4 HYDROLOGY AND HYDROGEOLOGY

4.1 Topography and Hydrology

General topography of Santiago Island features ***a volcanic island with steep mountainous and hilly areas*** occupying more than 80% of the total land. The island features few flat areas, such as the central plateau corresponding to highly eroded mountains and narrow alluvial plains along rivers or along the coast.

The island is divided into ***5 hydrogeological basins*** from the topographical, hydrogeological features as presented in Figure 4-1, and the evaluation on the potential of groundwater development was made for these basins and sub-basins.

The precipitation of Santiago Island by basin is shown in following table. There is a typical rainfall pattern in this island, namely, ***rainfall increases with altitude.*** Whereas the central highlands receive 400~700 mm/annum, lower areas have limited rainfalls of 100~200mm/annum. Referring the Isohyet map presented in Figure 4-2, the total volume of mean annual precipitation in each of the above-mentioned basins is calculated as follows:

	Total rainfall amount	Mean rainfall
- Tarrafal basin (188 km^2)	55.97 million m^3	270mm
- Santa Cruz basin (355 km^2)	114.97 million m^3	330mm
- Santa Catarina basin (128 km^2)	33.20 million m^3	260mm
- S. J. Baptista basin (155 km^2)	28.48 million m^3	180mm
- Praia basin (179 km^2)	38.20 million m^3	210mm
Santiago Island (1,005 km^2)	270.82 million m^3	(270mm)

There are ***no perennial rivers*** in the island, due to a short rainy season and limited precipitation. Until several years ago, there were some perennial flows in the upper reaches of rivers originating in springs, however, those surface flows changed to sub-surface flows along with the decline of spring discharge.

Forty-nine (49) permanent springs out of 100 springs were surveyed at the end of the dry season. All of the observed ***springs flow out from the PA Formation.*** The discharge rate ranges from 0.2 to 28.2 m^3/h and averages about 5.4 m^3/h. The discharging portions of those springs are either at the boundary of basement rocks and PA Formation or at the intersection of vertical joints and horizontal joints.

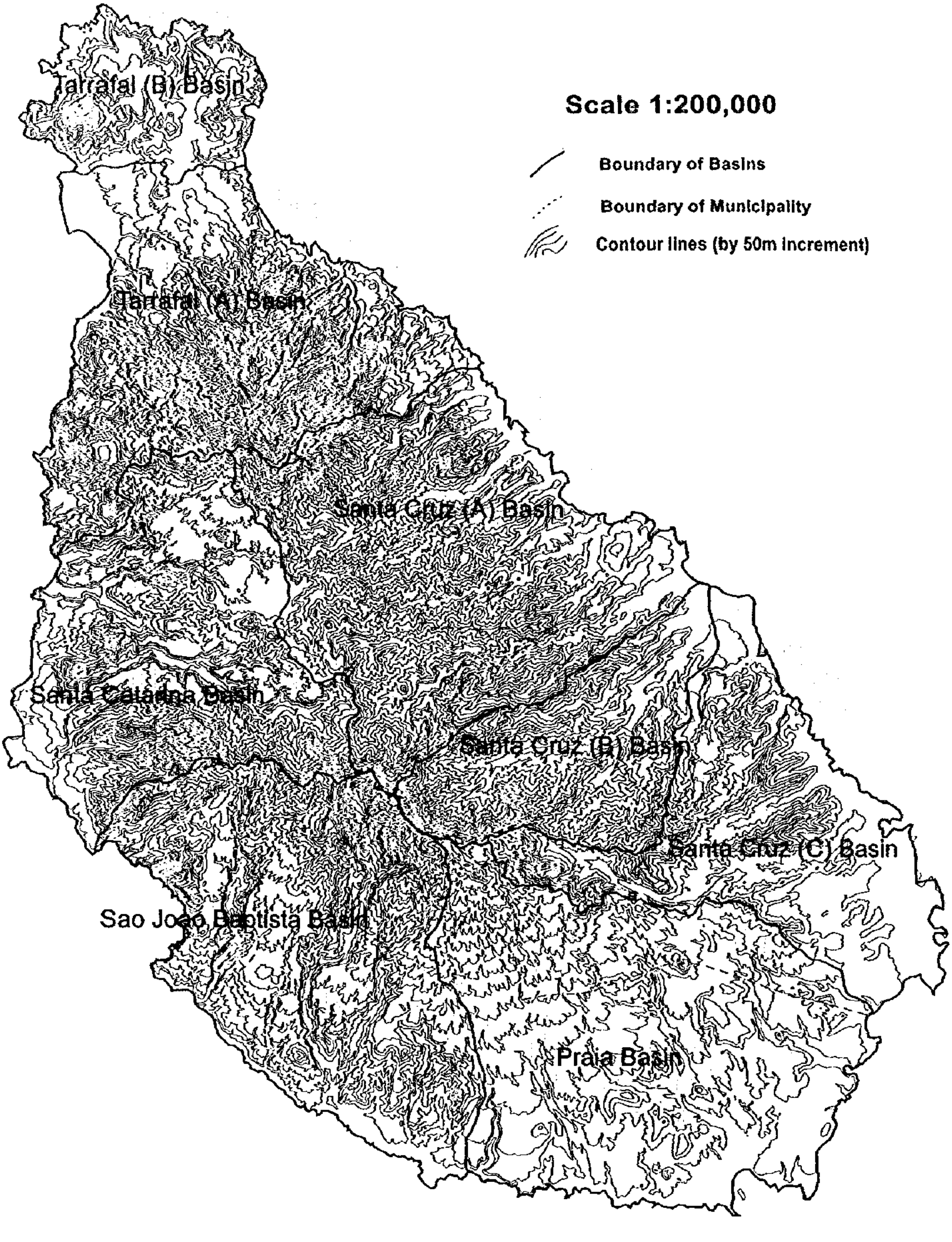


Fig. 4-1 Hydrogeological Basins and Topographic Contour Map

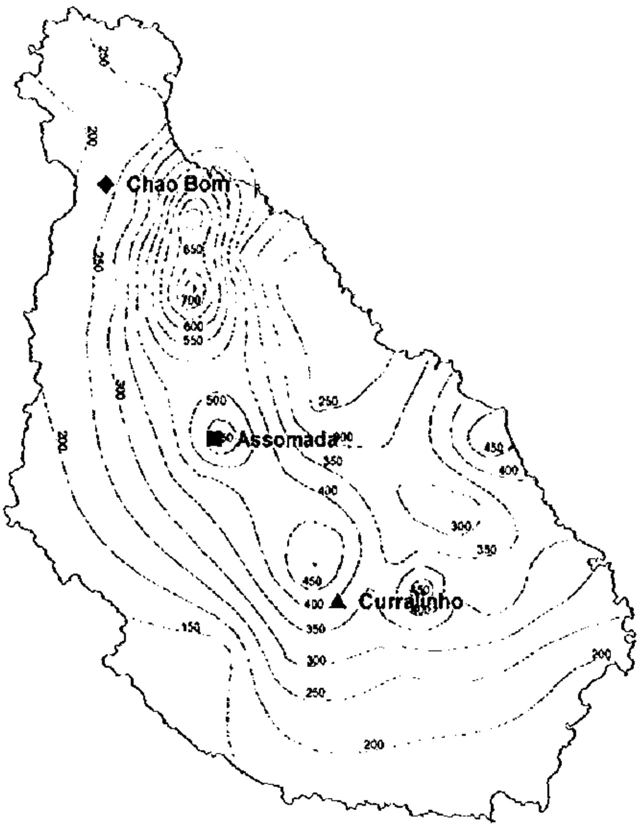


Fig. 4-2 Isohyet Contour Map (compiled data from 1961 to 1990)

(Source: ZONAGE BIOCLIMATIQUE DE L'ILE DE SANTIAGO (CAP-VERT), Centre Regional AGRHYMET, Jul 1996)

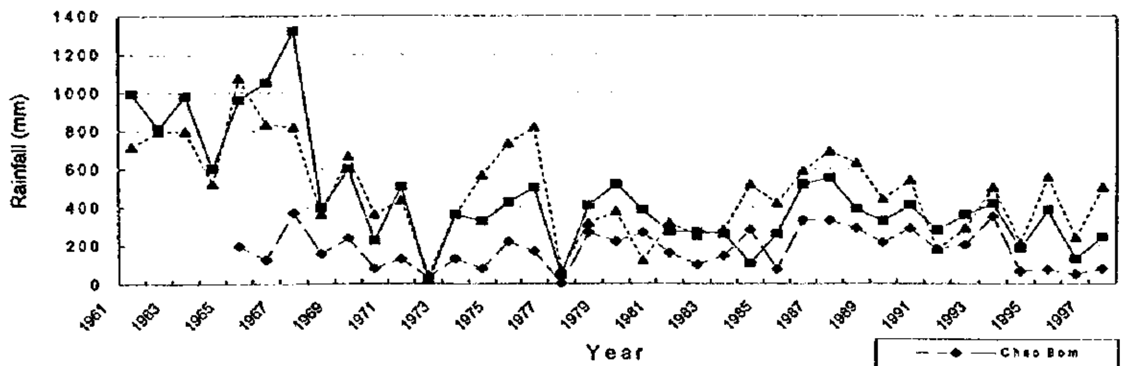


Fig. 4-3 Annual Rainfall (from year 1661 to 1997)

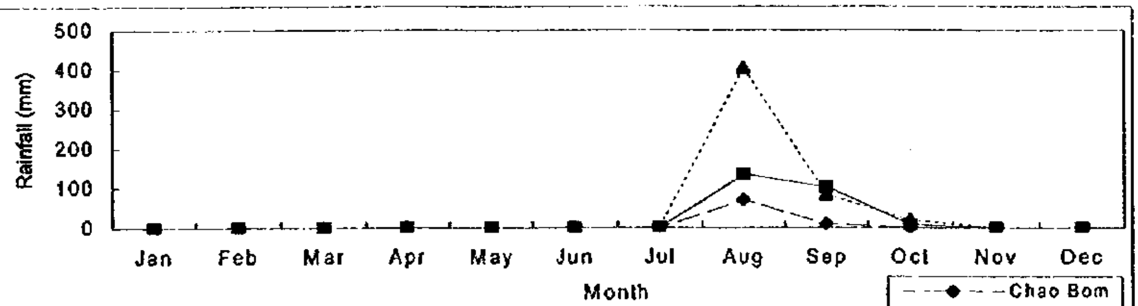


Fig. 4-4 Monthly Rainfall (of year 1997)

4.2 Geology and Hydrogeology

The *geology* of Island consists mostly of volcanic rocks, occupying 94% of total land surface. The formations of ***volcanic rocks are classified into 3 types*** by the geologic age of their volcanic activity which are, Pre-Miocene and Miocene oldest volcanic formations (gabbro, carbonatite, Basement Volcanic Complex, Orgas Formation and Flamengos Formation), Mio-Pliocene rock Units (Assomada formation and Pico da Antonia formation) and Pleistocene members (Monte das Vacas Formation). Other geological units existing in the island are diluvial terrace deposits and recent alluvial deposits.

Geological Map is shown in Figure 4-5, and Geological Cross Section is presented in Figure 4-6.

The major directions of the ***lineaments are group of NW-SE and NE-SW***, which are parallel to the direction of two major mountain ranges.

The ***hydrogeological characteristics*** of each formation, briefly given, are as follows:

- Pre-Miocene to Miocene ***Basement formations*** are composed mainly of rather ***impermeable*** rocks and their surface portions are highly weathered to clayey material.
- ***Miocene to Pliocene Volcanic Complex*** involving Pico da Antonia Formation (PA) and Assomada Formation (A) are composed mainly of lava and tuff of relatively high porosity which can be ***good aquifers.***
- Terrace deposits in this island are very limited in both extent and thickness, groundwater exploitation from this bed is impossible.
- The ***alluvial deposits*** of the island from riverbeds and coast sediments. Riverbed deposits are ***usually excellent aquifers***, consisting of high transmissivity materials.
- Recent Volcanics (Monte das Vacas Formation) formed by recent volcanism in the island contain an abundance of high porosity materials, but not so much potential for groundwater development is expected due to its small scale in distribution.

Hydrogeological map to present the survey result is attached in main report.

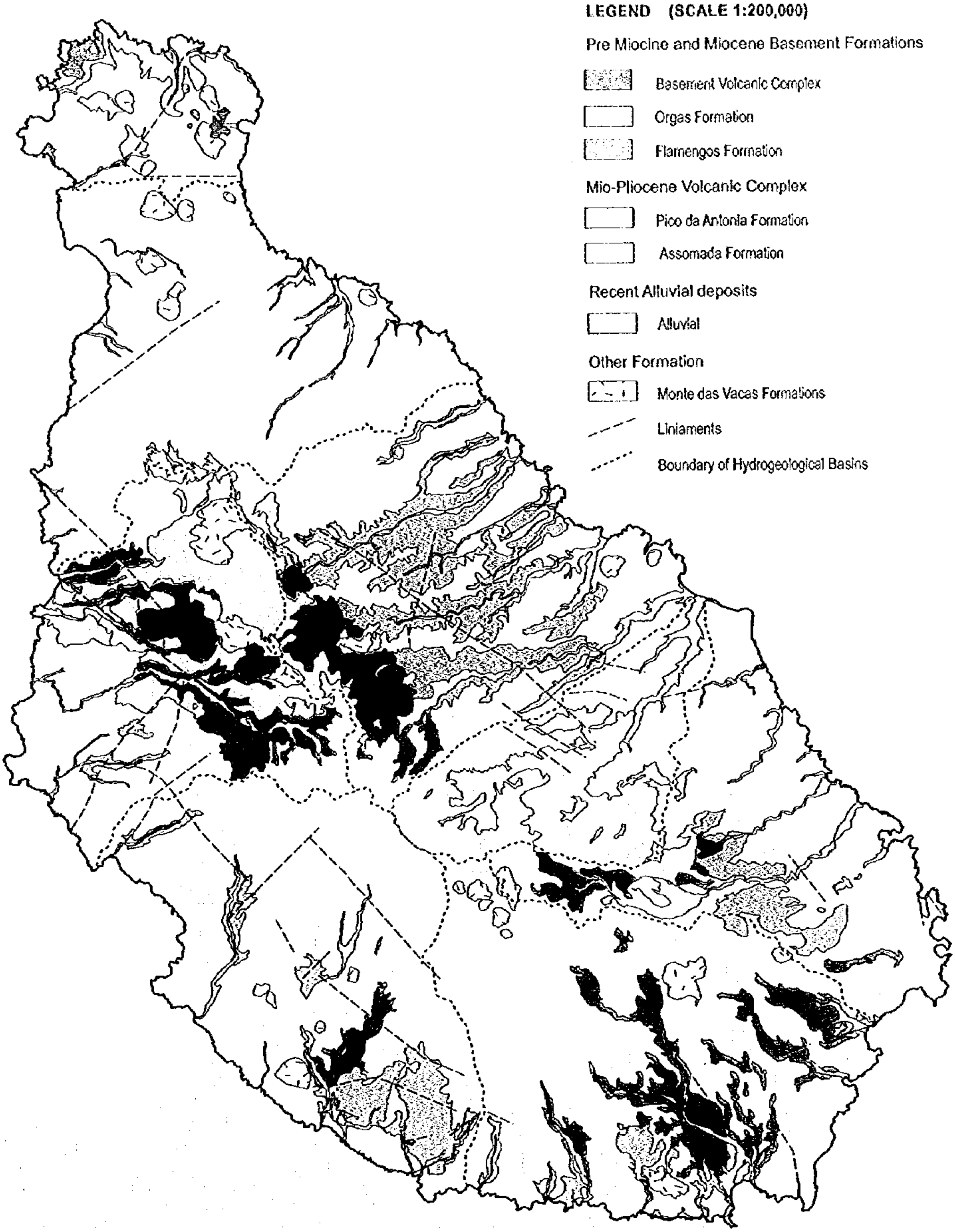


Fig. 4-5 Geological Map of Santiago Island

(After Carte Geologica de Cabo Verde, IGC, 1973 with some additions)

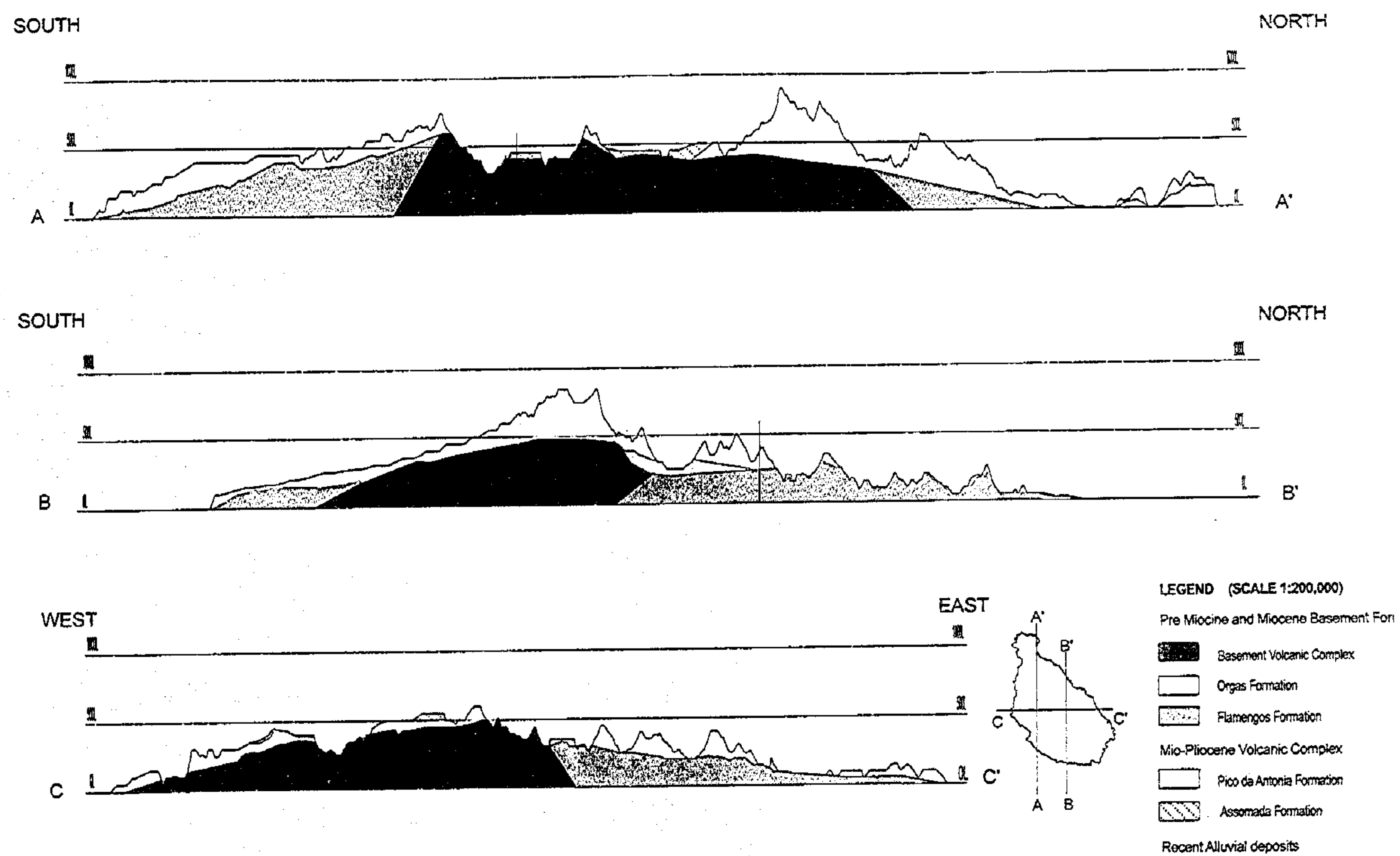


Fig. 4-6 Geological Cross Section of Santiago Island

4.3 Result of Hydrological and Hydrogeological Surveys

The results of hydrological and hydrogeological survey and its description are summarized in the tables and figures in the main report. Main findings through the survey are summarized as follows;

The electrical resistivity survey revealed that the resistivity values are low in the Basement Complex and Flamengos Formation at less than 200Ω m. Resistivity values of respective rock type or formations are tabulated in Table 4-1

Fluctuation in water level of deep wells is generally small, mostly within a range of 1 meter. Fig. 4-7 presents the result of simultaneous groundwater measurement results.

The pumping tests were accomplished satisfactory on 14 of the 19 tested wells. The hydrogeological parameters by geological formations are summarized in Table 4-2.

The water sample taken from the PA Formation shows comparatively lower values of sulfates and bicarbonates, while water from Alluvium generally contains comparatively high levels of anion and cations.

Estimated total number and yield of springs by basin is shown in Table 4-3.

Table 4-1 Resistivity Values by Rock types

Formation	Rock or Soil Facies	Resistivity Value (Ω m)
Alluvial deposits	Sand, Clay, Conglomerate	*45 – 350*
Vacas Formation	Scoria, basalt lava	*790 – 1300*
Assomada Formation	Basalt lava, pyrocrastics, breccia	*300 – 2200*
Pico da Antonia Formation (PA)	Basalt lava, pyrocrastics, tuff breccia	*20 – 705*
Flamengos Formation	Basalt lava flow, volcanic debris	*17 – 140*
Basement Complex(CA)	Basaltic dykes, gabro, basaltic volcanic rocks	*17 – 136*

Figure 4-7 Simultaneous Groundwater Monitoring Results

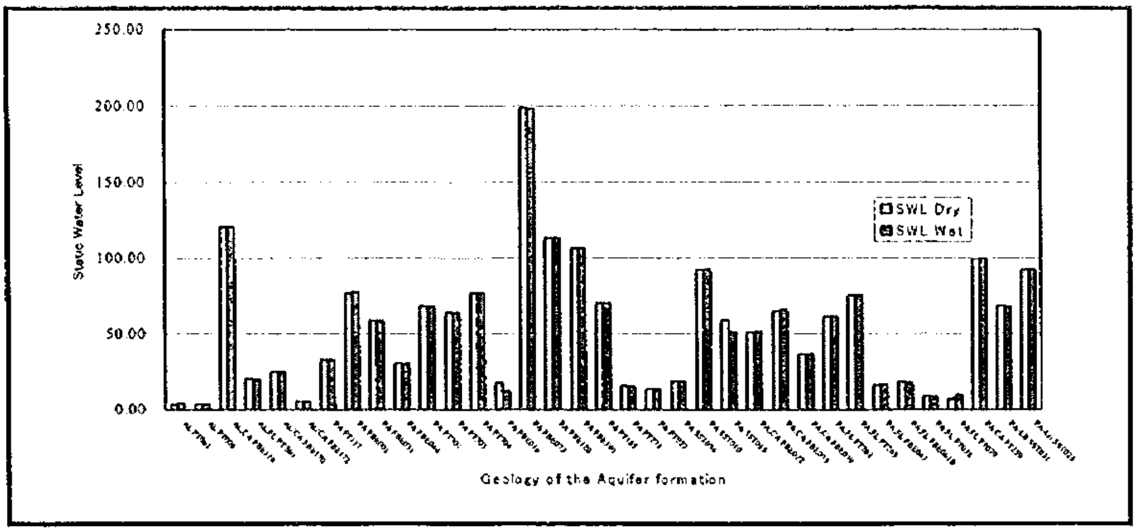


Table 4-2 Hydrogeological Parameters by Geological Formations

*( )= average

Geological Formation	Sample Number	Discharge (m^3/d)	Specific Capacity ($m^3/d/m$)	Transmissivity (m^2/day)
Alluvium	3	432 – 909 (687)	791 – 2667 (1441)	1934 – 5026 (3775)
Assomada Formation	3	288 – 480 (462)	28 – 96 (50)	5 – 109 (66)
Pico da Antonia Formation	3	216 – 823 (538)	99.5 – 5879 (3122)	107 – 8861 (4905)
Flamengos Formation	2	240 – 567 (404)	57 – 282 (170)	1.3 – 130 (66)
CA	2	149 – 196 (173)	14 – 21 (18)	12 – 42 (27)

Table 4-3 Estimated Total Yield of Spring by Basin

BASIN		1991(Database)				Estimation 1998			
		Number		Discharge (m3/day)		Number		Discharge (m3/day)	
Tarrafal	A	143	162	1117	1402	64	66	815	1028
	B	19		285		2		213	
Santa Cruz	A	397	619	9619	18409	339	549	8077	15528
	B	128		6299		122		5344	
	C	94		2491		88		2107	
Santa Catarina			195		6621		187		5614
S. J. Baptista			116		3579		113		3031
Praia			58		6106		52		5179
Total			1150		36117		967		30380

4.4 Groundwater Resources Balance and Development Potential

4.4.1 Groundwater of Santiago Island

Hydrogeological Map (1/500.000) was prepared to present the existing relevant data and materials with the results of the hydrogeological surveys and interpretation. Hydrogeological Map is attached in the main report.

From the results of the surveys and interpretation, the groundwater in the Island are characterized as follows:

- Major aquifers in the area are Assomada formation, Pico da Antonia formation and Alluvium.

- Hydrogeological parameters such as transmissivity and storativity are generally high in these aquifers.

- Water level fluctuation in the deep wells does not depend on the seasonal rainfall.

The summary of the Aquifer and its groundwater condition by hydrogeological basin is presented in Table 4-4

Table 4-4 Summary of Aquifer and Groundwater Condition by Basin

Name of the Basin		Aquifer (PA) Thickness	Aquifer (PA) Distribution	Alluvium Distribution	Flow Direction	Water Gradient
Tarrafal	A	Thin	Poor	Poor	S – SE(radial)	Steep
	B	Thick	Abundant	Poor	NNW	Gentle
Santa Cruz	A	Thin	Poor	Abundant	NE	Gentle
	B	Thin	Poor	Abundant	NE	Gentle
	C	Thin	Medium	Abundant	E – NE	Gentle
Santa Catarina		Thick	Medium	Medium	WSW	Steep
São João Baptista		Thick	Abundant	Medium	SSW	Steep
Praia		Thick	Abundant	Medium	SSE	Gentle

4.4.2 Water Resource Development Potential by Area

Macroscopic water balance method was applied using equation of $P = ET + SR + I$, where the input of water from precipitation (P) is being equated to the outflow of water by evapotranspiration (ET), surface runoff (SR) and infiltration (I).

In this Study, the estimation was made on each of the 8 hydrogeological basins using most probable ratios representing the basins' topographic and geological characteristics. Mean annual rainwater volume is calculated by basin based on the rainfall record from 1960 to 1991 compiled by AGRHYMET.

For the calculation of ET, the Thornthwaite Method was applied by area, and for infiltration ratio, following experimental figures were adopted in accordance with surface geology and gradient:

Basement rocks : 5%

Aquifer (PA, FI, AI) : 10% (surface gradient is more than 20 degrees)

: 15% (between 5 and 20 degrees)

: 20% (almost flat land = less than 5 degrees)

Table 4-5 presents the area, of basin, average annual precipitation and rainwater volume received by basin, evapotranspiration, surface runoff, and infiltration, by each hydrogeological basin.

The infiltrated water, which is considered as an apparent groundwater development potential, totals approximately 35 million m^3/year.

However, when taking the factors of efficiency and economy into consideration, the exploitable water may be **more or less 1/2** of the apparent potential volume. Therefore, the exploitable groundwater resource of Santiago Island is estimated at **about 17.5 million m^3/year.**

Table 4-5 Precpitation, Evapotranspiration, Surface runoff and Infiltration by Basin

Hydrogeological Basin		*Total Aria(km²)*	*Annual Average Precepitation (mm)*	*Evapotranspiration**		*Surface runoff*		*Infiltration***	
				(mm)	*(%)*	*(mm)*	*(%)*	*(mm)*	*(%)*
TARRAFAL(A)		142.576	325	98	30	185	57	42	13
	Volume (million m³)		46.337	13.972		26.359		6.006	
TARRAFAL(B)		45.306	213	107	50	79	37	27	13
	Volume (million m³)		9.650	4.848		3.589		1.214	
SANTA CRUZ(A)		171.023	320	99	31	178	55	43	14
	Volume (million m³)		54.727	16.931		30.362		7.434	
SANTA CRUZ(B)		71.114	349	98	28	212	61	39	11
	Volume (million m³)		24.819	6.969		15.043		2.807	
SANTA CRUZ(C)		112.909	313	104	33	176	56	33	11
	Volume (million m³)		35.341	11.743		19.882		3.716	
SANTA CATATINA		128.259	259	94	36	131	51	34	13
	Volume (million m³)		33.219	12.056		16.863		4.300	
S.J. BAPTISTA		154.782	184	92	50	67	36	25	14
	Volume (million m³)		28.480	14.240		10.367		3.873	
PRAIA		179.194	213	102	48	80	38	31	15
	Volume (million m³)		38.168	18.278		14.344		5.546	
SANTIAGO ISLAND		1005.163	272	99	36	138	51	34	13
	Volume (million m³)		273.404	99.762		138.746		34.896	

(rainfall data source: ZONAGE BIOCLIMATIQUE DE L'ILE DE SANTIAGO (CAP - VERT), Centre Regional AGRHYMET, Jul 1996)

* Potential Evapotranspiration calculated by Thornthwaite Method
** Infiltration rates are experimental figures : Basement Rocks =5%
: Aquifers (PA, Fl, Al) =10% (surface gradient is more than 20 degrees)
=15% (between 5 and 20 degrees)
=20% (almost flat (less than 5 degrees)

4.4.3 Water Balance in Each Hydrogeological Basin

The present annual discharge of groundwater is about **15 million m^3/year**, 4 million m^3 is exploited by the wells and 11 million is the discharge of the spring as shown in Table 4-6.

Table 4-6 Discharge of Groundwater Resources

Basin	Type of Source	Number	Discharge (million m^3/year)
Tarrafal A Basin	Production Well	13	0.539
	Spring	64	0.298
Tarrafal B Basin	Production Well	0	0
	Spring	2	0.078
Santa Cruz A Basin	Production Well	26	1.180
	Spring	339	2.948
Santa Cruz B Basin	Production Well	18	0.725
	Spring	122	1.950
Santa Cruz C Basin	Production Well	18	0.381
	Spring	88	0.770
Santa Catarina Basin	Production Well	8	0.151
	Spring	187	2.050
S. J. Baptista Basin	Production Well	7	0.250
	Spring	113	1.106
Praia Basin	Production Well	12	0.657
	Spring	52	1.890
Total			14.971

In the water balance analysis by basin, the outflow is above mentioned discharge.

While, inflow was assumed to be the total recharge by rainwater and spring, i.e. half of infiltrated rain water and 58 % of spring water (most of water discharged by spring becomes underground stream, returning about 58 % to groundwater).

The balance of recharge / discharge is the groundwater development potential by basin, as shown in Table 4-7.

Some of the basins show the negative potential, suggesting the over exploitation.

Table 4-7 Groundwater Balance by Basin

		RECHARGE			Exploitable Amount of Water (1/2 of Income)	DISCHARGE			TOTAL BALANCE	Development Potential
		Recharge by Rainwater	Recharge by Spring	Sub - total		Production of Wells	Spring Discharge	Sub - total		
Tarrafal	A	6.006	0.173	6.179	3.003	0.539	0.298	0.837	5.342	2.166
	B	1.214	0.045	1.259	0.607	0.000	0.078	0.078	1.181	0.529
Santa Cruz Basin	A	7.434	1.710	9.144	3.717	1.180	2.948	4.128	5.016	-0.411
	B	2.807	1.131	3.938	1.404	0.725	1.950	2.675	1.263	-1.272
	C	3.716	0.447	4.163	1.858	0.381	0.770	1.151	3.012	0.707
Santa Catarina Basin		4.300	1.189	5.489	2.150	0.151	2.050	2.201	3.288	-0.051
S.J.Baptista Basin		3.873	0.641	4.514	1.937	0.250	1.106	1.356	3.158	0.581
Praia Basin		5.546	1.096	6.642	2.773	0.657	1.890	2.547	4.095	0.226
Total		34.896	6.432	41.328	17.448	3.883	11.090	14.973	26.355	2.475

4.4.4 High Potential Areas for Groundwater Development

The surface of basement Complex is regarded as the bottom of the basins, and its shape in the basin gives important factor to determine the high potential area for groundwater development. A presumed contour map of the basement rock is presented in Fig. 4-8. Based on the structure of the basement rocks and nature of overlying geological formations, the following areas have been identified as high potential areas for groundwater exploitation, and are presented in Fig. 4-9.

- Assomada highland
- Lower Tarrafal volcanic plateau
- Lower Praia volcanic plateau
- Mouth of major rivers in the north-eastern section of the island

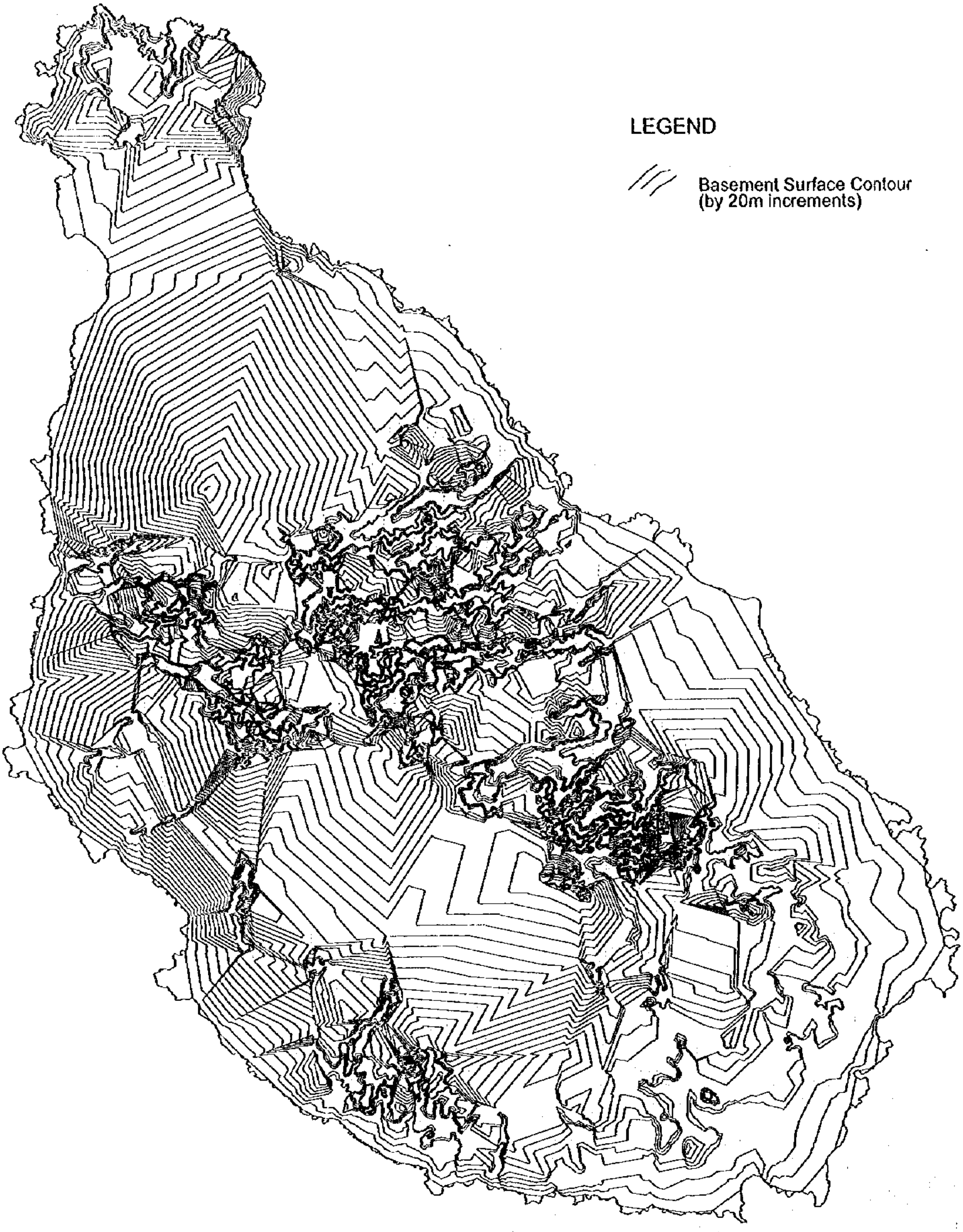


Fig. 4-8 Basement Rock Surface Contour Map

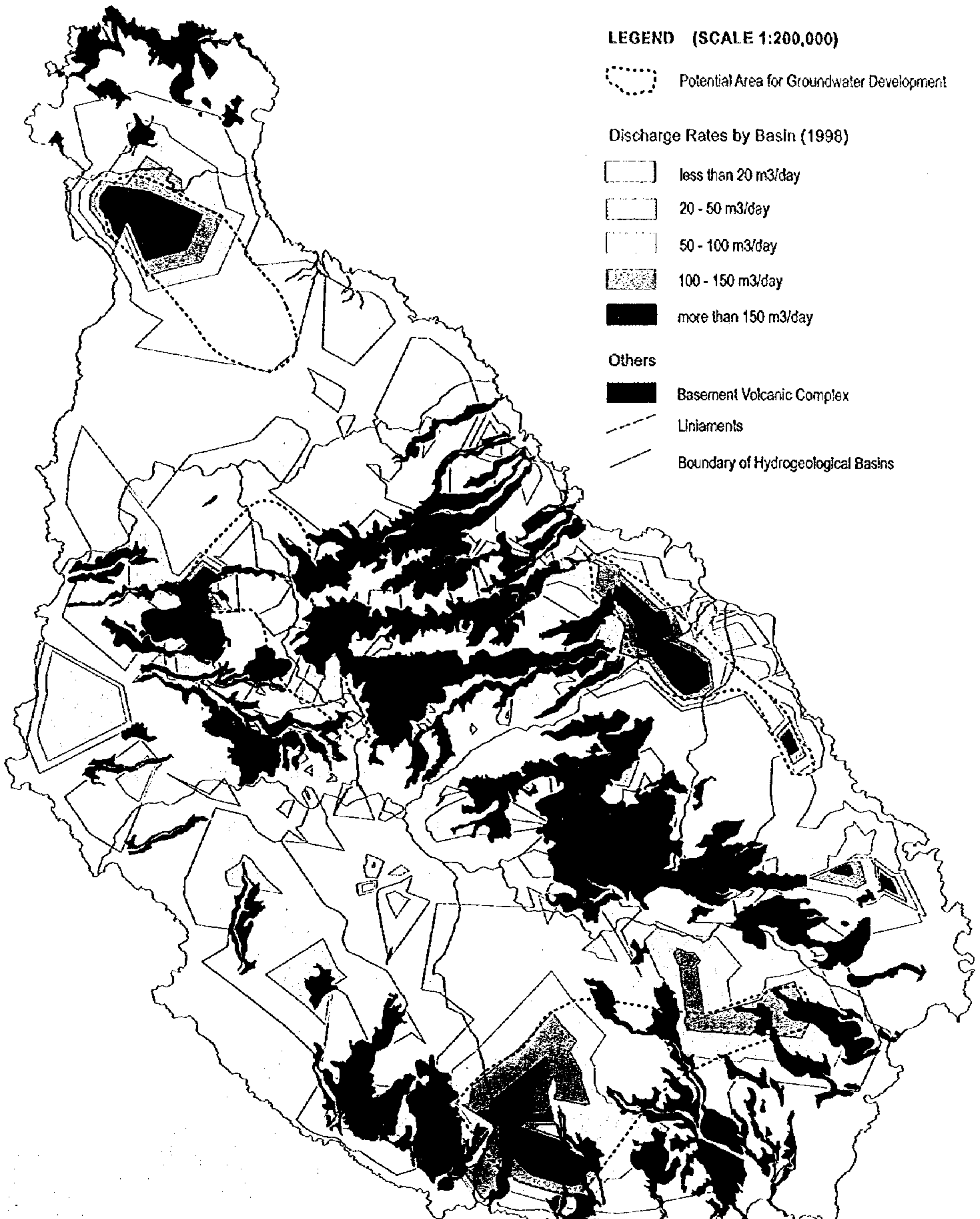


Fig. 4-9 Potential Area for Groundwater Development

5 DATABASE

5.1 Reconstruction of GIS/Database System

Based on the request of INGRH for the reconstruction of the destroyed database, particularly the database for well inventory management, JICA has procured a set of hardware/software (GIS software included) not only for data retrieval and well data arrangement, but also for the construction of various databases.

The activities for the construction of the GIS/Database in Cape Verde were carried out twice in Stage 1 of the First Phase. The first time was in June where the activities mainly involved confirming the request from the Cape Verdean side and discussing what type of hardware/software is required. Surveys were also carried out on the existing database system and their use, as well as on spare parts availability in Cape Verde.

Based on the series of discussions and understandings reached pertaining to the operation of the present database in INGRH and in Cape Verde, equipment and material supply procedures were undertaken in Japan. The selected hardware/software were delivered to INGRH in November, after a 1 month operation test was completed in Japan.

The following shows the major software/hardware procured.

Software:
-GIS (Microimages) TNTmipsD40, Printer Driver P8, Digitizer Driver X3
-Operation System (Microsoft) Windows95 (English version)
-Database (Microsoft) Fox Pro
-Office 97 Pro (Microsoft) Word, Excel, Access
Hardware:
-Personal Computer (COMPAQ) DESKPROEP (Desktop/Minitower)
-17" Monitor (COMPAC) Presario5610 (Minitower)
-Total Memory 128 MB
-SCSI Board For connection of JAZ drive
-External back-up memory (IOMEGA) JAZ drive
-Printer (HP) with Cable Deskjet1120C
-Digitizer (CALCOMP) A2 size
-UPS (APC) Smart-UPS700 (Max 700VA/450W)
-Transformer 100-220V

The second set of activities were carried out in Cape Verde: 1) compilation of the operation manual, 2) confirmation of items/number of delivered materials, 3) hardware assembly, and confirming whether the operation system and applications are properly set up and functioning, and 4) explanations on the use and functions of GIS, and training through actual database construction work using GIS on geographical information such as contour line, river system, roads, etc.

Although the training period was limited to only one week due to delays in the custom's office release of the material in November, technology transfer (i.e. hardware operation, database soft conversion) was smoothly carried out, particularly due to the counterpart personnel's adeptness in handling computer hardware.

Thus, database reconstruction for well inventory and management was arranged in INGRH. The system is not only useful for well inventory management but for various database construction as well.

5.2 Database of Hydrogeology and Water Supply Facility

Various data were accumulated and assessed during the course of the Study. The data pertained to hydrogeology (result of pumping test, groundwater level, water quality, result of georesistivity soundings, water quality, etc.) and water supply (village population, ratio of supply service coverage, existing supply facility, etc.), and was input in Microsoft Excel for the construction of a new database. If these data are to be used for the construction of a new database, the only requirement would be converting the files from Excel to the newly installed software.

6 DEVELOPMENT PLANS

6.1 Groundwater Development Plan

6.1.1 Concept for Water Supply Source Development Plan

The water supply project in Santiago Island aims to meet the water demand of the whole island by developing water resources by every possible means. The projected water demand in 2005 for domestic use is about 3600 m^3/day (except for Praia City), assuming a unit supply amount of 20 ℓ/c/d for the rural area and 50 ℓ/c/d for the household connection system, in accordance with the Master Plan.

Of the 205 communities in Santiago Island (5 towns and 200 villages, excluding Praia City), 45 have relatively satisfactory water supply service levels, as a result of sufficient and favorable water sources, i.e. springs, boreholes. In the remaining 158 villages, however, the residents (except those who live near the source) are inconvenienced by domestic water sources mainly due to their inaccessibility or a shortage thereof.

In order to cope with such situation, the best way to solve the problem is to increase the intake points and supply volume by constructing wells at villages where groundwater development is technically and economically possible, and also by effectively using water from springs with sufficient yield and in accessible location.

The development of new water sources in certain villages will favorably benefit other villages as well, not because they will be using water from these new sources but because they can acquire more water from the tank lorry as a result of the reduction in the number of tank lorry water distribution recipients (tank lorries distribute water to villages without water sources).

For any of the villages, except the ones under household connection services, a unit supply amount of 20 ℓ/c/d will be the target of the development regardless of water source type, for the future projects.

6.1.2 Groundwater Development Plan

Although groundwater balance is apparently negative in some parts of Santiago Island, as discussed in 4-4, groundwater development is still possible as long as there is rain to recharge the resources. The amount of water for rural water supply is far smaller than the annual recharge, therefore, groundwater development for rural water supply is possible depending on zonal characteristics.

Based on this viewpoint and assuming that groundwater resource development will be carried out for no other reason but the aforementioned, the plan was established according to the following premise:

1) Target year: End of every project phase
   Year 2003 for the first project phase

2) Village selection criteria for the first project phase:

   - Villages without public water supply sources and, therefore, urgently needing the project
   - Villages where groundwater resource development is technically feasible (borehole wells and springs)
   - Villages where pumping facility operation cost is expected to be comparatively low (not so deep water table for the well, and only slight elevation difference for springs)

3) Required water volume:

The required water volume is to be determined by multiplying the assumed unit supply amount (20 ℓ/c/d) by the projected population (2003) of each village. The total amount of groundwater to be developed for each village will be considered the volume to be developed in the first project phase.

4) Facilities to be constructed:

For the villages where borehole well is to be constructed:

- Borehole well with submersible motor pump
- Diesel engine generator or solar energy system with control house/shed
- Reservoir tank at the villages where existing reservoir is not enough
- 2 sets or more of public faucets (2 taps each), pipelines connected to reservoir tank

For villages using existing spring sources:

- Transmission pipeline installation from the source to the community center
- Reservoir tank and 2 sets of public faucets (2 taps each)
- Intake box equipped with centrifugal pump and control house (to be built at the village where the spring is at an elevation lower than the community

5) Beneficiaries:

Beneficiaries from this first project phase are not limited to the population of selected villages. Water developed in these villages will not be delivered elsewhere, however, other recipients of the tank lorry water delivery services can avail of the water volume formerly appropriated for the target villages of this first project phase.

6.2 Project Formulation Plan

6.2.1 Project Implementation

The 122 villages (60% of the 205 communities in Santiago Island) will eventually require the implementation of the project, excluding following 38 villages;

- Improvement projects are ongoing in or being planned for 33 villages
- Topographic features of 5 villages significantly hampers project implementation

These 122 villages are divided into 2 groups, "A" and "B", according to urgent need for the project:

Group A: 59 villages urgently requiring the implementation of the project

Group B: 63 villages also requiring the project but of less urgency than Group A

Since it is almost impossible to cover these villages in one project, it is necessary to sub-divide Group A and B into 4 groups as shown below. The phased implementation of the project has been established according to this group classification.

Group A-1:	First phase	34 villages
Group A-2:	Second phase	29 villages (27 from *Group A*, and 3 from *B*)
Group B-1:	Third phase	29 villages from *Group B*
Group B-2:	Fourth phase	30 villages from *Group B*

A concrete project formulation plan for the first phase and tentative plans from the second phase onwards have been established in this Study program. Plans formulated for the second phase onwards are tentative on the assumption that the implementation of the first phase might incur changes in current conditions.

6.2.2 Project Formulation Plan

One of the major reasons observed in this study program as to why water supply services in the area are inefficient is the absolute shortage of intake points and water source volume.

The selection of sites for the first project phase (*Group A-1*), therefore, was based on the availability of water sources for development, and the following, which were adopted to ensure the effective implementation of the project:

- Population scale (over 200, to ensure effective project implementation and in view of the establishment of a community based management system.

- Accessibility for facility construction works

Based on the above criteria, 34 villages were selected and tabulated in Table 6-1. These villages have no public borehole wells, and acquire water from the tank lorry or from nearby springs and dug wells.

Table 6-1 Selected 34 Villages for First Phase Project

No.	ZONA	Population Census 1990	Population 1998	Population 2003	Supply Amount 1998 (ℓ/c/d)	Consumption 1998 (ℓ/d)	Water Demand 2003 (Pop.x 20ℓ/c/d)
Tarrafal							
9	Curral Velho	324	369	400	8.0	2,952	8,000
19	Trás os Montes	396	349	379	25.0	8,725	7,580
	Sub-total	720	718	779	* 16.3	11,677	15,580
São Miguel							
4	Chã de Ponta	554	700	757			15,140
10	Monte Bode	277	316	343	(6.0)	(1,896)	6,860
11	Monte Pousada	402	598	649	11.0	6,578	12,980
18	Ribeirão Milho	197	340	367			7,340
	Sub-total	1,430	1,954	2,116	* 11.0	6,578	42,320
Santa Catarina							
12	Boa Entradinha	531	603	658			13,160
13	Bombardeiro	1,023	1,180	1,291			25,820
15	Chã de Tanque	1,013	1,174	1,287			25,740
19	Entre Picos de Reda	295	342	375			7,500
36	Pata Brava	299	345	377			7,540
40	Pingo Chuva	369	417	457			9,140
43	Ribeira da Barca	1,557	1,809	1,987			39,740
47	Saltos Acima	670	769	840			16,800
57	Covão Grande	492	568	621			12,420
60	Jalalo Ramos	534	607	662			13,240
63	Leitãozinho	492	561	612			12,240
	Sub-total	7,275	8,375	9,167			183,340
Santa Cruz							
17	Ribeirão Almaço	174	260	283	(2.0)	(520)	5,660
25	Achada Costa	303	360	403	4.7	1,692	8,060
27	Fundura	219	282	311	8.1	2,273	6,220
31	Levada	218	310	336	2.2	682	6,720
	Sub-total	914	1,212	1,333	* 4.9	4,647	26,660
São Domingos							
6	Milho Branco	538	650	732	12.3	7,995	14,640
8	Praia Baixo	701	833	928	4.5	3,749	18,560
11	Achada Mitra	255	303	337	6.2	1,879	6,740
13	Banana	266	316	351	5.9	1,864	7,020
15	Dacabalaio	210	250	270	14.6	3,650	5,400
16	Fonte Almeida	698	830	939	4.5	3,735	18,780
20	Mato Afonso	386	460	512	12.2	5,612	10,240
24	Po de Saco	168	210	241	(9.7)	(2,037)	4,820
27	Rui Vaz	812	956	1,057	5.8	5,545	21,140
	Sub-total	4,034	4,808	5,367	* 7.4	34,029	107,340
Praia							
10	São Tomé	230	256	274			5,480
18	Belém	447	495	529			10,580
27	Santana	906	1,008	1,078			21,560
28	Tronco	186	206	221			4,420
	Sub-total	1,769	1,965	2,102			42,040
	Total	16,142	19,032	20,864	* 8.3	56,931	417,280

* : Average ( ): Water source from dug well or spring

6.3 Proposed Water Supply Facility

6.3.1 Facility Design for the First Project Phase (34 villages)

The following 4 types of facility are proposed for the 34 villages. Thirty-two (32) of these villages will be constructed with borehole wells as a source, while the effective use of existing springs is considered for the remaining 2 villages.

Type 1: One borehole well and one reservoir tank connected to the source by transmission pipeline are to be constructed at or near the center of the village, or at a different location in consideration of water availability. If the capacity of the existing tank is deemed satisfactory, the reservoir tank will not be constructed. A submersible motor pump will be used to pump up water to the reservoir tank. A diesel engine generator or solar energizing system will be used to operate the pump; the use of the latter will be limited to places with a total pump head of less than 100m.
2 sets of public faucets each attached with 2 taps will be constructed, one beside the tank and the other 200-300m away.

Type 2: 1 borehole well and multiple tanks (for reservoir/distribution and pressure deducing tank) and long distribution pipes are to be laid from the tank all the way to some sets of public faucets.

Type 3: Intake facility is to be improved at the location of the spring and the transmission line will be laid to the center of the village. Water is transmitted to the village by natural flow. 1 reservoir tank and 2 sets of public faucets are to be installed at the center of the village.

Type 4 Intake facility is to be constructed at the spring with the installation of a centrifugal pump to pump up water to the new reservoir tank to be installed at the center of the village. 2 sets of public faucets with 2 taps each are to be constructed in the community.

The type and dimension of the facilities proposed for the 34 villages are tabulated in Table 6-2, and the facility basic design drawings are in Fig.6-1 to Fig. 6-9.

6.3.2 Construction Cost

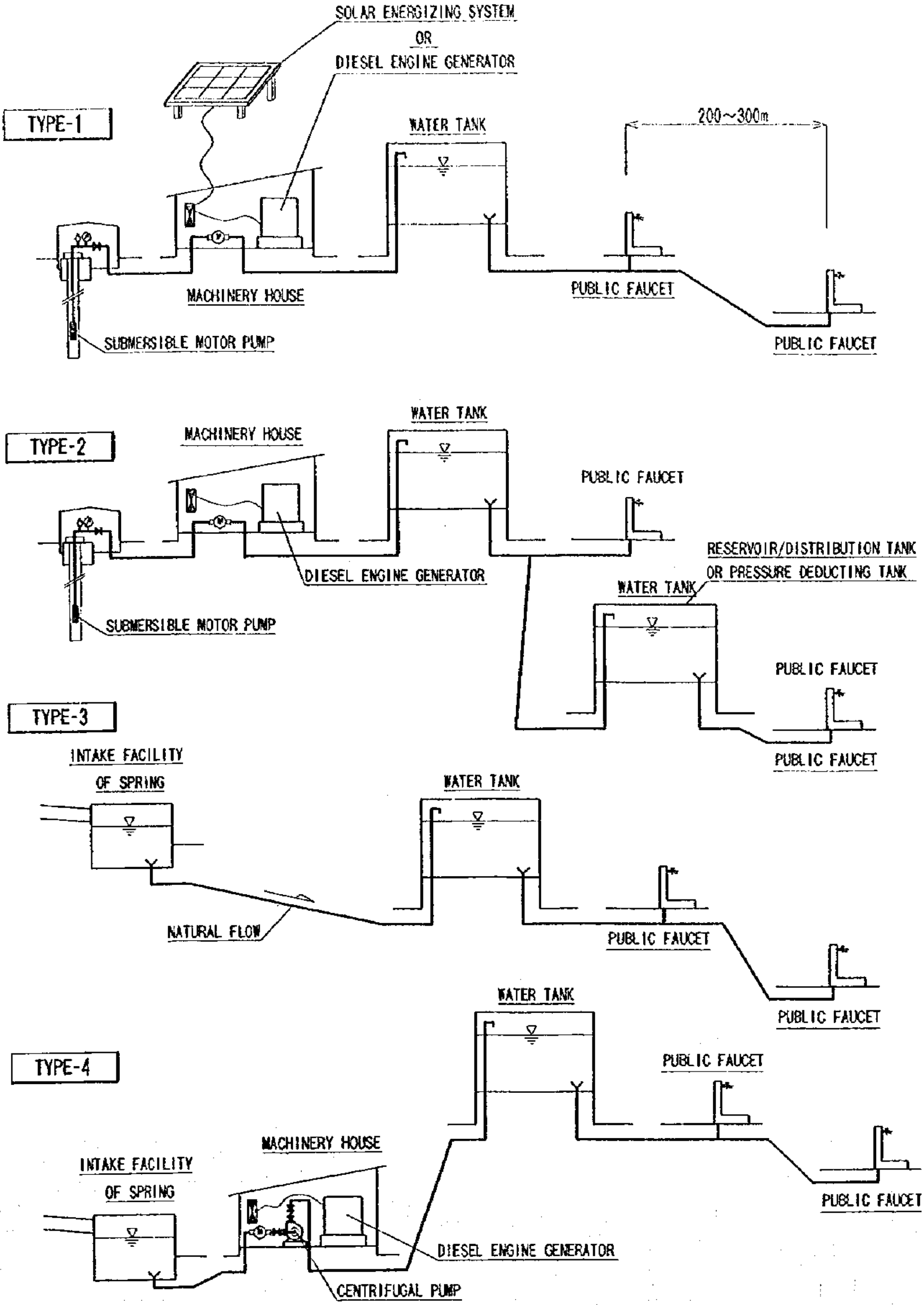
For construction of the facilities tabulated in Table 6-2, the estimated cost approximates 5.78 million USD including 20 % of administrative and engineering costs.

With procurement of drilling machine / supporting vehicles and other equipment / materials, the total project cost is estimated at approximately 9.78 million US Dollar.

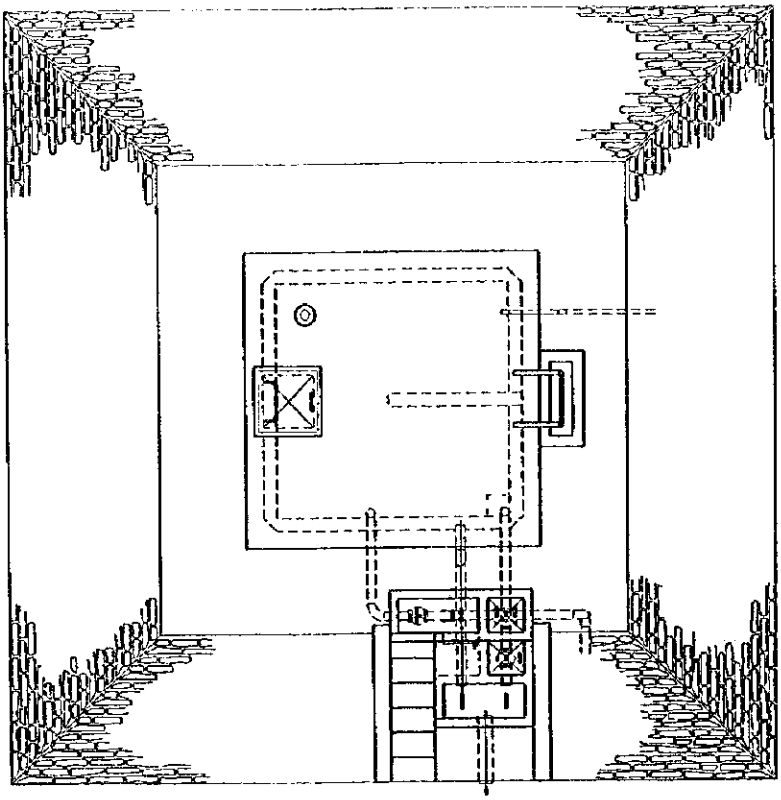
Table 6-2 Planed facility in 34 villages of Group A-1

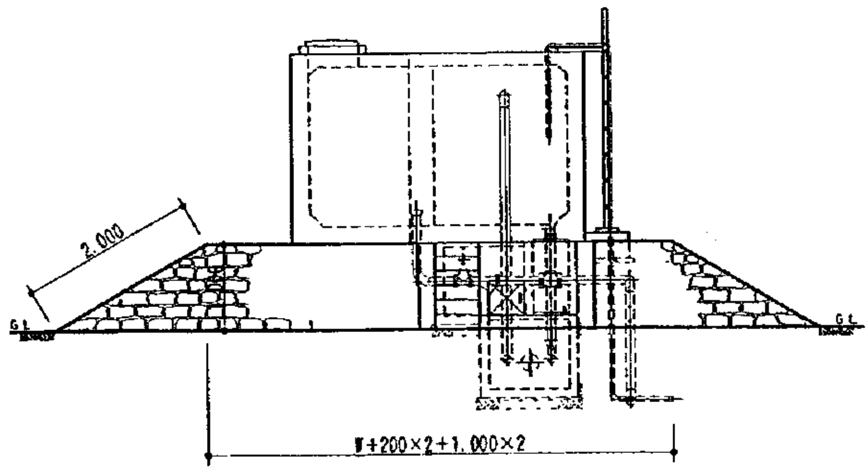
No.	ZONA	Population			Water Demand 2003	Well				Transmission Pipe Line				Specified Pump Head	Reservoir		Public Faucet	
		CENSUS 1990	1998	2003	(Pop.X 20l/c/d)	Target Depth (GL -m)	SWL (GL -m)	Pumping Rate (m^3/min)	Pump Level (GL -m)	Elevation Difference (m)	Pipe Diameter (mm)	Distance (m)	Head Loss (m)	(m)	Existing	New	Existing	New
Tarrafal		720	718	779	15,580													
9	Curral Velho	324	369	400	8,000	250	200	0.02	216.0	20.0	50	100.0	1.527	241.5	30m^3			2
19	Trás os Montes	396	349	379	7,580	140	110	0.02	124.0	5.0	50	20.0	0.305	129.3	40m^3		1	1
São Miguel		1,430	1,954	2,116	42,320													
4	Chã de Ponta	554	700	757	15,140	220	180	0.03	196.0	-40.0	50	150.0	4.851	196.0	30m^3			2
10	Monte Bode	277	316	343	6,860	180	160	0.01	176.0	10.0	50	50.0	0.212	186.2		15m^3		2
11	Monte Pousada	402	598	649	12,980	200	170	0.03	184.0	10.0	50	50.0	1.617	195.6		15m^3		2
18	Ribeirão Milho *	197	340	367	7,340	100	60	0.02	76.0	20.0	50	100.0	1.527	97.5		15m^3		2
Santa Catarina		7,275	8,375	9,167	183,340													
12	Boa Entradinha	531	603	658	13,160	130	110	0.03	124.0	-80.0	50	300.0	9.701	124.0	40m^3			2
13	Bombardeiro	1,023	1,180	1,291	25,820	110	90	0.05	104.0	-150.0	80	600.0	5.061	104.0		30m^3		2
15	Chã de Tanque	1,013	1,174	1,287	25,740	100	60	0.05	76.0	30.0	80	100.0	0.843	106.8	60m^3		1	1
19	Entre Picos de Reda	295	342	375	7,500	200	170	0.02	184.0	60.0	50	718.0	10.966	255.0	40m^3			2
36	Pata Brava	299	345	377	7,540	Spring				-60.0	50	150.0	2.291	0.0		15m^3		2
40	Pingo Chuva *	369	417	457	9,140	100	70	0.02	84.0	0.0	50	20.0	0.305	84.3	40m^3			2
43	Ribeira da Barca	1,557	1,809	1,987	39,740	FBE-170	25	0.08	40.0	50.0	100	2300.0	15.612	105.6	22m^3		1	1
47	Saltos Acima	670	769	840	16,800	150	120	0.04	136.0	0.0	50	20.0	1.101	137.1	40m^3		1	1
57	Covão Grande	492	568	621	12,420	170	140	0.03	156.0	-30.0	80	700.0	2.295	156.0	40m^3		1	1
60	Jalalo Ramos *	534	607	662	13,240	90	20	0.03	36.0	50.0	50	50.0	1.617	87.6	40m^3			2
63	Leitãozinho	492	561	612	12,240	120	100	0.03	116.0	-150.0	50	600.0	19.402	116.0	40m^3			2
Santa Cruz		914	1,212	1,333	26,660													
17	Ribeirão Almaço	174	260	283	5,660	140	140	0.01	156.0	60.0	50	200.0	0.847	216.8		10m^3		2
25	Achada Costa	303	360	403	8,060	150	130	0.02	144.0	36.0	40	43.0	1.947	181.9	40m^3			2
27	Fundura	219	282	311	6,220	130	110	0.01	124.0	50.0	50	500.0	2.118	176.1	11m^3			2
31	Levada	218	310	336	6,720	From Achada Costa									20m^3			2
São Domingos		4,034	4,808	5,367	107,340													
6	Milho Branco	538	650	732	14,640	120	100	0.03	116.0	-30.0	80	1500.0	4.917	116.0	22m^3		1	1
8	Praia Baixo *	701	833	928	18,560	70	20	0.04	36.0	-40.0	80	1400.0	7.814	36.0	22m^3		1	1
11	Achada Mitra	255	303	337	6,740	150	120	0.01	136.0	20.0	50	10.0	0.042	156.0	22m^3			2
13	Banana	266	316	351	7,020	150	100	0.01	116.0	20.0	50	400.0	1.695	137.7	33m^3		1	1
15	Dacabalaio	210	250	270	5,400	150	100	0.01	116.0	50.0	50	200.0	0.847	166.8	50m^3			2
16	Fonte Almeida	698	830	939	18,780	180	150	0.04	164.0	10.0	100	100.0	0.188	174.2	22m^3			2
20	Mato Afonso	386	460	512	10,240	120	90	0.02	104.0	60.0	50	200.0	3.055	167.1	22m^3		1	1
24	Po de Saco	168	210	241	4,820	150	100	0.01	116.0	-20.0	50	200.0	0.847	116.0		10m^3		2
27	Rui Vaz	812	956	1,057	21,140	150	120	0.04	136.0	80.0	100	700.0	1.318	217.3	33m^3		1	1
Praia		1,769	1,965	2,102	42,040													
10	São Tomé *	230	256	274	5,480	100	60	0.01	76.0	-80.0	50	1400.0	5.931	76.0	10m^3		1	1
18	Belém	447	495	529	10,580	120	90	0.02	104.0	20.0	50	200.0	3.055	127.1	10m^3		1	1
27	Santana *	906	1,008	1,078	21,560	Spring				80.0	50	200.0	3.055	83.1		10m^3		2
28	Tronco	186	206	221	4,420	160	140	0.01	156.0	30.0	50	50.0	0.212	186.2		10m^3		2
	TOTAL	16,142	19,032	20,864	417,280													

* Solar enagized system can be applied. With the system, O/M cost will become lower by omitting pump operation cost.



FACILITY TYPES

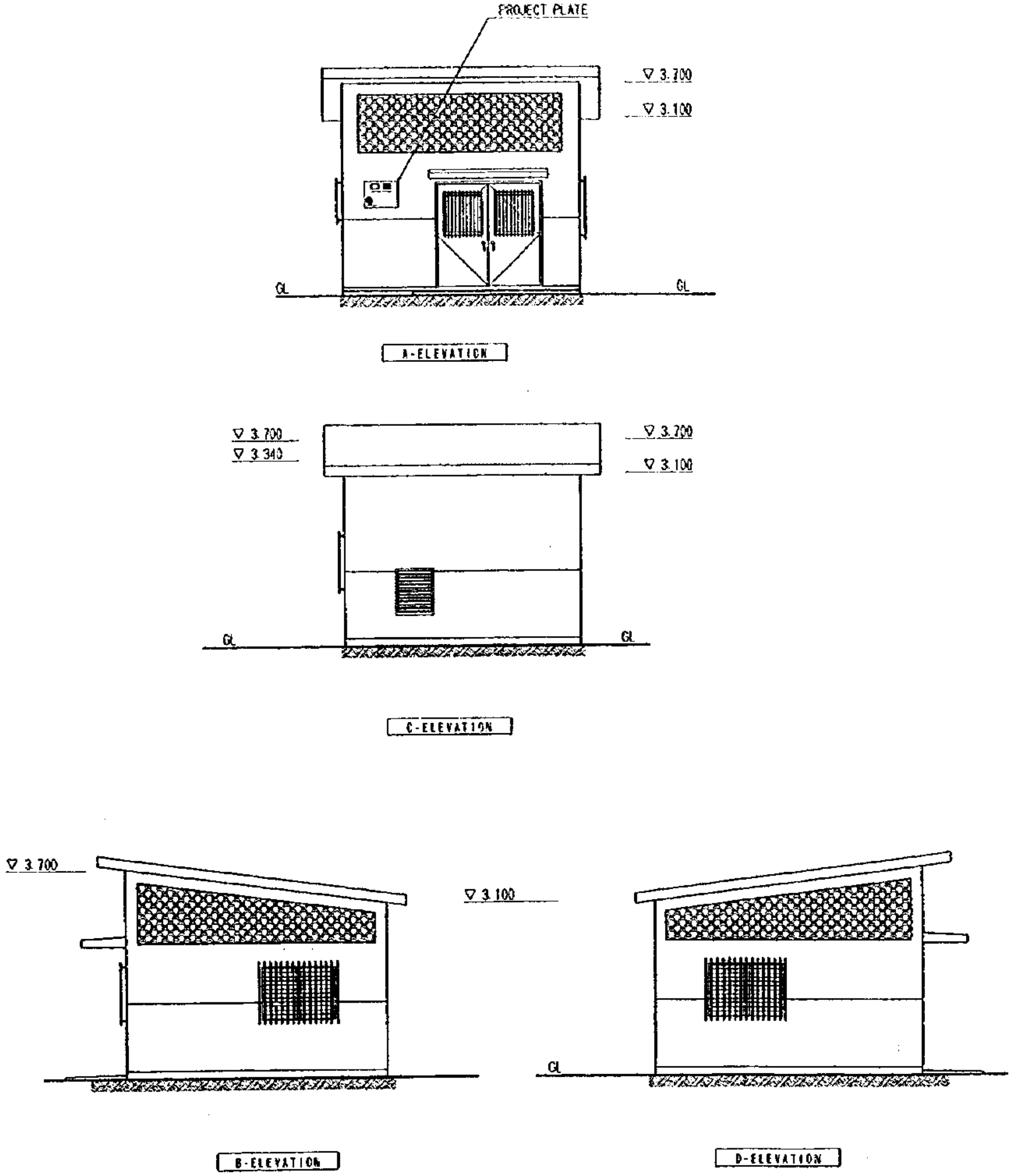




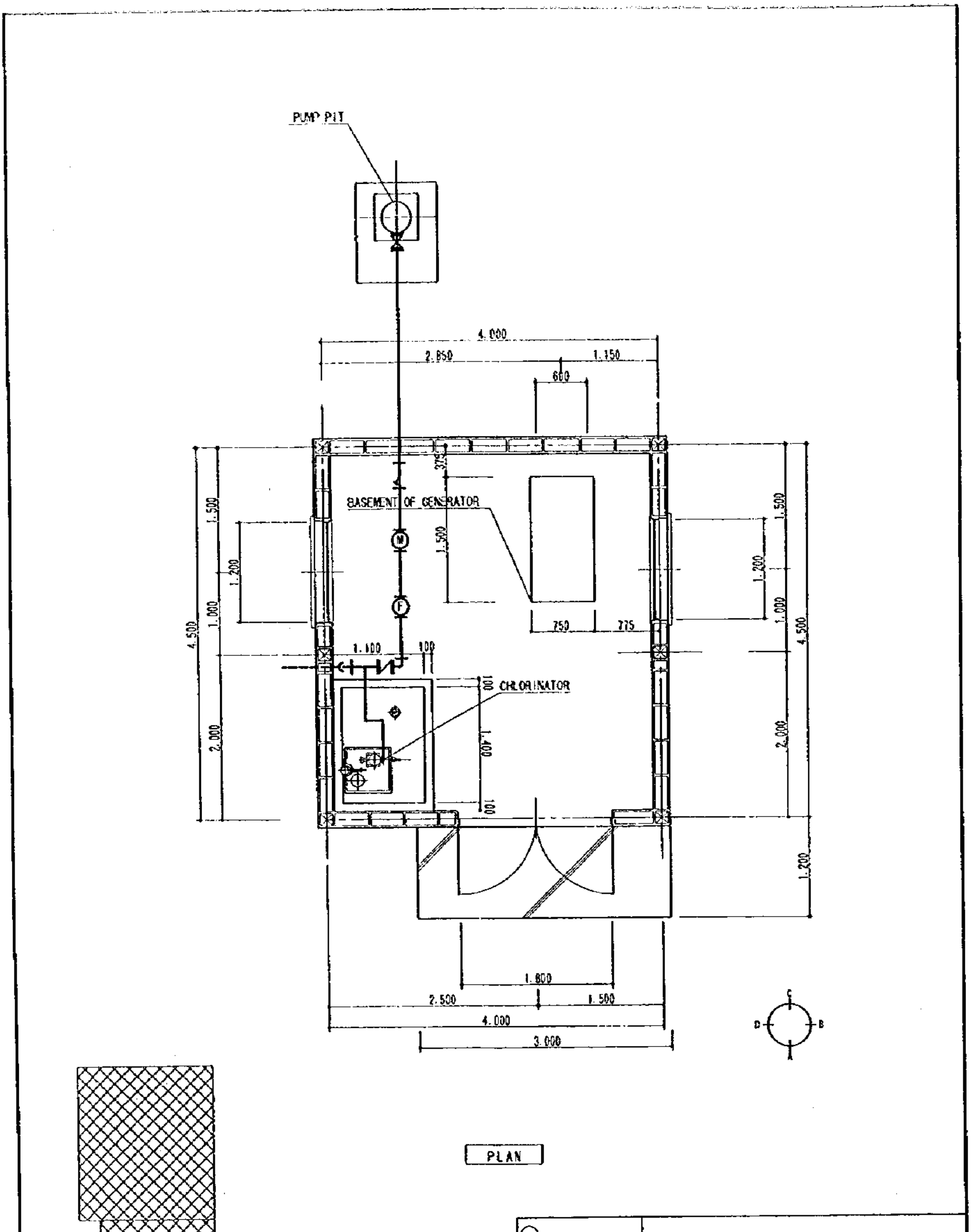
DIMWNSIONS

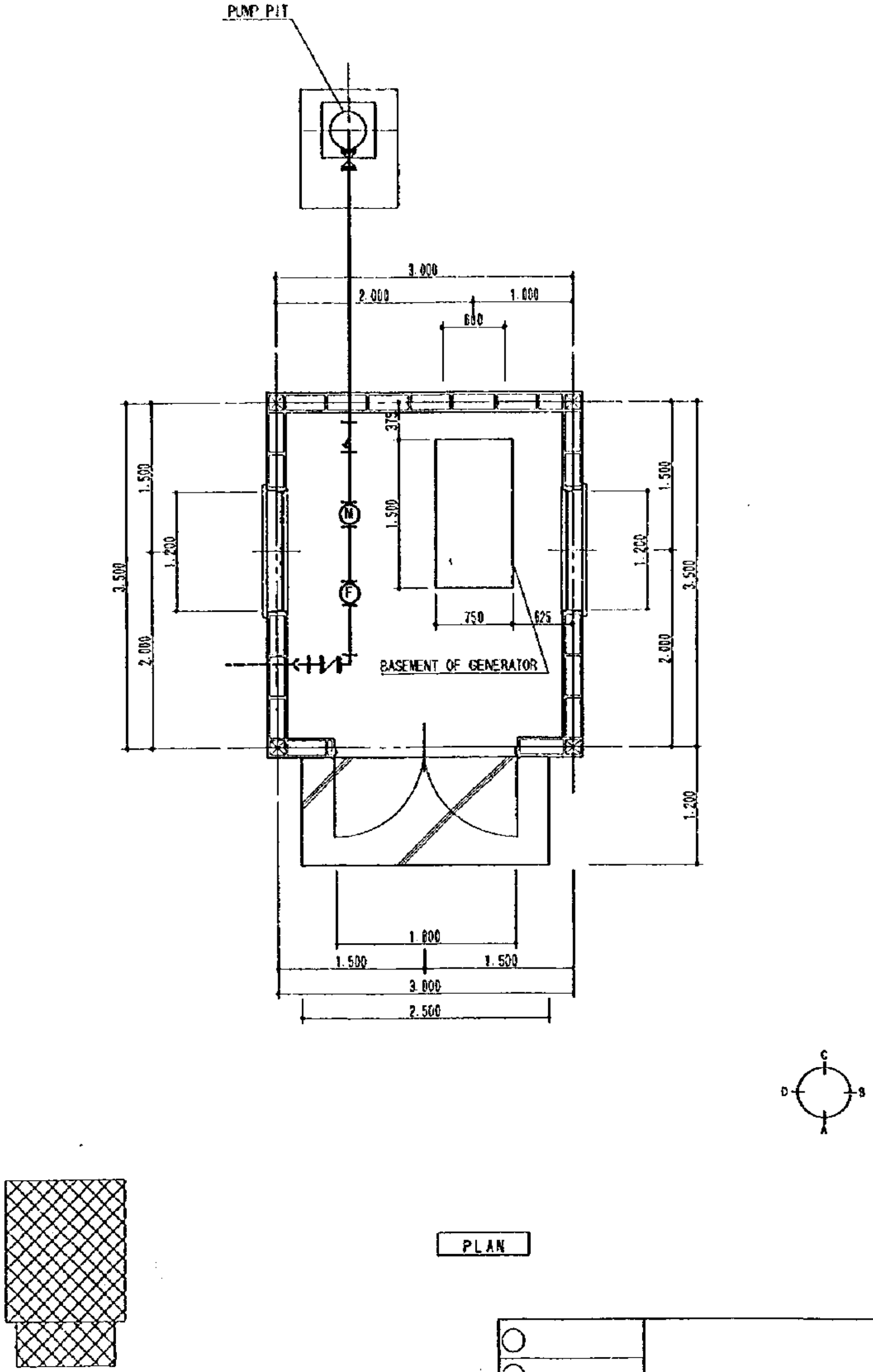
TANK CAPACITY	L	T	H	t1(Wall/Slab)	t2(Cover)
30 m3	5.000	5.000	1.850	200	150
20 m3	4.000	4.000	1.850	200	150
15 m3	3.500	3.500	1.850	200	150
10 m3	3.000	3.000	1.850	200	150

WATER TANK

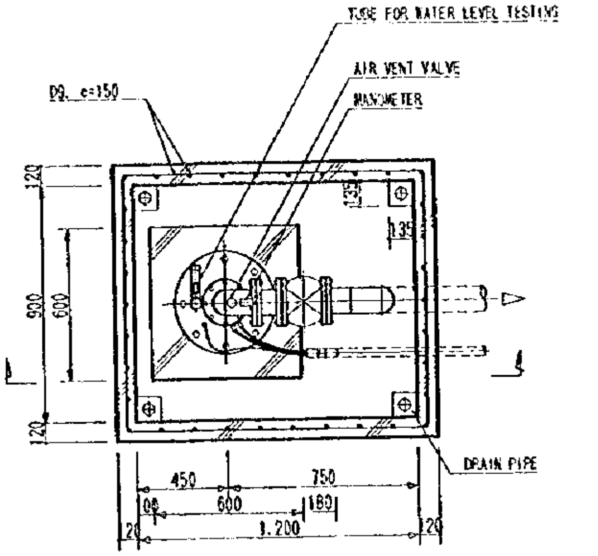


WELL MACHINERY HOUSE

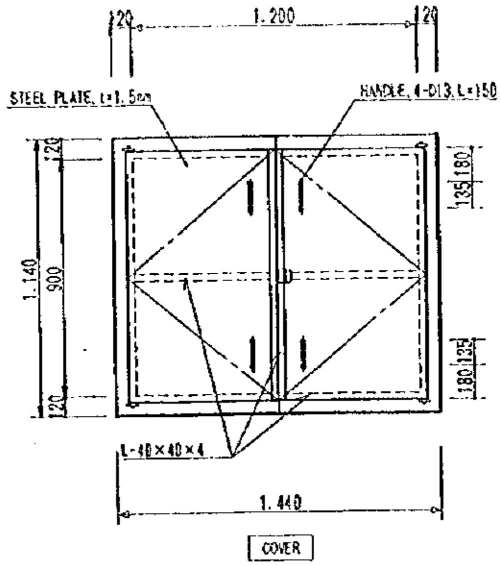

PUMP PIT
4.000
2.850
1.150
600
375
BASEMENT OF GENERATOR
1.500
1.500
1.200
1.000
4.500
2.000
750
775
1.100
100
CHLORINATOR
100
1.400
100
1.200
1.800
2.500
1.500
4.000
3.000
C
D
B
A
PLAN
MACHINERY HOUSE : TYPE-A



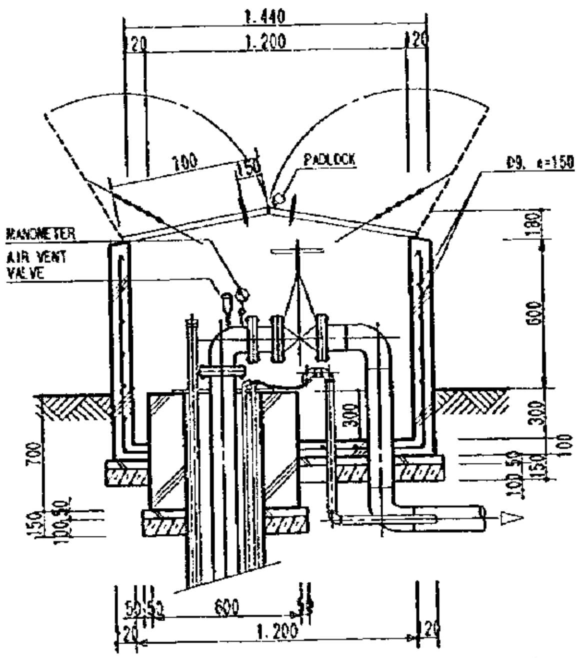
MACHINERY HOUSE : TYPE-B



TUBE FOR WATER LEVEL TESTING
AIR VENT VALVE
MANOMETER
D9, e=150
DRAIN PIPE
PLAN

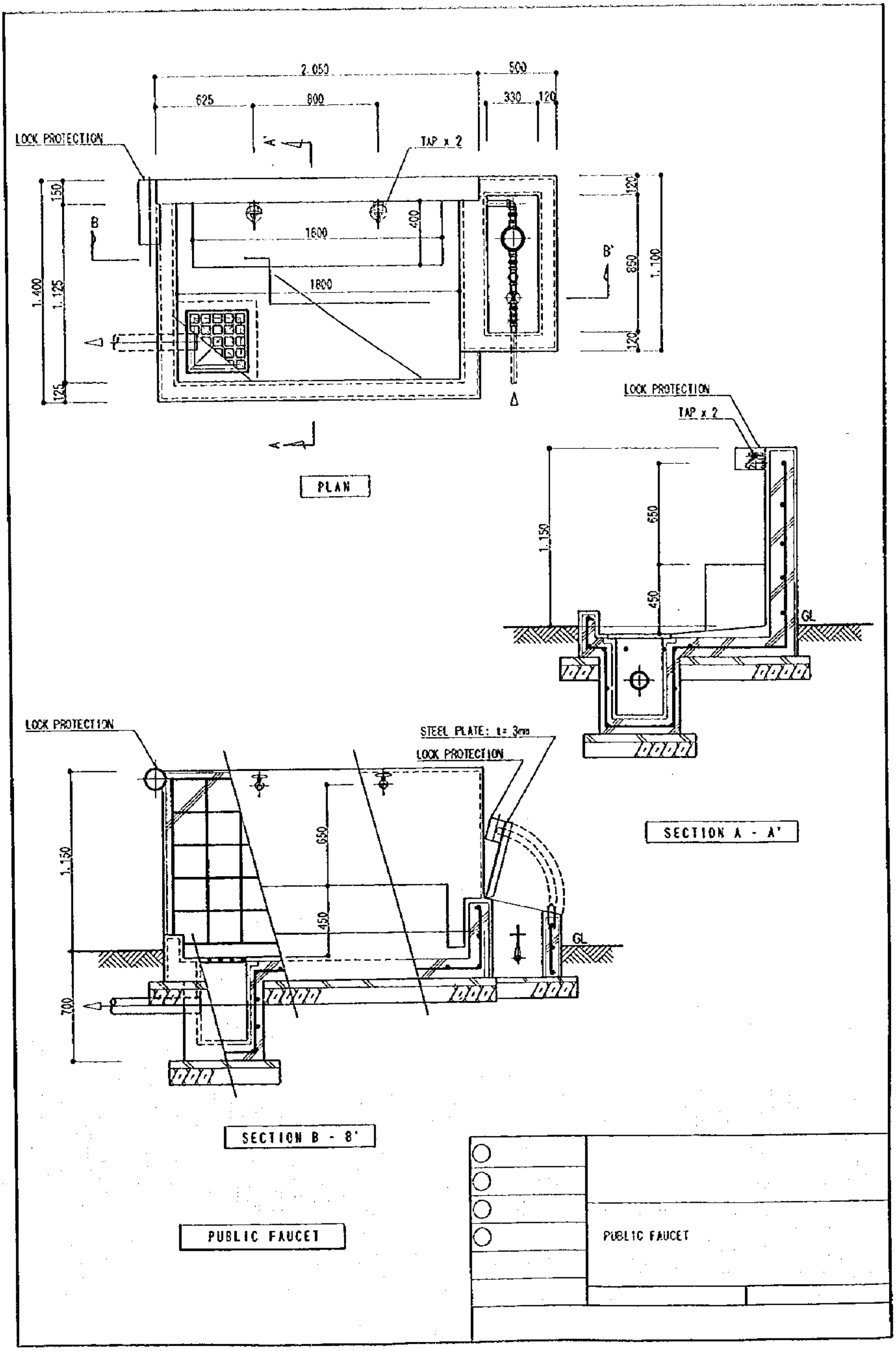


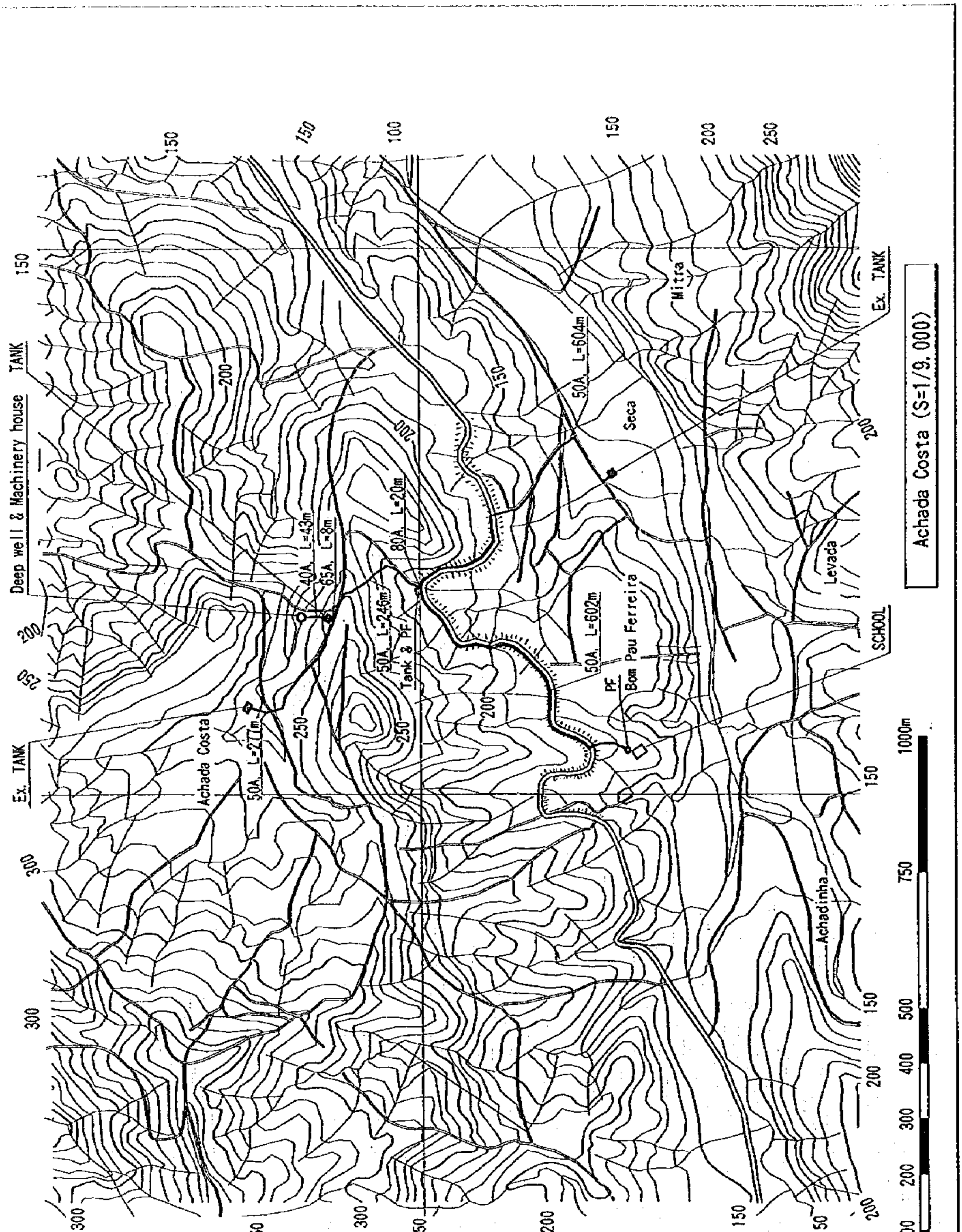
STEEL PLATE, t=1.5mm
HANDLE, 4-D13, L=150
L-40×40×4
COVER

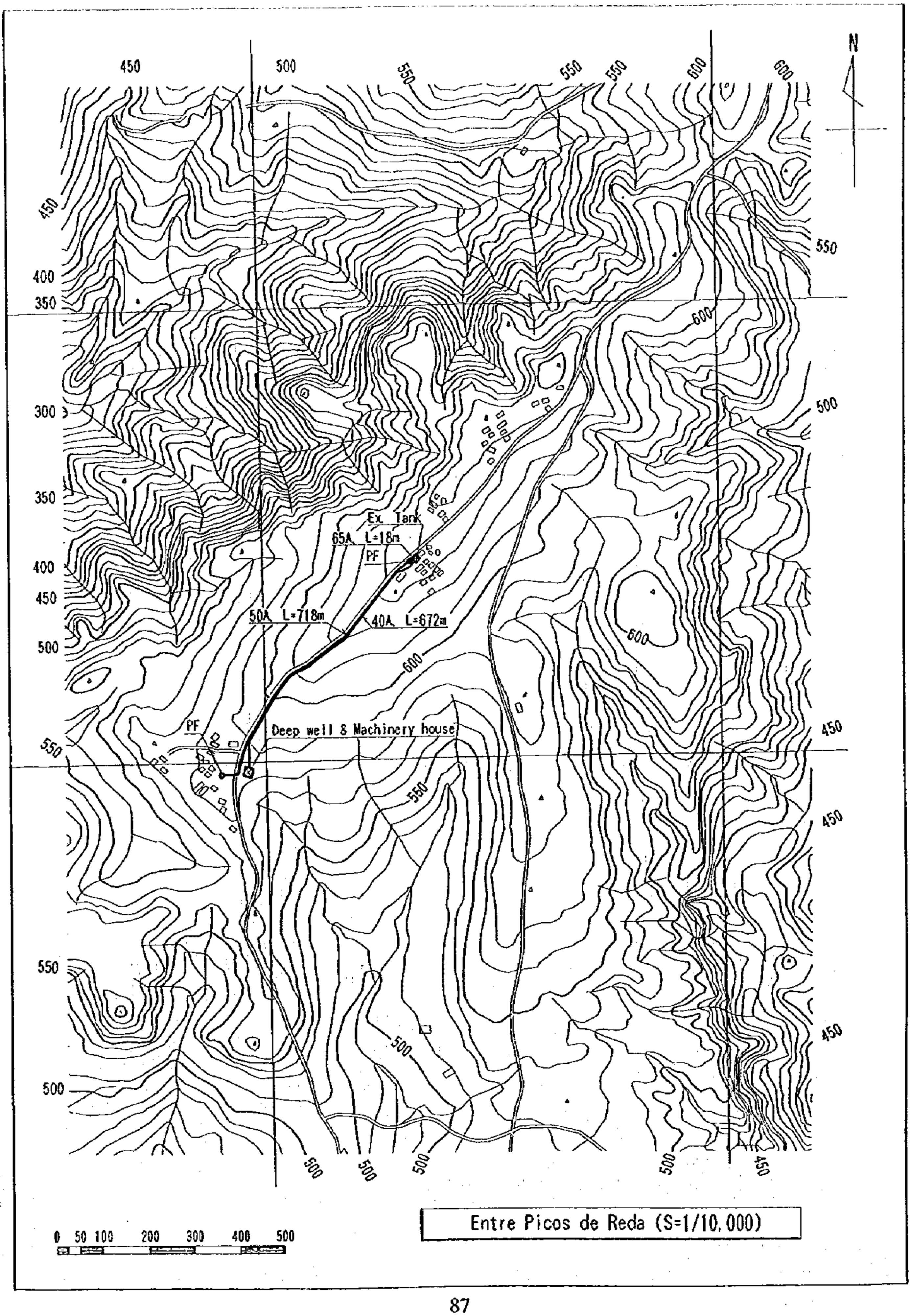


PADLOCK
D9, e=150
MANOMETER
AIR VENT VALVE
SECTION

	PUMP PIT


2.050
500
625
800
330
120
LOCK PROTECTION
TAP x 2
1600
1800
400
150
1.400
1.125
125
120
850
1.100
PLAN
LOCK PROTECTION
TAP x 2
1.150
650
450
GL
SECTION A - A'
LOCK PROTECTION
STEEL PLATE: t= 3mm
LOCK PROTECTION
1.150
650
450
700
GL
SECTION B - 8'
PUBLIC FAUCET
PUBLIC FAUCET


Deep well & Machinery house
TANK
Ex. TANK
Achada Costa
50A L=277m
40A L=43m
65A L=8m
80A L=20m
50A L=246m
Tank & PF
50A L=604m
Seca
Mitra
Ex. TANK
50A L=602m
PF
Bom Pau Ferreira
SCHOOL
Levada
Achadinha
N
0 50 100 200 300 400 500 750 1000m
Achada Costa (S=1/9.000)


Ex. Tank
65A. L=18m
PF
50A. L=718m
40A. L=672m
PF
Deep well & Machinery house
Entre Picos de Reda (S=1/10,000)
0 50 100 200 300 400 500
N

6.3.3 Facilities for the Villages for the 2nd to 4th Project Phase

The execution of the phase I project will provide some villages with improved water transportation services, as the reduction of the recipients of the tank lorry delivery services would lighten up the delivery service schedule, depending of course on the number of villages that will be covered by the phase I project (26 in total: 2 in Tarrafal, 3 in Sao Miguel, 8 in Santa Catarina, 3 in Santa Cruz, 8 in Sao Domingo, and 2 in Praia).

Since the rotation of the transportation service is not analyzed in this study program, it is difficult to point out at the moment, which of the villages will indirectly benefit from the phase I project. Therefore, the tentative plan for the remaining 88 villages was prepared based on existing conditions.

The facilities and services recommended to improve the existing water supply conditions in the 88 villages are tabulated in Table 6-3,4,5 (Facilities for *Group A-2* and *Group B* Villages), and detailed below.

Water supply sources/means:

- Borehole well or spring:
  At villages where groundwater development is technically and economically feasible. "*Well*" in the table refers to the possibility of groundwater development by well construction, while "*Spring*" indicates the possibility of the development of springs as water supply sources.
- Tank lorry:
  In villages where water resource development is not available, tank lorry transportation/delivery services will be improved, by replacement of worn-cut trucks with new ones. In the table, "tank lorry" is used to indicate such villages.

Water supply facilities:

- As in Group A-1, at least 2 sets of public faucets will be installed to reduce the waiting time when fetching water and to make water fetching possible any time of the day. Since all villages will be installed with faucets, no particular notation is made in the table.
- Construction of reservoir tank:
  A reservoir tank will be constructed in villages having none. If the existing tank capacity is not enough, a new tank with a capacity exceeding the daily water demand (projected population times 20 liters) will be constructed. "Tank 20m^3" is used in the table to indicate the villages where this facility will be constructed.

The basic design of the facilities will be similar to those for *Group A-1* (phase I project). The number of facilities proposed for the 88 villages by Municipality is presented in the following table 6-6.

Table 6-3 Planed Facility in 29 Villages (Phase II)

No.	ZONA	Grouping	Population			Supply Amount 1993	Consumption 1998	Water Demand 2009	Proposed Supply Facility		
			CENSUS 1990	1,998	2,009	(ℓ/c/d)	(ℓ/d)	(Pop x 20ℓ/c/d)	Water Source	Reservoir tank	Public Faucet
Tarrafal											
São Miguel											
3	Casa Branca	A-2	711	750	814	8.0	6,000	16,280	Well	$20m^3$	2
9	Moto Correia	A-2	371	424	507	11.0	4,664	10,140	Tank Lorry	Existing	2
13	Pedra Barro	A-2	335	382	458	15.0	5,714	9,160	Well	Existing	2
14	Pedra Serrado	A-2	485	553	663	10.3	5,714	13,260	Well	Existing	2
17	Principal	B-1	1,277	1,457	1,750	10.0	14,570	35,000	Spring		
	Sub-total		3,179	3,566	4,192		36,662	83,840			
Santa Catarina											
14	Chã de Lagoa	A-2	476	552	676			13,520	Tank Lorry	Existing	2
20	Figueira das Naus	A-2	1,091	1,257	1,531			30,620	Tank Lorry	Existing	2
35	Palha Carga	A-2	1,248	1,444	1,765			35,300	Tank Lorry	Existing	2
44	Ribeirão Isabel	A-2	519	598	728			14,560	Tank Lorry	$15 m^3$	2
48	Sedeguma	A-2	302	321	389			7,780	Spring		
49	Serra Malagueta	A-2	478	552	673			13,460	Tank Lorry	Existing	2
56	Burbur	A-2	253	289	349			6,980	Spring		
64	Manhanga	A-2	235	268	325			6,500	Spring		
65	Mato Fortes	A-2	201	230	277			5,540	Tank Lorry	$10 m^3$	2
66	Mato Limão	A-2	246	281	340			6,800	Tank Lorry	$10 m^3$	2
33	Mato Gege	B-1	1,196	1,380	1,683			33,660	Spring		
67	Picos Acima	B-1	1,499	1,730	2,107			42,140	Spring		
	Sub-total		7,744	8,902	10,843			216,860			
Santa Cruz											
5	Boaventura	A-2	477	522	616	4.6	2,401	12,320	Tank Lorry	$15 m^3$	2
6	Boca Larga	A-2	289	289	349	1.5	434	6,980	Spring		
11	Matinho	A-2	579	1,141	1,484	2.0	2,282	29,680	Spring		
14	Rebelo	A-2	147	196	233	17.8	3,489	4,660	Tank Lorry	Existing	2
18	Ribeirão Boi	A-2	678	641	754	1.9	1,218	15,080	Tank Lorry	Existing	Existing
22	São Cristóvão	A-2	603	700	835	4.7	3,290	16,700	Tank Lorry	Existing	2
23	Serelho	A-2	434	466	534	3.9	1,817	10,680	Tank Lorry	Existing	Existing
	Sub-total		3,207	3,955	4,805		14,931	96,100			
São Domingos											
4	Chão de Coqueiro	A-2	195	213	242	8.1	1,725	4,840	Tank Lorry	Existing	Existing
9	Praia Formosa	A-2	621	740	939	7.6	5,624	18,780	Well	Existing	Existing
14	Chaminé	A-2	119	150	178	13.2	1,980	3,560	Tank Lorry	Existing	2
21	Mendes Faleiro Cabra	A-2	101	120	151	14.8	1,776	3,020	Tank Lorry	Existing	Existing
	Sub-total		1,036	1,223	1,510		11,105	30,200			
Praia											
8	São Martinho Grande	A-2	861	960	1,117			22,340	Spring		
	Sub-total		861	960	1,117			22,340			
Total			16,027	18,606	22,467			449,340			30

Table 6-4 Planed Facility in 29 Villages (Phase III)

No.	ZONA	Grouping	Population			Supply Amount 1998	Consumption 1998	Water Demand 2009	Proposed Supply Facility		
			census 1990	1,998	2,009	(l/c/d)	(l/d)	(Pop x 20l/c/d)	Water Source	Reservoir tank	Public Faucet
Tarrafal											
4	Achada Meio	B-1	172	196	235	19.0	3,724	4,700	Tank Lorry	Existing	Existing
11	Figueira Muita	B-1	103	116	137	16.0	1,856	2,740	Tank Lorry	Existing	Existing
16	Ponta Lobrão	B-1	283	322	385	21.0	6,762	7,700	Well	Existing	2
	Sub-total		558	634	757		12,342	15,140			
São Miguel											
19	Ribeireta	B-1	343	237	282			5,640	Tank Lorry	10m^3	2
20	Tagarra	B-1	743	789	947			18,940	Well	20m^3	2
21	Varanda	B-1	457	500	568	7.0	3,500	11,360	Spring		
	Sub-total		1,543	1,526	1,797			35,940			
Santa Catarina											
3	Achada Lazão	B-1	128	148	181			3,620	Spring		
4	Achada Leite	B-1	186	216	265			5,300	Spring		
9	Arribada	B-1	124	143	174			3,480	Tank Lorry	Existing	2
10	Banana Semedo	B-1	485	562	688			13,760	Spring		
11	Boa Entrada	B-1	1,063	1,232	1,508			30,160	Spring		
16	Charco	B-1	311	361	443			8,860	Spring		
18	Entre Picos	B-1	293	339	416			8,320	Tank Lorry	Existing	2
21	Fonteana	B-1	1,038	1,200	1,466			29,320	Spring		
25	Gil Bispo	B-1	844	977	1,194			23,880	Well		
37	Pau Verde	B-1	289	332	404			8,080	Tank Lorry	Existing	2
38	Pedra Barro	B-1	489	567	696			13,920	Tank Lorry	Existing	2
39	Pedra Serrado	B-1	127	144	175			3,500	Tank Lorry	Existing	2
52	Aboboreiro	B-1	740	851	1,032			20,640	Well		
59	Faveta	B-1	337	386	467			9,340	Tank Lorry	10m^3	2
69	Purgueira	B-1	430	495	601			12,020	Tank Lorry	Existing	2
	Sub-total		6,884	7,953	9,710			194,200			
Santa Cruz											
10	Librão	B-1	434	515	604	4.2	2,163	12,080	Tank Lorry	Existing	Existing
12	Monte Negro	B-1	587	804	967	1.3	1,045	19,340	Tank Lorry	Existing	Existing
28	João Goto	B-1	232	357	425	5.0	1,785	8,500	Well	Existing	2
	Sub-total		1,253	1,676	1,996		4,993	39,920			
São Domingos											
17	Godim	B-1	277	330	419	11.3	3,729	8,380	Tank Lorry	Existing	Existing
19	Loura	B-1	350	390	455	7.5	2,925	9,100	Tank Lorry	10m^3	2
22	Mendes Faleiro Rende	B-1	218	260	329	7.2	1,872	6,580	Tank Lorry	Existing	Existing
23	Nora	B-1	380	458	592	12.4	5,677	11,840	Well	Existing	Existing
	Sub-total		1,225	1,438	1,795		14,203	35,900			
Praia											
1	Agostinho Alves	B-1	113	126	147			2,940	Well	Existing	2
	Sub-total		113	126	147			2,940			
Total			11,576	13,353	16,202			324,040			26

Table 6-5 Planed Facility in 30 Villages (Phase IV)

No.	ZONA	Grouping	Population			Supply Amount 1998	Consumption 1998	Water Demand 2009	Proposed Supply Facility		
			CENSUS 1990	1,998	2,009	(l/c/d)	(l/d)	(Pop x 20l/c/d)	Water Source	Reservoir tank	Public Faucet
Tarrafal											
3	Achada Longueira	B-2	869	930	1,114	11.5	10,695	22,280	Well	Existing	Existing
	Sub-total		869	930	1,114		10,695	22,280			
São Miguel											
12	Palha Carga	B-2	628	716	859	11.0	7,880	17,180	Well	Existing	Existing
	Sub-total		628	716	859		7,880	17,180			
Santa Catarina											
2	Achada Gomes	B-2	350	403	489			9,780	Replacement of Pump	Existing	Existing
5	Achada Lém	B-2	2,390	2,762	3,370			67,400	Replacement of Pump	Existing	Existing
22	Fonte Lima	B-2	823	954	1,168			23,360	Spring		
23	Furna	B-2	453	521	633			12,660	Spring		
24	Gamchemba	B-2	215	249	304			6,080	Spring		
26	Japluma	B-2	193	220	266			5,320	Spring		
28	João Dias	B-2	508	590	726			14,520	Spring		
30	Librao	B-2	529	614	754			15,080	Replacement of Pump	Existing	Existing
58	Degredo	B-2	204	233	282			5,640	Spring		
62	Leitão Grande	B-2	964	1,101	1,337			26,740	Replacement of Pump	Existing	Existing
42	Ribeira Acima	B-2	254	295	362			7,240	Spring		
70	Rebelo	B-2	133	154	188			3,760	Spring		
	Sub-total		7,016	8,096	9,879			197,580			
Santa Cruz											
8	Chã da Silva	B-2	996	1,219	1,515	6.0	7,314	30,300	Replacement of Pump	Existing	Existing
32	Longueira	B-2	441	326	388	10.0	3,260	7,760	Spring		
35	Pico Antónia/Padjom	B-2	659	664	779	12.9	8,566	15,580	Replacement of Pump	Existing	Existing
	Sub-total		2,096	2,209	2,682		19,140	53,640			
São Domingos											
1	Achada Baleia	B-2	267	317	401	14.6	4,628	8,020	Replacement of Pump	Existing	Existing
2	Baia	B-2	441	524	648	12.7	6,655	12,960	Replacement of Pump	Existing	Existing
3	Cancelo	B-2	226	270	344	12.3	3,321	6,880	Replacement of Pump	Existing	Existing
5	Dobe	B-2	140	167	213	11.8	1,971	4,260	Replacement of Pump	Existing	Existing
18	Lagoa	B-2	190	230	299	16.9	3,887	5,980	Spring		
	Sub-total		1,264	1,508	1,905		20,462	38,100			
Praia											
11	Veneza	B-2	176	196	227			4,540	Spring		
14	João Varela	B-2	309	344	399			7,980	Replacement of Pump	Existing	Existing
17	Beatriz Pereira	B-2	185	205	237			4,740	Replacement of Pump	Existing	Existing
19	Chã de Igreja	B-2	182	203	235			4,700	Replacement of Pump	Existing	Existing
22	Gouveia	B-2	249	219	361			7,220	Replacement of Pump	Existing	Existing
23	Mosquito de Horta	B-2	117	128	149			2,980	Replacement of Pump	Existing	Existing
24	Mosquito Grande	B-2	122	135	156			3,120	Spring		
26	Porto Mosquito	B-2	492	549	638			12,760	Replacement of Pump	Existing	Existing
	Sub-total		1,832	1,979	2,402			48,040			
Total			13,705	15,438	18,841			376,820			

Table 6-4 Number of Proposed Facility / Service for 88 Villages

		Water Source			Supply Facility		
		Well	Spring	Tank Lorry	Replacement of Pump	Reservoir tank	Public Faucet
Tarrafal	Phase 2	0	0	0	0	0	0
	Phase 3	1	0	2	0	0	2
	Phase 4	1	0	0	0	0	0
	Total	3	0	3	0	0	2
São Miguel	Phase 2	3	1	1	0	20m³x1	8
	Phase 3	1	1	1	0	20m³x1,10m³x1	4
	Phase 4	1	0	0	0	0	0
	Total	5	2	2	0	3	12
Santa Catarina	Phase 2	0	5	7	0	15m³x1,10m³x2	14
	Phase 3	2	6	7	0	10m³x1	14
	Phase 4	0	8	0	4	0	0
	Total	2	19	14	4	4	28
Santa Cruz	Phase 2	0	2	5	0	15m³x1	6
	Phase 3	1	0	2	0	0	2
	Phase 4	0	1	0	2	0	0
	Total	1	3	7	2	1	8
São Domingos	Phase 2	1	0	3	0	0	2
	Phase 3	1	0	3	0	10m³x1	2
	Phase 4	0	1	0	4	0	0
	Total	2	1	6	4	1	4
Praia	Phase 2	0	1	0	0	0	0
	Phase 3	1	0	0	0	0	2
	Phase 4	0	2	0	6	0	0
	Total	1	3	0	6	0	2
Total	Phase 2	3	9	16	0	6	30
	Phase 3	8	7	15	0	4	26
	Phase 4	2	12	0	16	0	0
	Total	13	28	31	16	9	56

6.3.4 Project Coat for 2nd to 4th Phase Projects

The total projects cost including 20% of administrative and engineering cost, and procurement of 5 tank lorries is estimated at 4.43 million US Dollars.

6.4 Operation and Maintenance Plan

6.4.1 Autonomous Management System for O/M Structure

Rural water supply operation and maintenance in Santiago Island is currently being carried out by a central administrative unit and the municipality. Except in some of the villages in the municipality of Praia, users do not participate in the activities, as previously mentioned in Section 3.3.5.

As mentioned in Section 3.3, there is an absolute shortage in water supply source and volume, as well as lack of staff for maintenance services. Because of these limitations many villages do not receive public water supply services; the daily domestic water consumption rate is generally low in most villages in the Island. This, however, is also influenced by the reluctance of the users to actively participate in the operation and maintenance activities. The low consumption rate, on the other hand, may be also attributed to the users' need to budget the household money to accommodate other expenses by limiting their purchase of water (as previously mentioned, water is sold on a "cash on delivery" basis). Water users entirely rely upon municipal services.

Municipal autonomy in water supply services is a recent development in the Republic. From INGRH, responsibilities for rural water supply management were gradually delegated to municipalities. However, extreme shortage in manpower for operation and maintenance and the lack of skilled staff hamper the development of the municipal service level or the expansion of the services within the municipality.

Shortage in water sources may be solved by developing other sources. This development and service expansion, however, would only aggravate. already inefficient operation and maintenance services, unless the rural water supply system is totally revamped. Restructuring the system would entail the integration of the user participation concept. It is, therefore, important to conduct activities that would encourage community participation in the operation and maintenance of the rural water supply system. Operation and maintenance activities, however, should always be carried out in accordance with state and municipal standards..

Ongoing rural water supply projects, jointly executed by the government and the United Nations Equipment Fund (*FENU*) and covering 18 villages in the Island, introduced the community participation ideology and conducted in-depth social studies as well as educational programs prior to the construction works. The construction works will be completed by the end of 1999 and the new management system, which will be based on community participation, will begin operation from the start of 2000. It is, therefore, recommended that the monitoring of the new system and the conduct of educational activities should be continued until the system is in solid footing.

6.4.2 Establishment of Community-based Organization

In order to take part in the O/M work for the water users level, it is essential to formulate the water users association and management committee in the villages concerned. Since rural areas of Santiago Island have an experience to formulate and manage the farmers association in use of irrigation water, and also, people in rural communities have willingness to participate in O/M of water supply as described in 2-4, it will not be so difficult matter to establish and operate the community-based committee in this area.

The recommended type of the committee and its role in domestic water management are as follows;

1) Composition of water association/committee

All family who wish to utilize the improved water supply facility in the community shall join the water association and elect the following committee members;

- President of the association for general management and responsible for close connection with the Municipal Office
- Accountant to collect monthly O/M fee and manage it
- Member to operate the facilities and maintain them in good condition for use
- Member responsible for hygiene and health, and also for water quality control

2) O/M fee collection system and management

Under the new management in utilizing the improved water supply system, people will not buy water from the water vendor. The money monthly collected from the association members is used purely for O/M purpose of following;

- Daily operation cost to pay for such materials as fuel, oil, oil filter, etc.
- Cost for minor repair of generator, water taps and others
- Deposit for future heavy repair of generator or motor pump (Either at Municipal Office or at the Committee concerned)
- Deposit for pump replacement (Same as above mentioned deposit)
- Cost for maintenance services by the staff of Municipal Office (for such services as periodical inspection and training of committee/association members regarding hygiene, water quality treatment, technique of repair, etc.)

- Water use tax to be paid to the state (for general management of water resources)
- Wages for Committee members (Optional, to pay or not will be discussed in the association)

3) Estimation of operation and maintenance cost

Under the condition that a 20 liters of water is supplied daily to all the person of the association with 500 members (100 families), the averaged O/M cost is calculated as follows just for comparison with the existing water charge per 20liters;

- Pump/generator operation cost per 20liters: 1.70CVE/20liters (1.45~8.76)
- Cost for minor repair (assumed as 50CVE/day) 0.10CVE/c/d (20 liters consumption)
- Deposit for heavy repair (20,000CVE/2year) 0.06CVE/c/d
- Replacement of pump (after12 years, 570,000CVE) 0.28CVE/c/d
- Maintenance service (Twice a month, 2,333CVE/m) 0.17CVE/c/d
- Water use tax (8CVE/m3) 0.30CVE/20 liters
- Wages for committee member (36,000CVE/m/4p.) 2.59CVE/c/d

Sub-total 5.02CVE/c/d

Above O/M cost per 20liter consumption varies with number of population served from maximum of 11.42CVE in Tronco of Praia, and minimum of 1.69CVE in Ribeira da Barca of Santa Catarina. Given the condition as voluntary basis for the committee member, maximum will come to 4.33CVE, and minimum 1.11CVE/20 liters. The monthly O/M cost amounts approximately 650CVE/m for 5person-family (Ribeirão Almaço), and 170CVE/m for the same family(Ribeira da Barca).

The O/M cost per person is mostly lower than the present water charge, but it is higher at the villages with a smaller population than 300. Also, it must be noted that the O/M cost should be paid at the villages where water charge is so far free.

In order to adjust the uneven O/M cost per person by villages, each of Municipal office will have to consider a financial assistance to the villages concerned by collecting surplus service charge from the largely populated villages, for example.

In determining the O/M cost, thorough discussions between the municipal office and the villages concerned are required, prior to implementation of the project. The discussions pertaining to the service contents are also required.

Table 6-8 presents the estimated pump operation cost for pumping of 10 m^3 from the wells and spring.

Table 6-7 O/M Cost in 34 Villages of Group A-1

	No.	ZONA	Population 2003 (Capita)	Pump Operation Cost (Ecv/20ℓ)	Cost for Minor Repair (Ecv/20ℓ)	Deposit for Heavy Repair (Ecv/20ℓ)	Deposit for Pump Replacement (Ecv/20ℓ)	Twice a Month Service (Ecv/20ℓ)	Water Use Tax (Ecv/20ℓ)	Wages for Committee Member (Ecv/20ℓ)	Sub-total per 20ℓ Consumption: With Wages (Ecv/20ℓ)	Sub-total per 20ℓ Consumption: Without Wages (Ecv/20ℓ)	Present Water Charge (Ecv/20ℓ)	Comparison
Tarrafal	9	Curral Velho	400	2.29	0.13	0.07	0.33	0.19	0.30	3.00	6.31	3.31	5.00	Lower (Higher with wages)
	19	Trás os Montes	379	2.29	0.13	0.07	0.34	0.21	0.30	3.17	6.51	3.34	5.00	Lower (Higher with wages)
São Miguel	4	Chã de Ponta	757	2.05	0.07	0.04	0.17	0.10	0.30	1.59	4.32	2.73	5.00	Lower even with wages
	10	Monte Bode	343	3.06	0.15	0.08	0.38	0.23	0.30	3.50	7.70	4.20	0.00	―――
	11	Monte Pousada	649	2.05	0.08	0.04	0.20	0.12	0.30	1.85	4.64	2.79	5.00	Lower even with wages
	18	Ribeirão Milho *	367	1.43	0.14	0.07	0.35	0.21	0.30	3.27	5.77	2.50	0.00	―――
Santa Catarina	12	Boa Entradinha	658	1.53	0.08	0.04	0.20	0.12	0.30	1.82	4.09	2.27	5.00	Lower even with wages
	13	Bombardeiro	1,291	0.76	0.04	0.02	0.10	0.06	0.30	0.93	2.21	1.28	0.00	Lower even with wages
	15	Chã de Tanque	1,287	1.02	0.04	0.02	0.10	0.06	0.30	0.93	2.47	1.54	10.00	Lower even with wages
	19	Entre Picos de Reda	375	2.29	0.13	0.07	0.35	0.21	0.30	3.20	6.55	3.35	8.00	Lower even with wages
	36	Pata Brava	377		0.13	0.07			0.30	3.18	3.68	0.50	0.00	―――
	40	Pingo Chuva *	457	1.44	0.11	0.06	0.28	0.17	0.30	2.63	4.99	2.36	5.00	Lower even with wages
	43	Ribeira da Barca	1,987	0.68	0.03	0.01	0.07	0.04	0.30	0.60	1.73	1.13	5.00	Lower even with wages
	47	Saltos Acima	840	1.15	0.06	0.03	0.15	0.09	0.30	1.43	3.21	1.78	5.00	Lower even with wages
	57	Covão Grande	621	1.53	0.08	0.04	0.21	0.13	0.30	1.93	4.22	2.29	5.00	Lower even with wages
	60	Jalalo Ramos *	662	0.96	0.08	0.04	0.20	0.12	0.30	1.81	3.51	1.70	5.00	Lower even with wages
	63	Leitãozinho	612	0.96	0.08	0.04	0.21	0.13	0.30	1.96	3.68	1.72	2.50	Lower (Higher with wages)
Santa Cruz	17	Ribeirão Almaço	283	3.06	0.18	0.10	0.46	0.27	0.30	4.24	8.61	4.37	0.00	―――
	25	Achada Costa	403	1.43	0.12	0.07	0.32	0.19	0.30	2.98	5.41	2.43	3.00	Lower (Higher with wages)
	27	Fundura	311	3.05	0.16	0.09	0.42	0.25	0.30	3.86	8.13	4.27	2.00	―――
	31	Levada	336	1.43	0.15	0.08	0.39	0.23	0.30	3.57	6.15	2.58	3.00	Lower (Higher with wages)
São Domingos	6	Milho Branco	732	0.96	0.07	0.04	0.18	0.11	0.30	1.64	3.30	1.66	4.00	Lower even with wages
	8	Praia Baixo *	928	0.72	0.05	0.03	0.14	0.08	0.30	1.29	2.61	1.32	5.00	Lower even with wages
	11	Achada Mitra	337	1.92	0.15	0.08	0.39	0.23	0.30	3.56	6.63	3.07	5.00	Lower (Higher with wages)
	13	Banana	351	1.43	0.14	0.08	0.37	0.22	0.30	3.42	5.96	2.54	4.00	Lower (Higher with wages)
	15	Dacabalaio	270	1.91	0.19	0.10	0.48	0.29	0.30	4.44	7.71	3.27	7.00	Lower (Higher with wages)
	16	Fonte Almeida	939	1.54	0.05	0.03	0.14	0.08	0.30	1.28	3.42	2.14	4.00	Lower even with wages
	20	Mato Afonso	512	1.83	0.10	0.05	0.25	0.15	0.30	2.34	5.02	2.68	5.00	Lower even with wages
	24	Po de Saco	241	1.91	0.21	0.11	0.54	0.32	0.30	4.98	8.37	3.39	0.00	―――
	27	Rui Vaz	1,057	1.23	0.05	0.03	0.12	0.07	0.30	1.14	2.94	1.80	7.00	Lower even with wages
Praia	10	São Tomé *	274	1.92	0.18	0.10	0.47	0.28	0.30	4.38	7.63	3.25	4.00	Lower (Higher with wages)
	18	Belém	529	1.15	0.09	0.05	0.25	0.15	0.30	2.27	4.26	1.99	5.00	Lower even with wages
	27	Santana *	1,078	0.82	0.05	0.03	0.12	0.07	0.30	1.11	2.50	1.39	0.00	―――
	28	Tronco	221	4.58	0.23	0.12	0.59	0.35	0.30	5.43	11.60	6.17	0.00	―――
		Average	20,864	1.70	0.11	0.06	0.28	0.17	0.30	2.61	5.17	2.56	3.78	

* Solar enagized system can be applied. With the system, O/M cost will become lower by omitting pump operation cost.

Table 6-8 Running Cost

Fuel Consumption Rate = 0.127 ℓ/PS/h. Gas oil : 40.00 ECV/ℓ

	No.	ZONA	Population 2003 (Capita)	Daily Demand 2003 (20ℓ/c/d)	Pump Rate (m^3/min)	Pump Run. Hours (hrs)	Pump Out put (Kw)	Generator Out-Put Power Gene. (KVA)	Generator Out-Put Power Engine (PS)	Fuel Consumption (ℓ/d)	COST Total Daily Cost (ECV/d)	COST Daily Cost / Capita (ECV/C/d)	COST Pump Operation Cost (ECV/m^3)	NOTE
Tarrafal	9	Curral Velho	400	8,000	0.020	6.67	2.20	18	23.5	19.9	915.40	2.29	114.43	
	19	Trás os Montes	379	7,580	0.020	6.32	2.20	18	23.5	18.9	869.40	2.30	114.70	
São Miguel	4	Chã de Ponta	757	15,140	0.030	8.41	3.70	25	31.5	33.7	1,550.20	2.05	102.40	
	10	Monte Bode	343	6,860	0.015	7.62	2.20	18	23.5	22.8	1,048.80	3.06	152.89	
	11	Monte Pousada	649	12,980	0.030	7.21	3.70	25	31.5	28.9	1,329.40	2.05	102.42	
	18	Ribeirão Milho	367	7,340	0.020	6.12	1.10	10	14.7	11.5	529.00	1.45	72.08	
Santa Catarina	12	Boa Entradinha	658	13,160	0.030	7.31	2.20	18	23.5	21.9	1,007.40	1.54	76.56	
	13	Bombardeiro	1,291	25,820	0.060	7.17	2.20	18	23.5	21.5	989.00	0.77	38.31	
	15	Chã de Tanque	1,287	25,740	0.060	7.15	3.70	25	31.5	28.7	1,320.20	1.03	51.29	
	19	Entre Picos de Reda	375	7,500	0.020	6.25	2.20	18	23.5	18.7	860.20	2.30	114.70	
	36	Pata Brava	377	7,540		Spring								
	40	Pingo Chuva	457	9,140	0.020	7.62	1.10	10	14.7	14.3	657.80	1.44	71.97	
	43	Ribeira da Barca	1,987	39,740	0.090	7.36	3.70	25	31.5	29.5	1,357.00	0.69	34.15	
	47	Saltos Acima	840	16,800	0.040	7.00	2.20	18	23.5	20.9	961.40	1.15	57.23	
	57	Covão Grande	621	12,420	0.030	6.90	2.20	18	23.5	20.6	947.60	1.53	76.30	
	60	Jalalo Ramos	662	13,240	0.030	7.36	1.50	10	14.7	13.8	634.80	0.96	47.95	
	63	Leitãozinho	612	12,240	0.030	6.80	1.50	10	14.7	12.7	584.20	0.96	47.73	
Santa Cruz	17	Ribeirão Almaço	283	5,660	0.015	6.29	2.20	18	23.5	18.8	864.80	3.06	152.80	
	25	Achada Costa	403	8,060	0.020	6.72	2.20	10	14.7	12.6	579.60	1.44	71.92	
	27	Fundura	311	6,220	0.015	6.91	2.20	18	23.5	20.7	952.20	3.07	153.09	
	31	Levada	336	6,720	0.015	7.47	0.75	10	14.7	14.0	644.00	1.92	95.84	
São Domingos	6	Milho Branco	732	14,640	0.030	8.13	1.50	10	14.7	15.2	699.20	0.96	47.76	
	8	Praia Baixo	928	18,560	0.040	7.73	0.55	10	14.7	14.5	667.00	0.72	35.94	
	11	Achada Mitra	337	6,740	0.015	7.49	1.50	10	14.7	14.0	644.00	1.92	95.55	
	13	Banana	351	7,020	0.020	5.85	1.50	10	14.7	11.0	506.00	1.45	72.08	
	15	Dacabalaio	270	5,400	0.015	6.00	2.20	10	14.7	11.3	519.80	1.93	96.26	
	16	Fonte Almeida	939	18,780	0.040	7.83	3.70	25	31.5	31.4	1,444.40	1.54	76.92	
	20	Mato Afonso	512	10,240	0.025	6.83	2.20	18	23.5	20.4	938.40	1.84	91.65	
	24	Po de Saco	241	4,820	0.015	5.36	1.10	10	14.7	10.0	460.00	1.91	95.44	
	27	Rui Vaz	1,057	21,140	0.050	7.05	3.70	25	31.5	28.2	1,297.20	1.23	61.37	
Praia	10	São Tomé	274	5,480	0.015	6.09	0.75	10	14.7	11.4	524.40	1.92	95.70	
	18	Belém	529	10,580	0.025	7.05	1.50	10	14.7	13.2	607.20	1.15	57.40	
	27	Santana	1,078	21,560	0.100	3.59	5.50	30	42.0	19.2	883.20	0.82	40.97	
	28	Tronco	221	4,420	0.010	7.37	2.20	18	23.5	22.0	1,012.00	4.58	228.96	
		Total / Average	20,864	417,280	0.031	6.88	2.21	16.2	21.8	19.0	872.88	1.73	86.20	

7 PROJECT EVALUATION

7.1 Introduction

The Project has been designed to satisfy basic human needs of the people residing in rural areas of Santiago island. Out of 206 communities (zonas) in Santiago Island, a total of 122 communities in rural areas has been selected as the target communities for the implementation of the Project.

The objectives of the Project are: i) to provide and distribute sufficient and safe potable water to meet the needs of domestic water users in 122 communities by the year 2009; and ii) to establish improved operation and maintenance system in prioritized communities through participation of the communities' residents.

Based on the phased project implementation concept, the Project will be implemented in four phases, each phase covering 29 to 34 communities. Phase-1 project works will be implemented by the year 2003 and Phase-2 to Phase-4 by the year 2009.

7.2 Evaluation of Economic Benefits

7.2.1 Overall Benefits

The Project has been designed to satisfy basic human needs of the people residing in rural areas of Santiago island. The implementation of the Project is expected to yield various kinds of benefits including direct as well as indirect benefits. These benefits include, among others, increased number of beneficiaries, health improvement, time saving, consumer satisfaction and improved quality of life of the people in general. The Project is also expected to yield indirect benefits such as employment generation as a result of time saving, reduction in morbidity and mortality of children as a result of increased time of women for child care, increased activities of rural population for community development as a result of time saving and so on.

Although most of these benefits are difficult to quantify, efforts have been made to evaluate them in qualitative manner.

7.2.2 Increased Beneficiaries

One of the significant effects of the Project is the increased beneficiaries as a result of increased supply of safe water.

Phase-1 Project works will cover 34 communities in Santiago island with the estimated population of 20,900 persons in 2005, which will grow to about 23,300 persons in 2009. Phase-2 to Phase-4 Project works will cover 88 communities with the estimated population of about 57,500 persons in 2009. Total beneficiaries in 2009 are estimated to be 78,400 persons as presented in the following table.

Anticipated Beneficiaries in the Project Area

	Phase-1		Phase-2 to Phase-4		Total
	No. of Target Communities	Beneficiaries in 2003	No. of Target Communities	Beneficiaries in 2009	Beneficiaries in 2009
Tarrafal	2	779	4	1,871	2,650
São Miguel	4	2,116	9	6,848	8,964
Santa Catarina	11	9,167	39	30,432	39,599
Santa Cruz	4	1,333	13	9,483	10,816
São Domingos	9	5,367	13	5,210	10,577
Praia Rural	4	2,102	10	3,666	5,768
Total	34	20,864	88	57,510	78,374

7.2.3 Improvement in Health Conditions

One of the main objectives of rural water supply program is to improve health conditions in rural areas. The proposed Project has also been designed to reduce the incidence of waterborne diseases through provision of improved water quality and increased water use.

The better access to water may change personal hygiene habits, promoting increased bathing and clothes washing. Increased water use for bathing, washing and food preparation can lead to a reduction in water-washed diseases (e.g. skin diseases). Improved water quality can be expected to reduce the incidence of waterborne diseases (e.g. diarrhea). In addition, spending more time on child care and food preparation may lead to a reduction of child mortality and morbidity.

The extent of the effects which provision of clean water will give to water users in their health conditions can be estimated from the result of analyses conducted by USAID and WHO. (Refer to World Development Report, 1992). It is estimated that out of the total reduction in the incidence of diarrhea diseases due to provision of clean water and improvement in sanitation, 78% is attributable to provision of clean water and the remaining is attributable to improvement in sanitation. It is also reported that incidence of diarrhea has been reduced by 22% due to provision of clean water and improvement in sanitation. It can be concluded from these analyses that provision of clean water alone can reduce the incidence of diarrhea diseases at least by 17%. It should be noted, however, that improved water quality alone is not sufficient for eventual impact on human health improvement. Water supply should have links with other activities such as hygiene practice, sanitation, health education, and so on.

7.2.4 Time Saving Effect of Water Collection

One of the main objectives of water supply project is to reduce the workload of the residents, particularly women and children, for water collection. Time for water collection consists of travel time, queuing time and fill time. By providing stable supply of water through the improved facilities, water users will have better access to water sources. As a result, time for water collection will be significantly improved. Saved time may be used for social, educational, agricultural or commercial activities.

7.3 Financial Analysis

7.3.1 Financial Project Cost

Financial Project costs have been estimated on the basis of the market prices as of March 1999. The Project costs comprise the costs for construction, equipment, and engineering services. Price contingency is not considered. Base costs of the Project at the price level of March 1999 amount to US$ 14.21 million.

Financial Project Costs

Unit: Million US Dollars ($)

	Phase-1	Phase-2 to Phase-4	Total
A. Construction	4.62	2.54	7.16
B. Equipment	4.00	0.64	4.64
C. Engineering Services	1.16	1.25	2.41
Total	9.78	4.43	14.21

7.3.2 Financing Plan

(1) Financing of Capital Investment Costs

Financial sources of the Project will be derived from the government budget and financial assistance from foreign countries and international organizations.

In consideration of the investment costs and financial status of the government of Cape Verde, financial assistance from foreign sources will be indispensable. External assistance in terms of grant aid will be necessary to cover the entire foreign currency portion and a part of local currency portion of the Project costs.

(2) The Government's Contributions

1) Financing of Capital Costs

The Government will be responsible for financing a part of capital costs for the implementation of the Project. The State budget allocation for the Project will be arranged through INGRH.

2) Financing of Operation and Maintenance Costs

Presently INGRH and water supply section of each municipality are responsible for the operation and maintenance costs for water production and water supply facilities. The proposed Project recommend that water users in the target communities should form the Water Users Committees (WUCs) for proper operation and maintenance of their facilities. (Refer to Chapter 6). One of the duties of the WUC is to collect the water charge to cover the operation and maintenance costs.

INGRH and each municipality administration are expected to extend technical assistance for these WUCs through training on the operation and maintenance, dispatch of mechanics in case of heavy damages of the facilities, hygiene education, etc.

3) Provision of Project Staff

INGRH will be responsible for arranging technical and administrative staff necessary for the implementation of the Project. INGRH will take action to recruit some technical staff from other government agencies (e.g. INERF) when necessary.

7.3.3 Recovery of Capital Cost and Recurrent Cost

(1) Recovery of Capital Cost

It is the policy of the government of Cape Verde that beneficiaries are responsible for covering a part of the investment costs in water supply project. However, in consideration of the present income level of the residents in the Study Area, it is suggested that water charge should be maintained at levels to ensure recovery of the operation and maintenance costs.

(2) Recovery of Operation and Maintenance Costs

Annual operation and maintenance costs (O&M costs) for the water supply facilities are estimated at 5.0 CVE per capita per day including cost for minor repair, deposit for heavy repair, replacement of pump, maintenance service, water use tax and wages for committee members, although O&M costs varies depending on the size of the community. The community with smaller population is compelled to burden higher water charge. To avoid such a situation, it is recommended that the water charge should be fixed at each municipality using the average O&M costs per head.

As mentioned in Chapter 6, the O&M costs include cost for pump/generator operation cost, minor repair, deposit for heavy repair, replacement of pump, maintenance service, water use tax and wages for committee members. If the wages for committee members are excluded from the calculation, water charge will be reduced to 2.4 CVE on the average.

In the case of water charge of 5.0 CVE, the monthly water charge payment will be about 750 CVE per household, which is estimated to be about 11% of the household income. In the case of 2.4 CVE, the monthly payment will be 360 CVE, which is estimated to be about 5.6% of the household income. The latter case is considered to be within the capacity to pay of the residents in rural areas.

7.4 Institutional Evaluation

7.4.1 Existing Institutional Situation

(1) National Level (INGRH)

Based on the national policy of decentralization, INGRH has concluded a concession contract attributing to each municipality the exclusive right to explore the production and distribution units to provide potable water for the population in each municipality. The production and distribution of irrigation water is also the object of a concession. Main tasks of INGRH are to rationalize the exploitation of water resources and to support the autonomous services of water and energy in each municipality.

With regard to operation and maintenance (O&M) activities, INGRH is responsible for water quality and manpower training on operation and maintenance.

(2) Municipal Level

Each Municipality has a Department of Water and Energy Services, except in the Municipality of Praia where the water supply services are undertaken by EMAP. In Tarrafal, São Miguel, Santa Cruz and São Domingos, the Municipal Water and Energy Services is responsible for the production and distribution of domestic as well as irrigation water to urban and rural population. In Santa Catarina, the Municipal Water and Energy Services is providing domestic water mainly to the town of Assomada and its surroundings, while INGRH branch office is providing water to rural population.

With regard to operation and maintenance activities, each Municipality is responsible for the daily operation of borehole motor pumps and other water supply facilities under INGRH's supervision and technical assistance. In the Municipality of Santa Catarina, the O&M services in rural areas are directly undertaken by INGRH branch office in Assomada.

In the Municipality of Praia, EMAP undertakes systematic O&M work without serious problems thanks to a sufficient number of educated and experienced staff. On the contrary, other Municipalities are not in a position to improve the poor service level due mainly to shortage of adequate manpower and budget.

7.4.2 Proposed Institutional Arrangement

(1) National Level (INGRH)

INGRH will be the project owner and the responsible agency for implementation of the proposed Project. For smooth and effective implementation of the Project, a Project Team will be assigned at INGRH headquarters. A team of technical staff comprising a water supply engineer, a water quality specialist and some administrative staff will be stationed in the office under a Project Director who is responsible for overall management activities of the Project. The Project Team will play an intermediary role between the INGRH, municipalities, and the communities. During the construction stage, the Team will be assisted by a team of engineering consultants.

With regard to operation and maintenance (O&M) activities, INGRH shall be responsible for monitoring on water quality, manpower training on operation and maintenance, and technical assistance to each Municipality on heavy repairs of the existing facilities.

(2) Municipal Level

With regard to operation and maintenance activities, each Municipality will be responsible for monitoring of the existing facilities in the communities, manpower training for water users associations, and technical assistance for heavy repairs on the existing facilities in the communities.

(3) Community Level (Formation of WUCs)

Taking into consideration the existing situation of rural water supply program, it has been recommended that water users themselves should be involved in O&M activities. The participation of villagers who live near the facilities in the daily O&M work will lead to the reduction of O&M services costs burdened by the Municipal offices.

It is recommended, therefore, that a Water Users Committee shall be established in each community where a new water supply facility will be constructed. The construction of the Project facilities will be commenced in the community where the agreement will be made between the community and municipal administration concerning the establishment of a Water Users Committee (WUC).

The activities of WUCs will include collection of O&M cost, daily inspection of water supply facility, periodical cleaning of the facility, repair of minor damage of the facility, check of water flow to report to the municipal administration, and animation of the population in the community.

Establishment of WUCs is expected to stimulate a full sense of ownership of water supply facilities located in the community. It is also expected that the water users are encouraged to make substantial contribution in cash or in kind for operation and maintenance works.

7.5 Technical Evaluation

7.5.1 Concept for Improvement in Water Supply Service

The proposed Project has been designed on the basis of the following concepts.

(1) Upgrade of the existing water supply service level through additional groundwater development and construction of upgraded water supply facilities, to the level of 20 liters unit daily supply amount per person in average

(2) Upgrade of the existing water supply service level through expansion of the service coverage area (e.g. increase in source points, increase in the number of tank lorries, etc.)

(3) Expansion of the service hour to entire daytime.

The level of technology adopted in the Project design will not involve any technically special knowledge compared to the present level, and therefore the Project work will be conducted without any difficulty from construction stage to operation and maintenance stage.

7.5.2 Improved Operation and Maintenance System

A distinct difference between the conventional and proposed O&M systems is that preventive maintenance and minor repairs of water supply facilities will be conducted by the committee members of the WUCs to be established in each community. Municipal Water and Energy Services will be responsible for provision of spare parts to WUCs, training for caretakers, and assistance in case of serious repairs.

Establishment of WUCs is expected to stimulate a full sense of ownership of the Project facilities located in the community. It is also expected that the water users are encouraged to make substantial contribution in cash or in kind to operation and maintenance works for their own water supply facilities.

7.6 Social Evaluation

(1) Improvement in Health Conditions

One of the most important objectives of water supply projects is to improve health conditions and living conditions of the people through provision of safe water. The proposed Project is also designed to reduce the incidence of waterborne diseases through provision of improved water quality and increased water use.

Increased water use for bathing, washing and food preparation can lead to a reduction in water-washed diseases. Improved water quality can be expected to reduce the incidence of waterborne diseases. In addition, spending more time on child care and food preparation may lead to a reduction of child mortality and morbidity.

(2) Time Saving for Water Hauling

One of the main objectives of water supply project is to reduce the workload of the residents, particularly women and children, for water collection. By providing stable water supply in the community, the residents, particularly women and children, no longer have to spend a lot of time to wait for the supply of water. The better access to water sources will lead to the reduction of waiting time for water collection. Saved time may be used for social, educational, agricultural or commercial activities.

(3) Opportunities for Better Farming

The proposed Project will give additional water source for the communities. Therefore, these communities will have surplus water from traditional water sources (e.g. dugwell) which can be used for irrigating food and tree crops grown in the backyard gardens. As a result, farming activities will give more chance for them to increase their agricultural production.

(4) Consideration for Women

Women constitute the majority in the total population because of emigration practices. According to the 1990 Census, women in the Study Area represented 54.2 % of the total population. Close to 41% of households are headed by women whose incomes are 26% lower than those of male headed households. The role of women in agricultural as well as domestic works is considerably important in the Study Area.

In agriculture, women perform planting, weeding and harvesting. Heavy and dangerous tasks such as clearing forest and land preparation are generally performed by men. The daily tasks of cooking, water collection, cleaning the house and washing clothes are usually conducted by women.

Although the Project has been formulated to benefit all the people in the Study Area regardless of sex, the Project will give greater impact on women and children who are playing a major role in water hauling. As mentioned elsewhere, time saving for water collection is estimated at 0.55 hours per day which can be used for social, educational, agricultural and commercial activities.

In addition to time saving for water collection, significant effect on health improvement for women is expected to arise as a result of improved water quality and increased use of water. Improved water quality will reduce the incidence of waterborne diseases. Increased water use for bathing, washing and food preparation will lead to a reduction in water-washed diseases for women.

8 CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

The major conclusions derived from the Study are detailed below.

1) **Existing Condition of the Rural Water Supply in Santiago Island**

≪Public supply service coverage≫

Santiago Island comprises of 6 municipalities, 206 communities, 1 city (Praia, the capital of the Republic and Praia Municipality), 5 towns (Capital of each municipality) and 200 villages. As of 1998, the Island is estimated to have a total population of 225,681, 136,001 of which is rural; the rest of the population reside in Praia City.

Of the 206 communities (5 towns and 200 villages), only 145 (70.7%) are covered by the public water supply services. These 145 communities have a total population of approximately 105,000. Accordingly, the public water supply service coverage is 77.1% of the total rural population. However, since not all residents receive public water supply services, the actual percentage of service coverage in some of the municipalities is estimated to be lower, at less than 70% (68~69%); the percentage differs by municipality. Residents not covered by the services collect water from springs and shallow wells, and/or buy water from private water vendors. Rainwater is also stored in individual rainwater storage, for use.

The number of villages without public water supply services is 60 (29.3%), amounting to a population of approximately 31,000 (22.9% of rural population).

≪Type of water supply services and average consumption of potable water≫

The rural water supply services in the Island basically operates by the following 3 types of supply system, but mostly through public faucets:

- - Household connections (8.3 % in number of communities)
- - Public faucets (60.9%) -Spring as a source (4)
  -Borehole well as source (124)
  -Rainwater collection system as source (4)
- - Direct delivery service by tank lorries (1.5%)

The public faucet supply system is divided into 2 types, according to whether the reservoir tank is or not connected to the water source:

- Reservoir tank connected by pipelines to the water supply source, i.e. borehole wells (65), springs (5), and rainwater storage container (4). This is used by a total of 74 communities

- Reservoir tank filled with water transported by tank lorries: 75 communities (36.6% of the entire rural communities)

The percentages, however, vary by municipality.

The daily unit supply amount (liter per person per day: ℓ/c/d) ranges from 7 to 20 ℓ/c/d: averaging approximately 11 ℓ/c/d for public faucets and 33 ℓ/c/d for household connection. The Master Plan, on the other hand, targets a daily unit supply amount of 20 ℓ/c/d and 50 ℓ/c/d, respectively. In villages not covered by public supply services, daily consumption rate ranges from 4 to over 20 ℓ/c/d, depending on source availability. The shallow wells used as domestic water source are all (100%) contaminated but in varying degrees.

Such poor service level is mainly attributed to the shortage of water supply sources in the Island.

≪Water supply sources≫

Groundwater, through springs and wells, is the most commonly used water supply source in the Island. Rainwater and desalinated seawater are also used, although the latter is only used in Praia City.

There are 102 borehole wells in the island producing an average of approximately 9500 m^3/day: 60% for irrigation (5,700m^3/day) and 40% for domestic purposes (3,800m^3/day). Except for Praia City, nearly 7,600m^3/day of well water is used in the Island: 5,700m^3/day (75%) for irrigation and 1,900m^3/day (25%) for domestic purposes. Since the amount of water for domestic use is much smaller than for irrigation, the number of wells appropriated for domestic use may be expanded regardless of limited availability of groundwater resources in the island. This can be done if the government places higher priority on domestic water use rather than irrigation use.

There are nearly 1,000 springs in the Island and the total yield of these springs as of 1998 is estimated at about 30,000m^3/day. The number of springs and their yield tend to decrease annually due to recent decline in rainfall. Since the majority of the springs is inconveniently located for domestic use, only 415m^3/day (1.4% of total estimated yield) is used for such purpose. To maximize the use of springs, a detailed survey on these resources seems necessary.

Four community rainwater collection systems have been constructed; additional collection systems are being constructed at the moment. This type of system, however, does not ensure a stable water supply all year round, due to significant fluctuations in rainfall recently. This system is useful though to ease the tight schedule of the tank lorry transportation/delivery services during the rainy season and certain months after the rainy season.

≪Water charge collection system≫

Water charge for household connections is collected monthly and based on the amount of water consumed. For public faucets, however, a water vendor collects money from the residents under the "cash on delivery" system. This collection method is quite reasonable as it ensures payment every time the faucet is used. However, this payment system does not help improve public health, even if the water supply amount is increased, because it prevents the residents from purchasing the actual water amount they really need due to economic reasons. Conclusively, the "cash on delivery" system is not a suitable means of meeting the residents most basic needs.

2) Number of classified communities

The communities with comparatively satisfactory water supply service levels number 45 (22%), including 5 towns. These communities are classified under "*C*" (no urgent need for the project).

The remaining 160 communities require the project sooner or later; improvement projects are currently being carried out on 20 of these villages with the financial and technical assistance of FENU (17 villages) and UNICEF (1). An additional plan covering 12 communities has also been prepared with the expectation that financial assistance will be obtained from FENU. The 127 communities are, therefore, not covered by any water supply improvement plan.

Out of the 122 villages, 59 ("*A*" villages) have an urgent need for the project, while 63 are given second priority and fall under "*B*". Five villages, including 1 dispersed village, will be excluded from the project formulation plan due to difficult access conditions; these villages are classified under "*D*".

The implementation of the project by phase was arranged for the villages in "A" and "B", totaling 124.

3) Groundwater Resources in Santiago Island

≪Hydrogeological structure≫

Santiago Island is an isolated island that is almost totally made up of rocks of volcanic origin. The hydrogeological basement of the island was formed during tectonic movements and volcanism in the Miocene and Pre-Miocene periods (18 to 26 million years ago, and more). The basement rock is widely or sporadically exposed in the Island, but mostly overlain by volcanic formations of the Miocene and Pliocene periods (the latter probably several to 16 million years ago), and by recent volcanic formations and alluvial deposits.

The groundwater resources in the Island are stored in or flow downwards mostly in overlying formations (especially the Assomada and Pico da Antonia formations that are not in basement rocks, and into alluvium layers). It can be said, therefore, that the volume and locality of groundwater to be developed depend on the: 1) shape of the surface formation, e.g. basin structure, gradient, etc., and 2) distribution pattern of the overlying formation, e.g. extent, covering thickness, etc.

Accordingly, the following 4 areas in the Island were considered promising for groundwater development based on the results of various hydrogeological surveys:

- Assomada highlands
- Lower Tarrafal volcanic plateau
- Lower Praia volcanic plateau
- Mouth of major rivers in the northeastern section of the Island

≪Groundwater balance, recharge, and discharge≫

Since groundwater resources in Santiago Island all originate from rainwater, the macroscopic water balance analysis was carried out on the 8 hydrogeological basins based on the assumption that: 1) rainwater permeates into the ground and become groundwater (infiltration rate differs by place depending on surface geology and topographic features), 2) because there are no perennial rivers, recharge elements are limited to rainwater ground infiltration and some discharge from springs that join the underground stream, 3) rainwater that infiltrates the ground and recharge by underground stream are the inflow used in balance analysis is, 4) in consideration of technically and economically exploitable groundwater resources, more or less half of the inflow shall be the groundwater development potential in each hydrogeological basin, 5) the total of artificially exploited volume from wells and spring discharge is the outflow in the balance analysis.

As a result, the balance of apparent groundwater development potential by basin is estimated as follows (unit: million m^3/year).

- Tarrafal Basin (A) and (B) 2.695
- Santa Cruz Basin (A), (B), and (C) -0.976
- Santa Catarina Basin -0.051
- Sao Joao Baptista Basin 0.581
- Praia Basin 0.226

These figures suggest that a high volume of groundwater can be developed in basins showing positive values. On the contrary, groundwater discharge was observed to be excessive in areas showing negative values. If the present total volume of groundwater discharge is continued, a marked drawdown in well water level or extensive seawater intrusion into the wells are foreseen to occur.

Nonetheless, it is without a doubt that groundwater resources in the Island are limited due to decreasing rainfall amount in the past 3 decades. Therefore, policies for water use prioritization, e.g. allocating some of the water amount currently used for irrigation for domestic use, should be taken by accelerating the use of sound irrigation methods, especially in areas where groundwater development potential is apparently negative or groundwater resources are scarce.

≪Groundwater development plan≫

The groundwater development plan was established according to the projected water demand for 2003, for 32 of the villages, and entails the construction of borehole wells. The water demand projected for 2005 is estimated at 400m^3 a day by multiplying the unit supply amount of 20 liters/capita/day by the total population of 32 villages in 2003 (20,000). (The effective use of springs was planned for 2 of the 34 villages; new sources will not be developed in these 2 villages.)

Although majority (26) of the 32 villages are located in the hydrogeological basins of Santa Cruz and Santa Catarina where the potential for the development of groundwater resources is negative, these villages were chosen in view of the absolute shortage of the supply sources and in expectation of the following:

- Groundwater can be exploited even in areas with negative potential, so long as rainfall continues and the amount to be developed for water supply is insignificant when compared with annual rainfall
- Groundwater currently obtained from wells for irrigation is 3 times bigger than the amount allocated for domestic use in the concerned area
- The national policy on the use of sound irrigation methods will be accelerated especially by reducing the unit cost of water for irrigation in accordance with the reduction of water volume for irrigation

4) Project Formulation Plan

≪Phased project implementation plan≫

In Santiago Island, 51 villages (classified under "A") urgently require the implementation of the project, followed by 63 villages (classified under "B"). Since it is almost impossible to cover these villages in one project, "A" and "B" were each sub-divided into 2 groups and the 4 phases for project implementation was planned as shown below.

Phase 1 34 villages (32from *Group A-1* and 2 from *Group A-2)*

Phase 2 29 villages (26 from *Group A-2* and 3 from *Group B-1*)

Phase 3 29 villages (from *Group B-1*)

Phase 4 30 villages from *Group B-2*

Phase 1 entails a concrete water supply facility/services improvement plan for villages with a shortage in water supply sources and where water source development is feasible.

An outline of the facilities/services to be improved from the 2nd to the 4th phase was made.

≪Outline of the Phase 1 project≫

The phase 1 project will cover 34 of the villages mostly in *Group A-1* and aims to meet the water demand in 2003 by constructing water supply facilities in all of the candidate villages assuming that the mediocrity of existing supply services is due mainly to the shortage of water sources. In order to meet the total water demand of the 34 villages in 2003, approximately 400m^3/day will be produced in this project through the construction of 30 wells (total drilling depth of 4,300m, provide water to 31 villages), effective use of 1 existing well, and establishment of a conveyance system from 2 spring spots. 31 wells will be equipped with submersible motor pump energized by a diesel engine generator (25) or solar panels (6). Water conveyance systems from the spring will consist of 1 pump-up and 1 natural flow type. Other major facilities to be installed for the 34 villages are 11 reservoir tanks, 56 sets of public faucets, about 20,000m transmission/distribution pipe, and 32 sets of energy control panel with a shed.

The construction cost for the above facilities including procurement of drilling machine and other equipment / materials, is estimated at 9.78 million dollars.

The implementation of the phase 1 project will provide 10 villages (total population: 5000 in 2003) with water supply services, and 24 villages (total population: about 15,000 in 2003), will have an increase in their water supply amount, from 8.9 ℓ/c/d on average to 20 ℓ/c/d. The residents of the 34 villages (total population of 20,000 in 2005) will be the direct beneficiaries of the project.

24 villages are currently receiving a total daily water amount of 130m^3 through the tank lorry transportation/delivery service. If this amount is applied to other villages to supply sufficient water, the indirect beneficiaries of this project will range from 10,000 to 20,000, resulting in a total of at least 30,000 beneficiaries.

≪Outline of projects from phase 2 to 4≫

The villages to be covered from Phase 2 to 4 will be 88, each phase targeting the years 2005, 2007 and 2009, respectively. Since some of the villages will indirectly benefit from the Phase 1 project, the number of villages classified under *Group A-2*, *B-1* and *B-2*, will vary, especially affecting villages requiring the planning of a more appropriate transportation service. Among the 88 villages, the availability of new water sources for development by well (12) construction and spring water conveyance (28) is limited in 40 villages. Existing well rehabilitation or pump replacement will be carried out in 16 villages.

For the remaining 32 villages, the only means of increasing the water supply volume is transportation by tank lorries, by improving the rotation routine, and also procurement of new tank lorries. The rotation schedule of the tank lorry should be rearranged during and after the phase 1 project implementation.

With regard to facilities, a new reservoir tank will be installed or the existing tank capacity will be increased for 9 nine villages, and the villages where public faucet construction is required assuming 2 sets each in the community counts for 50 villages.

The total direct construction cost from phase 2 to 4 is estimated at US$ 3.28 million, and the total project cost including administrative and engineering cost approximates

US$ 4.43 million, including the procurement of 5 tank lorries.

5) **Project Evaluation**

Project evaluation in Chapter 7 indicates that the proposed Project is expected to yield various kinds of benefits, which will justify the earlier implementation of the Project. In consideration of the financial status of the government of Cape Verde, however, the recovery of initial investment costs will be quite difficult. Under such a situation, financial assistance from foreign sources will be indispensable. External assistance in terms of grant aid will be necessary to cover the entire foreign currency portion and a part of local currency portion of the Project costs.

8.2 Recommendation

1) **Recommendation on groundwater resources conservation**

Groundwater in Santiago Island is the only the water supply source in the rural area, and is exploited either through springs or wells. For the sustainable use of groundwater resources for domestic purposes, groundwater exploitation should be carefully controlled, especially since the decline in precipitation in the past decades have restricted groundwater resources.

Since the use of spring water has no adverse impacts on groundwater conservation, other practical ways of using this source should be taken into consideration rather than artificial exploitation by well construction. The inconvenient location of the majority of the springs in this Island, however, limits the amount of spring water used for domestic reasons: less than 2% in volume and less than 8% in number of springs.

The results of the studies seem to indicate the need to conduct a detailed survey on spring development. Also, it is recommended that further developments in long distance conveyance systems for domestic use should be made.

The artificial exploitation of groundwater resources for domestic consumption in the rural area only produces a very small water amount different from when compared with the recharge volume by rainwater, so in densely populated urban areas, it would be safe to assume that water for domestic use may be increased. In the rural area, the amount of water used for irrigation is huge, 3 to 4 times the amount for domestic use, somehow causing excessive pumping. Limiting the use of groundwater for irrigation is strongly recommended, therefore, through the introduction of sound irrigation techniques.

2) Recommendations for the operation and maintenance structure

In addition to the absolute shortage in water supply sources, two conditions seriously inconvenience rural water supply operations in Santiago Island. These conditions are: limited service hours and service based on the "cash on delivery" system. These conditions, however, are foreseen to hinder further developments in the social environment and public health, because the residents are very much accustomed to them.

Residents should be able to collect water whenever they need during the day, and freed from any psychological pressure that the economic effects of acquiring a sufficient water amount would inflict.

This may be difficult to realize, however, considering that the municipal administration in charge of rural water supply O/M is suffering from an extreme shortage in manpower.

Therefore, the establishment of a community based autonomous management system and its incorporation into the present O/M structure are recommended.

3) Recommendation on Establishment of Water Charge Policy

As previously mentioned in section 6-4, money will be collected not as payment for water use but as payment for the O/M of the new water supply facilities, which will be managed by a water association.

The O/M cost to be burdened by the community will depend on the village population, and would widely vary, therefore, from village to village (from less than ECV1 to more than ECV 5 per 20 liters of water consumed). The huge disparity in the share in the O/M costs is foreseen to result in difficulties in implementing an autonomous management system, as well as difficulties in the management of the municipal department for energy and water.

Therefore, the amount to be paid by the users should be adjusted and the fund management should be properly carried out to keep the municipal water supply office in operation. To solve this issue, a new municipal water charge policy should be established prior to implementation of the Project.