7.3.8 Taheza Basin

(1) Topography

This basin is mainly covered with the valley plain formed by Taheza River which flows with NNE to SSW direction. The boundaries between the valley plain and the mountainous area are not clear in both sides because of the very gentle slopes of both mountainous areas. However, in the lower reaches along the left bank of Taheza River, a mountain which has steep slope and flat top juts out into the stream of Onilahy River, with NE to SW direction, causing the width of Onilahy River to be narrower.

Taheza River is a perennial river which has a great volume of water even in the dry season. In the drainage area of its lower reaches, there is an extensive rice field irrigated with water from the river.

(2) Geology

Both mountainous area of Taheza River are composed of the Lower and Middle Isalo Groups. The distributions of those Isalo Groups are controlled by a large number of faults which have NE-SW direction. The Lower Isalo Group crops out mainly in the horst zone, and the Middle Isalo Group crops out mainly in the graben zone.

A ridge that is jutting out into the stream of Onilahy River, on the left bank near the mouth of Taheza River, is the horst of the Lower Isalo Group which is composed of gravelly coarse-grained sandstone with a cross bedding. This continental sandstone of the Lower Isalo Group is affected by hydrothermal alteration and silicification, and it has generally higher grade of consolidation compared with that of the continental sandstone of the Middle to Upper Isalo Groups. Besides, this continental sandy deposit consists of two lithofacies of reddish brown sandstone and yellowish white colored sandstone, and sometimes it is intercalated with very hard, iron-rich thin layers.

The test drilling site at Analamary (544m) is located in the district of uppermost reaches of Taheza River, and is composed of reddish brown coarse-grained sandstone of the

Middle Isalo Group. The lithofacies in this test borehole are composed of brown coarse sandstone in the upper portion, up to 63 m below the ground level, and purplish gray-gray medium-grained sandstone with silty sandstone in the lower portion exceeding GL-63 m. These lithofacies in the lower portion seem to be the continental deposits of the Lower Isalo Group.

In the river bed of Taheza River, fluviatile deposits of the Alluvium are distributed locally. Information on the thickness and the component materials of this fluviatile deposits is extremely poor.

(3) Groundwater level and flow pattern

Information on the groundwater level and groundwater flow mechanism in this basin is extremely poor because the majority of villages in this province have traditional river water sources, and only a few villages have artificial water sources such as dug well.

From the results of test drilling and pumping test at Analamary, highly productive confined aquifers which are composed of coarse-grained sandstones, mainly of the Middle Isalo Group and partially of the Lower Isalo Group, were confirmed, and the static water level in this borehole was GL-35 m.

The drilling site of this borehole is located near the divide between Taheza River basin and Fiherenana River basin. Therefore, the confined groundwater in this borehole seems to be supplied mainly from lateral recharge, having moved for a long time from the north-eastern mountainous region.

In Bezaha (GL 130 m), outside the Study Area, there are two boreholes with depths of 48 m and 168 m which were drilled for oil exploration. These boreholes have artesian flows with 40-45°C. As for the main aquifer of this hot spring, it seems to be coarse-grained sandstone of the Lower Isalo Group controlled by the fault with NE-SW direction. However, the thermal source of this hot spring is not yet clear.

(4) Groundwater quality

In this basin, two spring water samples, from Analamary and Antanimora, and one confined groundwater sample from the borehole at Analamary were taken to analyze their suitability for drinking water and the characteristics of the ion components. The chemical quality of these samples is good for drinking water, and the characteristics of the ion components are as follows.

Spring water		Confined groundwater
Analamary	: type IV ----------	type II
Antanimora	: type II	

* The dissolved contents have a very low value of less than 30 mg/l.

(5) Groundwater development potential

Taheza River basin is composed mainly of coarse-grained-gravelly sandstone of the Lower to Middle Isalo Groups. The aquifer capacity of the Lower Isalo Group is generally assumed to be not necessarily of high productivity, due to probable silicified matrix of its highly consolidated sandstone. On the other hand, as shown in the results of test drilling and pumping test at Analamary, i.e pumping discharge of 360-600 l/min and specific capacity of 41.76 l/min/m, the aquifer capacity of the Middle Isalo Group is generally estimated to be highly productive.

It is, however, recommended that a sufficient investigation on hydrogeological structure be conducted to achieve a successful groundwater development, due to the complicated geological environment in this basin, such as the presence of the graben and horst structures.

7.3.9 Sakanavaka Basin

(1) Topography

This basin is mainly covered by the intramountain basin (GL 300~400m) formed in the middle reaches of Sakanavaka River. The western edge of the basin is distinguishable due to the presence of the cliff with relative height of 50m, which has an echelon disposition with NNE-SSW direction. However, the eastern edge of the basin is indistinguishable due to a very long and gentle slope of the western flank of Lambosy Massif. The southern side of the basin is a slope of the northern flank of Manamana Massif, and it is reported that this slope has many active landslides, which cause and a great volume of debris to flow down into valleys.

Sakanavaka River is recharged from many tributaries which are perennial streams running down toward the south-west on a long and gentle slope of the western flank of Lambosy Massif. However, in the western area of the basin, Mamakiala River is the only perennial big tributary.

(2) Geology

The cliff with relative height of 50 m, which has an echelon disposition with NNE-SSW direction, seems to have been formed by faulting activities, and these faults separate the geological components in this basin.

The western side of the fault zone is composed of mixed facies of continental and marine deposits of the Middle Jurassic (the Upper Isalo Group), while the eastern side is mainly composed of marine deposits of the Upper Jurassic. In principle, those sediments are inclined 5°-10° westward.

The test drilling site at Tandrano(GL-400 m) consists of brown fine-grained sandstone intercalated frequently withhin mudstones in the upper portion, up to 50 m below the ground level, and blue-gray fine to medium-grained sandstone with some thin mudstone in the lower portion deeper than GL-50 m. This suggests that the upper formation of the Middle Jurassic in this basin is mainly composed of marine deposits.

In the western side of tan imaginary line that links Ankazoabo with Tandrano, blue-gray to white sandstone with a cross bedding is widely distributed, and sometimes is intercalated with limestone and calcareous sandstone. In this region, sandstone is generally of a low grade consolidation, while limestone and calcareous sandstone are generally compact and hard.

(3) Groundwater level and flow pattern

In this basin, the depth of existing wells ranges from 5 to 15 m, using unconfined groundwater in sandstone aquifer of the Upper Isalo Group. The static water tables range from GL-4 m to GL-13 m.

According to the results of test drilling at Tandrano, the main aquifer in the region consists of alternation of sandstone and thin mudstone, and it seems to be unconfined aquifer in the upper portion and confined aquifer in the lower portion.

(4) Groundwater quality

As shown in Fig.7.3.1, the ion components of both unconfined and confined groundwater in this basin are of the type I or type II, and low concentrations of chlorine and low electric conductivities are generally seen.

(5) Groundwater development potential

The highly productive aquifer in this basin consists mainly of continental sandstone of the Upper Isalo Group, i.e., at the test borehole in Tandrano, pumping discharge of 300-600 l/min and specific capacity of 41.67 l/min/m were obtained. In general, the Upper Isalo Group is mainly composed of continental sandstone in the lower portion, deeper than GL-50 m, which is principally a highly productive aquifer.

Since layers in this basin are gently sloped westward, highly productive aquifer of this continental sandstone is widely distributed on the western slope of Lambosy Massif. However, the upper layer of this aquifer consists mainly of marine deposits with clayly materials, and has low aquifer capacity and partially poor water quality.

Therefore, it is generally difficult to expect the presence of highly productive aquifer in the shallow portion of the western side of the imaginary line that links Ankazoabo with Tandrano.

7.3.10 Isahena Basin

(1) Topography

This basin is mainly covered with the intramountain basin(GL 300-350m) formed in the middle reaches of Isahena River. However, there are indistinguishable topographical boundaries between the basin and the mountainous areas. Clearly seen in the western side of the basin are continuous cliffs bordering the eastern side of Lambosy Massif, which has cuesta.

(2) Geology

In this basin, the Middle Isalo Group is widely distributed with dipping of around 5° westward. However, the lithofacies of this layer are different between the western side and the eastern side of Isahena River. The western half of this basin corresponds to the eastern flank of Lambosy Massif, and is mainly of white coarse-grained sandstone that has cross-bedding and low grade consolidation.

The test drilling site at Berenty-Betsileo consists of calcareous sandstone, marly sandstone, marl and silty sandstone in the upper portion, up to 60m below the ground level, while it consists mainly of alternation of fine-grained sandstone and mudstone in the lower portion deeper than GL-60 m. Such a variation of lithofacies in the Middle Isalo Group clearly indicates that its sedimentary environment changed gradually from a marine area to a continental area.

In the river bed of Isahena River, fluviatile deposits of the Alluvium are distributed locally. Information on the thickness and the component materials of this fluviatile deposits is extremely poor.

(3) Groundwater level and flow pattern

The majority of villages in this basin have traditional river water sources. Therefore, information on the groundwater level and groundwater flow mechanism is extremely poor.

A remarkable confined aquifer could not be found from the results of test drilling at Berenty-Betsileo. The static water table of multiple aquifers in the borehole was GL-15.5m.

(4) Groundwater quality

As shown in Fig.7.3.1, the ion component of the unconfined groundwater is mainly of type IV, but has low concentration of chlorine and low electric conductivity. However, the confined groundwater from the test borehole at Berenty-Betsileo is of the type II, and has high concentration of total dissolved contents, high electric conductivity, and salty taste. These characteristics of the confined groundwater from the borehole at Berenty-Betsileo seem to be caused by release of fossil water from marl or marly sediments. It is reported that the presence of the so-called salty tasting water is found in the area between Berenty-Betsileo and Mangoky River.

(5) Groundwater development potential

The Middle Isalo Group in this basin intercalates many layers of sandstone that can be aquifer. However, continental sandstone that has coarse-grained lithofacies and high permeability is mainly distributed in the western side of Isahena River, which has a rather narrow recharge area.

On the other hand, sandstone layer that is distributed in the eastern side of the region has groundwater recharged from Isalo Massif, and is frequently intercalated with marl mudstone which is an impermeable layer. The pumping discharge from this aquifer at Berenty-Betsileo was 68-80 l/min, and the specific capacity was only 1.53 l/min/m with drawdown of 44.45m. As mentioned above, the water quality is poor due to its salty taste.

As a conclusion, this basin is evaluated to have a low potentiality for groundwater development in terms of quantity and quality.

Table 7.3.1 Existing Wells of the Study Area (1)

Abbreviation

Village No.:Candidate village number used in the Study

Well No.:Number registered in the well inventory arranged by the Study

GL(m) :Ground level read on the topographical map.

Depth(m):Depth of the well from the ground surface to the bottom

Lithofacies of Aquifer:

SWL(GL-m)Static water level when the simultaneous observation was carried

1 Nov.~Dec., 1989 the end of the dry season

2 Feb.~Mar., 1990 rainy season

3 June~July, 1990 dry season

4 Sept., 1990 dry season

Water Quality:Analytical results of the groundwater sampled from the well.

pH:Potential of hydrogen

Hard.:Hardness.

EC:Electric conductivity

TypCharacteristics of Ion conponent shown in the trilinear diagram.

A. Mangoky Delta

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
	Ambahikily	5701	19.0	17.50		2.25	----	1.75	----				
	---------	5805*	19.0	3.29		1.25	----	1.15	----				
	---------	5806	19.0	1.45		1.59	----	1.69	----				
	---------	5807	19.0	3.94		1.66	----	1.62	----				
5	Ambalamoa	5809	14.0	6.55		4.55	----	2.63	----	7.4	240	687	I'
16	Ambiky	5815	51.0	2.50		2.10	----	1.85	----	7.5	378	1,220	I'
11	Andranomanitsy	5702*	23.0	11.60		1.75	----	2.15	----				
11	---------	5810*	23.0	4.39		----	----	----	----				
12	Berantala	5811	25.0	2.94		2.24	----	2.34	----	7.3	134	251	I'
17	Marovato	----	74.0	1.30		----	0.60	----	----				
	Morombe	5801		6.05		4.07	----	4.36	----				
7	Namatoa	5803	20.0	4.19		3.15	----	2.97	----	6.8	142	348	I
7	--------	5804	20.0	4.56		3.80	----	1.90	----				
13	Tanandava	----	30.0	15.48		----	----	----	----				
13	---------	5812	26.0	7.74		2.16	----	2.87	----				
13	Tanandava	5813	27.0	4.84		3.74	----	2.86	----				
13	---------	5814	30.0	6.64		1.44	----	1.86	----				
	Tsianihy	5808	19.0	6.60		4.65	----	3.06	----				

Table 7.3.1 Existing Wells of the Study Area (2)

B. Lake Ihotry Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
23	Ampoza	5817	117.0	10.70		6.00	5.96	5.81					
28	Analatelo	----	----	2.00		2.00	1.00	----					
	Andranoteraka												
	---- Nord.	5706*	----	18.00		----	----	----					
	---- Sud.	5707*	----	14.50		----	----	----					
	---- Sud.	5821	----	6.70		5.30		5.26					
24	Ankilifolo	5816	120.0	10.00		2.65	4.45	4.69					
	Ankilimasy	5705*	167.0	36.00		----	----	----					
	Antanimieva	5713*	150.0	14.00		----	----	----					
	---------	5714*	150.0	16.00		----	----	----					
	---------	5824	150.0	----		----	----	----					
21	Antranosatra	5819	71.0	7.90		0.00	----	----					
27	Basibasy	5712*	----	14.00		----	----	----					
27	---------	5822*	----	8.00		4.60	----	----		7.6	740	2,330	III'
	Befandriana												
	---- Sud.	5703	152.0	36.00		----	----	----	----				
	---- Sud.	5704*	152.0	27.00		----	----	----	----				
	Bekimpay	5710*	105.0	13.10		3.90	----	----	----				
	---------	5825	105.0	5.45		3.90	----	----	----				
26	Bemoka	----	95.0	3.20		----	2.60	----	----				
26	---------	5711*	95.0	12.00		----	----	----	----				
29	Mangotroka	5823	148.0	4.70		4.60	1.60	2.40	----				
22	Manoy	5818	84.0	11.00		8.65	----	7.86	----	7.5	460	1.970	IV'
	Maroforoha	5708*	----	12.50		----	----	----	----				
	---------	----	----	2.00		1.10	0.90	----	----				
25	Sihanaka	----	133.0	2.70		0.80	1.60	----	5.74				
25	---------	5709*	133.0	21.80		6.07	3.18	----	----				

C. Manombo Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
	Ambahiza	2719*	171.0	30.50		----	----	----	----				
	Ambalavenoka	2709*	58.5	----		----	----	----	----				
	Ambatolily	----	69.0	12.00		3.80	3.45	----	----				
	---------	2707*	69.0	12.00		3.45	2.70	3.82	----				
	---------	2708*	69.0	----		----	----	----	----				
55	Ampasikibo	2720	175.0	25.00		----	----	----	----	6.8	652	1,560	I'
59	Ampihamy	2715*	122.0	22.00		----	----	----	----				
59	---------	2807	122.0	10.65		9.33	9.00	----	----				
53	Analamisampy	2723	190.0	21.70		----	----	----	----	7.4	218	696	I'
65	Ankaraobato	2712	73.0	14.60		----	----	----	----	7.3	270	842	I'~II'
65	---------	2711*	73.0	11.20		4.50	----	4.78	----				
	Ankililoaka	2713*	82.0	13.80		----	----	----	----				
	---------	2714*	82.0	12.80		1.70	----	1.28	----				
	---------	2805	82.0	6.33		6.28	5.40	6.38	----				
	---------	----	82.0	2.40		1.45	1.80	----	----				
	Ankililoaka	----	82.0	2.40		1.45	1.80	----	----				
	---------	----	82.0	7.50		6.10	----	----	----				
	---------	2806	82.0	4.20		1.42	0.87	0.66	----				
101	Ankilimalinika	2701*	30.0	25.00		----	----	----	----				
101	---------	2801	30.0	13.21		12.73	12.36	12.56	----				
57	Antseva	2716*	139.0	19.60		----	----	----	----				
57	---------	2808	139.0	10.00		6.57	5.55	6.35	----	7.1	540	1.470	I'
54	Belitsaka Sud.	2721*	184.0	24.00		----	----	----	----				
54	---- Nord.	2722*	184.0	15.20		----	----	----	----				
54	---------	5802	184.0	4.87		1.67	----	1.67	----	7.4	452	1,110	I'
68	Benetsy	2702*	37.0	22.58		----	----	----	----	7.3	760	6,560	III'
68	---------	2802	37.0	17.78		----	----	----	----				
	Betsioky Nord.	----	219.0	67.00		----	----	----	----				
	---------	----	219.0	52.00		----	----	----	----				
	---------	----	219.0	72.00		----	----	----	----				
	Betsioky Nord.	2727	219.0	90.00		----	----	----	----				
	Mandatsa	2726*	205.0	20.80		----	----	----	----				
	Milenaka	2710*	63.0	26.00		----	----	----	----				
56	Namaboha	2717*	164.0	26.88		----	----	----	----				
56	---------	2718*	164.0	26.80		----	----	----	----				
	Saririaka	2703*	40.0	26.00		----	----	----	----				
	---------	2803	40.0	13.35		13.08	11.65	11.05	----				
52	Soahazo Sud.	2724*	198.0	16.00		----	----	----	----				
52	---- Nord.	2725*	198.0	28.00		----	----	----	----				
	Tsianisiha	2704*	48.0	15.50		----	----	----	----				
	---------	2705*	48.0	25.00		----	----	----	----				
	---------	2804	48.0	16.95		16.93	10.25	----	----				
	Tsihosy	2706*	60.0	20.80		----	----	----	----				

Table 7.3.1 Existing Wells of the Study Area (3)

D. Fiherenana Delta

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
	Airport	1807	4.0	8.04		6.00	5.86	5.71	----				
	Androvakely	----	13.0	----		4.35	4.40	----	----				
	Andranomena	1705	23.61	60.60		10.62	4.20	----	----				
	---------	1706	23.61	60.00		----	----	----	----				
	Befanamy	1804	15.0	8.56		5.90	6.05	5.50	6.01				
	Belalanda	2730	5.0	6.90		6.40	6.28	6.33	----				
74	Miary	----	----	----		2.15	0.28	3.14	2.86				
74	---------	1701	24.36	41.00	Pls(fr),ss(cal)	20.10	----	20.67	20.17				
74	---------	1702	22.67	41.70		----	----	----	----				
74	---------	1703	23.53	65.62		----	----	----	----				
74	---------	1704		----		22.60	22.40	22.40	22.63				
74	---------	1802*		----		4.42	2.26	4.32	5.10				
74	---------	1803*		----		----	----	4.22	4.99				
	Motombe	1806	4.50	3.60		2.30	1.12	1.23	----				

When pumping

E. Belomotra-Vineta Plateau

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
	Anadabo	3805	----	11.66		11.00	11.54	11.73	----				
	Andamasiny Vineta	3701*	400.0	22.40		----	----	----	----				
	Andranohinaly	2728*	270.0	219.00		----	----	----	----				
	Andranovory	2729*	483.0	136.00		----	----	----	----				
	Andravakely	1805	9.0	----		4.35	4.40	3.90	4.40				
78	Befoly	5820	225.0	9.75		5.55	----	5.35	----				
95	Tranokaky	----	430.0	11.66		----	11.00	----	----				
95	---------	3703*	430.0	24.00		----	----	----	----	7.1	220	630	I'

I. Fiherenana Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
82	Laborano	3806	582.0	2.45		0.40	----	0.02	----				
92	Mahaboboka	3705*	300.0	14.00		----	----	----	----				
92	---------	3704*	300.0	----		----	----	----	----				
	Miary Lamatihy	3807	350.0	3.30		2.22	----	1.60	----				
	Sakaraha	3702*	460.0	32.00		10.35	10.25	10.36	----				
	---------	3801	460.0	16.80		10.60	10.00	10.20	----				
	---------	3802	460.0	2.29		----	1.63	1.21	----				
	---------	3803	460.0	8.20		----	7.87	7.76	----				
	---------	3804	460.0	10.80		----	10.58	10.35	----				

G. Sakondry Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
98	Bereketa	3808*	362.0	8.40		6.90	6.90	7.07	----				

H. Taheza Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type

Table 7.3.1 Existing Wells of the Study Area (4)

I. Sakanavaka Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
	Ankazoabo	4702*	410.0	31.00		----	----	----	----				
	----------	4802	410.0	5.43		4.75	----	4.30	----				
	----------	4803	410.0	12.24		11.00	----	10.70	----				
	----------	4804	410.0	14.00		13.02	----	12.79	----				
	----------	4805	410.0	5.54		4.10	----	4.18	----				
40	Tanandava	4701*	450.0	15.48		----	----	----	----				
40	----------	4801	450.0	6.14		5.85	----	5.80	----				
34	Tandrano	4806*	400.0	7.95		----	----	----	----				
34	----------	4807	400.0	11.07		10.06	----	6.80	----				
34	----------	124C	400.0	7.95		----	----	----	----				

J. Isahena Basin

No.	Village Name	Well No.	GL (m)	Depth (m)	Lithofacies of Aquifer	SWL(GL-m) 1	2	3	4	Water Quality pH	Hard.	EC	Type
46	Berenty Betsileo	4808	385.0	17.20		----	----	----	----				
42	Ipetsa Atm.	----	463.0	3.60		1.10	1.90	----	----				

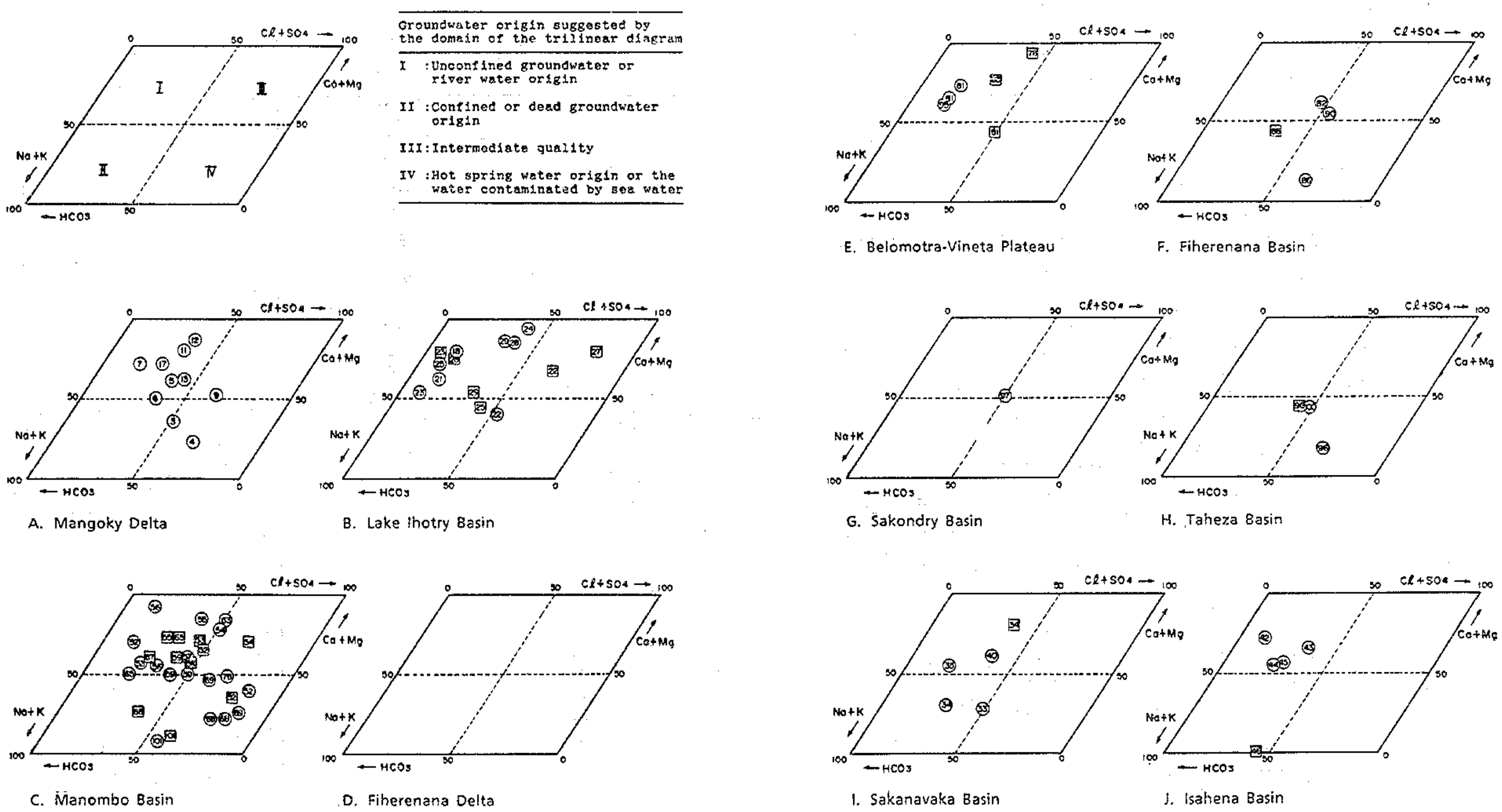


Fig. 7.3.1 Groundwater Quality shown on the Trilinear Diagram

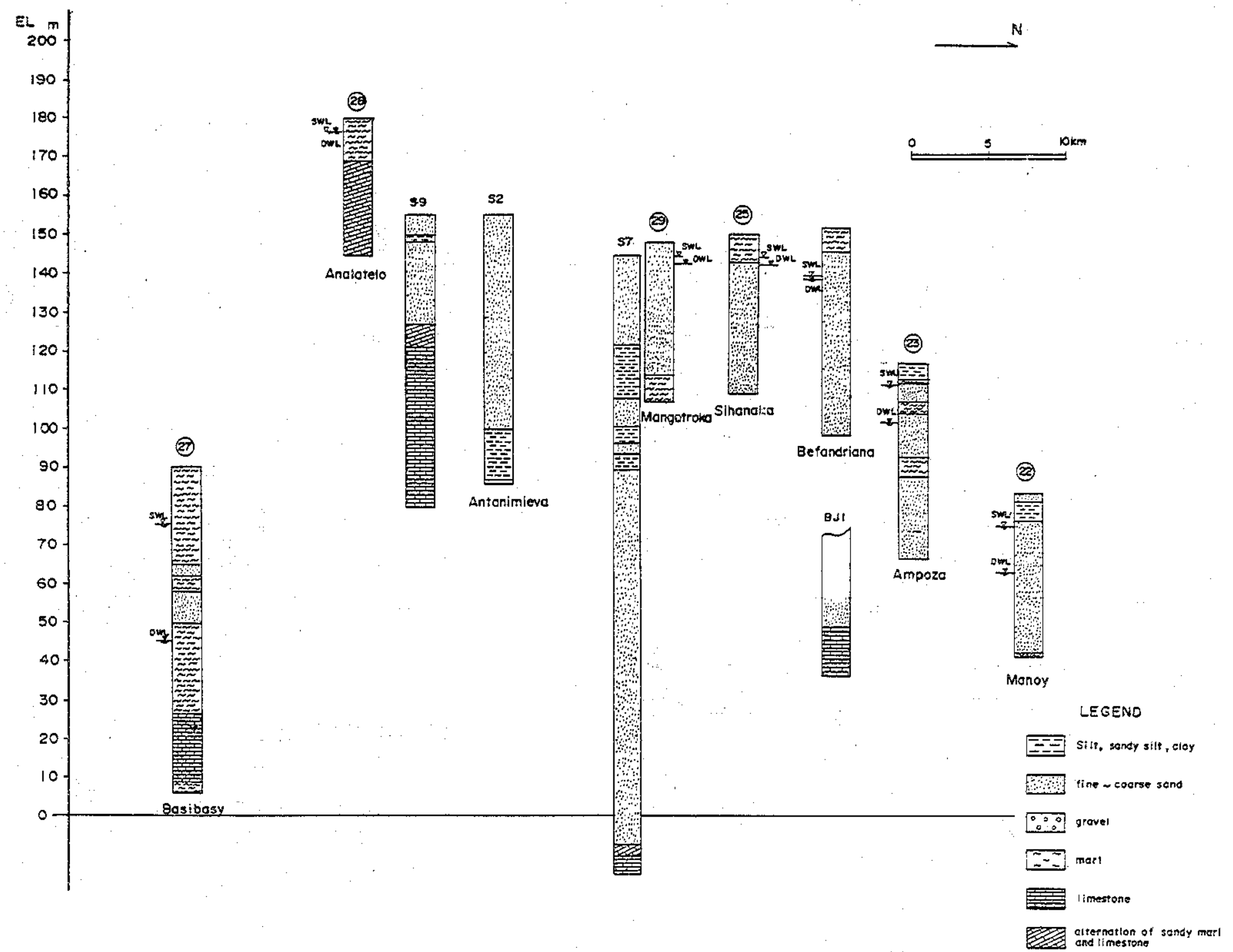


Fig. 7.3.2 Geological Columnar Sections of Lake Ihotry Basin

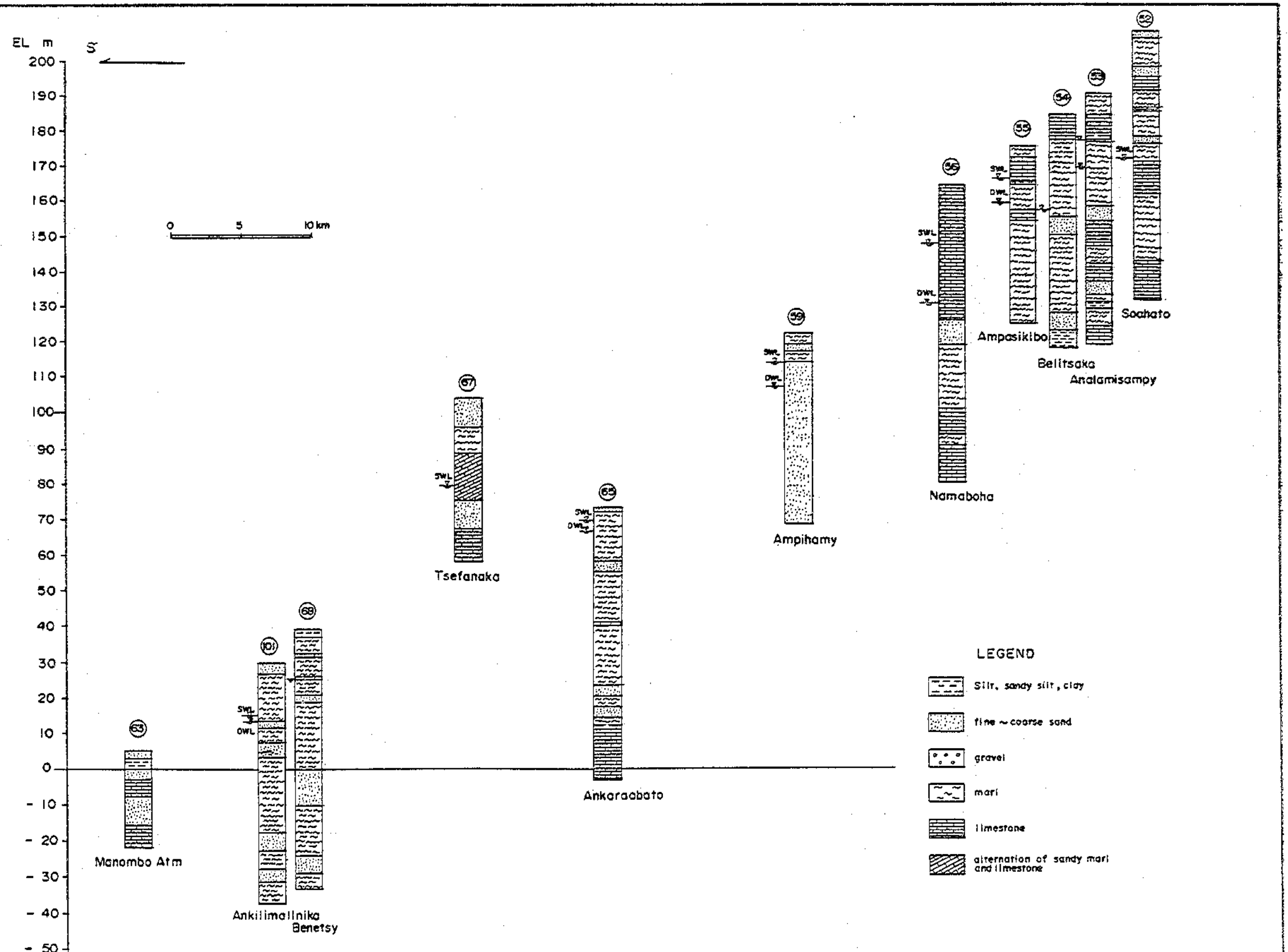


Fig. 7.3.3 Geological Columnar Sections of Manombo River Basin

8. CANDIDATE VILLAGES AND WATER SUPPLY

8. CANDIDATE VILLAGES AND WATER SUPPLY

8.1 Needs for Water & Community Potential

8.1.1 General

Following the preliminary fact-finding survey during Phase I of the Study, a detailed survey was performed to prepare the ranking of the candidate villages according to the degree of priority. This detailed survey on existing conditions of individual communities had the purpose of confirming and appraising the following:

- real community need for safe water, to justify a new supply system;
- community commitment to the future operation and maintenance of the proposed supply facility; and
- community capacity and potential concerning its physical, financial, institutional, and human resources, which may assure their commitment.

Collected data and appraisal results for individual communities are compiled in the data sheet, a sample of which is shown as Supporting Report (1). The following description is to summarize the survey results.

8.1.2 Community Real Water Need

(1) Cattle watering

In the study area, as is usual in rural areas, water is required for livestock watering as well as domestic use for dwellers. However, estimation of the real demand for livestock watering is practically impossible without precise data on livestock population, which shows remarkable fluctuations over a relatively short period. In the formulation of water supply plans for the Study Area, the watering for cattle has an overwhelming importance over other types of livestock. As for cattle in the area, the majority consists of beef cattle grazing on the field outside village living areas. The pasturing cattle is usually able to get to traditional water sources such as river, canal and marsh, without particular difficulties.

Only for some communities on route 9, such as 52 Soahazo, 53 Analamisampy, 54 Belitsaka etc., the installation of separate watering places (abreuvoir) for the pasturing cattle will be required urgently. Combining domestic water supply with cattle watering could have appreciable economic benefits for those communities. On the other hand, draft cattle, kept within the living area of the village and used for farming and pulling carts, is far less in number than pasturing cattle but plays an important role in the rural daily life.

Consequently, watering draft cattle is quite necessary. However, in general, the amount of water required for draft cattle within the village living area is relatively small, to the extent of being manageable within the design margin of the domestic water supply.

(2) Villages with absolute supply shortage

An absolute shortage of the domestic water is observed in several villages on route 7, some of which, for instance 77 Andranovory, 78 Befoly, 79 Ankororoka, 95 Tranokaky, are included as candidate villages. Those villages with scarce conventional water sources such as river, canal and shallow groundwater, solely depend on the delivery from water vendors who charge unimaginable high prices, i.e. 2,500 FMG to 4,000 FMG per drum (200 liters) depending on transportation means (tractor trailer or cart) and distance.

A typical family is said to buy a drum of water every 2 to 3 days. It is easy to understand that the expenditure for buying water is really a heavy burden for an average household, if a comparison is made with farmers sales price of rice, which is 200 FMG a kilogram, and with the average daily wage of a common worker, which is 1,000 to 1,500 FMG.

The population along route 7, from Toliara to Tranokaky, is estimated at approximately 23,000 distributed in more than 20 concentrated communities. Though most of these communities are not subjects of the present study, in the light of basic human needs, a comprehensive regional water supply program is desirable in the future. Figure 8.1.1 is a sketch of the population distribution on route 7.

(3) Villages with shortage of a safe water supply

For the majority of villages, except those with absolute supply shortage, existing water supply sources are not unbearably bad in quantity, convenience, and reliability during all seasons. In general, those villages have several traditional water sources, natural and artificial, within their living area or in the neighborhood. A considerable number of villages have access to both traditional dug wells and rivers or canals.

However,the water is not necessarily safe for domestic use, mainly due to probable bacteriological contamination. In the strict sense of the word, almost all existing water sources, except a few protected dug wells, have not satisfied the community need for safe water supply.
Regarding conventionally used river water and irrigation canal water, main complaints from users are focused on the following two points:

- High turbidity of river water during the rainy season, which precludes rural people from using river water occasionally.

- Threat to the health of users of water from rivers, ponds and canals by diseases attributable to bacteriological contamination.

Concerning various kinds of diarrheas, users get used to them as an every day occurrence, and there are well known, simple preventive measures like boiling water. However, schistosomiasis, another prevalent water borne disease in the area, is feared by the villagers as a serious epidemic. In 106 villages proposed for the study, more than 30 villages are reported as suffering from schistosomiasis, which is hard to wipe out in practice because of the difficulty to effectively control the snail population in the stagnant water. After all, the only effective prevention measure is to reduce or avoid contact with infected water, that is, provision of a safe water source.

(4) Ranking of candidate villages

For the ranking decision of candidate villages, the community needs are evaluated independently, taking into account the above described factors.

8.1.3 Community Commitment

(1) The community commitment to participate in the operation and maintenance of the water supply facility is essential for the long term utilization of the facility.

However, in the Study Area, regardless of the type of water supply facility, community participation was never encouraged in the operation and maintenance. Almost all cases of community water supply facilities built in the Study Area suggest that scarce participation of community members in the maintenance activity might be one of the key factors for the short useful life of most supply facilities.

1) Handpump-based community water supply facilities

Of these facilities built with the assistance of USAID and other organizations, only 2 handpumps are still in working order, while scrapped pumps are found in such villages as 25, 34, 54, 56, 77, etc.
Through interviews with villagers, it has become quite obvious that involvement or participation of the community users were not designed from the beginning of project planning. This neglect of an effort to awaken user's positive commitment is strongly correlated to the present deteriorated and abandoned state of pumps, even though other causes also might be involved.

2) Community water works by SAMANGOKY

SAMANGOKY, a semi-governmental corporation for plantation (rice, cotton, etc.) in Morombe prefecture, built several small community water works in villages such as 15 Talatavalo, 11 Andranomanitsy, 13 Tanandava, to serve water to its contracted plantation workers. The water works were constructed, operated and maintained solely at SAMANGOKY'S expense, neglecting users involvement and participation. When SAMANGOKY'S budget were curtailed for some reason, the water works could not be maintained any longer.

3) Community water works by foreign aid

Already abandoned community water works observed in Befandriana, Ankazoabo, Befoly, etc. are examples of this case. For instance, Ankazoabo's case shows the typical regrettable outcome of a public service facility isolated hopelessly from the user interests. Here, again, hardware contributed to the community by an aid agency started its operation without any organized support from beneficiaries. As a care-taker, an employee of the Firaisam-pokontany office was assigned.
At the beginning, the pump was operated and water was supplied only for users who brought petrol. Later, the Firaisam-pokontany office began to bear all the necessary cost. The plant was never regarded as a common property which had to be taken care of by the community itself.

(2) The past record of meager community commitment in the maintenance of the community water supply facility in the Study Area does not mean at all that the rural community is unreliable. Probably, it rather reflects the attitude of planners, who were strangers to the community in most cases, and never tried to utilize the community commitment effectively. In fact, in other social activities, rural community members have shown their positive commitment to the maximum extent, for instance, in the construction of primary schools and dispensaries in their community.
The study team, through repeated dialogues with villagers to set up the maintenance system for pilot water supply facilities, has been convinced that rural dwellers have keen interest and enthusiastic willingness to participate in the maintenance activity.

(3) For the ranking decision of candidate villages, the community commitment is evaluated together with the community capacity and potential.

8.1.4 Community Capacity and Potential

(1) Classification of Villages

The villages existing in the Study Area can be characterized into 4 categories on the basis of their location and state of development.

- Large communities on main roads 7 and 9 : Befandriana, Ampasikibo 55, Ankaraobato 65, Benetsy 68, Ankilimalinika 101, Andranovory 77, etc.

- Medium size communities on main roads 7 and 9 or near the roads : Andranomanitsy 11, Belitsaka 54, Namaboha 56, Ampihamy 59.

- Large communities in remote places : Ambiky 16, Ankilivalokely 47, Tanandava-Antanifotsy 49, Beroroha 61, Manombo Atm 63, Ambohimahavelona 80, Ankilivalo 100, etc.

- Medium and small communities in remote places

Large communities located on main roads 9 and 7 are characterized by a large population of more than 1,500 which are highly concentrated. A few small retail shops and a lot of street stalls carry on business. Traffic is busy, in particular on a regular market day (once a week). Non-agriculture population is considerable. As a whole, the level of cash income is relatively high.

Large communities in remote places have population exceeding 2,000. Several local administrative offices are located in those communities. However, in spite of a large population, retail shops are scarce, indicating a low purchasing power of inhabitants. Extensive farming is the only means to make a living. A relatively favorable condition for agriculture,combined with administrative reasons, induce the present large-scale concentrated population.

Medium or small size communities in remote places,with poor feeder roads, have a very limited social and economic interchange with the outside world. People in these communities are mostly engaged in subsistence agriculture on predominantly barren land.

The introduction of new rural water supply systems into these communities may have different effects depending on the category of the community.
However, most probably, the effect will be confined to human-oriented improvement rather than directly stimulating or inducing economic development. As an exceptional case, communities on route 7, where excessively high water prices

prevail, can obtain economic benefits by the introduction of new water supply systems, if the amount presently paid to water vendors is devoted to productive activities. In general, to the extent that a safe water supply leads to improved health, productivity may be increased, thereby resulting indirectly in economic growth.

(2) Community capacity and potential

Although the size and the state of development of the community have been described above, a more important factor for water supply planning is a judgment on the community capacity for the long-term maintenance of a water supply system donated by outsiders. In the appraisal of such a community capacity, a negative approach, that is, assessing the various kinds of resource constraints in the community, will be more realistic and efficient. The resources required to maintain the introduced water supply system include four kinds, namely, physical, financial, institutional and human resources.
Resource constraints encountered in the candidate villages are examined in the following sections.

1) Physical resources

Regarding groundwater characteristics, availability, potential capacity and quality etc., have been described in detail in other chapters. Hereupon, suffice it to say that favorable water tables for handpumps, which are the most preferred means for rural water supply, are not necessarily available everywhere in the study area. Inevitable recourse to motorized pumps in many places will result in greater capital investment and will require well-designed maintenance systems.

Energy required for the water supply system will have to rely on imported petroleum products, because electrification has not reached the rural area. The price of petroleum products, for example gas oil and petrol, can be considered as being reasonably acceptable for community users. However, a difficult problem for rural communities is availability of the products. Because of the low degree of motorization in the area, oil distribution system is not yet established in the rural area. Rural community users will have to make time-consuming trips to service stations located far from their living places. For the village located in a remote place, if they need fuel oil for pump operation, the burden is not the price of fuel oil but difficult access to suppliers. In this respect, communities on roads 7 and 9 have a relative advantage.

2) Financial resources

At first sight, it might appear that financial constraints found commonly in beneficiary communities hamper the recovery of operation and maintenance costs of the water supply. The fact is that community water services installed in the past in this region did not rely on beneficiary's contribution at all. However this should not be the case.

FIVONDRONANA (prefecture) and FIRAISAM-POKONTANY (district) offices do not have enough financial capacity to contribute money to a beneficiary village. Local taxes, consisting of land tax, sales and slaughter of cattle, market tax etc., are in principle, to be collected by the government representative (DELEGUE) who is stationed in individual offices. Collected taxes are sent to the FARITANY (province) office, and only a limited small amount of tax money is distributed back to FIRAISAM-POKONTANY and FIVONDRONAM-POKONTANY offices. In fact, it is not only difficult for the office to spend its meager tax revenue on water supply service but also unfair to tax payers who do not enjoy the benefit of the service.

On the other hand, individual community users might be reasonably solvent, with rather positive willingness to pay for a water supply service, as the study team has found through their field survey and actual establishment of several maintenance systems for the pilot water supply facilities. One difficulty in the management of money collected from users may be the lack of banks in rural areas.

Villagers, almost all of whom are farmers, can pay cash money only during the harvest season, for instance, twice a year for rice farmers, while the operation and maintenance of water supply facilities require continuous expenses throughout the year. Hence, a proper way to manage the collected money is quite necessary.

As a whole, solvency of villagers is roughly estimated as below :

- Large communities on route 9 may have sufficient solvency to cover not only recurrent costs but also a portion of capital costs.
- Large communities in remote places can bear recurrent costs of motorized pump-based community water works.
- Small, poor communities in remote places can bear recurrent costs of handpump-based water points.
- Medium size communities on route 7, which have to rely an water vendor's supply at the moment, can bear recurrent costs plus a portion of capital costs, but it should be mentioned that the water price currently paid by those villagers to water vendors considerably exceeds their sound solvency level. The price they presently pay to water vendors would not be the sum they would willingly pay for a normal water supply service.

3) Institutional resources

Prevailing weakness in the existing institutional structure, as confirmed by the field survey,is probably the heart of the difficulty for maintaining water supply facilities in long-term working order.

- FOKONTANY (village)

The administrative organization of a FOKONTANY consists of an Executive Committee composed of 8 to 12 members who are elected by popular vote, and one of whom becomes the President.The average FOKONTANY cannot afford a proper office nor a permanent staff, so that essential records on the FOKONTANY'S present and past depend on personal recolections. A few FOKONTANY offices have a small ordinary budget.

FOKONTANY, as a beneficiary body, must organize a local water committee responsible for creating the local support for the long-term maintenance of the water supply facility. However, it will be difficult to perform the task without external support.

- FIRAISAM-POKONTANY (District)

A typical organization of FIRAISAM-POKONTANY consists of an indirectly-elected PRESIDENT a VICE-PRESIDENT, CONSEIL (council) and a DELEGUE (delegate). It has an exclusive office with a small permanent staff.
Although the office has a small ordinary budget and is responsible for some activities for the sake of FOKONTANY which hierarchically depend from the office, data and information on FOKONTANY are hardly available in the District office.

The DELEGUE, assigned by the FARITANY office, is in charge of technical matters and collection of local taxes in the administrative area. As the District technical adviser, the DELEGUE may be the right person for the community water supply operation, provided he can set aside enough time for the new task.

- MIEM Toliara branch

MIEM (Toliara) has a role to provide technical assistance to FOKONTANY in the maintenance of rural water supply facilities.
Within the MIEM (Toliara) organization, the Department of Garage and Workshop is in charge of technical services for FOKONTANY. This Department is staffed with an assistant engineer, a technician and 15 workers.

If a rural water supply project is implemented in the Toliara area, the branch capability for managing, coordinating and planning will have to be considerably strengthened to satisfy the expected increase in technical services for FOKONTANY. Due to an acute shortage of machinery and tools, actual repair work is impossible in the workshop. A few old vehicles cannot cope with the increasing burden on the branch for logistic support, as more and more water supply facilities are installed in the rural area.

4) Human resources

Skilled or trained manpower to support the operation and maintenance of rural water supply facilities is presently scarce in rural communities.

Members of rural societies of the study area earn a living by farming on rather sterile land. The farming tools are limited to two or three primitive types and therefore, there is no real demand to repair or manufacture those tools in the community.
As transportation means, a few carts are used in the community and the bicycle has not yet been introduced.
A typical house in the community is made of logs and clay, simple enough to be built by laymen without any skill.

Under these circumstances, the rural community has had no pressing needs to encourage formation of craftsman in the society. However, the situation might be rapidly changing, starting from big communities on main roads where a wave of motorization and energy innovation, from firewood to charcoal, have taken place in the past one year.

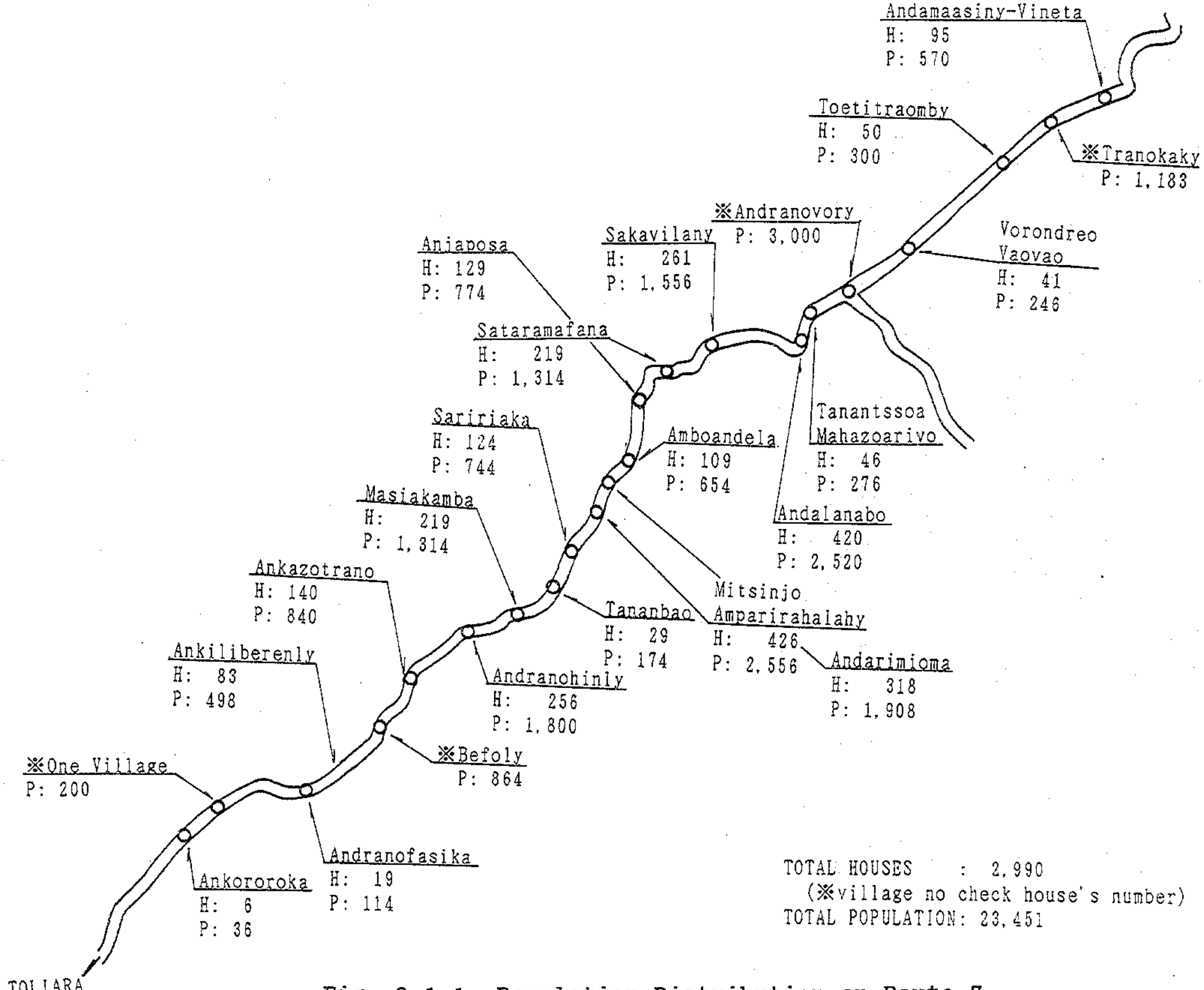


Fig. 8.1.1 Population Distribution on Route-7

8.2 Priority Assignment

Phase I field work and subsequent analyses in Japan resulted in the selection of 48 potential villages for detailed survey and 8 villages for rehabilitation survey. These villages were selected on the basis of groundwater availability, village accessibility, community needs and the community willingness to participate in the operation and maintenance of the water supply facilities. Further,based on the results of the site survey in Phase II, and hydrogeological investigations in Phase I and Phase II, a comprehensive analysis was conducted to define the process and criteria for the selection of priority villages for detailed survey in Phase III.

This process and criteria were based on the following three considerations.

1) Hydrogeologically, the availability of groundwater in the site must be promising in terms of quantity and quality.

2) The need for groundwater development in the site must be strong. Development investment must promise a significant gain for the general welfare of the inhabitants.

3) The inhabitants must be capable to pay at least the operation and maintenance cost, and be organized to manage the water supply system by themselves.

Fig. 8.2.1 shows the summary of the criteria, and the following table shows the resulting order of priority villages.

Resulting Order of Priority Villages

Priority	No. of Village	Population
Aa	19	42,545
Ab	12	15,124
Sub-total	31	57,669
Ba	4	4,718
Bb	15	13,629
Sub-total	19	18,347
Ca	12	7,992
Cb	6	6,250
Sub-total	18	14,242
D	26	12,308
Grand-Total	94	102,566

* Not accessible village: 4 (26,32,48,51)
Abandoned village: 6 (10,19,20,50,85,87)
Sufficient water by pilot facility: 2 (28,95)

Table 8.2.1 Priority Assignment(1)

No	Village Name	Potential for Groundwater Development (Natural Conditions): Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Social and Economic Conditions: Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	Comprehensive priority for groundwater development
1	Ankazomanga	-Local aquifer in delta deposits. -Dug well (5-10m depth)	C	Very poor/poor particularly in wet season	Ⅲ	C - Ⅲ	600	River	Ⅲ	C	Ⅲ - C	D
2	Beadabo	Ditto	C	Ditto	Ⅲ	C - Ⅲ	600	River	Ⅲ	C	Ⅲ - C	D
3	befasy	Ditto	C	Ditto	Ⅲ	C - Ⅲ	600	Dug Well	Ⅲ	C	Ⅲ - C	D
4	Ankilifolo(1)	Ditto	C	Ditto	Ⅲ	C - Ⅲ	400	Dug Well	Ⅲ	C	Ⅲ - C	D
5	Ambalamoa	-Moderately productive aquifer in Neritic sediments of the Upper Eocene. -6" Borehole 150m (150 l/min)	B2	Generally good but poor in wet season	Ⅱ	B2 - Ⅱ	1,000	Protected Dug Well	Ⅱ	B	Ⅱ - B	Bb
6	Tsianhy	Ditto	B2	Ditto	Ⅱ	B2 - Ⅱ	1,389	Dug Well	Ⅱ	B	Ⅱ - B	Bb
7	Namatoa	Ditto	B2	Ditto	Ⅱ	B2 - Ⅱ	750	Protected Dug Well	Ⅱ	A	Ⅱ - A	Bb
8	Mangolovolo	-Highly productive aquifer in swampy area. -6". Borehole 30m (350 l/min)	A1	Ditto	Ⅱ	A1 - Ⅱ	1,500	River	Ⅰ	A	Ⅰ - A	Aa
9	Ankida	Ditto	A1	Ditto	Ⅱ	A1 - Ⅱ	15	Spring	Ⅲ	C	Ⅲ - C	D
10	Vorisy	-Productive aquifer in Neritic sediments of the Upper Eocene	A2	Ditto	Ⅱ	A2 - Ⅱ	0	—	—	—	—	—
11	Andranomanintsy	-Highly productive aquifer in Neritic sediments of the Upper Eocene. -6" Borehole 200m (350 l/min)	A3	Ditto	Ⅱ	A3 - Ⅱ	1,400	Dug Well Canal	Ⅰ	A	Ⅰ - A	Ab
12	Berantala	Ditto	A3	Ditto	Ⅱ	A3 - Ⅱ	506	Protected Dug Well	Ⅲ	C	Ⅲ - C	D
13	Tanandava	Ditto	A3	Ditto	Ⅱ	A3 - Ⅱ	620	Canal	Ⅰ	C	Ⅰ - C	Ca
14	Antsakoabe	Ditto	A3	Ditto	Ⅱ	A3 - Ⅱ	800	Canal	Ⅰ	B	Ⅰ - B	Ab
15	Talatavalo	-Moderately productive aquifer of the Neritic sediments of the Upper Eocene. -6" Borehole 200m (100 l/min)	B2	Ditto	Ⅱ	B2 - Ⅱ	642	Canal	Ⅱ	C	Ⅱ - C	Ca
16	Ambiky	Ditto	B2	Ditto	Ⅱ	B2 - Ⅱ	1,360	Dug Well River	Ⅰ	A	Ⅰ - A	Bb

Table 8.2.1 Priority Assignment(2)

No	Village Name	Potential for Groundwater Development (Natural Conditions): Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Social and Economic Conditions: Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	Comprehensive priority for groundwater development
17	Marovato	Ditto	B2	Ditto	II	B2 - II	375	Unprotected Spring	III	B	III - B	D
18	Andranoboka	Ditto	B2	Ditto	II	B2 - II	600	Dug Well Canal	III	B	III - B	D
19	Satrambondro	Ditto	B2	Very poor/poor particularly in wet season	III	B2 - III	0	—	—	—	—	—
20	Mahavozokely	Ditto	B2	Ditto	III	B2 - III	0	—	—	—	—	—
21	Antranosatra	Ditto	B2	Generally good but poor in wet season	II	B2 - II	570	Dug Well	II	C	II - C	Ca
22	Manoy	-Drilled depth 42m (4"). -pumping rate 280 (-308)l/min. SWL 8.37m, DWL 28.53m, EC 1.600 μs/cm, pH 7.0.	A2	Ditto	II	A2 - II	540	Protected Dug Well	I	A	I - A	Aa
23	Ampoza	-Drilled depth 50m(4"). -pumping rate 283(-310)l/min, SWL 5.28m, DWL 15.20m, EC 440 μs/cm, pH 7.2.	A2	Ditto	II	A2 - II	700	Dug Well	II	B	II - B	Bb
24	Ankilifolo(2)	6" Borehole 50m (250 l/min)	A2	Ditto	II	A2 - II	450	Dug Well	III	C	III - C	D
25	Sihanaka	-Drilled depth 41m (4"). -P/Rate 300(-307)l/min, SWL 5.74m, DWL 7.6m, EC 350 μs/cm, pH 7.6.	A2	Ditto	II	A2 - II	700	Dug Well	I	B	I - B	Ab
26	Bemoka	Difficult site for G/Water development due to poor water quality.	D	Very poor all year round	III	D - III	—	—	—	—	—	—
27	Basibasy	-Drilled depth 83.0m (4"). -P/Rate 201(-222)l/min, SWL 14.46m, DWL 44.27m, EC 2,740 μs/cm, Salty taste.	D	Poor in wet season	II	D - II	1,000	Canal	I	B	I - B	D
28	Analatelo	-Drilled depth 35m (4"). -P/Rate 301(-321)l/min. SWL 3.18m, DWL 3.24m, EC 362 μs/cm, pH 7.4.	A2	Ditto	II	A2 - II	400	Dug Well	II	B	II - B	Completed
29	Mangotroka	-Drilled depth 41m (4"). -P/Rate 336 l/min, SWL 3.57m, DWL 5.29m, EC 145 μs/cm, pH 7.2.	A2	Ditto	II	A2 - II	600	Dug Well	I	B	I - B	Ab
30	Nosy-Ambositra	-Highly productive aquifer of porous limestone. -6" Borehole 50m (350 l/min).	A2	Very poor all year round	III	A2 - III	1,000	Canal	I	B	I - B	Cb
31	Tsiarmpioke	Ditto	A2	Ditto	III	A2 - III	800	River	II	C	II - C	Cb
32	Betaratsy	-Highly productive aquifer of Isalo III^2 F. -6" Borehole 150m (300 l/min).	A3	Ditto	III	A3 - III	—	—	—	—	—	—

Table 8.2.1 Priority Assignment(3)

No	Village Name	Potential for Groundwater Development (Natural Conditions): Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Social and Economic Conditions: Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	Comprehensive priority for groundwater development
33	Andranomanintsy	Ditto	A3	Poor in wet season	II	A3 - II	780	Dug Well	II	C	II - C	Ca
34	Tandrano	-Drilled depth 150m(8"). -P/Rate 300(-660) l/min, SWL 32.72m DWL 39.92m, EC 400 μs/cm, pH 7.1	A3	Ditto	II	A3 - II	3,500	River Dug Well	I	A	I - A	Ab
35	Ampandramitsetaky	-6" Borehole 150m (300 l/min).	A3	Ditto	II	A3 - II	800	Unprotected Spring	I	B	I - B	Ab
36	Andranomafana	-Moderately productive aquifer in Isalo III[2] F. -6" Borehole 100m (120 l/min).	B1	Very poor all year round	III	B1 - III	600	River	III	B	III - B	D
37	Mamakiala	Ditto	B1	Ditto	III	B1 - III	300	River	III	B	III - B	D
38	Berenty-Ankilimasy	Ditto	B1	Ditto	III	B1 - III	108	Dug Well	III	C	III - C	D
39	Betsinefo	Ditto	B1	Poor in wet season	II	B1 - II	34	River	III	C	III - C	D
40	Tanandava	Ditto	B1	Ditto	II	B1 - II	400	Dug Well River	I	B	I - B	Ba
41	Ampoza	-Highly productive aquifer of Isalo III[2] F. -8" Borehole 150m (250 l/min).	A3	Ditto	II	A3 - II	320	River	II	C	II - C	Ca
42	Ipetsa Atm	-Highly productive aquifer of Isalo II F. -6" Borehole 150m (250 l/min).	A3	Ditto	II	A3 - II	120	River	II	C	II - C	Ca
43	Mondabe Atm	-Local aquifer in river bed. -Dug well (5-10m depth).	C	Very poor in wet season	II	C - II	100	River	III	C	III - C	D
44	Soatanimbary	Ditto	C	Ditto	II	C - II	70	Dug Well River	III	C	III - C	D
45	Sahanory Atn	Ditto	C	Ditto	II	C - II	200	Dug Well River	III	C	III - C	D
46	Berenty-Betsileo	-Drilled depth 140m(6") 30(-60) l/min, EC 2,300 us/cm -Dug well (5m)(500 l/min).	(A3) A1	Ditto	II	A1 - II	2,340	River	I	A	I - A	Aa
47	Ankilivalokely	-Highly productive aquifer of Isalo II F. -6" Borehole 200m (200 l/min).	A3	Ditto	II	A3 - II	1,230	River	I	A	I - A	Ab
48	Ilemby	Ditto	A3	Very poor all year round	III	A3 - III	–	–	–	–	–	–

Table 8.2.1 Priority Assignment(4)

No	Village Name	Potential for Groundwater Development (Natural Conditions)					Social and Economic Conditions					Comprehensive priority for groundwater development
		Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	
49	Fanandava-Antaifasy	-Highly productive aquifer of Isalo II F. -6" Borehole 100m (200 l/min).	A2	Poor in wet season	II	A2 - II	2,010	Dug Well River	I	A	I - A	Aa
50	Anjamitikitra	Ditto	A2	Ditto	III	A2 - III	0	—	—	—	—	—
51	Anaviary	Ditto	A2	Very poor all year round	III	A2 - III	—	—	—	—	—	—
52	Soahazo	-Drilled depth 76m(4"). -P/Rate 130(-293) l/min, SWL 36.17m DWL 37.25m, EC 1,040 μs/cm, pH 7.3.	A2	Generally good but poor in wet season	II	A2 - II	2,837	Dug Well	I	A	I - A	Aa
53	Analamisampy	-Drilled depth 71m(4"). -P/Rate 30(-38) l/min, SWL 3.11m DWL 23.30m, EC 1,400 μs/cm, pH 7.0.	A2	Ditto	II	A2 - II	756	Well with Hand pump	I	A	I - A	Aa
54	Belitsaka	-Drilled depth 68m(4"). -P/Rate 200(-270) l/min, SWL 12.78m DWL 24.13m, EL 2,050 μs/cm, pH 7.0	A2	Ditto	II	A2 - II	1,315	Protected Dug Well	I	A	I - A	Aa
55	Ampasikibo	-Drilled depth 50m(4"). -P/Rate 280 l/min, SWL 9.16m DNL 18.12m, EC 840 μs/cm, pH 7.0.	A2	Ditto	II	A2 - II	2,000	Well with Hand pump	I	A	I - A	Aa
56	Namaboha	-Drilled depth 83m(4"). -P/Rate 250(-268) l/min, SWL 16.50m DWL 33.17m, EC 890 μs/cm, pH 7.1.	A2	Ditto	II	A2 - II	1,505	Dug Well	I	A	I - A	Aa
57	Antseva	-Productive aquifer of the Upper Eocene (Neritic Sed). -4" Borehole 70m (200 l/min).	A2	Ditto	II	A2 - II	800	Protected Dug Well	II	B	II - B	Bb
58	Ankatrakatra	Ditto	A2	Ditto	II	A2 - II	460	Dug Well	I	B	I - B	Ab
59	Ampihamy	-Drilled depth 53m(4"). -P/Rate 296(-315) l/min, SWL 8.30m DWL 15.33m, EC 896 μs/cm, pH 7.2.	A2	Ditto	II	A2 - II	1,468	Dug Well	II	A	II - A	Ba
60	Ambondro	-Productive aquifer of the Upper Eocene (Neritic Sed). -4" Borehole 50m (200 l/min).	A2	Very poor all year round	III	A2 - III	1,000	Canal	II	B	II - B	Ba
61	Beroroha	Ditto	A2	Very poor in wet season	II	A2 - II	2,270	Canal	I	B	I - B	Ab
62	Antsomarify	Ditto	A2	Ditto	II	A2 - II	1,200	Canal	II	B	II - B	Bb
63	Manombo-Atm	-Drilled depth 27m(6"). -P/Rate 420 l/min, SWL 4.53m DWL 5.53m, EC 1,000 μs/cm, pH 7.2.	A2	Ditto	II	A2 - II	5,000	Protected Dug Well	I	A	I - A	Aa
64	Antandroka	-Productive aquifer of the Upper Eocene (Neritic Sed). -4" Borehole 50m (200 l/min).	A2	Very poor all year round	II	A2 - II	700	Dug Well	I	C	I - C	Ca

Table 8.2.1 Priority Assignment(5)

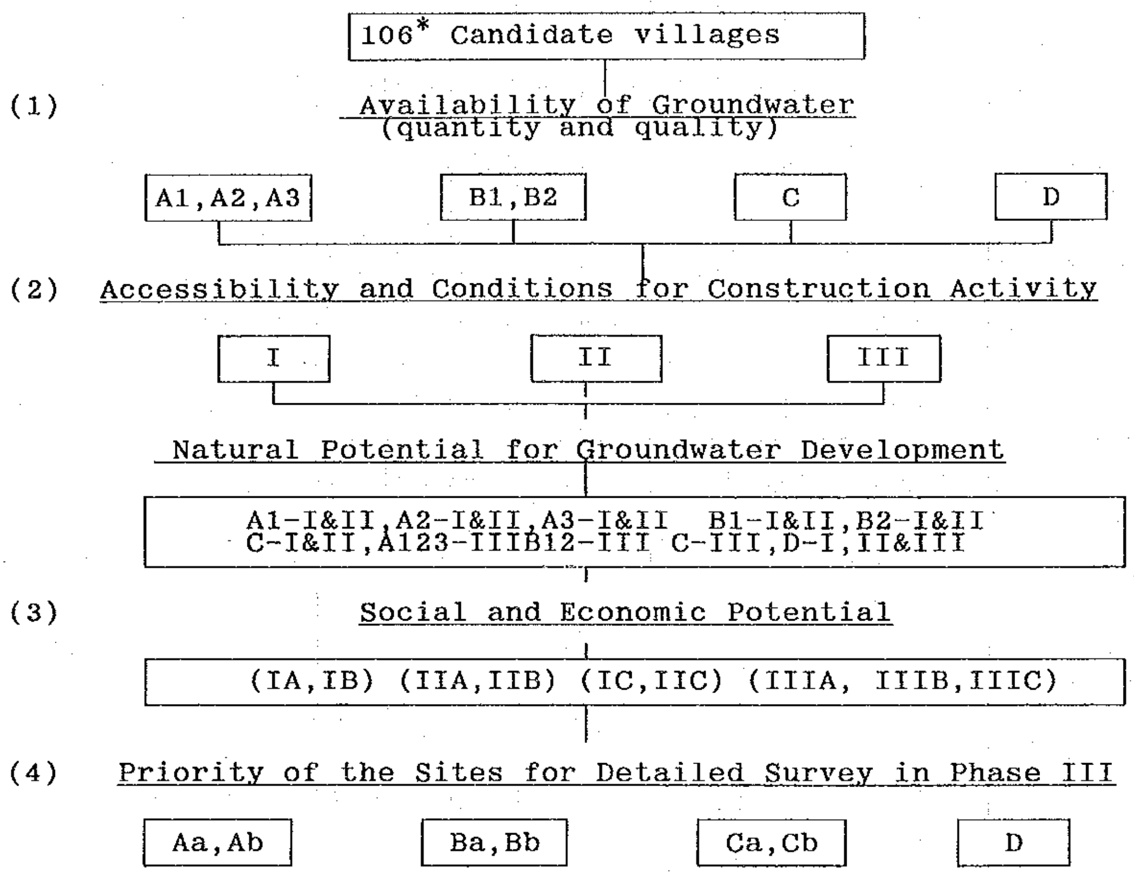
No	Village Name	Potential for Groundwater Development (Natural Conditions)					Social and Economic Conditions					Comprehensive priority for groundwater development
		Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	
65	Ankaraobato	-Drilled depth 75.5m(4") -P/Rate 345(450) l/min, SWL 4.30m DWL 12.30m, EC 670 μs/cm.	A2	Generally good but poor in wet season	II	A2 - II	1,850	Canal	II	A	II - A	Ba
66	Andoharano	-Highly productive aquifer of limestone -4" Borehole 50m (350 l/min).	A2	Poor in wet season	II	A2 - II	300	Canal	III	C	III - C	D
67	Tsefanoka	-Drilled depth 45m(4") -P/Rate 280 l/min, SWL 24.30m DWL 30.40m, EC 602 μs/cm, pH 7.2.	A2	Ditto	II	A2 - II	880	Canal	I	C	I - C	Bb
68	Benetsy	-Drilled depth 72m(6") -P/Rate 300 l/min, SWL 13.51m DWL 17.51m, EC 977 μs/cm, pH 7.4.	A2	Generally good but poor in wet season	II	A2 - II	2,000	Protected Dug Well	I	A	I - A	Aa
69	Andrevo	-Local aquifer in the coastal area (poor W/Q) -Dug well (5-10m depth).	C	Ditto	II	C - II	2,200	Canal Dug Well	II	B	II - B	Ca
70	Anjamala	-Highly productive aquifer of porous limestone -4" Borehole 50m (300 l/min).	A2	Very poor all year round	III	A2 - III	150	River	III	C	III - C	D
71	Ampihalia	Ditto	A2	Ditto	III	A2 - III	1,000	Canal	II	B	II - B	Cb
72	Behompy	Ditto	A2	Ditto	III	A2 - III	1,000	River	II	B	II - B	Cb
73	Ambolonkira	-Highly productive aquifer of porous limestone. -4" Borehole 50m (300 l/min).	A2	Ditto	III	A2 - III	450	River	II	B	II - B	Cb
74	miary	Ditto	A2	Generally good	I	A2 - I	2,000	JIRAMA'S Public Hyd	III	B	III - B	D
75	Befanamy	Ditto	A2	Ditto	I	A2 - I	700	JIRAMA'S Public Hyd	III	B	III - B	D
76	Tsivonoabe	-Local aquifer in the coastal area (poor W/Quality) -Dug Well (5-10m depth).	C	Ditto	I	C - I	30	Dug Well	III	C	III - C	D
77	Andranovory	-Moderately productive aquifer of fissured basalt. -6" Borehole 150m (150 l/min).	B2	Good/Excellent	I	B2 - I	3,000	Water vendor Rain water	I	A	I - A	Aa
78	Befoly	-Drilled depth 228.5m -P/Rate 110 l/min, SWL 178.56m, EC 403 μs/cm -6" Borehole 250m(200 l/min).	A3	Ditto	I	A3 - I	864	Water vendor Rain water	I	B	I - B	Ab
79	Ankororoka	-Productive aquifer of fissured limestone. -6" Borehole 250m (200 l/min).	A3	Ditto	I	A3 - I	100	Water vendor Rain water	II	C	II - C	Ca
80	Ambohimaha-Velona	-Highly productive aquifer of porous limestone. -Existing much spring water.	A2	Very poor in wet season	II	A2 - II	2,000	Spring	III	B	III - B	D

Table 8.2.1 Priority Assignment(6)

No	Village Name	Potential for Groundwater Development (Natural Conditions): Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Social and Economic Conditions: Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	Comprehensive priority for groundwater development
81	Manoroka	-Drilled depth 58m(4"). -P/Rate more than 300 l/min, SWL 5.25m, DWL 5.25m(s:0m), EC 1,150 μs/cm	A2	Ditto	Ⅱ	A2 - Ⅱ	1,000	Protected Dug Well	Ⅱ	B	Ⅱ - B	Bb
82	Laborana	-Productive aquifer of Isalo II F. -6" Borehole 200m (200 l/min).	A3	Poor in wet season	Ⅱ	A3 - Ⅱ	240	Protected Dug Well	Ⅰ	C	Ⅰ - C	Ca
83	Andranolava	-Highly productive aquifer of Isalo II F. -4" Borehole 100m(250 l/min).	A2	Very poor in wet season	Ⅱ	A2 - Ⅱ	1,500	River	Ⅰ	B	Ⅰ - B	Ab
84	Lambomakandro	Ditto	A2	Ditto	Ⅱ	A2 - Ⅱ	200	Dug Well River	Ⅱ	C	Ⅱ - C	Ca
85	Besakoa(1)	Ditto	A2	Ditto	Ⅱ	A2 - Ⅱ	0	—	—	—	—	—
86	Besakoa(2)	Ditto	A2	Poor in wet season	Ⅱ	A2 - Ⅱ	1,200	Dug Well	Ⅱ	B	Ⅱ - B	Bb
87	Ampandra	Ditto	A2	Good/Excellent	Ⅰ	A2 - Ⅰ	0	—	—	—	—	—
88	Maninday	-Drilled depth 73.50(6"). -P/Rate 360(-480) l/min, SWL 16.37m, DWL 24.56m, EC 110 μs/cm.	A2	Ditto	Ⅰ	A2 - Ⅰ	700	Canal	Ⅱ	B	Ⅱ - B	Bb
89	Bevoalavo	-Highly productive aquifer in the river bed. -Dug Well (10m depth).	A1	Very poor in wet season	Ⅲ	A1 - Ⅲ	240	Dug Well	Ⅲ	C	Ⅲ - C	D
90	Tanambao	Ditto	A1	Poor in wet season	Ⅱ	A1 - Ⅱ	800	Dug Well River	Ⅱ	B	Ⅱ - B	Bb
91	Ambahimalitsy	Ditto	A1	Ditto	Ⅱ	A1 - Ⅱ	800	River	Ⅱ	C	Ⅱ - C	Ca
92	Mahaboboka	-Ditto -6" Borehole 30m (300 l/min).	A1	Good/Excellent	Ⅰ	A1 - Ⅰ	2,000	Dug Well River	Ⅰ	A	Ⅰ - A	Aa
93	Mahasoa	-Moderately productive aquifer in fissured basalt. -6" Borehole 150m (100 l/min).	B2	Ditto	Ⅰ	B2 - Ⅰ	30	River	Ⅲ	C	Ⅲ - C	D
94	Andamasiny-Vineta	Ditto	B2	Ditto	Ⅰ	B2 - Ⅰ	550	River	Ⅰ	B	Ⅰ - B	Bb
95	Tranokaky	-Drilled depth 181m(6") -P/Rate 110 l/min. SWL 16.24m, DWL , EC 970 μs/cm.	B2	Ditto	Ⅰ	B2 - Ⅰ	1,180	Water vendor Hand pump	Ⅰ	A	Ⅰ - A	Completed
96	Analamary	-Drilled depth 204m(6") -P/Rate 360(-720) l/min, SWL 39.0m, DWL 47.68m, EC 270 μs/cm, pH 6.4	A2	Poor in wet season	Ⅱ	A2 - Ⅱ	1,000	Canal	Ⅰ	B	Ⅰ - B	Ab

Table 8.2.1 Priority Assignment(7)

No	Village Name	Potential for Groundwater Development (Natural Conditions): Availability of Groundwater (in terms of quantity/quality)		Accessibility/Conditions for Construction Activities		Potential for Groundwater Development	Social and Economic Conditions: Population	Existing Water Source	Community Needs	Community Capacity and Potential	Social and Economic Potential	Comprehensive priority for groundwater development
97	Antanimora	-Highly productive aquifer of Isalo II F. -6" Borehole 150m (250 l/min).	A3	Ditto	Ⅱ	A3 - Ⅱ	300	Dug Well	Ⅲ	C	Ⅲ - C	D
98	Bereketa	-Highly productive aquifer in the river bed. -4" Borehole 50m (250 l/min).	A1	Ditto	Ⅱ	A1 - Ⅱ	500	Dug Well River	Ⅱ	B	Ⅱ - B	Bb
99	Ankilimitraloka	-Local aquifer -Dug Well (10m depth)	C	Ditto	Ⅱ	C - Ⅱ	800	River	Ⅱ	B	Ⅱ - B	Bb
100	Ankilivalo	-Highly productive aquifer of Isalo II F. -4" Boreholle 100m (250 l/min).	A2	Very poor all year round	Ⅲ	A2 - Ⅲ	2,000	Dug Well	Ⅱ	B	Ⅱ - B	Cb
101	Ankilimalinika	-Drilled depth 66m(4") -P/Rate 152(-155) l/min, SWL 14.35m, DWL 10.02m, EC 2,485 μs/cm, pH 7.5	A2	Poor in wet season	Ⅱ	A2 - Ⅱ	3,845	River and Dug well	Ⅰ	A	Ⅰ - A	Aa
a	Befandriana	-Drilled depth 53m(6") -P/Rate 300 l/min, SWL 12.39m, (S) 0.985m, EC 565 μs/cm, pH 7.2	A2	Poor in wet season	Ⅱ	A2 - Ⅱ	3,000	River	Ⅰ	A	Ⅰ - A	Aa
b	Betsioky Nord	-Borehole depth 90m, -P/Rate 144 l/min, (S)9.98m, SWL 59.35m, EC 2,800 μs/cm. -6" Borehole 150m (200 l/min).	A3	Ditto	Ⅱ	A3 - Ⅱ	2,000	Dug well	Ⅰ	A	Ⅰ - A	Aa
c	Andranohinaly	-Highly productive aquifer of limestone. -6" Borehole 250m (250 l/min).	A3	Good/Excellent	Ⅰ	A3 - Ⅰ	1,800	Water Vendor	Ⅰ	A	Ⅰ - A	Aa
d	Sakaraha	-Borehole depth 30.8m(6") -P/R 144 l/min, SWL 10.66m, (S)10.97m, EC 184 μs/cm. -6"Borehole 100m (300 l/min).	A2	Ditto	Ⅰ	A2 - Ⅰ	3,935	River and Dug well	Ⅰ	A	Ⅰ - A	Aa
e	Ankazoabo	-Borehole depth 27.25m(6"), -P/R 50 l/min, (S)1.08m, SWL 12.22m, EC 840 μs/cm. -6" Borehole 100m (150 l/min).	B1	Poor in wet season	Ⅱ	B1 - Ⅱ	3,000	Dug well and Canal	Ⅰ	A	Ⅰ - A	Aa



* Including 8 candidate villages for rehabilitation survey and one additional site (Ankilimalinika(101)) which was proposed by MIEM.

Fig. 8.2.1 Criteria and Procedure for Assigning Priority Order to Candidate Villages (1)

< Criteria >

1. Availability of groundwater

A1 :	Existence of highly productive aquifer is expected at a depth of less than 20 m	Expected pumping discharge: more than 200 l/min.
A2 :	Existence of highly productive aquifer is expected between 20 m and 100 m	
A3 :	Existence of highly productive aquifer is expected between 100 m and 250 m	
B1 :	Existence of moderately productive aquifer is expected at a depth of less than 100 m	Expected pumping discharge 50-200 l/min
B2 :	Existence of moderately productive aquifer is expected between 100 m and 200 m	
C :	Local and discontinuous aquifer exists within 20 m, including Herzberg's lens aquifer in coastal area.	
D :	No significant aquifer exists within 250 m (difficult site for groundwater development).	

2. Accessibility

I : Excellent or good in both dry and rainy seasons

II : Generally good in dry season (II-1)
Poor in rainy season (II-2)
Very poor in rainy season (II-3)

III : Very poor in both dry and rainy seasons

3. Social and Economic Potential

This potential is evaluated based on the following viewpoints.

3.1 Need for safe water in terms of quality (taste, disease), quantity and distance

I ----- High
II ------Medium
III------Low

3.2 Community's positive participation in maintaining the water supply facility, financially and institutionally

A ----- High
B ----- Medium
C ----- Low

4. Lay out of the priority criteria

----> Social and economic potential

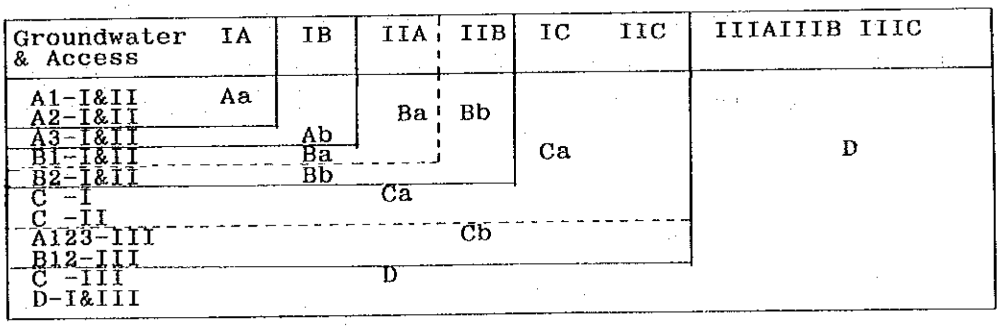


Fig. 8.2.1 Criteria and Procedure for Assigning Priority Order to Candidate Villages (2)

8.3 Water Supply System

8.3.1 General

A detailed survey for water supply planning was conducted in the candidate villages during Phase III, following results obtained in Phase I and Phase II.
The survey consisted of the following activities.

1) Supplementary survey of the village, related local administrative offices and local government agencies

2) Comprehensive inspection and examination of the operation and maintenance practice of pilot water supply facilities, which have been installed on the test wells drilled during the study

3) Monitoring performance of pilot facilities and water consumption pattern by users

4) Selection of common bases for planning, through a review of collected data and information

5) Preparation of a basic description of water supply plans for individual villages

The following descriptions summarize findings and considerations for the water supply planning.

8.3.2 Water Supply District

In the Study Area, since rural population tends to settle in a concentrated community separated from others, a community can stand as a unit water supply district. The community (FOKOTANY or KOMITY), mostly less than several hundred meters in length, has favorable condition for a water supply system with point sources or, at most, a source with a simple distribution system. For that reason, either a FOKOTANY or a KOMITY is to be identified as a unit water supply district.

8.3.3 Beneficiary

Community residents are the primary beneficiaries of water supply, but cattle raised by the inhabitants is also taken into consideration as beneficiary.

The population of a community, in spite of poor statistics, can be estimated with a reasonable degree of accuracy. However, in the case of cattle, their number can be hardly guessed because of their ceaseless rove. In the water supply planning for the candidate villages, cattle kept in the neighboring land will be counted as beneficiary.

In general, in a water supply plan, community inhabitants and pasturing cattle cannot be treated on equal basis. The study team's understanding is that the purpose of this study is to establish a people-oriented water supply plan. As for a cattle-oriented water supply plan, which may also be necessary in the Study Area, it would require another independent study by carefully considering the natural carrying capacity of the land.
Public institutions existing in the community are small in scale, and are not counted as beneficiaries.

8.3.4 Level of Service

Appropriate levels of service, adaptable to the community, will consist of two lower types.

- A single or a few water points, such as a well with a handpump or a motorized pump, without a distribution system

- A simple gravity distribution system with several public hydrants, supplied from a single water source

In the Study Area, a few house connections were requested by inhabitants, particularly in large communities on road 9. However, considering the present relatively low income level of the rural society, the request cannot be included in the plan.
Within a given service level, real service quality declines with the amount of time spent by users queuing to

fill containers and with hauling time. Sufficient considerations were given to those factors in the detailed planning stage.

8.3.5 Population Served and Water Consumption

(1) Design year

Since the target year for the national rural water supply plan has been set as the year 2000, the design year for the water supply planning conform to that year.

(2) Population served

The population served in 2000 will be estimated based on the latest population data in 1990 or 1989, which was confirmed in the field survey in Phase I and Phase II. With scarce data on population growth rate in individual communities, for estimating the population in 2000, the study team had no other alternative but to use the national population growth rate (yearly 2.76%). The estimated population in 2000 with 2.76% yearly growth rate will increase by 31% from the present population. In the light of observations during the field survey, the increase appears to be excessive for the rural area. However, the value will be somewhat justified considering the livestock neglected in the water supply plan, and unavoidable use by people from other communities.
The population served for individual communities is shown in Table 8.3.1.

(3) Cattle served

1) The cattle raised in the village dwelling area are, at most, several tens of heads. The effect of this on the design of community water consumption is negligible, even supposing the cattle consumes water supplied for inhabitants.

2) Cattle grazing in neighboring land of certain 13 villages, with no sufficient or convenient surface water, are taken into consideration in separate supply systems, on the assumption that cattle owners are willing to maintain the supply points at their own expense.

(4) Daily per capita water consumption and total community consumption

1) Present per capita consumption

The actual daily per capita water consumption in the rural area varies not only by mode of life but also by conditions of the water supply source.
Figures indicated below are estimates by the study team for typical villages, based on data obtained through questionnaires.

- Communities on road 7: 8-12 lcd (liters per capita per day)
- Communities on road 9: 10-15 lcd
- Community with pilot water supply facility: 10-20 lcd

An analysis of answers to interview questions gave the following consumption pattern.

- For cooking and drinking	6-9 lcd
- For personal hygiene	4 lcd
- For washing clothes	3 lcd

2) Design average daily per capita consumption

For the purpose of designing a water supply system, average daily per capita consumption should exceed the values mentioned in 1). The reasons are:

- Actual per capita consumption observed is presumably a suppressed consumption, restricted by difficult supply conditions, to the extent of being definitely insufficient to keep a good personal hygiene.

- It is probable that in guessing actual consumption, an overlooked fact was that many women prefer to go to river or irrigation canal for washing clothes, thereby resulting in underestimated consumption. Likewise, most people prefer to bathe in rivers or irrigation canals. Because of a serious threat of schistosomiasis, the custom of washing and bathing in rivers and irrigation canals should be altered by providing convenient access to safe water.

The national water consumption target of 20 lcd is, in this context, considered as a practical and appropriate value. The study team, accordingly, employs 20 lcd for the water supply planning.

3) Daily per head consumption for cattle

According to cattle owner's advice, the study team uses 16 -30 liters per head per day for the water supply planning.

4) Community water consumption to be fulfilled by a new supply plan

The water consumption in individual communities to be supplied by a new supply plan is estimated by the following steps.

- The gross community water consumption is calculated according to the population, the number of cattle and the per capita (head) consumption.

- The community water consumption fulfilled by the existing protected dug wells and tube wells, if any, is estimated.

- The net community water consumption to be supplied by the new supply system will be the difference between the above two figures.

The above calculation procedure implies that traditional water sources other than protected dug wells are to be replaced by new safe water supply sources.
The net community water consumption is indicated in Table 8.3.1.

8.3.6 Outline of Proposed Water Supply System

(1) Water supply projects identified in the Study Area

Sub-projects identifiable in the candidate villages to supply safe water will be classified into three categories as described below.

1) Sub-project(a): Improvement of existing traditional water sources

A dug well, one of the most prevalent traditional water sources, can supply reasonably safe water when it is properly protected from contamination from surface ground. A simple concrete wall casing is installed easily for the purpose. The improvement project makes maximum utilization of local resources such as construction material and labor force, and is the least expensive and a widely adaptable sub-project for small and remotely located communities.

2) Sub-project(b): Deep tube well installation

This type of project is the most popular type for modern rural water supply and widely applicable in the Study Area.

In this type of project, sufficient attention must be given to the post-investment maintenance, since a lot of abandoned handpumps and motorized pumps can be observed in the Study Area. This type of project can be proposed occasionally as a better and more advanced alternative to existing traditional dug wells, in spite of its comparatively difficult maintenance.
A community which is looking forward to something better than subsistence, and many villages in the Study Area fall into this category, deserves to introduce this type of water supply instead of dug well-based water supply.

3) Sub-project(c): Comprehensive regional water supply system

This system for more than ten communities is considered in certain areas where no dependable water source is available. For instance, the long area along road 7 between Tranokaky and Toliara would be the case (population : 23,000 (See Fig.8.1.1)). Also Basibasy and 12 small communities on the 32 km road between Analatelo 28 and Basibasy 27 can be provided with safe water if a transfer main is installed from Analatelo to Basibasy (total population : 6,000). As a matter of fact, the groundwater available in Basibasy is salty, while that of Analatelo is plentiful and excellent in quality.

In this study, however, the planning concentrates on (b) type sub-projects. For the (a) type sub-projects, the study team will prepare a necessary technical recommendation for executing projects with self-help efforts of beneficiary communities and supporting agencies. With respect to (c) type sub-projects, a separate study is recommended in the future.

(2) Adaptable water supply facility or system

The water supply facility or system adaptable to the candidate villages are mostly determined depending on water tables and the scale of beneficiary community. The adaptable facility or system is indicated in Table 8.2.2.

The first five categories are self-explanatory in their adaptation to communities, with brief descriptions in the column "application". However, the last two categories may need brief explanations.

Community water work for Berenty-Betsileo (WW):

Berenty-Betsileo is a large community in a remote place in Fiv. Ankazoabo. A test boring carried out during this study has confirmed that the groundwater is salty, to the extent of being unsuitable for drinking. The only alternative is to pump up underflow water that is collected in a shallow well located near the river shore. Water treatment would be by gravity settling and, if necessary, by slow sand filtration. Because of the widely dispersed housing area, installation of a simple distribution network is required.
Separate cattle watering places are required, in particular, in communities on road 9 where cattle are kept on land adjacent to communities with inadequate surface water. The watering place is to be located outside the dwelling area but receiving water from the same source as domestic water.

(3) Appropriate technology

Machinery required for the above water supply facilities, such as handpumps, submersible motor pumps and diesel engine generators etc., fall under the category of appropriate technology generally accepted in the rural water supply program.

However, it is undeniable that the machinery, being not of the so-called maintenance-free type, sometimes places a relatively heavy burden on users, which may be beyond their self-help ability, mainly for repair works and logistic problems for acquisition of spare parts. An approach to the solution of these problems will be discussed later, together with the maintenance system.

8.3.7 Approach to Operation and Maintenance System

(1) Survey findings for the operation and maintenance of water supply facilities

1) Prior to the completion of the rehabilitation and 19-pilot facilities, preparation of community-level (user-level) organization for the operation and maintenance of the facility has started. An organization of community members for the purpose has been developed according to the following procedure.

Step-1	Step-2	Step-3	Step-4	Step-5
Kick off meeting	Action-plan meeting	Sign of minutes	Training in operation	Monitoring by the Organization
Explanation to community members about the organization and costs	-Selection of water committee and care takers -Setting up money collection system			
Participants				
-The study team and counterparts -MIEM (Toliara) -Community members	The same as the left	President of the community	-MIEM (Toliara) -Care-takers -The study team and counterparts	-Water commitee and care takers

The proposed maintenance system for pilot facilities consists of the following:

- user side : water committee and care-takers
- back up side : MIEM (Toliara)

During the kick-off meeting and the action plan meeting, essential issues with respect to operation, maintenance and management, which are mentioned below, were brought up and discussed.

- Beneficiaries sharing the monetary costs (fuel oil, spare parts,touch-up painting, repair of building, foundation and platform, leak from pipe, direct cost for technical support) and labor (cleaning and proper drainage and other routine housekeeping)

- Spare parts control

- Record keeping and regular patrol for preventive maintenance

A summary of decisions made in meetings, is shown in Table 8.3.3.

2) Findings through those activities are summarized below.

Community side

- A willingness to pay for the recurrent cost is clearly indicated by the village people.

- A positive approach to self-help schemes for the maintenance of the facility is recognized. In fact, some communities have started voluntary supplement to the facilities, such as fences, and self control of service hours.

- Lack of technician or skilled worker, although doubtlessly important, can be overcome with proper communication and coordination with the back-up organization.

- An inclination to discuss issues only by men, is observed, in spite of the important role of women and children in hauling water.

- Almost all water committees are organized based on the existing community hierarchy. A positive community participation is indicated by a strong custom to gather community members' opinions whenever new issues are to be decided. However one weakness that should be urgently addressed was the absence of women in those community meetings organized to set up the village water committee. Women should have protagonic roles in matters concerning water supply, given the fact that women and children shoulder the back of the heavy task of securing water for the family.

Supporting side (MIEM, Toliara)

- The Toliara branch appears to have a general understanding of the importance of technical service they will have to provide to villagrs.

- If a rural water supply project is implemented, the Toliara branch will have to develop capabilities in obtaining spare parts prior to real demands from users. This, in some cases, may require import of spare parts from foreign sources, implying cumbersome procurement procedures.

- The branch does not have sufficient staff. Transportation means and equipment/tools required for the support service are not enough.

Common problems

Means to manage the collected money and logistic problems concerning acquisition of fuel oil and spare parts are both indirect but important problems for operation and maintenance.

- Money management: In rural areas, money can be usually collected from people once or twice a year, only during harvesting. Collected money, therefore, must be safely kept somewhere for future spending. If collected money is mismanaged, people might lose their willingness to pay for the water supply service. In this case, the operation and maintenance, based on self-help scheme of users, will face, in no time, a critical situation.Therefore, a reliable service by a financial agency, for instance the National Agricultural Bank, should be extended to the rural communities.

- Logistic problem : Logistic support for the operation and maintenance of the water supply facility consists of timely procurement, storage and transportation of fuel oil and spare parts.

For the problem of fuel oil, with no easy access to reliable fuel suppliers, commitment of beneficiaries to keep up operation of their facility is the only dependable solution. However, the real difficulties are aggravated by bad road condition, lack of own vehicle and time consuming trips. Strong commitment alone can solve it.

As for the overall spare parts control, first of all, a central stocking system should be introduced in MIEM. A spare parts controller in charge of the stocks, in accordance with estimated future demand, should issue purchase orders early enough to meet real demand. Inventory control based on future demand is not an easy task.

When overseas procurement is required for spare parts, the acquisition of foreign currency and following import formality become necessary, which will require specialized professional assistance and will be very time-consuming. If this support is not thoroughly conducted, the newly built facilities will fall rapidly into disrepair and will be abandoned by communities unable to keep them functioning.

(2) Approach to a new maintenance system

1) The only way to establish a workable maintenance system tailored to meet actual conditions of the Study Area will be to start a trial system in the pilot water supply facility, and then make adjustments as the results dictate, and to expand it according to a set timetable if specified results are achieved.

However, the approach can function satisfactorily only if MIEM (Toliara) tests the soundness of the approach with monitoring, analyzing and appraising the operational results of the pilot supply facilities.

2) There is no particularly difficult problem for the community-oriented self-help scheme in operating and maintaining the community water supply system. However, for training local care-takers and for providing technical services and logistic support to large areas, a reliable back-up organization should be developed. Since neither existing local administrative offices nor local government agencies have a satisfactory capability for the work, MIEM (Toliara) branch, for the time being, must assume the responsibility.

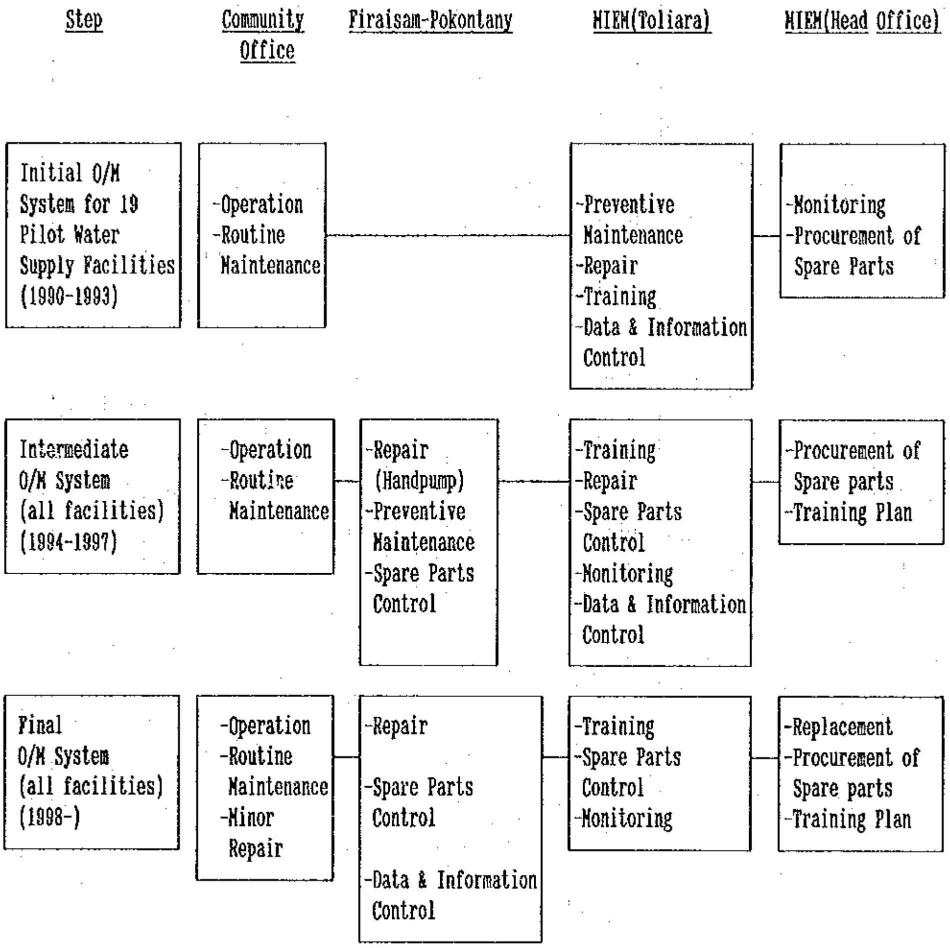
Accordingly, strengthening its management ability, technical capacity and equipment/tools availability is most urgently required. The present capability is hardly enough to support the maintenance of the 19-pilot water supply facilities.

3) In a long-term prospect, rural community water supply facilities will steadily increase, thereby expanding technical services demanded from MIEM. Then, the maintenance system, with MIEM (Toliara) providing the main support activity, would become a rather questionable system. The right course for the long term building of a real workable support system in the area would be strengthening of the middle-level local administrative offices, such as FIVONDRONANA and FIRAISAM-POKONTANY offices to the extent that they can back up beneficiary communities. Putting a new "water section" in their organization would be the first step, and start to support handpump-based supply facilities would be the second step.

Technical help, whenever they need, would be fulfilled, for instance, by employing private technicians at the expense of beneficiaries.

The following figure illustrates a proposed development plan for the overall operation and maintenance system. According to the plan, the system will shift through 3 four-year stages to a more community/local administrative office oriented system, while MIEM can increasingly concentrate in planning activities.

Proposed Development Plan for O/M System



4) Beneficiary's cost sharing can be extended to indirect costs required for technical service by MIEM so that a preventive maintenance can be certainly practiced. However, it will be unrealistic to expect for beneficiary community to make investments for spare parts which might be necessary in the future. On behalf of the beneficiary community, MIEM is requested to make the investment.

Table 8.3.1 Population Served and Community Water Consumption(1)

No	Village Name	Priority	Population in 1 990	Yearly Growth Rate	Population in 2 000	Cattle to be Served	Gross Water Consumption Domestic Use (m3/Day)	Cattle Watering (m3/Day)	Total (m3/Day)	Existing Safe Water Supply (m3/Day)	Net Water Required (m3/Day)
8	Mangolovolo	Aa	1,500	2.76%	1,965	—	39.0	—	39.0	—	39.0
22	Manoy	Aa	540	2.76%	707	400	14.0	7.0	21.0	4.0 (P)	17.0
46	Berenty-Betsileo	Aa	2,340	2.76%	3,065	—	61.0	—	61.0	—	61.0
49	Tanandava-Antaifasy	Aa	2,010	2.76%	2,633	—	53.0	—	53.0	—	53.0
52	Soahazo	Aa	2,837	2.76%	3,716	800	74.0	14.0	88.0	20.0 (P)	68.0
53	Analamisampy	Aa	756	2.76%	990	400	20.0	7.0	27.0	4.0 7.0 (P)	16.0
54	Belitsaka	Aa	1,315	2.76%	1,723	800	34.0	14.0	48.0	7.0 (P)	41.0
55	Ampasikibo	Aa	2,000	2.76%	2,620	800	52.0	14.0	66.0	4.0 7.0 (P)	55.0
56	Namaboha	Aa	1,505	2.76%	1,972	800	39.0	14.0	53.0	7.0 (P)	46.0
63	Manombo-Atm	Aa	4,638	2.76%	6,076	—	122.0	—	122.0	4.0 (P)	118.0
68	Benetsy	Aa	2,000	2.76%	2,620	800	52.0	14.0	66.0	4.0 (P)	62.0
77	Andranovory	Aa	1,524	2.76%	1,996	—	40.0	—	40.0	—	40.0
92	Mahaboboka	Aa	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
101	Ankilimalinika	Aa	3,845	2.76%	5,037	800	101.0	14.0	115.0	4.0 (P)	111.0
a	Befandriana	Aa	3,000	2.76%	3,930	—	79.0	—	79.0	24.0 (P)	55.0
b	Betsioky Nord	Aa	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
c	Andranohinaly	Aa	1,800	2.76%	2,358	—	47.0	—	47.0	—	47.0
d	Sakaraha	Aa	3,935	2.76%	5,155	—	103.0	—	103.0	—	103.0
e	Ankazoabo	Aa	3,000	2.76%	3,930	—	79.0	—	79.0	—	79.0
11	Andranomanintsy	Ab	1,400	2.76%	1,834	—	37.0	—	37.0	—	37.0
14	Antsakoabe	Ab	800	2.76%	1,048	800	21.0	14.0	35.0	—	35.0
25	Sihanaka	Ab	700	2.76%	917	—	18.0	—	18.0	4.0 (P)	14.0
29	Mangotroka	Ab	600	2.76%	786	—	16.0	—	16.0	4.0 (P)	12.0
34	Tandrano	Ab	3,500	2.76%	4,585	—	92.0	—	92.0	—	92.0
35	Ampandramitsetaky	Ab	800	2.76%	1,048	—	21.0	—	21.0	—	21.0
47	Ankilivalokely	Ab	1,230	2.76%	1,611	—	32.0	—	32.0	—	32.0
58	Ankatrakatra	Ab	460	2.76%	603	400	12.0	7.0	19.0	—	19.0
61	Beroroha	Ab	2,270	2.76%	2,974	—	59.0	—	59.0	—	59.0
78	Befoly	Ab	864	2.76%	1,132	400	23.0	7.0	30.0	—	30.0
83	Andranolava	Ab	1,500	2.76%	1,965	—	39.0	—	39.0	—	39.0
96	Analamary	Ab	1,000	2.76%	1,310	—	26.0	—	26.0	4.0 (P)	22.0
40	Tanandava	Ba	400	2.76%	524	—	10.0	—	10.0	—	10.0
59	Ampihamy	Ba	1,468	2.76%	1,923	800	38.0	14.0	52.0	4.0 (P)	48.0

Table 8.3.1 Population Served and Community Water Consumption(2)

No	Village Name	Priority	Population in 1 990	Yearly Growth Rate	Population in 2 000	Cattle to be Served	Gross Water Consumption Domestic Use (m3/Day)	Cattle Watering (m3/Day)	Total (m3/Day)	Existing Safe Water Supply (m3/Day)	Net Water Required (m3/Day)
8	Mangolovolo	Aa	1,500	2.76%	1,965	—	39.0	—	39.0	—	39.0
22	Manoy	Aa	540	2.76%	707	400	14.0	7.0	21.0	4.0 (P)	17.0
46	Berenty-Betsileo	Aa	2,340	2.76%	3,065	—	61.0	—	61.0	—	61.0
49	Tanandava-Antaifasy	Aa	2,010	2.76%	2,633	—	53.0	—	53.0	—	53.0
52	Soahazo	Aa	2,837	2.76%	3,716	800	74.0	14.0	88.0	20.0 (P)	68.0
53	Analamisampy	Aa	756	2.76%	990	400	20.0	7.0	27.0	4.0 7.0 (P)	16.0
54	Belitsaka	Aa	1,315	2.76%	1,723	800	34.0	14.0	48.0	7.0 (P)	41.0
55	Ampasikibo	Aa	2,000	2.76%	2,620	800	52.0	14.0	66.0	4.0 7.0 (P)	55.0
56	Namaboha	Aa	1,505	2.76%	1,972	800	39.0	14.0	53.0	7.0 (P)	46.0
63	Manombo-Atm	Aa	4,638	2.76%	6,076	—	122.0	—	122.0	4.0 (P)	118.0
68	Benetsy	Aa	2,000	2.76%	2,620	800	52.0	14.0	66.0	4.0 (P)	62.0
77	Andranovory	Aa	1,524	2.76%	1,996	—	40.0	—	40.0	—	40.0
92	Mahaboboka	Aa	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
101	Ankilimalinika	Aa	3,845	2.76%	5,037	800	101.0	14.0	115.0	4.0 (P)	111.0
a	Befandriana	Aa	3,000	2.76%	3,930	—	79.0	—	79.0	24.0 (P)	55.0
b	Betsioky Nord	Aa	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
c	Andranohinaly	Aa	1,800	2.76%	2,358	—	47.0	—	47.0	—	47.0
d	Sakaraha	Aa	3,935	2.76%	5,155	—	103.0	—	103.0	—	103.0
e	Ankazoabo	Aa	3,000	2.76%	3,930	—	79.0	—	79.0	—	79.0
11	Andranomanintsy	Ab	1,400	2.76%	1,834	—	37.0	—	37.0	—	37.0
14	Antsakoabe	Ab	800	2.76%	1,048	800	21.0	14.0	35.0	—	35.0
25	Sihanaka	Ab	700	2.76%	917	—	18.0	—	18.0	4.0 (P)	14.0
29	Mangotroka	Ab	600	2.76%	786	—	16.0	—	16.0	4.0 (P)	12.0
34	Tandrano	Ab	3,500	2.76%	4,585	—	92.0	—	92.0	—	92.0
35	Ampandramitsetaky	Ab	800	2.76%	1,048	—	21.0	—	21.0	—	21.0
47	Ankilivalokely	Ab	1,230	2.76%	1,611	—	32.0	—	32.0	—	32.0
58	Ankatrakatra	Ab	460	2.76%	603	400	12.0	7.0	19.0	—	19.0
61	Beroroha	Ab	2,270	2.76%	2,974	—	59.0	—	59.0	—	59.0
78	Befoly	Ab	864	2.76%	1,132	400	23.0	7.0	30.0	—	30.0
83	Andranolava	Ab	1,500	2.76%	1,965	—	39.0	—	39.0	—	39.0
96	Analamary	Ab	1,000	2.76%	1,310	—	26.0	—	26.0	4.0 (P)	22.0
40	Tanandava	Ba	400	2.76%	524	—	10.0	—	10.0	—	10.0
59	Ampihamy	Ba	1,468	2.76%	1,923	800	38.0	14.0	52.0	4.0 (P)	48.0

Table 8.3.1 Population Served and Community Water Consumption(3)

No	Village Name	Priority	Population in 1.990	Yearly Growth Rate	Population in 2 000	Cattle to be Served	Gross Water Consumption Domestic Use	Gross Water Consumption Cattle Watering	Gross Water Consumption Total	Existing Safe Water Supply	Net Water Required
73	Ambolonkira	Cb	450	2.76%	590	—	12.0	—	12.0	—	12.0
100	Ankilivalo	Cb	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
1	Ankazomanga	D	600	2.76%	786	—	16.0	—	16.0	—	16.0
2	Beadabo	D	600	2.76%	786	—	16.0	—	16.0	—	16.0
3	befasy	D	600	2.76%	786	—	16.0	—	16.0	—	16.0
4	Ankilifolo(1)	D	400	2.76%	524	—	10.0	—	10.0	—	10.0
9	Ankida	D	15	2.76%	20	—	0.4	—	0.4	—	0.4
12	Berantala	D	506	2.76%	663	—	13.0	—	13.0	—	13.0
17	Marovato	D	375	2.76%	491	—	10.0	—	10.0	—	10.0
18	Andranoboka	D	600	2.76%	786	—	16.0	—	16.0	—	16.0
24	Ankilifolo(2)	D	450	2.76%	590	—	12.0	—	12.0	—	12.0
27	Basibasy	D	1,000	2.76%	1,310	—	26.0	—	26.0	4.0 (P)	22.0
36	Andranomafana	D	600	2.76%	786	—	16.0	—	16.0	—	16.0
37	Mamakiala	D	300	2.76%	393	—	8.0	—	8.0	—	8.0
38	Berenty-Ankilimasy	D	108	2.76%	141	—	3.0	—	3.0	—	3.0
39	Betsinefo	D	34	2.76%	45	—	0.9	—	0.9	—	0.9
43	Mandabe Atm	D	100	2.76%	131	—	3.0	—	3.0	—	3.0
44	Soatanimbary	D	70	2.76%	92	—	2.0	—	2.0	—	2.0
45	Sahanory Atn	D	200	2.76%	262	—	5.0	—	5.0	—	5.0
66	Andoharano	D	300	2.76%	393	—	8.0	—	8.0	—	8.0
70	Anjamala	D	150	2.76%	197	—	4.0	—	4.0	—	4.0
74	Miary	D	2,000	2.76%	2,620	800	52.0	14.0	66.0	—	65.0
75	Befanamy	D	700	2.76%	917	—	18.0	—	18.0	—	18.0
76	Tsivonoabe	D	30	2.76%	39	—	0.8	—	0.8	—	0.8
80	Ambohimahavelona	D	2,000	2.76%	2,620	—	52.0	—	52.0	—	52.0
89	Bevoalavo	D	240	2.76%	314	—	6.0	—	6.0	—	6.0
93	Mahasoa	D	30	2.76%	39	—	0.8	—	0.8	—	0.8
97	Antanimora	D	300	2.76%	393	—	8.0	—	8.0	—	8.0

Table 8.3.2 Adaptable Water Supply Facilities

Facility	Supply	Installation	Application	Symbol
Protected dug well or infiltration gallery	Well	New or modification	- Shallow groundwater or underflow - Small village in remote place	WP
Tube well with handpump	Handpump	New	- Shallow groundwater - Concentrated population (200-800)	W.HP
Tube well with motorized pump and simple distribution	Public hydrant	New	- Deep groundwater - Concentrated population (500-2000)	W.HP
- do -	- do -	Modification of pilot facility	- Village with pilot facility	MP
- do -	- do -	Rehabilitation and extension of existing facilities	- Village with rehabilitation survey	W.MP .RH
Community Water work	- do -	New	- Only for Berenty-Betsileo	W.W
Separate cattle watering	Watering place	New	- Village with water shortage for cattle	C.T

Table 8.3.3 Community-level Operation and Maintenance System for Pilot Water Supply Facilities (1)

No.	Location	Installed Pump	Selected Member of Water Commity	Selected Care-Taker	Established Recurent Cost Recovery System	
					Subsidy	Collection from User
22	Manoy	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. SYLVAIN ② Mr. TOVONDRAINY ③ Mr. MBALIBE ④ Mr. RELAHY ⑤ Mr. HARIVE, KAMALISA, HERISOA ⑥ Mr. SYLVAIN, JEAN CLAUDE Mrs. MARIA, VELOAFARA	1	No	1, 000FMG/YEAR/FAMILY
25	Sihanaka	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. TSIALINO ② Mr. FITAHY ③ Mr. RAKOTOVAO ④ Mr. RELAHY ⑤ Mr. REBASY, BERSON, ANDRE, JOLY, VANTIO GILBERT ⑥ Mr. ALPHONSE, GUSTAVE	1	No	1, 00FMG/MONTH/FAMILY
27	Basibasy	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. JULES ② Mr. DANIEL ③ Mr. RAMDIMBISON Paul ④ Mr. PULBERT ⑤ Mr. RERAKANE, TSIKIZAHE, REZOLY, TSIARAI ⑥ Mr. MBOHINDRY Jean Baptiste, MAHASOLO, JEAN RONARD, DAMY SOAMANA	1	No	1, 00FMG/MONTH/FAMILY
29	Mangotroka	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. MANJARIMANA Retamay ② Mr. SOLONDRAINY ③ Mr. REVOZOGNONY ④ Mr. TSISUTRAINY ⑤ Mr. HENRI, RENEGNA, VELONDRAZA Albert TABIOKY Vonaly, MASINTSOKO ⑥ Mr. SOLDANY Dubois, RAZAFIMA TRATRA Sambson, BERA	1	No	2, 50FMG/MONTH/FAMILY
	Befandriana-Atsimo	GENERATOR DENYO JAPAN	① Mr. REPADLY ② Mr. ? ③ Mr. RANDRIATSITIANA Theodore, BOTO Celestin ④ Mr. NAVIO, BASILE ⑤ Mr. MICHEL Mahasovy, RANDRIANASOLO ⑥ Mr. RAKOTONIRINA Christian, BALOTO Gaston ⑦ Mr. RATEFISON Olivier, RAKOTD Sylvain, VICTOR Florent	3	No	2, 50FMG/MONTH/FAMILY

* ①:PRESIDENT, ②:VICE-PRESIDENT, ③:CASHER, ④:SECRETARY, ⑤:CONSULOR, ⑥:AVCTIONEER, ⑦:CARE-TAKER

Table 8.3.3 Community-level Operation and Maintenance System for Pilot Water Supply Facilities (2)

No.	Location	Installed Pump	Selected Member of Water Commity	Selected Care-Taker	Established Recurent Cost Recovery System	
					Subsidy	Collection from User
52	Soahazo	PANEL SOLAR and GENERATOR DENYO JAPAN	① Mr. REREDA ② Mr. VELOJATY ③ Mr. TSISESY ④ Mr. GERVAIS ⑤ Mr. DONNEE, ZEATAONY, RINO ⑥ Mr. RANDIVE ⑦ Mr. ZEATAONY, CLERMONT	2	No	5, 00FMG/YEAR/CAPITA
53	Analamisampy	HAND PUMP NSB-100. HL-R50 BELOW TYPE-NISAKU TOKYO	① Mr. TSITARA ② Mr. DENIS MAHIA ③ Mr. CELMON ④ Mr. DENIS, METHODE GERVAIS ⑤ Mr. VELOMIHARY Rendako, FREGIS Soafanahy, JEAN PAUL Arison ⑥ Mr. GILBERT Voahita, JUSTIN Mahia	1	No	?
54	Belitsaka	HAND PUMP NSB-100. HL-R50 BELOW TYPE-NISSAKU TOKYO	① Mr. TSIBONINTSY ② Mr. RAYMOND ③ Mr. JEAN TRIEL, SERGE ④ Mr. BERTIN, BEMAINTY ⑤ Mr. JEAN FELIX, BENARY, TSITOLORA, REFARA ⑥ Mr. ROLLANDISON, ALISOA, TSIFONOSY, MONISITA	1	No	?
55	Ampasikibo	HAND PUMP NSB-10C. HL-R50 BELOW TYPE-NISSAKU TOKYO	① Mr. HONALY Saleh ② Mr. REDAO ③ Mr. ZAMARY ④ Mr. FAHAROE ⑤ Mr. KALISOA VOROTSIHAKE, RAFIDY, MAHARENGITSAIKY, MAKA, TSITIAHINY, TSANAFARA, TSIAOTRA, MANGELO, REVEZO	1	No	1, 00FMG/MONTH/FAMILY
56	Namaboha	HAND PUMP NSB-100. HL-R50 BLOW TYPE-NISSAKU TOKYO	① Mr. ZERISTE ② Mr. CEBASTIEN DANIELSON ③ Mr. BEZANTY ④ Mr. MAHIA ⑤ Mr. REREDA, BAREBA, FRANCDIS, SETIFANA ⑥ Mr. RABEDARA Lovis Charles, RAHARISON	1	No	1. FOR MAN (>18 years) 5, 00FMG/YEAR/CAPITA 2. FOR GIRL (>18years) 2, 50FMG/YEAR/CAPITA

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Table 8.3.3 Community-level Operation and Maintenance System for Pilot Water Supply Facilities (3)

No.	Location	Installed Pump	Selected Member of Water Commity	Selected Care-Taker	Established Recurent Cost Recovery System	
					Subsidy	Collection from User
59	Ampihamy	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. NDIMBY JOJO ② Mr. FARADY ③ Mr. RENOKONY MAHATOMBO ④ Mr. ALPHONSE, KADOARA ⑤ Mr. KOTO Jean Hanio, KOKONY Tsihary REVAVANY, NAMOEZA ⑥ Mr. RETEFENE, ANDRIAMORASATA Mara	1	No	1. FOR MAN (mariied) 2, 50FMG/MONTH/CAPITA 2. FOR MAN (single) 1, 00FMG/MONTH/CAPITA
63	Manonmbo Atm	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. FARALY Rahoelison ② Mr. TINARIKE Julien ③ Mrs. SOARILININA, Mr. RESTA Solariko ④ Mr. RAYMOND Kenty, MATITAKELY Justin ⑤ Mr. MAHASARENTO Paul Xavier, JULES JACQUES, LAHA Mifona ⑥ Mr. FEREOLE Jean Martin SAFY Mampiondrike	1	Possible	1, 500FMG/YEAR/FAMILY
68	Benetsy	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. FANOGNEA ② Mr. TAPOFERA ③ Mr. NAOKE ④ Mr. ALPHONSE ⑤ Mr. MAHOLOTSE, MAVRICE, MAMPIONO, TSIAZOMPITAKE ⑥ Mr. RAHILISON, BOBA	1	No	1, 00FMG/MONTH/CAPITA (18 years old)
81	Manoroka	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. MANCTOB Tamboly ② Mr. FILAZA Seka ③ Mr. FLAVIENNE ④ Mr. MINO Mrs. EMININY HELENE ⑤ Mr. MIADA, MERCIE, ELIRY Alisony, SAROMBAKY, VELOMA Tsitindroty ⑥ Mr. FAMPY Mahatandrify, RABENASY, SAMISON, REHEVITSY	1	No	At first, 5, 00FMG/MAN (>18 years old)

* ①:PRESIDENT, ②:VICE-PRESIDENT, ③:CASHER, ④:SECRETARY, ⑤:CONSULOR, ⑥:AUCTIONEER, ⑦:CARE-TAKER

Table 8.3.3 Community-level Operation and Maintenance System for Pilot Water Supply Facilities (4)

No.	Location	Installed Pump	Selected Member of Water Commity	Selected Care-Taker	Established Recurent Cost Recovery System	
					Subsidy	Collection from User
95	Tranokaky	NIPPON PLEUGER SUBMERSIBLE MOTOR PUMP-JAPAN	① Mr. MANAMBIRA Lahimasy ② Mr. JEAN KELY ③ Mr. MIHA ④ Mr. JEAN ROSELA ⑤ Mr. VOERA, REMAMENO, SAMBEMANA, VONTSOBOY Manonjoasy ⑥ Mr. SOAMANINTSY, REHOLIANA, TSAMBOHOANY, FAHAZOANY ⑦ Mr. RAKOTOMAHAFALISOA Josephin, MASIMANA Joseph, RAYMOND Refaoke ⑧ Mr. ANDAKOANY	3	Possible	2,00FMG/MONTH/MAN (>18 years old)
101	Ankilimalinika	HAND PUMP-50MRC SOMECA ANTANANARIVO	① Mr. RAJOARY ② Mr. MBOATEANE, ARIZEMO ③ Mr. GEGENY ④ Mrs. BAO, JUSTINE ⑤ Mr. GASTON, Mrs. CHRISTINE, Mr. RENGOTOKE Alisony, FERDINAND BOLINY, ZAVALINE ⑥ Mr. ZITASON Remasy, LAURENT Makadala, SIZA Ferotsaike, Mrs. CLAUDINE Tsiazonera	1	Possible	50FMG/MONTH/MAN (>18 years old)

* ①:PRESIDENT, ②:VICE-PRESIDENT, ③:CASHER, ④:SECRETARY, ⑤:CONSULOR, ⑥:AUCTIONEER, ⑦:CARE-TAKER, ⑧:GUARD

8.4 Monitoring of Operation and Maintenance

8.4.1 General

Once the pilot facilities were in operation, the Study Team took every opportunity to observe real performance of the equipments and the maintenance practice by villages and MIEM (Toliara Office).

In short, as of late March 1991, the handpump (total 16 units) are not considered as completely satisfactory since troubles which began arising in December 1990, still remain to be solved. On the other hand, no problem has been observed in the 3-motorized pumping systems, not because of successful maintenance efforts, but thanks rather to strong and reliable mechanism in the pump and engine-generator.

8.4.2 Technical Performance

No problem was observed in submersible motor pumps and diesel engine generators (3 units) during the monitoring period.
However, it should be pointed out that the three motorized pumping systems have been operated for a short period, each with less than 200 hours. The potentiality of a solar pump system was evaluated based on the performance of the pilot facility up to now. Cost savings for operation and maintenance are clearly advantageous in comparison with the generator system. However, it is necessary to conduct continuous observations on climatic conditions and system performance. Details of monitoring results are discussed in Supporting Report(1).
Hand pumps, however, have been observed to be affected by considerable mechanical troubles, for the time of their initial start-up, excepting 5-hand pumps imported from Japan.

(1) Handpumps imported from Japan

The mechanism and performance of the pumps have been excellent in this initial satage (4 months). A shortcoming which can be pointed out is painting on the pump casing which is easily peeled off. From now on, an occasional touch-up painting on the casing should be carried out by users.

(2) Locally manufactured handpump

(a) The common defect of the pump is poor check mechanism against downward leak of water column in the riser main through the piston and foot valve. Consequently, the pump can hardly hold a water column firmly while the pump is not in operation. It definitely provides a major cause for poor performance of the pump, as reflected in the following.

- Obviously low pumping rate in comparison with other standard pumps.

Hand pump Manufacturer	No. of lever swings required to get 10liters of discharge
Local	28 - 45
Imported	17 - 30

(at constant swing rate but variable ground water levels)

- Surprisingly many idle (dry) swings, more than 100 swings, are required to get water with a new pump start-up, even after a short interruption in the pump operation (several tens seconds of interruption).

(b) The belt fixed to the pump rod for transfer of manual force from the lever to the piston is not properly designed, thereby causing frequent slip-off of the belt from the fixing clasp.

(c) Mechanical break-down of the piston is the main cause of serious troubles of the pump. However, details of the cause of breakdown is not yet known.

8.4.3 Institutional performance

The village water committee, which was supposed to operate and maintain the pilot facility, has worked only for collecting water charges, without taking any action toward equipment maintenance and repair.
It was observed that the water committee had a tendency to shift all responsibilities on the caretakers, without

providing them appropriate support.
The MIEM TOLIARA office, which was supposed to provide support to villagers, still remains in a rather passive attitude and seems to perceive their role as an intermediary to transfer information or requests from village users to equipment suppliers.
The regular and periodic inspection of equipment maintained by village care takers to give them the necessary instructions for preventive maintenance would have been the first experience for the office. However, judging from the manager's scant awareness on the details of technical tasks they have to perform, coupled with scarce technical capability among his subordinates, it would be hard to expect to type of successful support which was envisaged.
Although the MIEM Toliara office has organized a technical service term to villages, the work performed by this service term could not yet be seen. The vehicle assigned to the service team looked like poorly maintained, not in good enough condition to withstand future hard uses.
Under these circumstances, realistic measures to be taken are as follows.

(a) If possible, particularly in the initial stage of maintenance work the geographical area to be covered by the MIEM service team should be kept to the minimum, for instance within a radius of a few hours drive from Toliara City.

(b) The service team should have an exclusive staff and an independent budget within the Toliara office.

(c) A competent leader for the service team should be provided from the MIEM head office. Available persons in the TOLIARA office are not sufficiently qualified for the job, particularly in managing work, unless specialized and intensive training is provided.

8.4.4 Financial Performance

(a) Village level

At 3 sites equipped with motorized pumping systems, the average fuel oil consumption for the generator operation was found to be only 2 to 3 liters a day. The consumption

may increase in the upcoming dry season but, still, the payment for fuel oil is not considered as a heavy burden on villagers.
No village, however, has so far faced the problem of real payment for the repair work of equipment.
The problem, will only come into view in the future, when repair work will have to be really performed by the supplier or MIEM TOLIARA office.

(b) *MIEM TOLIARA office*

It is obvious that the current meager office operating budget is one of the obstacles to provide technical services efficiently. The fact that curing January and February 1991, the office could not dispatch the service team to the villages having pump problems, because of lack of office money to purchase fuel oil, persuasively proves the point.
If the service team can keep a completely independent budget, even if it is only a small amount, they could resonabily control their activity so as to meet villager's requests, more efficiently.

8.4.5 Monitoring results

Tables 8.4.1 and 8.4.2 show monitoring results of 19-pilot water supply facilities at the end of March 1991.

8.4.6 Per capita water consumption

Water consumption was measured at the pilot facility in Tranokaky in November 1990 and March 1991 in order to estimate water demand. Fig. 8.4.1 shows daily distribution of water consumption.
Water using population is estimated at around 3000 in Tranokaky, including 1000 in Mahatsua in the immediate surrounding of the pilot facility. Peak consumption was observed between 14:00-16:00, presumably for supper preparation.
Total water consumption volumes were 16,000 l/day and 15,200 l/day on 10 and 11 November 1990, respectively.
Based on these amounts and the estimated number of per capita water consumption is calculated as 6 and 16 l/day/person for Mahatsa and all Tranokaky, respectively.
The storage tank of this system is designed for 16 cubic

meters, and a full tank can satisfy one-day consumption.
In March 1991, after the rainy season, water consumption drastically decreased in reference to November 1990. Pump was operated every other day, and a half tank(=8 m^3/day) was enough for their consumption. Interviews with villagers shows their increased dependence on traditional water sources like dug wells and/or rainfall water stored during the rainy season.

The same outcome was observed in Soahazo. Daily water demand was satisfied with traditional water sources. These results suggest water consumption depends on such factors as season, i.e.,rainfall amount, water level of the dug well and villagers perception of sanitation and drinking water quality.
Availability of appropriate water sources is expected to accelerate the change of their water utilization pattern from traditional to improved source. Accordingly, a design water consumption of 20 lcd is used for water supply planning.

Table 8.4.1 Status of 19-Pilot Water Supply Facilities, March 1991 (1)

Village	Pump	Status On Dec. 1,90	Findings in Mar. 1991
Befandriana	Motorized Pump	Working	Working; 155 Hrs operation; periodic patrols by MIEM are continued; good O/M data recording.
52 Soahazo	Motorized pump by Solar battery	Working	Working; Back up engine generator is scarcely used, periodic patrols by MIEM are continued; good O/M data recording.
95 Tranokaky	Motorized pump	Working	Working; No O/M data recording resulting from no MIEM patrol, trouble may occur any day.
23 Ampoza	Local Handpump	Working	Working; No patrol by MIEM; around 10 to 20 idle swings (empty cycles) are required after interrupting operation for several ten seconds; probable cause is foot valve leakage
22 Manoy	Local Handpump	Working	Ditto
29 Mangotoroka	Local Handpump	Working	Ditto
25 Sihanaka	Local Handpump	Working	Working; no patrol by MIEM; villages have opened the pump casing. Without any consultation with MIEM; 3-fixing bolt/nuts on the casing are lost.
54 Belitosaka	Jap. Handpump	Working	Working; No patrol by MIEM; Touch-up painting on the pump casing is required.
53 Analamisampy	Jap. Handpump	Working	Working; No patrol by MIEM.

Table 8.4.1 Status of 19-Pilot Water Supply Facilities, March 1991 (2)

Village	Pump	Status On Dec. 1,90	Findings in Mar. 1991
101 Ankilimali -nika	Local Handpump	Working	Working; No patrol by MIEM.
68 Benetsy	Local Handpump	Working	Out of order since Dec. 1990; MIEM was informed but did not repair it; Probable cause of trouble may be the piston; fixing of force transmission belt is not working well.
59 Ampihamy	Local	Working	Out of order since Dec. 1990; MIEM was informed and took off the piston to repair, but no result until now.
56 Namaboha	Jap. Handpump	Working	Working; No patrol by MIEM; Touch-up painting is required
55 Ampasikibo	Jap. Handpump	Working	Ditto
63 Manombo	Local Handpump	Out of order	Out of order; No action by MIEM.
96 Analamary	Local Handpump	Working but extraordinary force is required due to pump internal friction.	Still working with Same difficulty, no action and no improvement.
81 Manoroka	Local Handpump	Working	Working; no patrol by MIEM; touch-up concrete work is required on the foundation.
28 Analatelo	Jap. Handpump	Working	Working; no patrol by MIEM.
27 Basibasy	Local Handpump	Out of order	Could not reach it, but it is assumed be still out of order without actual repair.

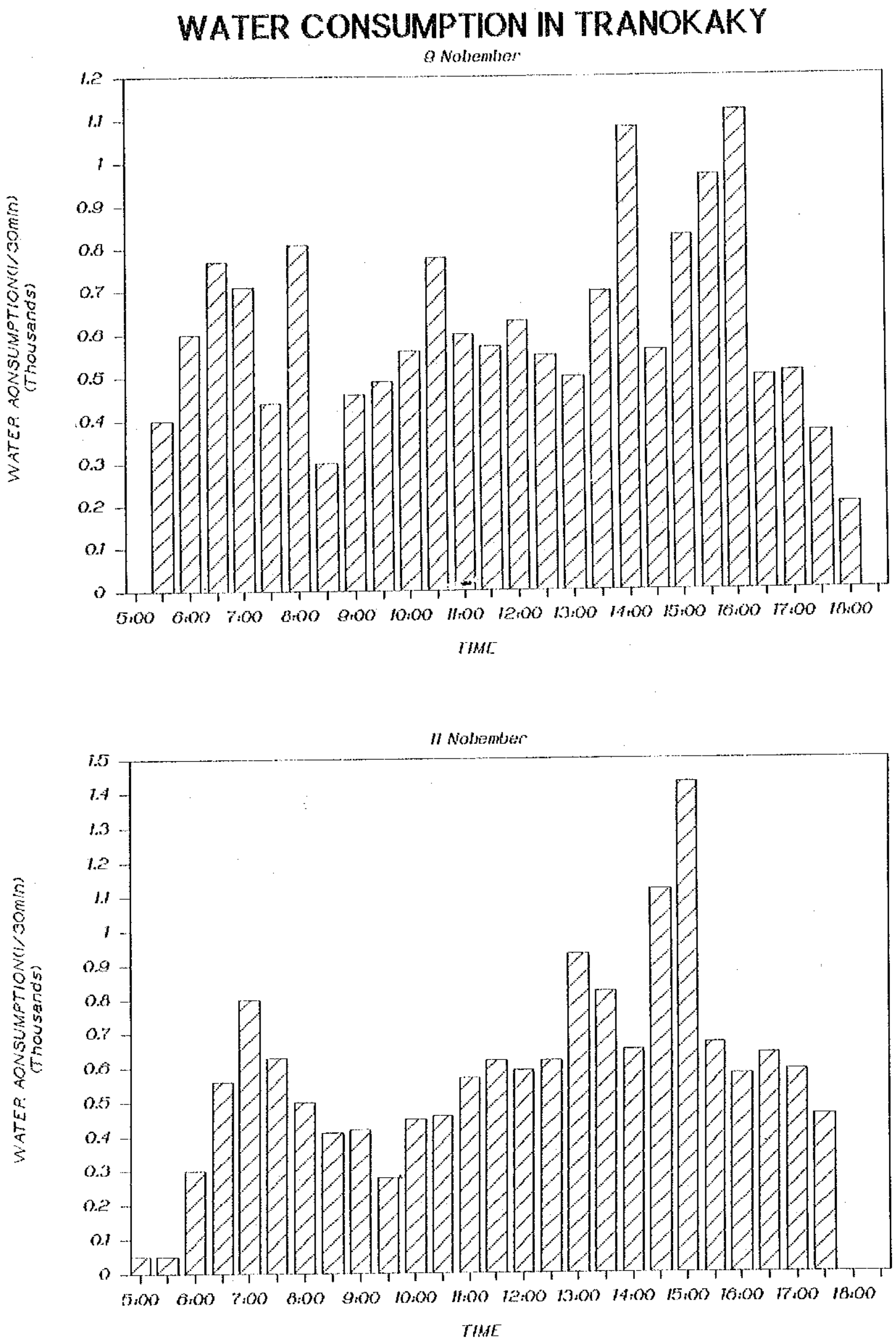

Fig. 8.4.1 Water Consumption in Tranokaky

9. THE PROJECT

9. THE PROJECT

9.1 Groundwater Development Plan

As stated in previous sections, the potential for groundwater development in the Study Area is generally high, except some poor areas due to their hydrogeological conditions and water quality. Groundwater is an important and a limited resource in this area, where annual rainfall of 400-800 mm makes it the driest area in Madagascar. Therefore, it is required to utilize this resource as efficiently as possible. From this viewpoint, the approach to develop groundwater is summarized as follows.

1) It is advantageous to employ handpump for lifting of groundwater from the viewpoint of construction cost, operation and maintenance and saving of discharge.
According to the results of yield investigation, 2 or 3 handpumps can be utilized simultaneously in the same village without causing drawdown.

2) When submersible motor pump is employed, it is necessary to keep a distance of more than 500 m between wells in order to avoid drawdown.

3) It is necessary to decide well location, depth and drilling method based on comprehensive hydrogeological analysis. Detailed hydrogeological structure is investigated by electric prospecting, after reviewing seasonal variation of groundwater level, water quality, yield and hydraulic information of existing wells.
The groundwater development potential indicated on the hydrogeological map, and the development scale described in the next sub-section are based on the above mentioned detailed research of local conditions.

4) Development of limestone plateau along route 7 requires 250-300 m of drilling because of low groundwater level at 170-220 m below ground surface. Additionally, the aquifer exists in the porous, fault and/or fracture zone in limestone, requiring the detailed research mentioned in 3) above.

5) It is necessary to consider water quality before the development, especialy in the area along route 9.
The problem of "salty water", caused by fossil salt water in dolomitic marl of marine deposit, exists within 30 m below ground surface. Therefore, deep drilling is required in order to get confined aquifer with good water quality, even for handpump equipped wells.

9.1.1 Aquifer and development scale

This subsection describes the general development scale of groundwater in each aquifer zone, as classified in the hydrogeological map, according to the groundwater potentiality.

(1) Class A1 aquifer zone

Aquifer is generally composed of unconsolidated sandy deposits of the Quaternary, such as river-bed deposit and sand dune deposit.
In this Class A1 aquifer zone, groundwater pumping at 250-600 l/min per well is expected in a borehole with a depth of 30-50 m and a diameter of 150 mm(6").

(2) Class A2 aquifer zone

This Class A2 aquifer zone is distributed in both the western region and the eastern region of the Study Area.
The Class A2 aquifer zone distributed in the western region is composed of neritic sediments of the Middle to the Upper Eocene, and divided into three(3) districts of Befandriana, Soahazo and Benetsy, based on detailed hydrogeological conditions.
From the results of the comprehensive analysis on hydrogeology, in particular the results of test drilling and pumping test, the following development scale of groundwater is expected in these districts.

a) Befandriana district

- Target depth and diameter
  of a borehole : 50 m, 100-150 mm
- Expected pumping discharge
  per borehole : 200-600 l/min

- Specific capacity of 5 test drillings in this district:
  23.03-304.57 l/min/m (average 142.60)

b) Soahazo district

- Target depth and diameter of a borehole : 50-100 m, 100-150 mm
- Expected pumping discharge per borehole : 200-360 l/min
- Specific capacity of 6 test drillings in this district :
  13.61-120.37 l/min/m (average 43.39)

c) Benetsy district

- Target depth and diameter of a borehole : 50-100 m, 100-150 mm
- Expected pumping discharge per borehole : 230-580 l/min
- Specific capacity of 4 test drillings in this district :
  46.56-115.70 l/min/m (average 82.92)

The Class A2 aquifer zone distributed in the eastern region of the Study Area is mainly composed of continental deposits of the Lower Jurassic, and the following development scale of groundwater is expected from the results of comprehensive analysis on hydrogeology.

- Target depth and diameter of a borehole : 70-100 m, 150 mm
- Expected pumping discharge per borehole : 300-600 l/min
- Specific capacity of 2 test drillings in this district :
  41.76-43.53 l/min/m (average 42.65)

(3) Class A3 aquifer zone

As shown in the hydrogeological map, the Class A3 aquifer zone is distributed in both the western region and eastern region of the Study Area, and its distribution pattern is similar to that of the Class A2 aquifer zone.

Hydrogeologically, the Class A3 aquifer zone distributed in the western region is divided into two districts of western side and eastern side of route 9.

The Class A3 aquifer zone in the western side district of route 9 is composed of neritic sediments of the Middle to the Upper Eocene, and groundwater pumping at 200-600 l/min per well is expected in a borehole with a depth of 100-200m and a diameter of 150 mm.
On the other hand, the Class A3 aquifer zone in the eastern side district of route 9 is mainly composed of porous or fissured limestone of the Lower to the Middle Eocene, and the following development scale of groundwater is expected from the results of comprehensive analysis on hydrogelogy.
It is, however, strongly recommended to drill a borehole of more than 250 m for groundwater development in the area of limestone plateau along route 7.

- Target depth and diameter of a borehole : 150-250 m, 150 mm
- Expected pumping discharge per borehole : 200-600 l/min
- Specific capacity of 2 test drillings and 3 existing boreholes of JIRAMA at Miary : 217.50-5,016.67 l/min/m (average 2,122.92)

The Class A3 aquifer zone distributed in the eastern region of the Study Area is composed of continental and neritic sediments of the Lower to the Middle Jurassic, and pumping discharge of 300-600 l/min per well is expected in a borehole with a depth of 120-200 m and a 150 mm diameter.

(4) Class B1 and B2 aquifer zone

The Class B1 aquifer zone is distributed in three districts of Sikily, Sakanavaka and Menamaty river basins, while the Class B2 aquifer zone is distributed mainly in four districts of Ambahikily of Mangoky River side, central part of Fiherenana River basin, Rezoky and Mangitraky River basins and Berenty-Betsileo of Isahena River basin.

Based on the results of comprehensive analysis on hydrogeology, in particular the results of geophysical prospecting, test drilling and pumping test, Table 9.1.1 shows the groundwater development scales which can be expected in those districts of the Class B1 and B2 aquifer zones.