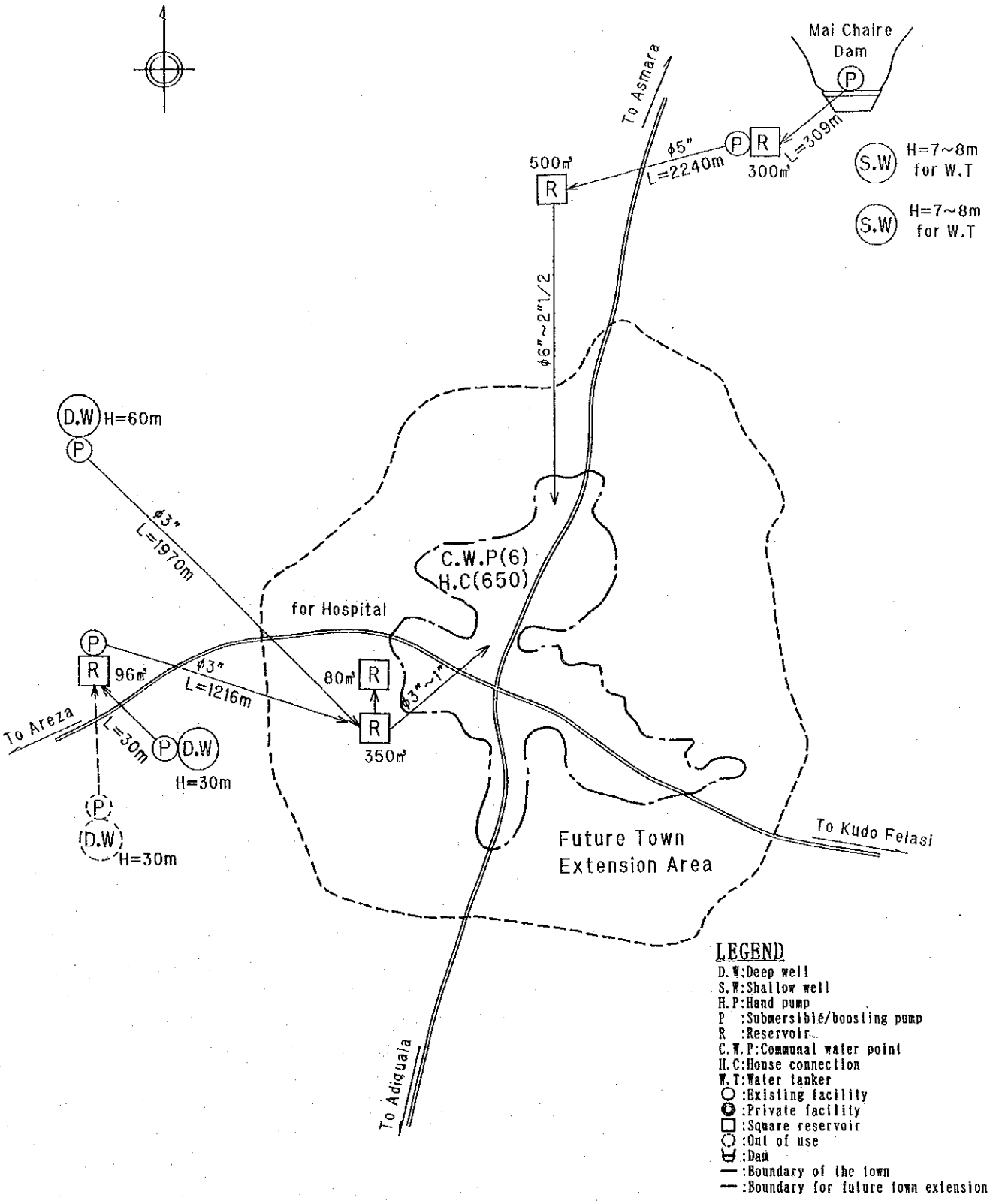
Surface water is collected to the underground reservoir (300 m^3 in capacity) near the dam by a submersible pump set in the dam reservoir and transmitted to the new reservoir (500 m^3 in capacity) on the top of the mountain outside town by two booster pumps (one is stand-by). The booster pumps are operated 10 hours per day. There are two dug-wells beside the dam for drinking water of the town supplied by one water wagon.

As for groundwater, there are several boreholes. One borehole is at approximate 2.0 km far from the municipality and the other near the underground reservoir (96 m^3 in capacity) is 1.3 km far from the municipality. Groundwater is directly transmitted to the old reservoir (350 m^3 in capacity) located on the top of the hill in the town by the submersible pump and the booster pump from the underground reservoir.

Water is distributed from two reservoirs to the town by gravity. The northern new reservoir of 500 m^3 in capacity covers to seven communal water points and the northern part of house connections in the town. Another reservoir of 350 m^3 in capacity covers one reservoir (80 m^3 in capacity) for a hospital and most of house connections. Distribution pipelines from two reservoirs are combined in the town. House connections can be used three days per week and communal water points are used four hours per day except Saturday sand Sundays.

Major problems of the existing water supply facilities are insufficient yield of well, water quality and quantity of the dam storage especially in March and April, the obsolete reservoir of 350 m3 in capacity, insufficient diameters of pipes, damaged communal water points, etc.

Figure 4.2.1 Outline of Water Supply Facility



4.2.3 Sanitary and Health Condition

(1) Public sanitation

Mendefera Town administration provides refuse truck. However, the service coverage is only to accessible areas which is 85% of the town. Each house gets two to three days service a week. Refuse is collected directly from the houses. There is no provision for refuse collection bins or containers in the town.

There is an Italian constructed sewerage system, combined for the sewage and storm water. The town administration of Mendefera, in spite of its budget constraint is maintaining and expanding the system. Open sewers are covered with concrete slabs, and an additional 400m length of pipeline has been installed. More expansion work were planed for 1997.

Four public latrines exist but due to problems in operation and maintenance only two are functional,. The Town administration has plan to construct additional public latrines in Mai Chenawi which is a densely populated area and in the new market which is yet to be constructed. Public service giving establishments such as bars and restaurants most of them have flush latrine. Other retail shops on the other hand do not have latrine facilities. The Municipality however is imposing a new regulation which oblige all establishments to have their own latrine facilities.

The main constraints for the improved sanitation of the town according to the Town administration, is budget to provide the required facilities and for operation and maintenance management. From the communities' side, low sanitation awareness (village habits are not changed) especially in those who migrated from the surrounding rural areas during the last regime, and un-affordability of private sanitation facilities provision are the major constraints.

(2) Private sanitation

In Mendefera there are three types of private latrines: (1) flush latrines with public sewerage pipeline connection, (2) flush or pour latrines with septic tanks and (3) pit latrines. Availability of household latrine in the town is only 50% and dominating type of latrine is flush latrine which is 41% (Appendix E, Table 4.4). During the study period the town administration is conducting a survey on the existing private latrines. The main objective of the survey is though to identify the number of public sewerage pipeline connection users and make them pay for the service they are getting,. For those with septic tanks, a vacuum truck comes from Asmara about once in about six month period on request by the town administration. For the last one and half years, provision of a latrine became compulsory for the newly build houses. There is a technical committee in the town administration whose responsibility is to strictly follow the implementation of the regulation with regard to the new houses construction and give approval for the ownership license. This regulation however, does not apply to previously constructed houses since the issuing of the new license is done by the Commission of Land and Houses.

With regard to conditions of latrine and related behaviors, the latrines as observed by the numerators who conducted the socio-economic survey is not so bad. However, about 53% of the latrine owners said they are not satisfies with the type and conditions of latrines they have, and 53% of them said they prefer septic tank type. If credit system for latrine construction is introduced more than 50% of the communities said they support such promotion program and the average repayment rate they afford is

27Nfa per month. The latrines are located at an average distance of 70m from the nearest water source (Appendix E, Table 4.5).

The main type of material used for anal cleansing are paper, water and stone (86%, 29% and 14% respectively) (Appendix E, Table 4.4).

With regard to waste disposal habits of the community, 95.3% of them said they use the Town administration refuse truck for solid waste and the remaining 4.7% dispose in their surrounding. For wastewater disposal due to the limited coverage of the sewerage system only 34% of the inhabitants have access to the system and only 7.3% are using pit but the majority (57%) dispose in the open field to their surrounding. With respect to animal waste by 80% of the owners use it for fuel. More than 50% of the communities having misconception about infant excreta dispose it in their surrounding.

(3) School sanitation

In Mendefera the government schools' sanitation facilities condition is not satisfactory. The main reason for such poor sanitation facilities condition is mainly misuse and poor management of operation and maintenance. Recognizing the need for school latrines, provisions have been made at different times by different respondents. In some schools a number of abandoned units of latrines with good superstructures are observed. The continuous blockage of latrines led school administrations exhausted by the situation and seem to be given up. The school directors mentioned that the lack of fences and budgets, and students' old habits as the main obstacle in the management of the latrines.

For the details of the condition of school sanitation facilities see Appendix E, Table 4.6.

(4) Hygiene/health conditions

Mendefera has a mini hospital which serves the town and also is a referral for the surrounding rural towns. The statistical data of the hospital show cases of water and poor sanitation related diseases. Among the 96% of the population who visit a physician for treatment, 10-20% are registered annually for water and poor sanitation related diseases. This figure does not include malaria cases which affected 6-13% of the population. The cases however, are decreasing annually (Appendix E, Table 4.7).

On the socio-economic survey conducted house to house, diarrhea, dysentery and malaria at the rate of 8, 7 and 10 person per household respectively are reported sick in six month period from the date of survey, and the infant death is 1.4person per household in 10 years period. The communities by about 96% prefer to visit physician when they are sick, and the average medical cost is about 19Nfa for diarrhea and dysentery and 57Nfa for malaria (Appendix E, Table 4.8).

With regard to hygienic behaviors, the hand washing habit with soap after defecation, before cooking, before eating, after disposal of children stool, and after handling animal dung is 74%, 46%, 43%, 62% and 11% respectively (Appendix E, Table 4.9). Food handling habit is relatively better. About 80% said they place utensils on the shelf, about 87% of them store left over food covered and 100% of the communities wash vegetable (Appendix E, Table 4.10).

With regard to self treatment to water related diseases about 87% of them have the knowledge of ORS preparation. The inhabitants, about 95% of them participated specially by cash, material and labor on community sanitation work (Appendix E, Table 4.11).

4.2.4 Financial Condition of WSS

Water Supply Service (WSS) of Mendefera earned 202,009 Nfa from Jan. to Aug. in 1997, while the expenditures incurred amounted to 179,723 Nfa, or a profit ratio of 11.0%. This ratio is considered a good financial performance.

Water sales by meter and cash accounted for 37.5% and 26.0% of incomes respectively, totaling 63.5%. Salaries and fuel occupied 35.6% and 18.4% of expenditures, respectively, totaling 54.0%.

Numbers of water supply facilities are 650 for house connections, 5 for communal water points and 1 for water tanker. Provision of these facilities in Mendefera is considered better as compared to other 6 towns.

Water tariffs per cubic meter are 1.5-2 Nfa for house connection users, 5 Nfa for communal water point users, 6.25 Nfa for users of water from the water tanker and 7 Nfa for users of water from water vendors. These tariffs are considered low.

Based on the forgoing figures, the water supply conditions in Menderera are better as compared to the other 6 towns.

WSS has 17 workers. Each worker earns an income of 18,978 Nfa, which is high among the 7 towns. The average monthly salary per worker is calculated at 579 Nfa.

The per capita per day consumption of water is 17.5 liters according to the results of the socio-economic survey. This per capita consumption is high.

In conclusion, the per capita consumption of water and labor productivity of WSS are high, while the profit ratio and remuneration are moderate. Water cost is acceptable to consumers.

(1) Population in 1997: 20,371

(2) Financial performance from Jan. to Aug., 1996

Unit: Nfa

Revenues		Expenditures	
Item	Amount	Item	Amount
Water sales by meter	75,712	Salaries	63,969
Water sales by cash	52,491	Per diem	1,938
Rental charge of meters	4,755	Electricity	3,490
Service charge	42,113	Fuel	33,088
Others	26,938	Supply materials	4,983
Total	202,009	Repairs	24,126
		Office supply	477
		Others	47,652
		Total	179,723

(3) Water tariffs

Unit: Nfa/m^3

House connection	Communal water point	Water tanker	Water vendor	Public well
1.5-2*	5	6.25	7	-

Note: *2 Nfa/m^3 is for establishments/institutions.

(4) Number of water supply facilities

House connection	Communal water point	Water tanker	Public well	Private well
650	5	1	0	0

(5) Number of personnel

Division	Functions	Male	Female	Total	Perm.*	C./T.**	Total
Head		1		1	1		1
Administrative	Guard	1		1		1	1
	Driver	1		1	1		1
Financial	Head		1	1	1		1
	Cashier	1		1		1	1
	Water seller		3	3		3	3
	Meter reader	1		1	1		1
Technical	Motor operator	4		4	3	1	4
	Plumber	4		4	2	2	4
	Total	13	4	17	9	8	17

Note: *=Permanent, **=Contract/Temporary

(6) Production and consumption of water in 1996 (m^3): 118,530 and 82,971.

(7) Average monthly salary: 579 Nfa.

(8) Per capita per day water consumption: 17.5 liters

CHAPTER 5 STRATEGY ON PLANNING

5.1 Basic Strategy on the Planning

(1) Target year

The project for water resource development, water supply and sanitation improvement is to be formulated as a phased plan to the year 2015. A preliminary assumption would be that the project would comprise 3 phases, with phase horizons of 2005, 2010, and 2015, respectively. Although the 2010~2015 period would comprise mid~long term planning, the subject project formulation would include preliminary facility design and funding plan for this stage as well. With regard to the first phase (priority project with a target date of around 2005) of the project, facility design and costing would be to the feasibility study level.

(2) Water resources development plan

The water resources development plan would focus primarily on groundwater and underflow. This would include study of the feasibility of tapping shallow groundwater in the Quaternary formation and weathered rock zone in and around the target towns, and deep groundwater in rock formations.
Although the water source development plan will focus primarily on groundwater, discharge measurement will be carried out for Mereb river as a candidate, long term water source for Mendefera.

(3) Water use

Water supply would give priority to domestic water, however, industrial water use would also be considered with special attention to future demand trend in this regard in the case of towns such as Debarwa and Dekemhare which are pursuing programs to attract industrial enterprises.

(4) Water supply and sanitation plan

Water supply and sanitation plan would comprise a) facility plan with appropriate attention to natural and socio-economic condition, b) project cost estimation, c) O&M plan for sustainability of facilities, d) institutional strengthening plan, e) examination of the financial feasibility of the project and f) project implementation schedule.

(5) Sustainability of the project

Water supply project for rural towns lies with the municipal government of the concerned town with the aim to achieve budgetary independence. Specific recommendations on an operating structure for water supply systems which is sustainable under independent budget will be done. This would include an examination of factors such as O&M costs, replacement of main equipment after depreciation, etc. Also, in cases where the capacity of beneficiaries to pay water fees is too low to achieve independent budget viability, specific recommendations are to be made with regard to ways to compensate for this gap.

5.2 Population Projection

5.2.1 Population as of 1997

According to figures made available from the Ministry of Local Government, the total population of the seven towns as of 1997 amounts to 89,660 of which 53% are females and 47% males (see Table 5.2.1 below). The figures include the population of the surrounding villages which were incorporated within the town administrations by the MoLG. The population of the surrounding villages amounts to about 11%.

Table 5.2.1 Present Population and Household Size of the Seven Towns

Town	Population
Debarwa	4,831
Mendefera	20,371
Adiquala	9,488
Dekemhare	21,675
Segeneiti	6,146
Adi Keyih	14,215
Senafe	12,934
Total	89,660

Source: Ministry of Local Government,
Town Administration Department, 1997

5.2.2 Basic Assumptions Adopted for Population Projection

Base population data (1997) for all towns is taken from the data provided by the Town Planning Department of the Ministry of Local Government.

It is assumed that during the development plan period, the population of these seven towns will grow very rapidly due to the following reasons:

- the fact that the climate in all these areas is conducive for human settlement,
- that present demand for urban land is quite high as attested by the number of applications received by the town administrations,
- due to the high influx of rural people in search of better employment opportunities, and in search of better public amenities like schooling, health, water, etc.
- the fact that these towns are market centers which attract potential investors in trade and other service and manufacturing activities
- the various infrastructure (road, electricity, telephone, market places, et.) planned to be implemented by the government in the very near future.

5.2.3 Projected Population

Despite the fact that there will be rapid population growth rates in the coming years, it cannot be assumed that all the seven towns will experience uniform growth rate. Therefore, for the present planning

purpose, the seven towns have been categorized into two: those that will likely experience very rapid population growth and those that are likely to have lower growth rates. Following is elaboration on this:

(1) Category One: Mendefera, Dekemhare and Debarwa

These towns are envisaged to undergo a rather fast population growth rate due to the planned economic development program envisaged to be under-taken by the government and the expected private sector investment to follow in, in and around these towns.

Thus, the growth rate for these towns will be:

- at 5% per annum from the years 1998 – 2005, and
- from the year 2006 until the year 2015 they will experience a slower growth rate of 4.5% due to the general expectation of declining population growth.

The number of returnees assumed to settle in these towns is assumed to increase up to the year 2010 and slightly decrease from the year 2011 onwards.

Therefore, the number of returnees assumed to inflow to these towns are:

- from 1997 to 2000 a total inflow of 900,
- from 2001 to 2005 a total inflow of 1200,
- from 2006 to 2010 a total inflow of 1200, and
- from 2011 to 2015 a total inflow of 1000.

(2) Category Two: Adiquala, Segeneity, Adi Keyih and Senafe

The growth rate adopted for these towns is 4.5% up to the year 2005 and a slightly lower one of 3.5% until the year 2015.

The number of returnees assumed to settle in these towns is assumed to increase up to the year 2010 and slightly decrease from the year 2011 onwards.

Therefore, the number of returnees assumed to inflow to these towns are:

- from 1997 to 2000 a total inflow of 750,
- from 2001 to 2005 a total inflow of 1000,
- from 2006 to 2010 a total inflow of 1000, and
- from 2011 to 2015 a total inflow of 750.

5.3 Water Demand Projection

5.3.1 Present Domestic Water Consumption

According to the social economic survey report, present water consumption is expected as follows;

There are many water supply modes in the towns. Main modes are individual connection like house

connection and yard connection, communal water point, water wagon and water vender by donkey. Present supply mode and its water consumption is shown in Table 5.3.1.

This table shows that the house connection is the highest consumption and it is more than 20 l/s/d in five towns. Water wagon supply is the second and its consumption is about 15 – 16 l/s/d. Communal water point is lowest consumption. It means that water wagon supply is very important in seven towns at present.

The average consumption of each mode of service for seven towns is estimated 20.8 l/s/d in house connection, 11.3 l/s/d in yard connection, 11.0 l/s/d in communal water point and 14.1 l/s/d in water wagon.

5.3.2 Approach on Domestic Water Demand

The average domestic water demand and percentage of consumers for each mode of service for the seven towns is estimated based on the following consideration:

(1) Hygiene

The hygienic behaviors are influenced by the availability of adequate water. Hence the estimated water demand need to be adequate enough to keep personal and household hygiene.

(2) Available infrastructure

The infrastructures taken into account are availability of sewerage systems, cistern flush and pour flush latrines, shower and kitchen sink which have great effect on domestic water demand. At present Mendefera, Dekemhare and Adiquala have sewerage system. The town administrations of these towns realized the need and developed plans to rehabilitate and expand the system. In each town the only constraint to its implementation is budget. Moreover, with the implementation of the prospective water supply development project, lack of proper sewerage system will be aggravated.

With regard to present household latrine availability, Dekemhare, Mendefera and Adi Keyih are categorized #1, with 60%, 54% and 47.5% coverage respectively. Senafe and Adiquala are categorized #2, with coverage of 40% and 36.7% respectively, and Segeneiti and Debarwa are categorized # 3 with only 25.4% and 11.1% respectively.

(3) Economic potential

The present economic potential of the people has a direct implication with the available infrastructures. The future economic development growth is difficult to tell but with the development of water supply system it is envisaged that other economic activities will also accelerate accordingly. Hence the present situation is taken into consideration in this approach.

(4) Water resources potential

The water resources potential in these towns are limited in general. Therefore, demand on water supply may also be conditioned in accordance with the water resources potential, if there is no other choice.

Table 5.3.1 Present Supply Mode and Water Consumption

Name of Town	Mode of Supply	Consumers Percentage	Consumption (l/s/d)	Remarks
Debarwa	H.C.	1.25	25.0	
	Y.C.	-	-	
	C.W.	41.7	8.56	
	W.W.	27.8	15.61	
Mendefera	H.C.	10.94	24.11	
	Y.C.	6.56	14.95	
	C.W.	29.2	10.13	
	W.W.	53.3	16.39	
Adiquala	H.C.	13.86	20.45	
	Y.C.	6.14	12.07	
	C.W.	63.6	14.31	
	W.W.	-	-	
Dekemhare	H.C.	5.67	25.59	
	Y.C.	8.67	15.67	
	C.W.	-	-	
	W.W.	78.1	16.51	
Segeneity	H.C.	3.0	11.66	
	Y.C.	5.0	5.94	
	C.W.	90.5	8.79	
	W.W.	-	5.59	
Adi Keyih	H.C.	4.95	28.73	
	Y.C.	10.64	12.64	
	C.W.	13.94	16.45	
	W.W.	78.86	-	
Senafe	H.C.	7.78	10.3	
	Y.C.	6.62	6.8	
	C.W.	83.8	8.04	
	W.W.	1.82	16.49	
Total / Average	H.C.	7.5	20.8	
	Y.C.	7.2	11.3	
	C.W.	36.1	11.0	
	W.W.	45.3	14.1	

- "H.C." means house connection.
- "Y.C." means yard connection.
- "C.W." means communal water point.
- "W.W." means water wagon including water vender by donkey.
- The sums of consumers are not 100% because of multiple answers and neglected other sources.

(5) The government policy

The government policy do not favor subsidy for the services. While determining the water tariff, all expenses including the cost of investment on the system, production cost, and expansion cost are believed to be covered by the consumers. Hence, it is inevitable that people's affordability will limit them from consuming more water.

(6) Population

Population has great impact on water supply and sanitation. With the increase in the population the environment caused by sanitation loses its absorbing capacity and the economic development of the town accordingly increases. Hence development of infrastructures is a pressing demand of the town. At present Adi Keyih, Mendefera and Dekemhare having high populations are categorized #1, Senafe in second level and Segeneiti, Adiquala and Debarwa are placed third level.

(7) Current water demand trend

In all towns the water demand trend for water supplied home is high and for human transported water is vise versa.

Therefore, the towns based on the above listed factor are categorized, and basic factors for water demand are estimated based on the present water supply condition, as follows (refer to Table 5.3.2).

- Category 1 - Mendefera, Dekemhare and Adi Keyih
  - Consumers % of population (in 2000) => HC:YC:CW= 25:30:45
  - Demand rate in 2000 => 30, 20, 15 lcd for HC, YC, and CW
  - Annual growth rate of supply modes => 3% (HC), 2% (YC, only 2005)
  - Annual growth rate of demand by mode => 3% (HC), 2% (YC)
- Category 2 - Senafe and Adiquala
  - Consumers % of population (in 2000) => HC:YC:CW= 20:30:50
  - Demand in 2000 => 25, 20, 15 lcd for HC, YC, and CW
  - Annual growth rate of supply modes => 3% (HC), 2% (YC, to 2010)
  - Annual growth rate of demand by mode => 3% (HC), 2% (YC)
- Category 3 - Debarwa and Segeneiti
  - Consumers % of population => HC:YC:CW= 15:20:65
  - Demand in 2000 => 25, 20, 15 lcd for HC, YC, and CW
  - Annual growth rate of consumers => 3% (HC), 2% (YC, to 2010)
  - Annual growth rate of demand by mode => 2% (HC), 2% (YC)

Note) HC: House Connection, YC: Yard Connection, CW: Communal Water point.

Average domestic water demand based on Table 5.3.2 is shown in Table 5.3.3.

Table 5.3.2 Water Consumption

Name of town	Present water consumption pattern			Expected water demand											
	Mode of supply	Consumption l/c/d	Consumers % of household 1)	Year 2000-2005				Year 2005-2010				Year 2010-2015			
				Consumers (% of hld)		Ave. Consumption (l/c/d)		Consumers (% of hld)		Ave. Consumption (l/c/d)		Consumers (% of hld)		Ave. Consumption (l/c/d)	
				2000	**2005**	2000	**2005**	2005	**2010**	2005	**2010**	2010	**2015**	2010	**2015**
Debarwa	House connection	25	1. 25	15	17	25	28	17	19	28	30	19	22	30	35
	Yard connection	–	–	20	22	20	22	22	24	22	24	24	27	24	27
	Communal water point	8. 56	41. 7	65	61	15	15	61	56	15	15	56	51	15	15
	Water tanker	15. 61	27. 8												
Mendefera	House connection	24. 11	10. 94	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	14. 95	6. 56	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	10. 13	29. 2	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	16. 39	53. 3												
Adiquala	House connection	20. 45	13. 86	20	23	25	29	23	27	29	34	27	31	34	39
	Yard connection	12. 07	6. 14	30	33	20	22	33	37	22	24	37	69	24	27
	Communal water point	14. 31	63. 6	50	44	15	15	44	37	15	15	37	0	15	15
	Water tanker	–	–												
Dekemhare	House connection	25. 59	5. 67	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	15. 67	8. 67	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	–	–	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	16. 51	78. 1												
Segeneiti	House connection	11. 66	3	15	17	25	28	17	19	28	30	19	22	30	35
	Yard connection	5. 94	5	20	22	20	22	22	24	22	24	24	27	24	27
	Communal water point	8. 79	90. 5	65	61	15	15	61	56	15	15	56	51	15	15
	Water tanker	5. 59	–												
Adi Keyih	House connection	28. 73	4. 95	25	29	30	35	29	34	35	40	34	39	40	47
	Yard connection	12. 64	10. 64	30	33	20	22	33	66	22	24	66	61	24	27
	Communal water point	16. 45	13. 94	45	38	15	15	38	0	15	15	0	0	15	15
	Water tanker	–	78. 86												
Senafe	House connection	10. 3	7. 78	20	23	25	29	23	27	29	34	27	31	34	39
	Yard connection	6. 8	6. 62	30	33	20	22	33	37	22	24	37	69	24	27
	Communal water point	8. 04	83. 8	50	44	15	15	44	37	15	15	37	0	15	15
	Water tanker	16. 49	1. 82												

1): The sums aren't necessarily 100% because of multiple answers and neglected other sources.

Table 5.3.3 Domestic Water Demand

(l/c/d)

Name of the Town	In 2005	In 2010	In 2015
Debarwa	18.8	19.9	22.6
Mendefera	23.1	29.4	34.8
Adiquala	20.5	23.6	30.7
Dekemhare	23.1	29.4	34.8
Segeneity	18.8	19.9	22.6
Adi Keyih	23.1	29.4	34.8
Senafe	20.5	23.6	30.7

5.3.3 Other Water Demand

Total water demand consists of the domestic water demand and non-domestic water demands such as governmental, institutional, commercial and industrial demands. There are no standard figures of these non-domestic water consumption in Eritrea.

As a result of the field survey, the following non-domestic water consumption is obtained.

Table 5.3.4 Non-domestic Water Consumption by Field Survey

Item	Number	Water consumption	
		m^3/d	l/shop/d
Hotel	12	2.65	221
Restaurant	12	2.51	209
Shop	12	2.41	201
Factory	12	11.95	996

On the other hand, there are standard figures of these demands in the similar country, as follows.

School	5 lit/pupil
Hospital, Clinic	100 lit/bed
Hotel	100 lit/bed
Bar, Tea shop, Restaurant	200 lit/shop
Church, Mosque	5 lit/visitor
Office	5 lit/person
Industry (dry)	5,500 lit/ha
Industry (wet)	22,000 lit/ha

Water consumption of 5 lit/person as shown above is considered the basic figure for drinking only. As for water consumption of industry, it is planned for industry area in Debarwa, Mendefera and Dekemhare. Light industry is planned in Mendefera but it is unclear what kind of industry is planned in the remaining two towns.

Finally, non domestic water demand adopted is as follows, based on the field survey, discussion with engineers concerned in Water Resources Department and the standard figures of the similar countries.

Table 5.3.5 Non-Domestic Water Demand

Item	Water Demand
School	5 l/pupil
Hospital, Clinic	100 l/bed
Hotel, Bar, Tea shop, Restaurant	210 l/shop
Church, Mosque	5 l/visitor
Office	5 l/person
Factory	1,000 l/factory
Light industry	5,500 l/ha
Other Industry	15,000 l/ha

Non-domestic water demand except for light industry and other industry is assumed to increase in a geometric ratio of population growth rate. Water demands of light industry and other industry planned for future extension are separated and estimated per hectare based on the town planning data. Therefore, non-domestic water demands in each target year employed the same figure as above, and added the following population growth rate.

Table 5.3.6 Increasing Rate per Year for Non-domestic Water Demand

Unit: %

Name of Town	1997-2005	2006-2010	2011-2015
Debarwa	8.80	7.93	7.32
Mendefera	5.99	5.65	5.44
Adiquala	6.27	5.62	5.22
Dekemhare	5.93	5.60	5.40
Segeneiti	7.15	6.35	5.81
Adi Keyih	5.70	5.15	4.82
Senafe	5.81	5.25	4.90

5.3.4 Loss and Peak Demand

(1) Physical loss

Physical losses caused by water leakage and waste from pipes, reservoirs and taps, illicit connections, etc., are put at 15 %, assuming that the new facilities will be constructed by the target year.

(2) Max. daily and peak hour water demand

Fluctuations of the maximum daily water demand and weekly or daily variations for peak hour water demand due to seasonal or monthly climatic conditions, are taken into consideration. It is found by the field survey that water consumption in rainy season is higher by 22 % than that in dry season. Rainwater is very important source during the rainy season for washing (95%) and drinking (5%).

It is very difficult to investigate the peak hour water demand because of insufficient water source and

obsolete water supply facilities. Well pumps are operated 3~12 hours daily to meet the reservoir capacity, and communal water points are used 2~3 times per day at present. However, water supply condition will be developed under this project, and as a result, communal water points will be decreased, while individual connections (house connections and yard connections) will be increased in future.

These factors, for example, employed for Keren-city Water Supply Project for an approx. 70,000 population are 1.2 for max. daily water demand and 1.5 for peak hourly water demand.

Finally, max. daily water demand and peak hourly water demand are worked out by assuming the following coefficient based on the field survey and the standard figures in Eritrea.

Max. daily water demand = C1 x Average daily water demand
Peak hour water demand = C2 x Max. daily water demand
Coefficient of C1 = 1.2
Coefficient of C2 = 1.5

5.4 Water Supply System

5.4.1 Water Supply System

Existing water sources of six towns except Segeneity are located far from and/or lower than the town. Therefore, water is transmitted from the water sources to the reservoir by pumps and is distributed from the reservoir to customers by gravity. Well pumps are operated daily for 2.5 hours in Debarwa, 4.0 hours in Senafe and 7 - 12 hours in the remaining towns at present. In case water source is far form the town such as Mendefera and Dekemhare, water is directly supplied to the customers by water wagons.

The project plan for the water supply system employs the same system with the existing one as a rule. Water sources are to be groundwater because it is the cheapest source and the water can directly used for drinking without treatment. In case groundwater is insufficient to satisfy the demand and/or located extremely far from the town, surface water will be planned. New water sources and the existing water sources to be used in the project are connected to the reservoir by pipelines, not by water wagons. The reasons are a) there are a few water wagons and these wagons have frequent breakdowns, and b) pipeline systems are more safe and steady than the water wagons. Water of the transmission line from water source to reservoir is supplied by pump and the distribution line from reservoir to water taps is by gravity. The transmission line has no direct connection to the distribution line.

5.4.2 Water Supplied Area

Seven towns under the project have each administrative district and the administrative district consists of sub zones in the town and/or some villages. There are schools, hospitals, shops, hotels, churches, mosques, etc., in the sub zones and villages. The center of the town is divided into some sub zones and many inhabitants are living in these sub zones at present.

Each town has their future town plan and future town extension area beside the center of the town. Almost all villages are close and/or near to the town center and are included in the future town extension areas. However, a few villages are far from the town center and there is no future town plan for such

villages at present.

Under the circumstances, water service areas are divided into following three areas under the project in accordance with the present town and water supply conditions, population, future town plan, topographical features and so on. Finally, the administrative districts including all villages are planned for the water supply facilities under the project.

a) Water service area in the project target year 2005 : the areas are center of the town and essential for rehabilitation and improvement of the existing water supply facilities,

b) Water service area in the project target year 2010 : the areas are close to the town center of. These areas are for the future town extension plan, and water of these areas are supplied by water wagons or water venders at present.

c) Water service area in the project target year 2015 : the areas are far from the town center but in the administration district.

5.4.3 Facility Plan

(1) General

Existing water supply facilities are mostly replaced under the project because of following reasons. However, the existing wells counted as the water sources in the project will be used continuously, and only well pumps will be replaced after developing the existing wells. Reservoirs having enough capacity will be used after rehabilitation.

a) Yield from wells is insufficient to cover the future water demand,

b) Well pumps are obsolete and have breakdowns,

c) Reservoirs have small capacity and insufficient water level,

d) Pipelines are also obsolete, insufficient diameter to distribute the future water demand, not standable to the future increasing pressure, unknown position, etc., and

e) Communal water points are damaged.

(2) Target years for pipeline

Water supply facilities have two types, namely, one is pipeline type which is difficult to expand the system to meet the future water demand such like transmission pipeline and main distribution pipeline, while another is easy to expand such like wells pumps, reservoirs, etc.

The facilities for easy expansion are constructed and enlarged to meet the water demand in the target year. However, in case that expanded capacity is as small as $10m^3$ or less and not economical for construction, the facilities are to be constructed to meet the future demand.

The pipe diameters of the transmission line and main distribution line are enlarged to meet the water demand in the target year; for example, the pipe diameter of 100mm in 2005 is replaced by 125mm in 2010 and by 150mm in 2015 in the same line. Therefore, construction of these pipelines shall consider the future water demand.

The diameters of the transmission pipeline and main distribution pipeline are planned for the water demand in the target year 2010 under the project. The transmission pipeline and main distribution pipeline in the target year 2015 will be equipped with another one line to meet the water demand in the target year 2015. The reasons to employ these diameters are a) it is difficult to expand the facilities to meet the water demand, b) the facilities covering the water demand in the target year 2010 is nearly 20 % increase from those in 2005, and is cheaper than construction of another one line (refer to Appendix D), c) the facilities covering water demand in the final target year 2015 are nearly 40 % increase from those in 2005, and the final future plan is still unclear at present.

(3) Pipe material

Water pressure, soil characteristics and topographical configuration are very important to select pipe material for the transmission pipeline and the distribution pipeline.

Water pressure depends on given topographical configuration and total length of the pipelines, especially for transmission pipelines. Some transmission pipelines are expected durable to more than 100m of dynamic water head, while the distribution pipelines are expected to less than 75m. Soil characteristics in the project areas vary in one town to another. The ground bed of each town consists of the following lithologies and it will be difficult to select different pipe material to meet the lithologies.

Debarwa:	unconsolidated soil and weathered laterite,
Mendefera:	soil and weathered crack rich basalt,
Adiquala:	soil and mostly hard fresh basalt including rock fragments,
Dekemhare:	alluvial deposits
Segeneity:	soil and heavily weathered granite,
Adi Keyih:	clayey soil including fine to coarse gravel,
Senafe:	soil and coarse sand including sand stone gravel.

Under these circumstances, following pipe materials are recommendable.

Ductile cast iron pipe for transmission pipeline:
the transmission line is very important and the maximum pressure of the line including water hammer is nearly 1961 kPa (20kgf/cm^2),

PVC pipe for distribution pipeline:
the maximum pressure of the distribution line including water hammer is less than 981 kPa (10 kgf/cm^2).

(4) Power supply

There are main diesel power plants at Mendefera, Dekemhare and Adi Keyih in Debub Region. Electricity in six towns except Debarwa is supplied by these diesel power plants at present.

There is a network plan to connect these diesel power plants with Asmara power plant, and Debarwa will be supplied with electricity by 2000. Therefore, power supply for new water supply facilities in all seven towns will served by these diesel power plant through the network.

(5) Major water supply facility

The following major water supply facilities are planned in the project.

- Intake facility: deep well, shallow well, well pump,
- Transmission facility: transmission pipeline, booster pump, pump pit,
- Distribution facility: reservoir, distribution pipeline,
- Water service facility: individual connection, communal water point,
- Electricity facility: power supply, generator,
- Others: pump house, valves, flow meter.

Basic items of new water supply facilities are planned below.

a) Well
- Diameters of well casing are 150 mm (6 inches) for the yield capacity of 10 lit/s or less, and 200 mm (8 inches) for the capacity exceeding 10 lit/s.
- Material for casing and screen are both PVC pipe.
- Existing wells to be used in the project will be developed.

b) Well pump
- Well pump operation 24 hours daily.
- Type of well pumps are submersible.
- Well pumps for the existing wells for use in the project to be newly replaced.
- One stand-by pump provided in the town.

c) Transmission pipeline
- Pipeline for new installation
- Diameters of pipe in the target year 2005 will be for max. daily water demand in the target year 2010.
- Additional line will be constructed for the water demand in the target year 2015
- Material is ductile cast iron pipe.

d) Booster pump
- Booster pump at less than 130 m head.
- Stand-by pump not planned in the project.
- Type of booster pump is centrifugal.

e) Pump pit
- Pump pit in suction pit for boosting pump.
- Capacity is 30-minutes pumping capacity.
- Min. capacity of the pit as $15m^3$.
- Tank is of reinforced concrete made.

f) Reservoir
- Capacity for grand type is 8-hour max. daily water demand, while that for elevated type is 1-hour demand.

- The reservoirs are reinforced concrete made for ground type and fiberglass reinforced plastics (FRP) made for elevated type.

g) Distribution pipeline

- Pipeline for new installation.
- Diameters of pipe in the target year in 2005 for the max. daily water demand in the target year of 2010.
- An additional line will be installed for the water demand in the target year 2015
- Min. pressure is 7 m.
- Material is PVC pipe.
- Minimum diameter of pipe is 50 mm.

h) Individual connection

- Diameter of pipe is 13 mm.
- Material is polyethylene pipe.
- Flow meter is equipped.

i) Communal water point

- There are 8 taps per communal water point.
- Communal water points for coverage of a radius of 150 m
- Communal water point is made of concrete.

j) Power supply

- Electricity is a main power source for pumps
- No generator planed under the project.

k) Pump house

- Pump house planned for pump panels, the booster pump and generator.
- Pump house is brick made.

l) Others

- Valves (stop valve, air valve, wash out valve, pressure reducing valve, etc.) are installed at the proper position.
- The chlorinating facility is installed on the reservoir.
- Flow meters are installed at the outlet of pumps and reservoirs and at inlet of communal water points and individual connections.

5.5 Sanitation Improvement

5.5.1 Objective and Scope of the Program

The main objective of the Sanitation improvement program is to reduce the water and poor sanitation related diseases and create a healthy and productive society. Ultimately a healthy and productive society will have self sustained economy and a happy family.

This program particularly focus on public and private sanitation facilities improvement and hygienic practices. Hence the scope of the study includes the following areas of sanitation improvement:

- improve public sanitation facilities such as:
  - provision of wastewater and soil waste disposal system
  - provision of solid waste disposal system
  - provision of public and community toilets
  - improve schools, hospitals etc. sanitation facilities
- improve private toilets
- develop sanitation/hygiene educational program
- develop a management structure for sanitation improvement program

5.5.2 General Approach

The general approach of this study on sanitation improvement formulation program is based on the following steps.

a) The first step for the sanitation improvement program formulation is getting a clear picture of the current sanitation and health condition of the town with regard to facilities and practices. Therefore all pertinent information from the grass root to higher official level was gathered by approaching relevant people, referring documents and from socio-economic survey. The type of information collected are on the existing public and private sanitation facilities, economic condition of the town in general and household in particular, sanitation practices and behaviors of the community are assessed.

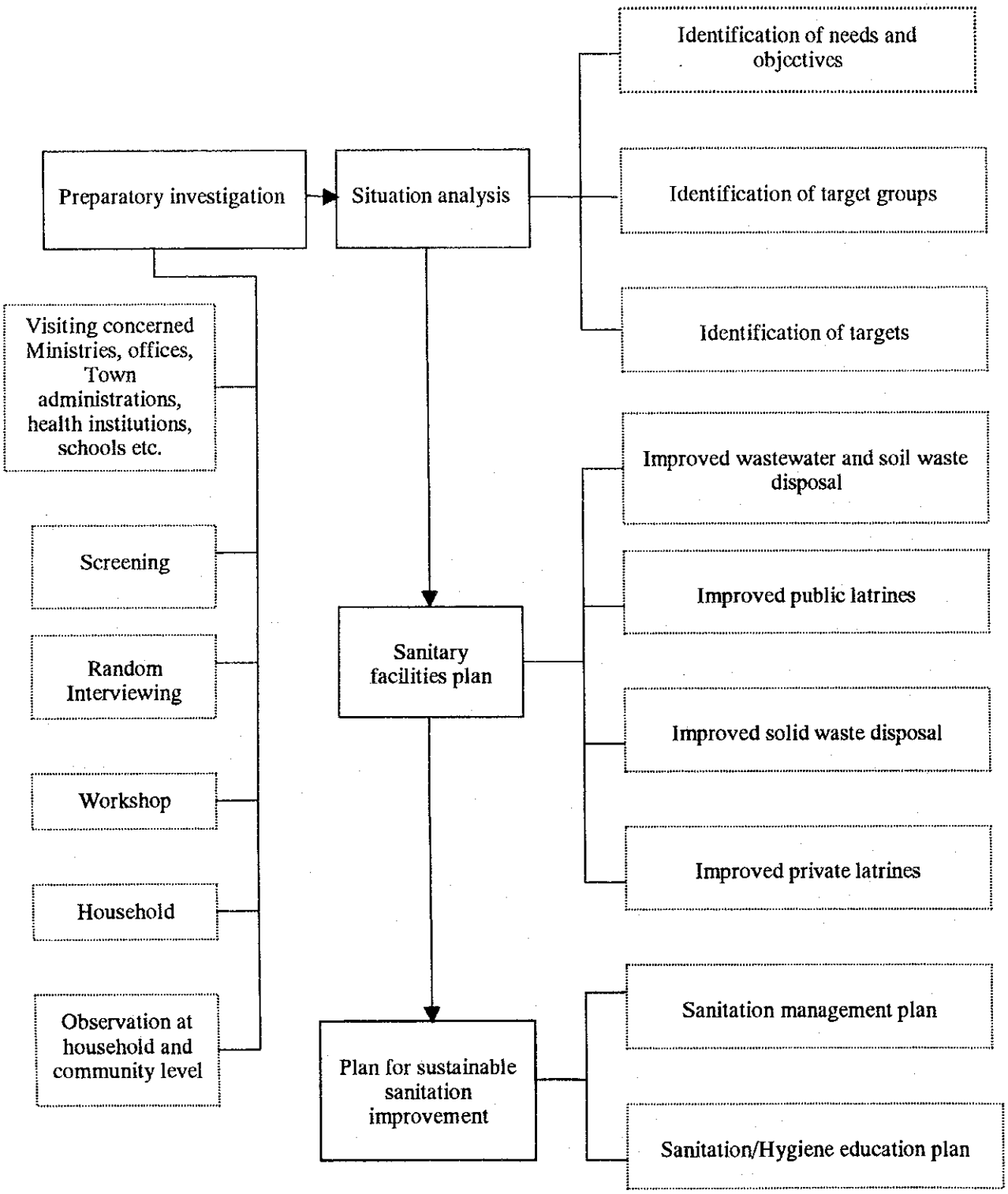
b) Following to the information collection process the situation is analyzed and needs and objectives, the specific targets and the specific target groups are identified.

c) Having a clear picture of the current condition on sanitation, social, cultural, economic etc. aspects the potential developments are foreseen and future plans for improved sanitation facilities program are formulated for three consecutive phases (year 2000-2005, year 2005-2010, and year 2010-2015).

d) Further in this study management and educational plans for effective and sustainable improved sanitation program is proposed.

For details of flow of the study approach please refer Figure 5.5.1.

Figure 5.5.1 Details of the Sanitation Improvement Program Formulation Approach



5.5.3 Areas of Focus and Basic Considerations

The needs and objectives, specific targets of the study and target groups for the sanitation development program are greatly influenced by socio-economic condition of the town and anticipated water demand. Hence the socio-economic study, water demand projections and water supply plans of this study are background for the sanitation improvement program formulation.

Moreover, explicit studies are carried out in areas of:

- Public, institutional and private sanitary facilities with respect to availability, coverage and conditions.
- Communities practice in using sanitary facilities.
- Social, economic, religious and cultural influences on sanitation facilities and usage.
- Availability of common water-born diseases, range of cases of sickness and death.
- Treatment practices for water-born disease.
- Sanitation behaviors in hand washing, utensil keeping, food and water storage, water drawing, infant excreta handling etc.
- Educational programs on sanitation, hygiene and health.
- Community management experiences.
- Community attitude on sanitation improvement programs and willingness to participate
- Government policy and programs on sanitation improvement.
- Existing management structure on sanitation.

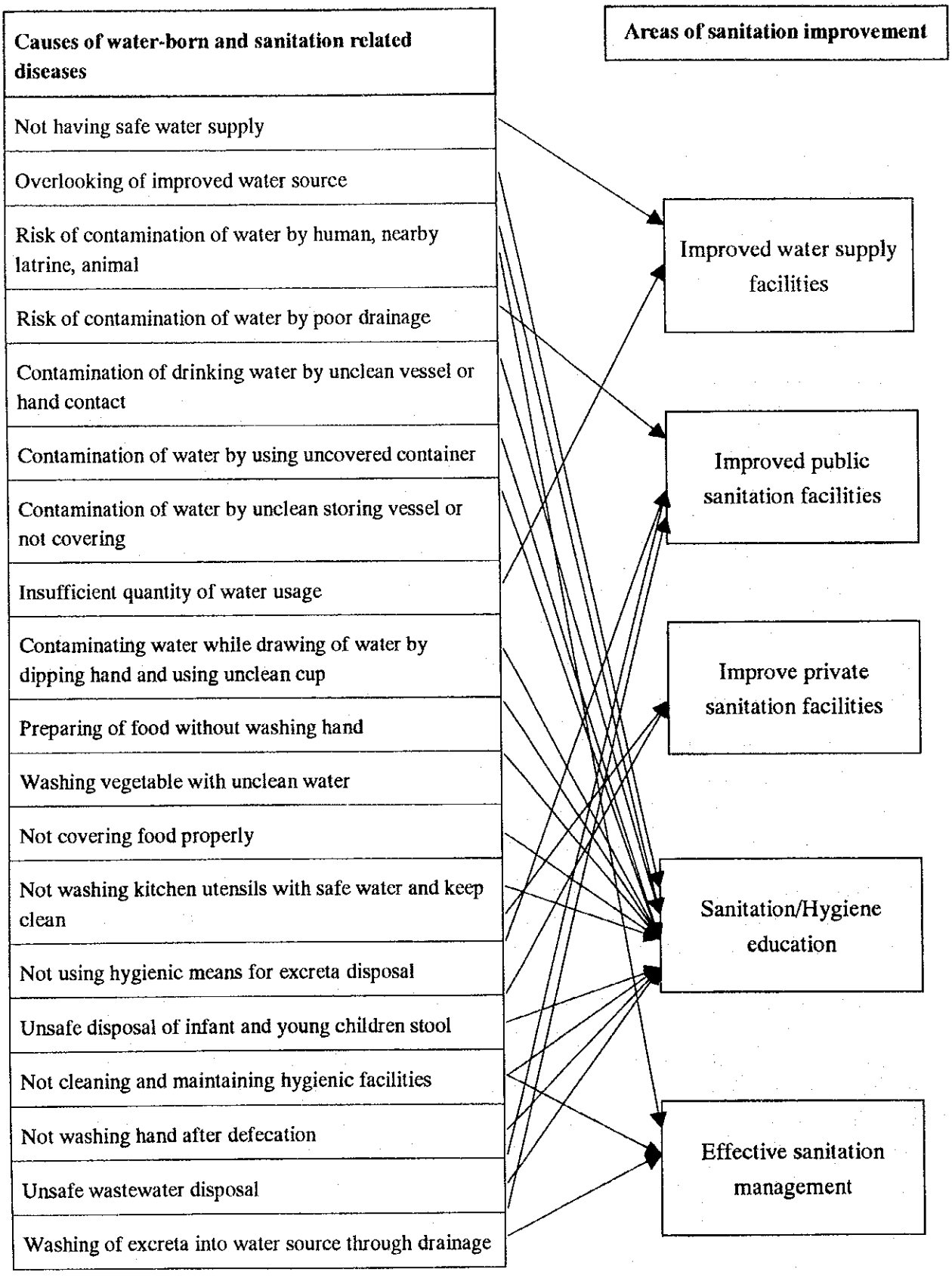
The sanitation facilities plans are developed ensuring the economic and technical feasibility and social and cultural appropriateness in the society. The basic factors considered are:

- make life easier and solve felt problems.
- functionally appropriate, easy to operate and maintain.
- affordable and materials easily available;
- in line with the cultural value and behavioral of the users;

The management plan formulated effectively address the operation and maintenance, staff strengthening, evaluation and monitoring aspect of the solid waste, wastewater and soil waste disposal, public and private latrines and sanitation/hygiene educational management.

To maximize the potential benefits of water supply and sanitation improvement programs on health, facilities need to be used and related behavioral risks reduced. Therefore, the sanitation improvement program is coupled with sanitation/hygiene education programs with the objective of establishing links between water and sanitation facilities on one hand and human practices on the other hand, especially with regard to the use, care, and maintenance of the facilities; the preservation of water safety and its use in sufficient quantities; and the safe disposal of wastewater , human and other solid waste.

Figure 5.5.2 Causes of Water-born and Sanitation Related Diseases and Areas of Sanitation Improvement



5.6 Financial and Economic Analysis

5.6.1 Water Prices and Revenues

(1) Determination of water prices

Water prices will be determined by category of customers and by target year based on:

a) Average monthly household income.

b) Distribution of household income by category of customers.

c) Willingness-to-pay for water.

d) The World Bank's recommendation of 4% of household income as the maximum limit of the payment for water.

e) The richer you are, the more you pay per unit volume of water: unit price for water point users < that for yard connection users < that for house connection owners and commerce/industry/institutions.

f) The more you consume, the more you pay per unit volume of water: the same as immediately above.

g) Future growth of household income.

h) Financial sustainability of water supply facilities to be constructed, i.e. sufficient revenues from water charge to cover the O & M and depreciation costs of the facilities.

(2) Projection of revenues

Revenue from water charges will be projected from:

a) No. of households by year and by category of customers

b) Annual water consumption per household by year and by category of customers

c) Water price by year and by category of customers

d) Bill collection rate, of which 95% is proposed

Another revenue source is the revenue from technical service charge. This revenue will be added on the purchase and transportation cost of connections.

The third revenue source is the revenue from meter rent.

Other revenues are the revenues from the sales of materials, contract fee, connection fee, fines, etc. These revenues were not taken into account as they are of minor importance, irregular and unpredictable.

5.6.2 Financial Analysis

Before financial analysis is carried out, the values will be determined based on the following factors (figures in parenthesis are proposed):

a) Project life (20 years for F/S projects; 30 years for M/P projects)

b) Discount rate (10%)

c) Financing conditions for the initial cost, i.e. subsidy or loan (subsidy)

d) Cost bearing by town people, i.e. the type(s) of cost to be borne by them:

i) O & M cost (yes)

ii) Replacement cost of all equipment and facilities (yes)

e) Durable life of equipment and facilities:

i) Pumps and other electro-mechanical equipment (15 years)

ii) Facilities including boreholes, reservoirs, pipes, communal water points,

iii) pumping stations and treatment plants (50 years)

f) Corporate income tax (free)

The initial cost, O&M cost and revenues will be estimated over a period of years, taking into account the above information and conditions.

Financial analysis comprises two forms of criteria: projection of financial statements and estimation of financial criteria.

(1) Projection of financial statements

Income statement, fund statement and balance sheet will be projected annually up to the last year of project life.

At the same time, major financial indicators such as cost revenue ratio, net profit ratio, the ratio of working capital to revenues and the ratio of net profits to total assets will be calculated based on those financial statements.

Financial feasibility of the project will also be evaluated based on the above statements and indicators.

(2) Estimation of financial criteria

Using cost benefit (revenue) streams, financial criteria including NPV, B/C and FIRR will be estimated.

Evaluation based on the values of the above criteria will be made regarding financial feasibility of the project.

5.6.3 Economic Analysis

(1) Estimation of benefits

a) Economic value of water

The major benefits accruing from the implementation of the Project are the reduction of water related diseases and general improvement of the town people on one hand, and the saving of water fetching time on the other.

Such benefits can be reflected in the price of water. Generally, water charge is controlled by the government to the level by far below the real economic value of water. The real economic value of water is usually clarified by the price at which the public is forced to buy water during its extreme scarcity. People in the 7 towns are forced to buy water from the water tank when there is no other alternative. Water cost is at 10 Nfa per cubic meter, which is 2 to 5 times higher than the water directly secured from the individual connection or the communal water point. In case even this alternative is not available, they buy water from the vendor at an exorbitant rate. In Debarwa, where water situation is more acute than in other towns concerned, such water is bought at 16 to 40 Nfa per cubic meter.

From the foregoing, it will be assumed that the level of the real economic value of water is at least 20 Nfa per cubic meter.

b) lcd and population growth in the "without" the project

Population in a town is projected to grow at the average annual rate of 5 percent. This projection has been made possible on the assumption that enough water will be available in future to cater for the rapidly growing population. Supposing water situation were as severe as at present in future, the growth of population would be much less.

It will be assumed in the "without project" case that the per capita per day consumption of water will not improve in the future and also that the growth rate of population will be half compared with the "with project" case.

(2) Economic cost

To carry out economic analysis of the Project, cost at the market prices shall be converted into economic terms.

The standard conversion factor will be assumed as 0.9, which will be applied to the local components of the capital cost.

(3) Economic analysis

Taking the above-mentioned matters into consideration, economic analysis will be performed for the Project in each town after preparing cost benefit streams for the project life period.

Through the economic analysis, the economic parameters such as NPV. B/C and EIRR will be calculated. In starting such analysis the preconditions adopted in the financial analysis will also be applied.

CHAPTER 6 DEVELOPMENT PROGRAM

Development programs for water resources ,water supply and sanitation are to be formulated ,based on the strategy on planning mentioned in the previous chapter, as a phased plan to the year 2015, with target years of 2005, 2010, and 2015.

6.1 Population and Water Demand Projection

Based on the population in 1997,informed by the Ministry of Local Government , the population in each target year are projected as marked in Table 6.1.1.

Administration of Mendefera has two sub zones and three villages, namely, western zone and eastern zone of Mendefera, Adi Bari, Adi Wegri and Adi Hare. The western zone and eastern zone are divided into 4 and 3 blocks respectively. Two sub zones and Adi Bari are at the center of the town, and the future town extension area is planned in the outskirts. Adi Wegri and Adi Hare are located in the western part of and about 1.0 to 1.2 km far from the town. Moreover, both villages have no development plan and their elevations are nearly same as the higher position of the town.

Therefore, water service area until the target year 2015 is planned as follows (refer to Figure 6.1.1).

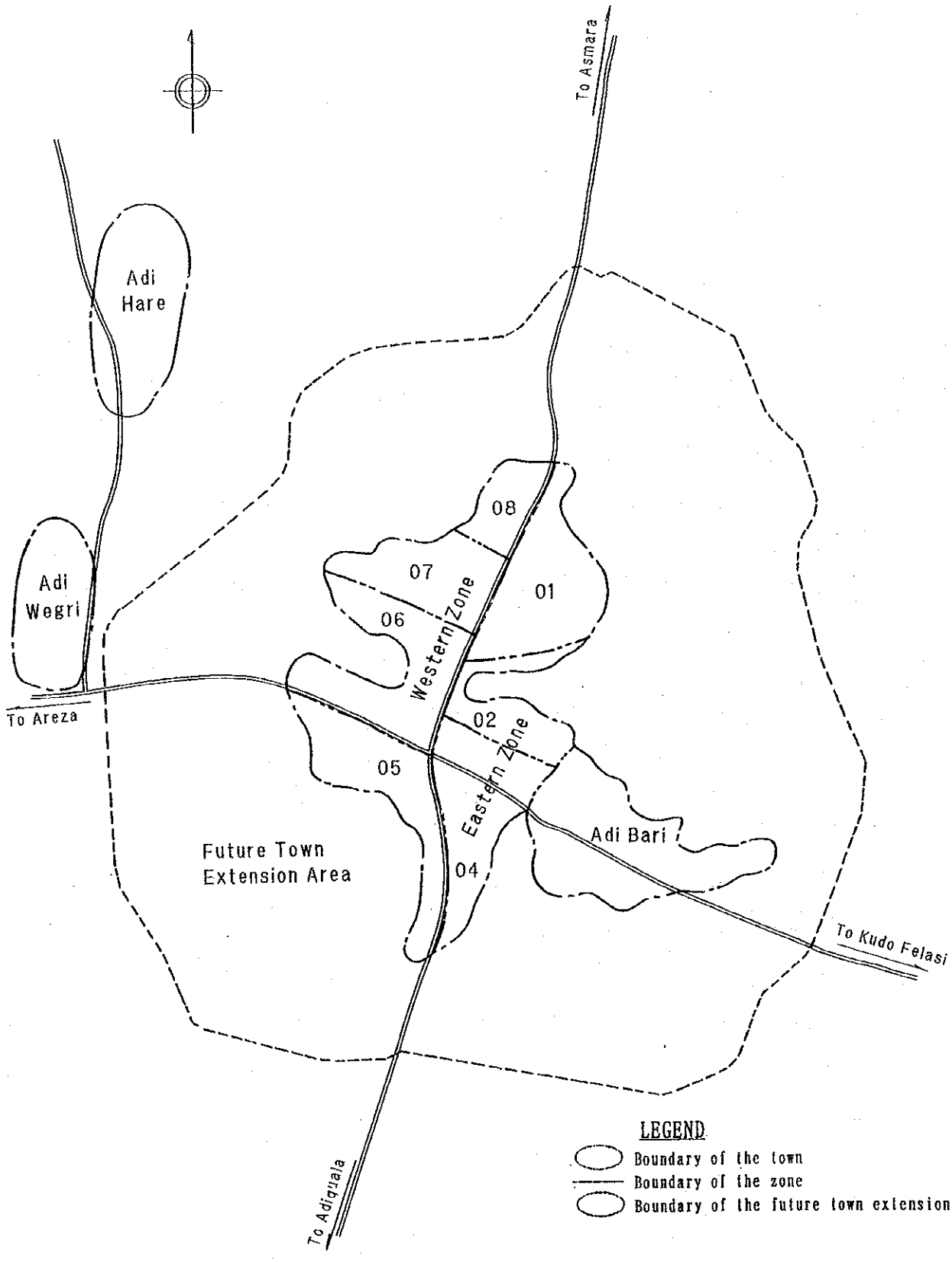
- Target year 2005: Western zone and eastern zone,
- Target year 2010: Adi Bari and eastern future town extension area,
- Target year 2015: Future town extension area in Western zone, Adi Wegri and Adi Hare.
-

Water demands are estimated from the projected population of the water service area and other factors (refer to Section 5.3.4.). Detailed calculation is shown in Appendix D.

Table 6.1.1 Population and Water Demand

Target Year	2005	2010	2015
Population projection	32,450	41,630	52,880
Supplied Population	19,750	33,270	52,880
Service ratio (%)	60.9	79.9	100.0
Average Water Consumption (l/c/d)	42.2	57.2	59.3
Average Daily Demand (m^3/d)	834	1,902	3,134
Max daily demand (m^3/d)	1,001	2,283	3,761
Peak hour demand (m^3/hour)	62.6	142.7	235.1

Figure 6.1.1 Outline of the Service Area



6.2 Water Resources Development Plan

6.2.1 Current Water Resources

In the town, there are two kinds of water resources: two boreholes (BH-4, 5) drilled along the Mai Takhala and surface water stored in Kilowlie Dam. Said two boreholes are installed by a submersible pump and directly connected to the reservoir tank, set at the hill-top in southwest of the town, delivering a pipe-born water for southern half of the town. Surface water in the dam is once led to an underground reservoir through a pump and then send to the reservoir tank set at the mountain top in the north of the town, covering water supply for northern half of the town. At just downstream of the dam, there are two dug-wells, and these are also utilized as public water source but by tankers.

Besides above mentioned Kilowlie Dam, as many as more than ten of small surface dams, so-called as micro dam, are constructed in this area, for mainly irrigation and/or livestock water uses. These are, however, severely silted already, and only a few dams are still available for their purpose reportedly. Besides those, there are two proposed damsites along the main flow of the Mereb, called Mereb-3 near the Debarwa town and Mereb-5 at slightly down stream of the bridge along the Tera-Emni to Dekemhare road.

6.2.2 Potential of Water Resources

(1) Introduction

In general, to evaluate a potential for water resources development, especially for groundwater resources, on a certain area is quite difficult except for the area where has complete hydrological data such as rainfall, surface runoff, groundwater hydrograph, evaporation, etc., recorded for long enough period. Besides those, the properties of controlling aquifer of the area, such as thickness, extension, transmissivity, storage coefficient, etc. shall be required to evaluate the groundwater potential on a certain groundwater basin. Conversely, a water resources potential of an area can be estimated substantially, if such hydrological/hydrogeological data on the area were available. In this case, many water balance equations can be utilized, and a simulation study which is the most reliable way to estimate a water resources development potential can be applied.

Unfortunately, most of such data on around the town are not available at the moment, except for rainfall data. Measurements on surface runoff (the Mereb River) and groundwater level at Test or Observation Well (MEN-2, 3,and 4) are just started. Pan evaporation has been measuring at the Mendefera Station. Thus, the circumstances to evaluate a water resources potential exactly shall be established in near future. Right now, however, the water potential must be evaluated based on several suppositions.

(2) Potential of water resources

Basically, an origin of all water in a certain basin is rainfall. Considerable part of rainwater evaporates out before surface runoff or percolating through ground. And a part of remaining rainwater flows out through a river, then, only the last remaining part can percolate through ground recharging a groundwater. The maximum groundwater development potential, steadily available as water resources, is to be the volume of yearly recharging. Thus, the groundwater resources potential, the surface water potential as

well, can be estimated as follows:

a) Rainfall – (effective) Evapotranspiration = Effective rain (mm)

b) Effective rain x catchment area = Total water source (m^3)

c) Total water source – Surface runoff = Groundwater recharge (m^3)

For Mendefera, monthly mean rainfalls are available (refer to section 4.1.2). Usually, there is no evapo-transpiration data because of difficulty of direct measurement. Evapotranspiration value used to be converted from Pan Evaporation value, as its 60 to 80%. In this Study, 70% of the converting rate from Pan Evaporation to Evapotranspiration is to be adopted as an average. Normally, a rainfall minus 70% of evaporation shall be an effective rain, and thus, only July and August have an effective rain. However, the river flow of the Mereb starts from June and lasts in October in most of the year, so 10% or 20% of monthly rainfalls at the beginning and the ending of a rainy season are intentionally counted as an effective rainfall.

Then, the effective rainwater must be shared between a surface runoff and a groundwater recharging. In Debub region, there is quite a few runoff observation data; those are only one month measuring data on the Mereb at Debarwa Bridge. Although the data indicated that the runoff coefficient of the Mereb was less than 8%, the monthly rainfall for the data (1997) was almost a half of the mean monthly volume. Runoff coefficient varies in accordance with a rainfall, and so about 16% of mean annual runoff coefficient is supposed for the area. In this case, the final effective rainwater is to be shared between runoff and percolation by 6:4, and the ratio shall be adopted at all of the target areas. Thus, the yearly groundwater recharge amount, that means the maximum available groundwater potential, is estimated as shown in Table 6.2.1.

Table 6.2.1 Estimation of Groundwater Recharge

Mendefera	Jun	Jul	Aug	Sep	Oct	Annual (mm)	(%)
Rainfall (mm/m)	60.5	185.8	189.9	54.6	10.7	611.5	100.0%
P.E (mm/d)	5.4	5.6	4.6	5.1	5.0	2,107.9	100.0%
E. Evapotr.(-"-)	117.2	121.5	99.8	110.7	108.5	1,503.8	70.0%
E. Rain (mm/m)	6.1	64.3	90.1	10.9	1.1	172.4	28.2%
Runoff (-"-)	3.6	38.6	54.0	6.6	0.6	103.4	16.9%
Recharge (-"-)	2.4	25.7	36.0	4.4	0.4	69.0	11.3%
Act. E.T. (-"-)	54.5	121.5	99.8	43.7	9.6	439.1	71.8%

Note 1) P.E: Pan Evaporation, E.: Effective, E.T.: Evapotranspiration
Note 2) There are no effective rain during Nov.~May.

As shown in the table, the averaged yearly groundwater recharge is estimated as 69.0 mm/a, which is about 11% of the total rainfall. Almost all of top surface of the Mendefera plateau is only one catchment area and one groundwater basin so-called Mendefera basin (refer to Figure 6.2.1). The basin can be sub-divided into three sub-basins, those are the Mai Sheka/Mai Aron, the Mai Chare, and the remaining Mai Takhala sub-basins. Total area of the Mendefera groundwater basin is around 165 km^2 based on the 1:100,000 topo-map, and the areas of sub-basins are 73, 39, and 53 km^2 respectively. The situation results the total groundwater recharge volume is around 11.4 MCM/a, shared with 5.0, 2.7, and 3.7

MCM/a for respective sub-basins.

Finally, a safety groundwater development volume must be considered, because such ground-water recharge occurs during rainy season, mostly within only two months, but water demand continues throughout a year in almost same level. Such situation usually prevents a full-use of the maximum water resources potential, in particular in the area where groundwater flows out quickly. In such a case, from one-third to one-tenth of the yearly recharge volume shall be taken as a criterion on the maximum groundwater development, of course depending upon the local condition. In the case of Mendefera, the controlling aquifer of the area is the fissure type aquifer in basalt, showing fair yield sometime but hardly continuous, so that the hurdle of safety development must be set at the lowest level, as less than 2600 m^3/day. On the contrary, the future water demand of the town shall skyrocket after the year 2005, and shall come to more than 3700 m^3/day, as discussed in the section 5.2. Thus, the water demand in 2015, for the town of Mendefera, can not be covered by the groundwater, and the development of surface water must be considered, only for the water supply in 2015.

(3) Water quality

Water qualities of existing water supply system including some water sources were generally good for drinking, except for a dud-well and some consumer's taps which were contaminated by coliform bacteria, as explained in the section 4.1.4 and shown in Figure 4.1.5.

For the new water source, groundwater extracted from MEN-1 was analyzed in the laboratory of WRD. The result of analysis is attached in Appendix and shown as Figure 6.2.2, and the data indicate that the water quality of the borehole is also good for potable water.

6.2.3 Water Resources Development Plan

(1) Increasing of water demand

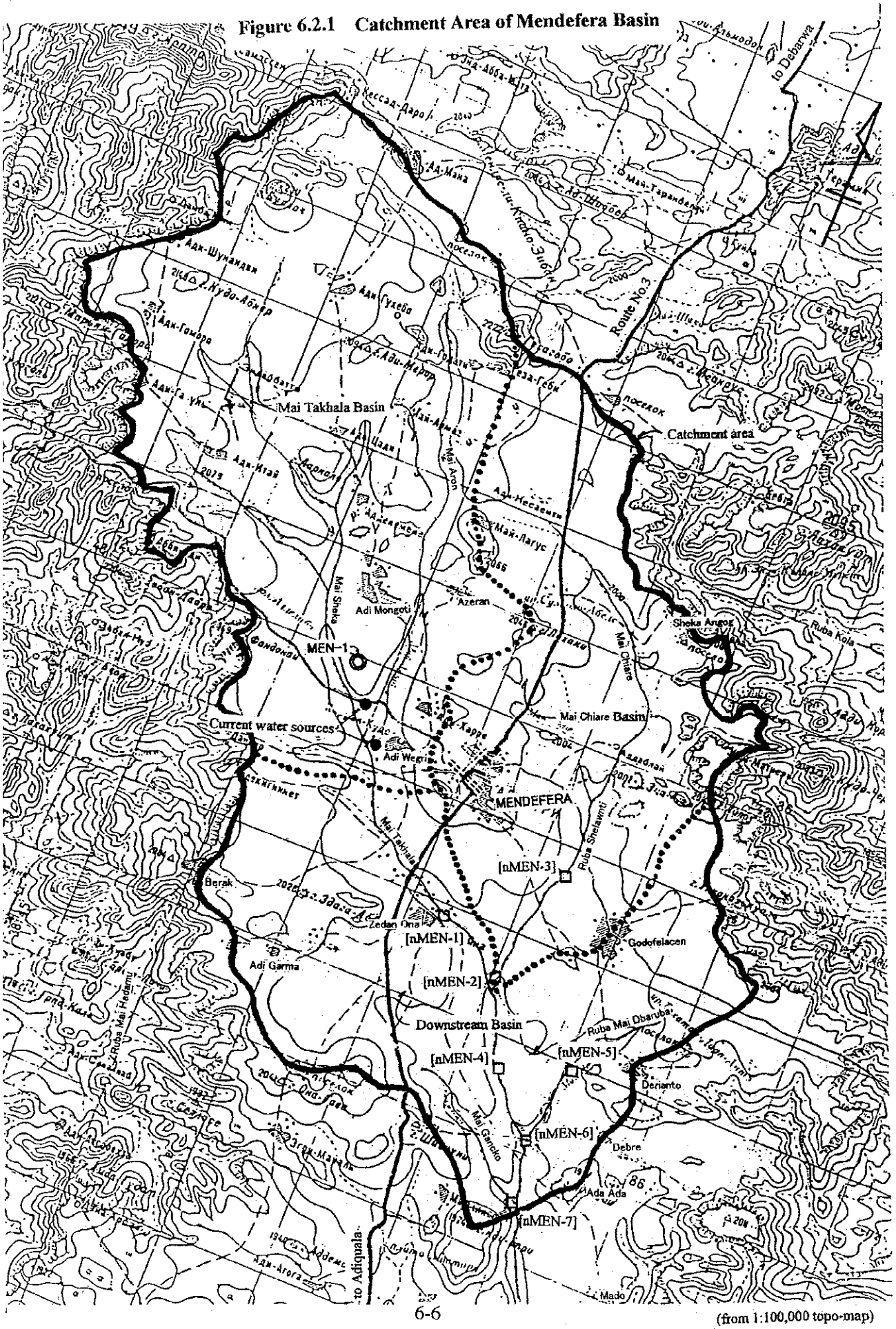
Water demand projection was already discussed in the previous section (6.1). And the Study projected out the skyrocketing water demands of Mendefera, 1001, 2283, and 3761 m^3/day in the year of 2005, 2010, and 2015, respectively. The increasing rate of water demand in the future is illustrated in Figure 6.2.3. As shown in the figure, the water demand shall increase drastically from 2005.

(2) Water resources development plan

The existing groundwater resources including the Test Well MEN-1 have a total yield of 725.7 m^3/day, which can cover the water demand in 2000 but 2005, as shown in Figure 6.2.3. To cover the water demand in 2005, supposedly two new production wells shall be required, because around 275 m^3/day of the shortage water in 2005 can hardly be supplied by only one well, considered from the aquifer property.

To satisfy the water demand in 2010, another 1282 m^3/day of water source shall be required. For the water source, again another some production wells shall be required to drill. The number of additional wells in this stage shall be five, because the average yield of those new wells can be estimated as 3.0 lit/sec at maximum. Proposed sites for new production wells, both for the year 2005 and 2010, are presented in Figure 6.1.1 together with the locations of current water sources and Test Well, however, the further systematic siting works to identify the exact drilling points shall be required in each stage.

Figure 6.2.1 Catchment Area of Mendefera Basin

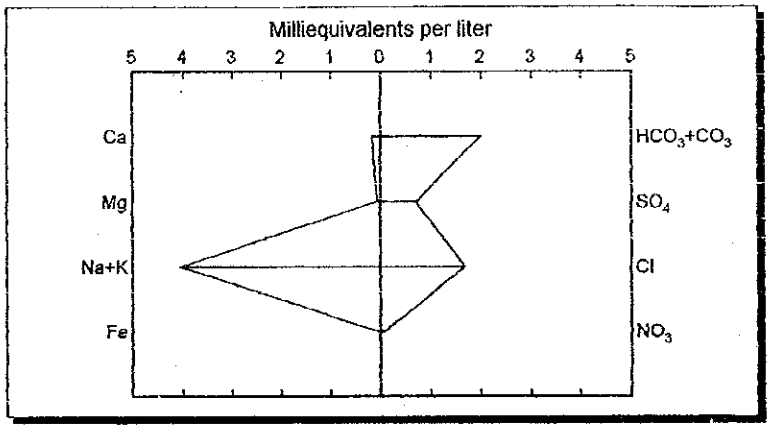


(from 1:100,000 topo-map)

Figure 6.2.2 Water Quality of MEN-1

STIFF Diagram

Well Ident	Description
MEN-1	up-str Mai Takh



Cations					
	Ca	*Mg*	*Na*	*K*	*Fe*
Milliequivalents per liter	0.1447	0.0576	4.0194	0.01790	0.0011
Milligrams per liter	2.90	0.70	92.40	0.70	0.02

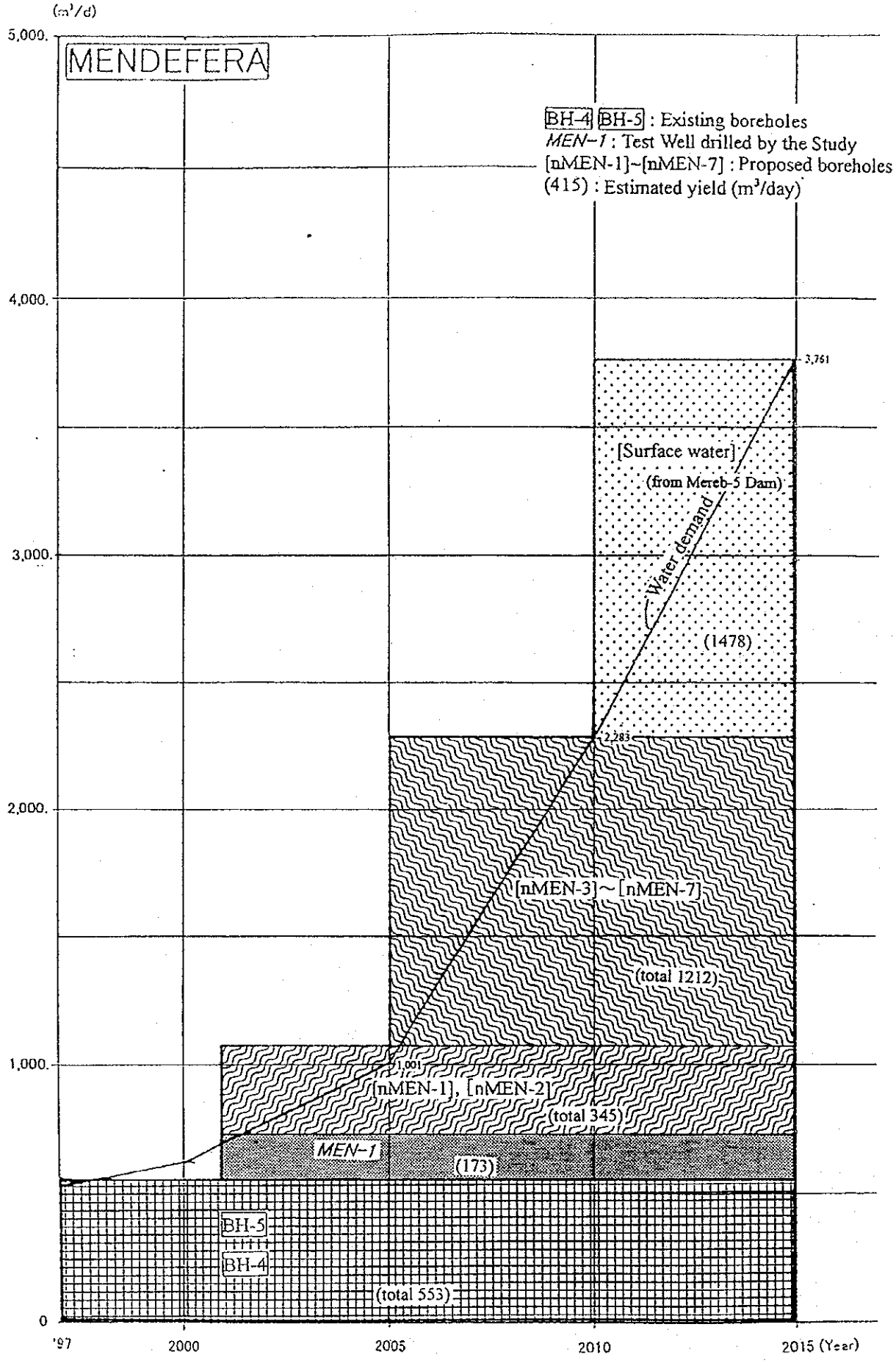
Anions					
	HCO3	*CO3*	*SO4*	*Cl*	*NO3*
Milliequivalents per liter	1.99958		0.70788	1.69260	0.07904
Milligrams per liter	122.00		34.00	60.00	4.90

Mn	NO2	PO4	F	B	SiO2
0.0036	0.00022		0.0137		
TDS	Hardness	Alkalinity	Conductivity	pH	SAR
	0.6		468.00	8.66	12.6382

Water Type	Cations (epm)	Anions (epm)
Sodium Bicarbonate	4.2	4.5

Error Balance
2.84

Figure 6.2.3. WATER DEMAND AND RESOURCES PLAN



For the year of 2015, the last target year, the groundwater has no longer a reserve of further development potential. Inevitably, the surface water from the Mereb Dam must be introduced for the water supply in Mendefera, in this moment. As mentioned in the above section, the surface water development potential of the Mereb is quite high, and the amount of water to be supplied from the dam in 2015 shall only be 1478 m^3/day.

6.2.4 Surface Water Development Plan

(1) Introduction

Eritrean rivers are seasonal and intermittent. Therefore, it is very difficult to find a suitable location for dam construction. However, two potential damsites in the Mereb basin were identified during the Asmara Water Supply Feasibility Study (1987). One of them, called as Mereb-3, locates about 1.0 km upstream of Debarwa bridge, and another called Mereb-5 locates about 10 km downstream of the former. The study on surface water development is, therefore, to make a re-examination of these two proposed sites.

For the purpose, a landmark survey in the field and a topo-mapping from aerial photos in the domestic work were conducted, and as a result, 1:10,000 scale topo-maps for the Mereb-3 and Mereb-5 sites were prepared under the Study.

(2) The proposed damsites

Locations of those two proposed damsites are presented in Appendix-B. The catchment areas of them, delineated on the existing 1:100,000 topo-maps, are around 195 and 492 km^2 for the Mereb-3 and 5, respectively.

From the topographical viewpoint, both sites are suitable for dam construction (refer to the Figures B-1 and 2 in Appendix B). However, considering a distance from source to supply point, an inflow amount and diversity of water use in the future, the Mereb-5 with a bigger catchment area is recommended for the development.

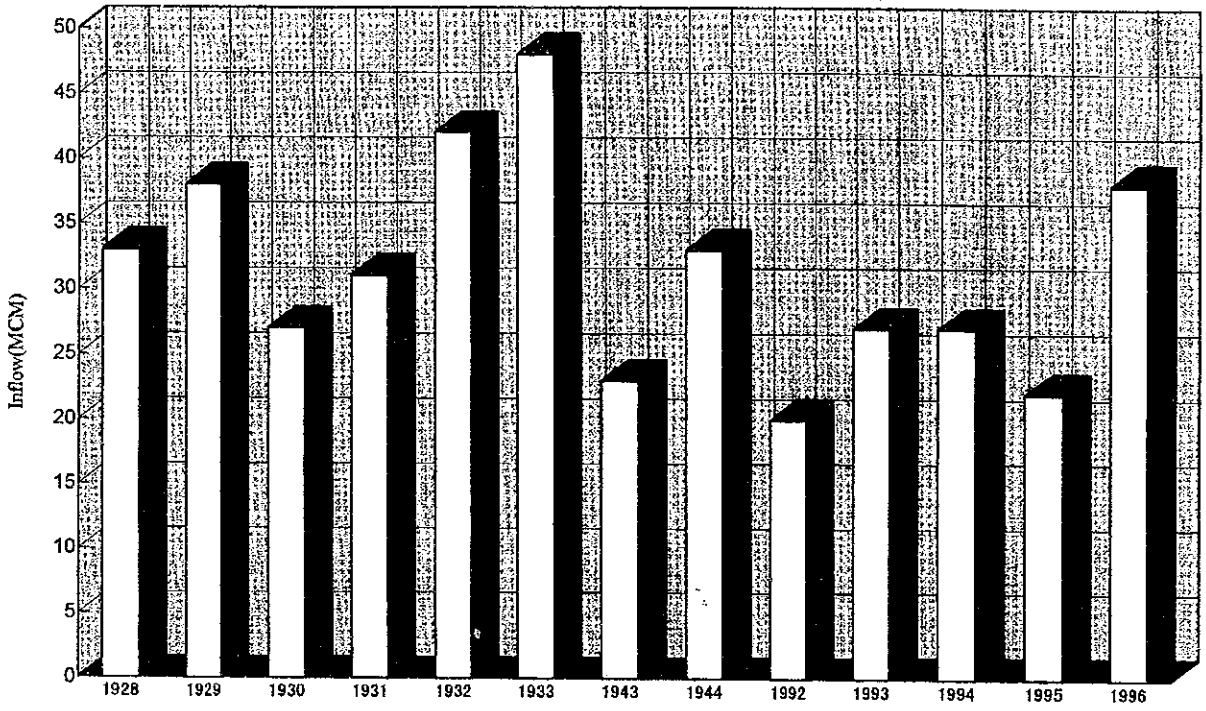
(3) Preliminary runoff analysis

The closest rainfall station is Debarwa and it has relatively long term rainfall record of monthly total. Review of available data (13 years, 1927~1996 with many missing data) shows that the highest rainfall was 1029 mm in 1923 and the lowest was 483 mm in 1992. The annual average may be calculated as 659 mm.

On the other hand, discharge measurement of the Mereb has not taken place before 1997. Only in May 1997, an automatic water level recorder and a staff gauge were installed at the bridge of Debarwa under the Sector Study Program. Thus, the data of this station are still be processed. However, according to the preliminary analysis of the data on August 1997, the total monthly discharge was 16.2 m^3/sec, against a rainfall of 102 mm (refer to Appendix-B). From this observed data and known catchment area (195 km^2), runoff coefficient may be calculated as around 7%. However, compensating some missing data, this figure is considered as 10%.

According to the runoff percentage, a calculation of annual runoff on all available rainfall data (13 years) was performed. In the calculation, rainfalls from October through March were not included, because the rainfalls during the period are too small to generate any runoff, there is no effective rainfall in other words. The calculation shows that the annual inflow into the Mereb-5 site varies from 20.0 to 48 MCM as shown in Figure 6.2.4 (further details are presented in Appendix-B).

Figure 6.2.4 Yearly Inflow Pattern to Mereb-5 Reservoir



(4) Reservoir capacity

In general, the optimum reservoir capacity is selected through reservoir operations for many years with known water demand and rainfall. In this case, it is not possible to follow the same procedure due to scarcity of data. Moreover, present known demand of surface water is only for Mendefera town by the year 2015, which is very small as around 1480 m^3/day, and it would not be economically viable. Therefore, it is assumed that the water demand will be diversified such as for industry, agriculture/livestock, and so forth, in the near future. And thus, a dam should be constructed with its maximum capacity, in order to store water for different uses year around.

The H-V and H-A curves on both Mereb-3 and 5 sites were measured on the new 1:10,000 topo-maps. These are attached in Appendix-B, and the H-V curve on the Mereb-5 is presented as Figure 6.2.5. From the viewpoint of inflow, it is possible to construct a dam with a reservoir capacity of 48.0 MCM at maximum. Even if an average value is selected, a dam of 31.0 MCM capacity may be constructed. However, from the topographical restrictions, it is only possible to construct a dam with a maximum capacity of 25.0 MCM as shown in Figure 6.2.5. Thus, the capacity of proposed dam is decided to be 25.0 MCM.