2.5.4 Transmission & Distribution Network

In most of SAAS there are no drawings or documents available describing the whole distribution network system. And an accurate length and situation of the distribution network is difficult to appreciate, but according to the level of losses, there is a noticeable leakage rate and insufficient maintenance and monitoring of the network system. The existing facilities in the island are summarized in Table 2.5-9.

Table 2.5-9: Existing Facilities

Municipality	Installed facilities	Capacity Details of Facilities	
Tarrafal	Transmission pipe Pumping Stations Reservoirs	Transmission Pipe	not available
		Distribution pipe	not available
		Pipe material	PVC, HDPE
		Pumps	10 wells 66-360 m^3/d
		Well Depth	100-150m
		Total capacity	2,700m^3/d
		Treatment type	chlorination
		Reservoirs	28/2,032m^3
		House connections	700 units
		Losses	25%
São Miguel	Transmission pipe Pumping Stations Reservoirs	Transmission Pipe	not available
		Distribution pipe	not available
		Pipe material	PVC, HDPE
		Pumps	10 wells 1.5-20m^3/d 2 solar powered 1 wind powered
		Treatment type	chlorination
		Reservoirs	35/2,058m^3
		House connections	2,210 units (2007)
		Connection Rate	60%
São Salvador do Mundo	Transmission pipe Pump Stations Reservoirs	Transmission Pipe	not available
		Distribution pipe	not available
		Pipe material	PVC, HDPE
		Pumps	+ 7 wells not equipped
		Treatment type	chlorination
		Reservoirs	50m^3 + 2 x 40m^3
		House connections	276 units
		Connection Rate	15%
		3 Tankers (10m^3,11m^3,17m^3)	
Santa Cruz	New desalination plant Transmission pipe Pump Stations	**Santa Cruz**	
		Transmission Pipe	not available
		Distribution pipe	not available
		Pipe material	PVC, HDPE
		Pumps	8 wells 1,000m^3/d
		Treatment type	chlorination
		Reservoirs	45/10~1,000m^3
		House connections	700 units
		Sewerage system	septic tanks
		Pedra Badejo	
		Transmission Pipe	not available
		Distribution pipe	not available
		Pipe material	PVC, HDPE
		Pumps	8 wells 1,000m^3/d
		Treatment type	chlorination
		Reservoirs	10-,1,000m^3
		House connections	700 units
		Sewerage system	septic tanks
		Desalination	500m^3/d

São Domingos	Pumps in wells Reservoirs Transmission/Distribution pipe	Transmission Pipe Distribution pipe Pipe material Well Pumps Treatment type Reservoirs House connections Connection Rate	not available not available PVC, HDPE 2 units 500 m^3/d 156, 72, 153, 240 m^3/d chlorination 54/11~200 m^3 800 units 90%
Praia	New desalination plant Transmission pipe Pump Stations	Transmission Pipe Distribution pipe Pipe material Pumps Treatment type Reservoirs House connections	not available 151 km/50-400 mm dia., 151 km STEEL, PVC, HDPE not available chlorination 8/400-2,500 m^3 Total 8,760 m^3 17,000 units
Ribeira Grande de Santiago	Transmission pipe Pump Stations Reservoirs No drawings available	Transmission Pipe Distribution pipe Pipe material Pumps Treatment type Reservoirs House connections	not available not available PVC, HDPE 4 wells Common use with agriculture chlorination 10/8-55 m^3 Total of 280 m^3 + Achada forte 1,000 m^3 under construction 782 units
São Lourenço dos Orgaos	Transmission pipe Pump Stations Reservoirs No drawings available	Transmission Pipe Distribution pipe Pipe material Pumps Treatment type Reservoirs House connections Connection Rate	not available not available PVC, HDPE 8 wells/2-10 m^3/d 1 with solar power chlorination 14/15-200 m^3 860 units 42%
Santa Catarina	Transmission pipe Pump Stations	Transmission Pipe Distribution pipe Pipe material Pumps Treatment type Reservoirs House connections	not available not available PVC, HDPE Total : 1,000 m^3/d chlorination not available 4,906 units

Source: Information collected from SAAS or Municipalities, 2010

2.5.5 Water Supply System in each Municipality

(1) Tarrafal

General Description:

Tarrafal is located in the most northern part of Santiago Island. The population of this municipality in 2008 was approximately 22,500.

Regarding operation of reservoirs, 2 cells of 150 m^3 are operated on a daily cycle basis. In the first day, the water is distributed to 6,000 people gravitationally from 5:00 am to 2:00 pm by using one of two cells until it will be empty. The other cell is filled up by pumping (38 m^3/h) from 7:00 am to noon at the same time. In the following day, the cell will be interchanged.

This municipality has a plan for tourism development. The western coast has beaches where turtles lay their eggs. Therefore, the western coast is not adequate as the candidate location of the desalination plant.

The outline of the current water supply system is as follows:

- Water production capacity in 2008 was 422,000 m^3. 75% is for potable water and 25% is for agriculture use.
- 98% people have access to water. 86% people are connected to the water network. Around 1,000 people living in high altitude areas get water by water trucks.
- Currently 12 wells are used for potable water.
- 4 wells are located on the seashore side and one is supplying salty water which is used for agriculture.
- Depth of wells is about 100-150 m.
- 28 reservoirs with 2,032 m^3 volume are in service.

(2) São Miguel

<u>General Description:</u>

São Miguel considers that the utilization of saline water is important as a water resource. Therefore, this municipality has a plan for desalination plant installation and a candidate site is also being investigated. The population of this municipality in 2008 was approximately 17,300.

Although there is a potential project of a desalination plant financed by a private-public partnership, the negotiation has been no agreement since 2007.

The outline of the current water supply system is as follows:

- 60% of households are connected to the water network.
- Water loss is 15-20 %.
- 35 reservoirs with 2,058 m^3 are in service.
- A desalination plant at Sao Miguel is planned to supply water to the northern part of the island under the private-public partnership scheme, in which an Italian company “CAIS” is the leading partner, with a type of contract of “take or pay”.
- This municipality refuses to buy water at the proposed price (2.95 euros/m^3) of the PPP company.

(3) São Salvador do Mundo

General Description:

São Salvador do Mundo was newly established in 2005, separating from Santa Catarina. However, its water supply is still dependent on Santa Catarina. Its own SAAS is not established yet. This municipality is mostly hilly. The population of this municipality in 2008 was approximately 10,500. The ratio of household connection is very low.

Although 40.3% of population can access to safety drinking water currently, it's far from the national target of 85.0%. The people who cannot access to safety drinking water may get daily water from spring, surface water etc. Only 2 towns have pipeline networks, and the other 16 towns receive water by water tanker.

The outline of the current water supply system is as follows:

- Water supply is still dependent on Santa Catarina. Currently, 730m^3/week is supplied from Santa Catarina in a very irregular way.
- Network connection is 276 households (15-16%).
- Balance of water is supplied by water trucks from Sao Domingo and Santa Cruz.
- Municipality owns three (3) water trucks of which capacity is 17, 11, 10 m^3, respectively
- This municipality has a plan to renew the distribution network using finance from the Ministry of Infrastructure, Cape Verde. After the completion of the renewal of the network and installation of pumps in 5 wells that are not currently equipped, this municipality will supposedly be able to handle its own water distribution system.
- Dam construction from Portuguese finance is planned.

(4) Santa Cruz

General Description:

A new desalination plant was commissioned in May 2009. Power for the plant is supplied by own diesel engine generators. Due to higher energy costs, the product water price is 185CVE/m^3. The population of this municipality in 2008 was approximately 29,000.

A cement factory financed by China with small port facility is planned and other large-scale port project is about to study.

The outline of the current water supply system is as follows:

- Water supply target is 50liters/day/person, but actual consumption is 30liters/day/person due to water leakages. Stolen water totals 30% of the supply water.
- Service time is 1-2 hours/day at higher locations and 8-10 hours/day at lower locations
- Water source is as follows:

- Desalination plant at Achada Ponta (500m^3/d), which started operation from May 2009
- 8 wells (1,000 m^3/d)

- Well water and desalinated water are blended in two main reservoirs (1,000 m^3 and 450 m^3)
- Number of reservoirs: 45 (10- 1,000 m^3)
- Network connection with taps and meters is 90% of all households.
- A part of distribution networks was replaced in 2000-2001.

(5) São Domingos

General Description:

São Domingos was newly established, breaking away from Santa Cruz. The population of this municipality in 2008 was approximately 14,200.

A distribution network development project financed by Luxembourg for 6,000 to 7,000 people (50% of the total population) has been undertaken.

There is worry about future capacity of underground water and a desalination plant project was submitted to INGRH and Luxembourg's cooperation in February 2009 that consists of 2,500 m^3/day desalination plant installed near San Francisco beach, 9 km pipeline to be connected to the existing network, and its project cost estimated to about 2.2 M Euros.

The outline of the current water supply system is as follows:

- Enough water resources from mainly 2 wells that give 500m^3/d
- Approximately 800 house connections
- 54 reservoirs (11-200 m^3)
- 3 parameters are tested for water quality on a monthly basis (pH, conductivity, residual chlorine)
- Automated remote control system exists between well pumps and reservoirs

(6) Praia

General Description:

Praia is the capital city of Cape Verde. The population of this municipality in 2008 was approximately 124,000. 40% of the population of Santiago Island lives in this municipality. Potable water sources are mainly from three (3) desalination plants.

The outline of the current water supply system is as follows:

- Water source is mainly from the Sea Water Desalination Plant.
  - 5,000 m^3/d x 1 train (1 train expansion space is available in future)

- 1,200 m^3/d x 2 trains (Container type)

- 15,500 m^3/d of potable water is currently desired according to an explanation given by ELECTRA.
- ELECTRA operates desalination plants and distributes water in Praia.
- Main reservoirs are 1,500 m^3 at the desalination plant site, 2,500 m^3 and 1,000 m^3 at Monte Babosa, 700 m^3 at Eugenio Lima, 400 m^3 at Achada Sao Felipe (expanding area), 1,500 m^3 at Ponta d'Agua, 400 m^3 at Achada Gran Tras near airport, etc.
- All the above-described reservoirs are connected through transmission pipelines, adding efficiency to the distribution system. Nevertheless, there is no remote controlled system; operations between pumps and reservoirs and even chlorination in Monte Babosa is done manually. Moreover, the general condition of all equipment is very bad due to the lack of maintenance and renewal.

(7) Ribeira Grande Santiago

General Description:

This municipality was newly established. A SAAS is not established yet. The population of this municipality in 2008 was approximately 9,600.

The outline of the current water supply system is as follows:

- Fountain water is stable and ample. Part of the water is also supplied to adjacent Praia.
- 4 wells exist and are used both for agriculture and potable water.
- 10 reservoirs exist (Capacity: 8-55 m^3).
- A new concrete reservoir of 1,000m^3 capacity will be soon commissioned at Achada Forte.
- Chlorination is done at reservoirs.
- Water consumption is 20 liters/day/person
- 629 household connections are in service, and additionally 153 connections are expected in 2010

(8) São Lourenço dos Orgaos

General Description:

This municipality was newly separated from Santa Cruz. The population was approximately 9,000 in 2008. The municipality covers an area of approximately 40 km^2. It is a rural and hilly area. This municipality is expecting future rural tourism development.

The outline of the current water supply system is as follows:

- 8 wells are working. Production of each well is 2-10 m^3/h.
- Well water is used for both potable and agriculture use.
  - Rainy season: 60% for agriculture and 40% for potable
  - Dry season: 40% for agriculture and 60% for potable
- Waterfall is also used for potable after treating by chlorination or bleaching
- Number of reservoirs
  - 14 reservoirs (15-200 m^3) for potable use
  - 12-17 reservoirs for agriculture use
- Number of meters is approximately 1,200. A fair number of families are connected without meters. Connections are 42-45%.
- A dam in the municipality was constructed by China, but is not in service due to lack of decision making.

(9) Santa Catarina

General Description:

This municipality had a population of approximately 47,000 in 2008 and it is the 2nd largest after Praia in Santiago Island. Assomada is located in this municipality. This municipality is located on a hilly area with an altitude of more than 500 m.

Actual capacity of water supply is limited to 1,000 m^3/day (approx. 16 liters/day/people) and it is far from actual daily demand of 3,000 m^3/day (60,000 people x 50 liters/day).

In addition, even if considering the water demand without for tourism and industry, 3,775 m^3/day will be required in 2020 for domestic use as minimum as per WHO recommendation.

A water supply and sanitation project financed by AFD (10 M Euros) has been undertaken. This project expected to add 500 m^3/day to existing capacity of water supply by using well.

The outline of the current water supply system is as follows:

- Local water is supplied to Sao Salvador do Mundo, the population of which is approximately 10,500.
- Current water loss is 30-40%.
- 4,906 household connections were in service as of December 2009
- Tourism-related facilities and slaughterhouses are planned.

2.6 Water Tariff and Waterworks Management

2.6.1 Current Water Tariff and Waterworks Management

Increasing tariff block structure is adopted for house connection by all water supply entities in Cape Verde. The tariff rate level and the tariff blocks setting corresponding to consumption is, however, varied from entity to entity. This phenomenon can be also seen in case of water tariff for public tap and tanktruck.

The main features can be seen as follows: 1) water tariff rate by tanktruck is most expensive level largely influenced by fuel cost in comparison to other supply type, 2) poor people with relatively low income living in rural area have to purchase more expensive water from tanktruck, 3) water tariff rate is set up through negotiation between SAAS and municipal government, 4) watwrworks management of most water supply entities is in deficit situation compensated by subsidy from municipal governments, 5) thereby most entities hardly have financial resources for investment.

(1) ELECTRA

1) Water tariff rate

The current water tariff for Praia city was updated by the ARE mainly because of increasing fuel prices in June 2008; the water tariff rate increased by 8.6% from the previous tariff rate. In comparison to the domestic water tariff rate between the ELECTRA and SAASs, the main features of the water tariff rate of the ELECTRA are as follows: (1) the progressive rates of the water tariff between the 1^{st} - 2^{nd} block and 2^{nd} - 3^{rd} block are 47% and 33%, respectively, which are generally higher than that of SAASs, meanwhile (2) the water tariff rate in the first block at 234 CVE/m^3 is largely similar to 220 CVE/m^3 in Sao Domingos, Santa Cruz, and Sao Miguel, and even cheaper than 253 CVE/m^3 in Ribeira Grande and 500 CVE/m^3 in Sao Lorenco dos Orgaos. Because the water tariff rate of SAASs is different region to region and without consistency, the difficulty in drawing one conclusion needs to be considered.

2) Waterworks management

In terms of financial situation, ELECTRA was in deficit from 2003-2008, except for 2006, according to the latest available data. The main causes of this financial sickness were generally recognized as a lack of overall operating profitability and investments. The operational profits from waterworks, however, achieved about a 5% increase from 883.3 million CVE in 2006 to 927.0 million CVE in 2008 mainly due to the tariff adjustment. The average price of water sales successfully grew from 298 CVE/m^3 in 2006 to 325 CVE/m^3 in 2008.

The main challenges in waterworks management are the continuing high water loss, which was still at 30.6% in 2008, and the relatively low water tariff collection efficiency, which was at about 90% in 2008.

The current water tariff rate table is shown as below.

Table 2.6-1: Water Tariff Rate Table of ELECTRA

(Unit: CVE/m3)

Category	Basic tariff	IVA (15%×20%T)	Total
Domestic			
0 - 6 ㎥	227.25	6.82	234.07
6 - 10 ㎥	333.51	10.01	343.52
10㎥<	443.83	13.32	457.15
Industry (Office, Factory,etc)	390.50	11.71	402.21
Tourism (Hotel, Pension, etc)	505.43	15.16	520.59
Social (Hospital, School, NGO, etc)	251.45	7.54	259.00
Commercial and Service			
≦20 ㎥	407.62	12.23	419.84
20 ㎥<	475.35	14.26	489.61

Source: ELECTRA (Approved 27/Jun/2008)

<Remark>

(1) The above table indicates main water tariff items except for connection fee, rental fee etc

(2) ADA

1) Water tariff rate

The water tariff rate for domestic use is 12 CVE per 25 liters by fountain, equivalent to 480 CVE/m^3, and 850 CVE/m^3 by the direct delivery of a water truck in Praia municipality. The ADA currently purchases the desalinated water from the ELECTRA for 262 CVE/m^3. In 2009, the sales volume was 137,273 m^3 for domestic customers and 2,032 m^3 for public customers such as the municipal government. They have only two water trucks; these have been utilized for more than twenty years, thus they frequently have problems.

The delivery cost for fountains and customer houses greatly reflects the fuel cost of water trucks, therefore, the water tariff level is necessarily higher than that of the ELECTRA. The domestic water tariff rate at fountains for 480 CVE/m^3 is more than double the first block rate of the ELECTRA as 234 CVE/m^3.

Table 2.6-2: Water Tariff Table of ADA

Type of service	Water tariff
Fountain (Public tap)	12 CVE/25l ≒ 480 CVE/m^3
Water truck (Direct delivery)	850 CVE/ m^3

Source: ADA

2) Waterworks management

Their financial balance is generally in the red, because: 1) their service profit only comes from the difference between the purchasing price and the selling price after deducting their cost, and 2) the water supply service by household connections seemed relatively profitable, but is out of their business. Especially after a water shortage caused by intake pump problems of the ELECTRA from February-April 2010, the provided water volume decreased by 70% from the usual level, the ADA had to buy water from Sao Domingos and even from a local private beverage company. It made the financial balance worse, so they had to apply for financial support from Praia Municipality in May 2010.

The separation of waterworks between the ELECTRA and the ADA could be pointed out as a structural problem, in spite of being in the same municipality. The water supply service by household connection, which seemed relatively profitable, was handed over to the ELECTRA at the end of 1990s. Thereby, the ADA has concentrated on water supply service from public taps. It might be said that the ADA is structurally suffering from a lower profitable service in comparison to the ELECTRA.

(3) SAAS

1) Water tariff rate

The water tariff setting for SAAS is mostly in an untouched field of the ARE, although economic regulation is in their scope of responsibility. It is important to note that the setting of the water tariff rate is still dependent on local initiatives, therefore the water tariff composition such as consumption range unit and tariff rate varies without consistency among SAASs. For instance, the first block of the tariff table for domestic water is between 80 CVE/m^3 in Santa Catarina SAAS and 500 CVE/m^3 in Sao Lorenco dos Orgaos SAAS.

The general procedure for water tariff setting is that: 1) each SAAS makes a proposal for setting a new water tariff rate on their own, 2) SAAS submits the proposal to the municipal government, and 3) the municipal assembly approves it after modification as necessary. A certain SAAS described setting up a new tariff rate after considering the people's socio-economic situation; however, it does not mean to take into account the result of a formal survey.

The current water tariff table and main performance indicators are shown as follows:

Table 2.6-3: Water tariff table of SAASs

Type of service \ SAAS	S.Domingos		Sta.Cruz		S.Miguel		Tarraffal		St.Catarina		Ribeira Grande		SLD Orgaos		S. Salvador	
	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3	unit	CVE/m3
Potable water	0-4	220	0-6	220	0-6	220	0-5	108	0-5	80	0-6	253	Minimum	500	(A)	80
(Domestic)	4-8	280	6-10	280	6-10	280	5-10	134	5-10	120	6-10	354	6-10	150	(B)	310
	8<	350	10<	340	10<	350	10-15	189	10-15	150	10<	442	11-15	170	(C)	270
							15<	269	15<	200			15<	300	(D)	200
Fountain											by PL	550	by PL	3 CVE/20L		
(Public tab)	by TT	262					by TT	450-1000	by TT	290	by TT	700	by TT	5 CVE/20L		
Direct delivery	by TT	660-960							by TT	700			by TT	1,200		
Irrigation	Dry	25	Dry	25	Dry	35			Dry	15						
	Drop	15	Drop	15	Drop	22			Drop	8						

Source: SAAS

<Remark>

(1) TT ---- Tank Truck, PL --- Pipeline

(2) Water tariff indicated above is main water tariffs for domestic use and agricultural use. Other water tariffs for commercial, public institution, etc is omitted form above table.

(3) In case of SLD Orgaos SAAS, water tariff system is different from other SAASs. Water tariff is calculated as: Miimum charge + Consumption charge.

(4) In case of S.Salvador SAAS, unit water tariff rate differently depends on suppliers as follows: (A) from St.Catarina by PL, (B) from S.Domingos by TT, (C) from S.Cruz by TT, (D) from S.Catarina by TT.

Table 2.6-4: Main performance indicators of SAASs

	Items	S.Domingos	Sta.Cruz	S.Miguel	Tarraffal	St.Catarina	Ribeira Grande	SLD Orgaos	S. Salvador
Basic Info	Purpose of water supply								
	- for drinking water	47%	80%	N.A.	75%	99%	33%	40-60%	100%
	- for irrigation	53%	20%	N.A.	25%	1%	N.A.	40-60%	0% #1
	No of connection	800	5,000	N.A.	3,724	4,906	782	860	276
	Number of Employees	93	23	N.A.	57	96	16	31	18
Performance Indicators	Non-Revenue Water (%)	12%	35%	15-20%	0.5%	30-40%	N.A.	10-12%	N.A.
	Staff/ 1000 Connections	116	4.6	N.A.	15	20	20	36	65
	Collection Efficiency(%)	88%	N.A.	N.A.	85%	60%	67%	80%	N.A.
	Operating Ratio#2	0.77	0.97	0.71	0.98	0.82	N.A.	N.A.	N.A.

Source: SAAS

#1 --- There are some wells for irrigation in S.Salvador, but these are not managed by the SAAS

#2 --- Operating Ratio = Annual revenue/ Annual expenditure of SAAS

2) Waterworks management

The main features and difficulties in waterworks management are summarized as follows, based on the main findings of our fieldwork and other study reports conducted by international donor agencies[2]:

[2] For instance, Lux-Dev(2008) "Elaboração de um modelo de cálculo das tarifas de água, PROJECTO CVE/069 –Relatório final",

- Many SAASs fall into a vicious circle. The percentage of non-payment debt by household and by public institutions is large, and many SAASs are financially in the red. Therefore, many SAASs can not make a sufficient investment for the improvement of old facilities.
- Revenue of SAAS is not sufficient to cover the cost of operation and maintenance and future investment.
- The water tariff rate for potable water is generally low, not covering the production cost
- The unit water prices per cubic meter are largely different by the type of service, even in the same municipality. In the worst case, the difference of unit prices between water truck and household connection reaches nearly ten times.
- The geological condition, namely differences in height, may influence the inefficient waterworks management in some SAASs. And poor people tend to live in hilly rural areas, especially in Sao Salvador, Sao Lorenco dos Orgaos, Sao Domingos and Santa Catarina.
- Water supply for irrigation is mostly non-profit making and water distribution by water truck also seriously damages the financial balance of SAAS. Even if the water supply and irrigation utilize groundwater resources from the same deep well, the water tariff for agricultural use is much cheaper than that of drinking water.
- The number of staff per connection is inefficiently large in many SAASs; therefore, the share of personnel costs is a relatively large part of the total expenditure in comparison to international experience.
- Water tariff collection efficiency is at a low level in some SAASs, and payment culture of water tariffs has not developed in customers due to poor Information, Education and Communication (IEC) activity.
- The capabilities of many staff have not been well-developed due to lack of training
- The percentage of non-revenue water is high at about 30-40%, for instance in Santa Cruz and Santa Catarina.

2.6.2 Water Tariff Setting by ARE

The ARE is involved in setting the water tariff rate of desalinated water, for instance, in the case of the ELECTRA, the CAIS project and the Aguas de Porto Novo in the Porto Novo Municipality of Sao Antantao Island. On the other hand, the ARE does not participate in water tariff setting in almost all the municipalities of Santiago Island, which still remains a local issue in practice. In the case of the Porto Novo Municipality, the ARE and the concessionaire agreed

Austraria Development Cooperation and IRC(2005) "Estudo sobre a reforma da estrutura tarifária dos Serviços Autónomos de Água e Saneamento Santiago, Cabo Verde, PROJECTO ÖEZA 2108-00/03, Relatório Final".

to use a formula for the calculation of the water tariff rate under the concession contract of public works with a BOT scheme. The ARE mentioned that the formula could be applicable for calculating the water tariff rate in the Project. The outline of the formula is shown as follows:

Formula: (Tc + To) * Vmin. take or pay + (Te) * Volume effective
where:
- **Tc** - Flat rate not adjustable corresponding to the Cost of Capital (Investment Recovery)
  - function of the construction cost, rate of return project, interest rate debt contracted and the credit agreement.
  - These costs will be spread over the lifetime of the facility to allow for the determining of the annual cost derived from the investment and its depreciation, which in turn will allow the calculation of a unit cost of production by the concept of amortization of the initial cost.
- **To** - Flat rate adjustable corresponding to the costs of operation and maintenance (O & M)
  - includes all costs associated with operating and maintaining the installation adjusted along the length of the contract for expected inflation and unexpected fluctuations in costs not controlled by project promoters.
- **Te** - Variable Rate corresponding to the Cost of Energy
  - is fixed from the consumption guaranteed by the promoters of the project (kWh/m^3), and possible to adjust it according to the fluctuation in the price of diesel or electricity supply as appropriate.
- **Vmin** - Volume minimum take or pay - minimum monthly volume of purchases of water during the period agreed in the contract, calculated according to the contractual value set at 600m^3/day.

Source: ARE

The ARE revises adjustable parameters such as *Te* and *To* if necessary, for instance, considering the variation of fuel prices and O&M cost.

Meanwhile, in the CAIS project covering construction of the desalination facilities and the O&M, the CAIS as a public-private company and the ARE proposed a selling price of the desalinated water at 2.97euro/m^3[3] to the relevant municipalities such as Santa Cruz, Sao Miguel and Santa Catarina; however, the price was not accepted due to the high price for the SAAS and for local people, according to the interview of the relevant municipalities. In the water tariff setting procedure, the build-up approach of the cost of capital, operation and maintenance and energy has been generally taken up by the ARE. There is still a challenge remaining in how to consider people’s affordability to pay sufficiently in the process of this tariff rate setting.

2.6.3 Affordability to Pay

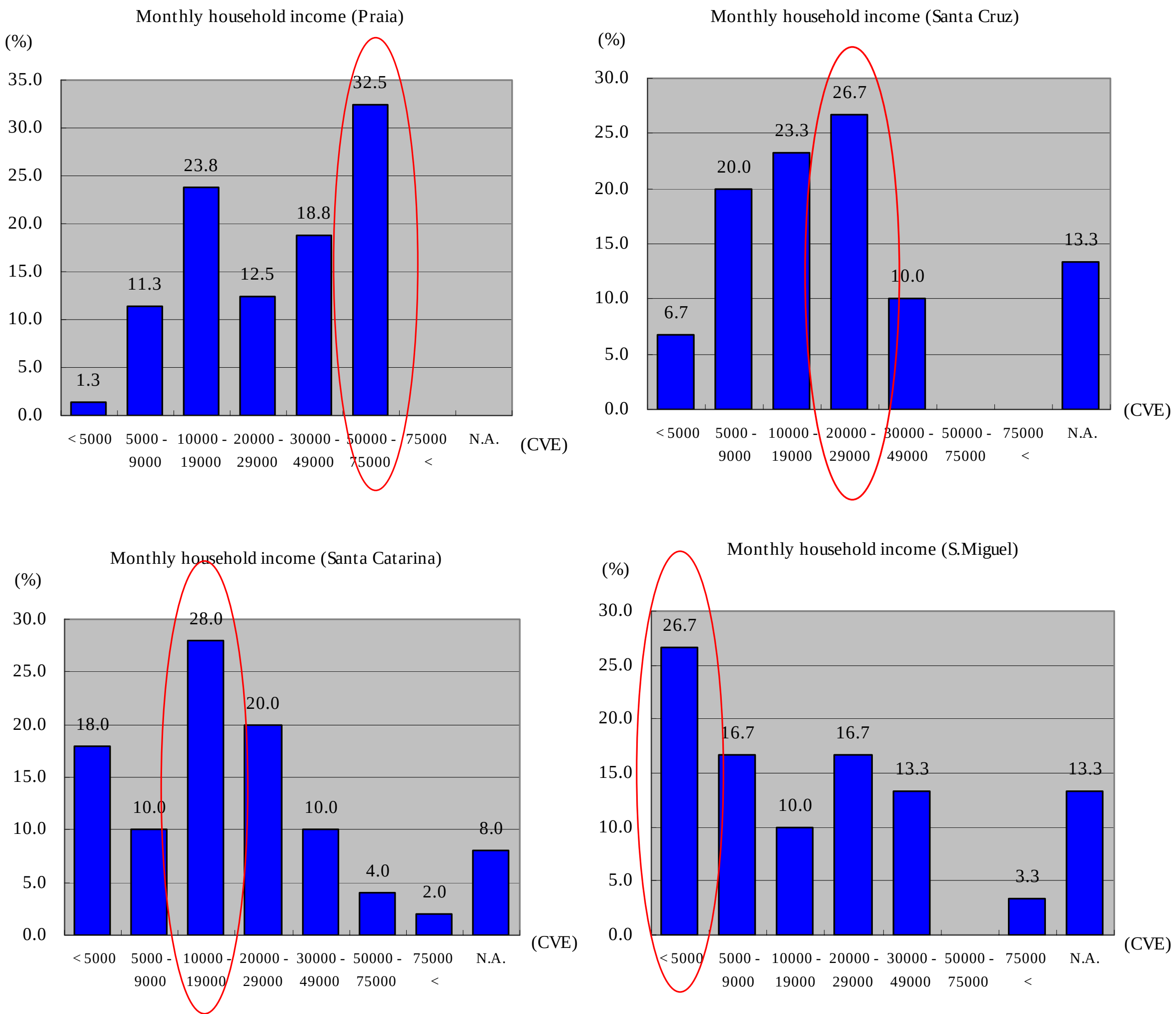
(1) Income gap

According to the result of a socio-economic survey, a remarkable gap can be seen in the average monthly household income between Praia Municipality and the other seven municipalities (Figure 2.6-1). In the socio-economic survey, the income level was classified

[3] It is equivalent to approximately 320CVE/m^3 (1 Euro =110.265CVE, as of 25 Feb 2010).

into 7 classes. The most dominant monthly income class of household in Praia Municipality was “50,000-75,000 CVE”, a 33% share of the total responses. In contrast, the most dominant monthly income in the other seven municipalities was between “10,000-19,000 CVE”, a 25-40% share of the total responses. In case of Sao Miguel Municipality, “less than 5,000 CVE” was the most dominant monthly income class of household with a 27% share of the total responses.

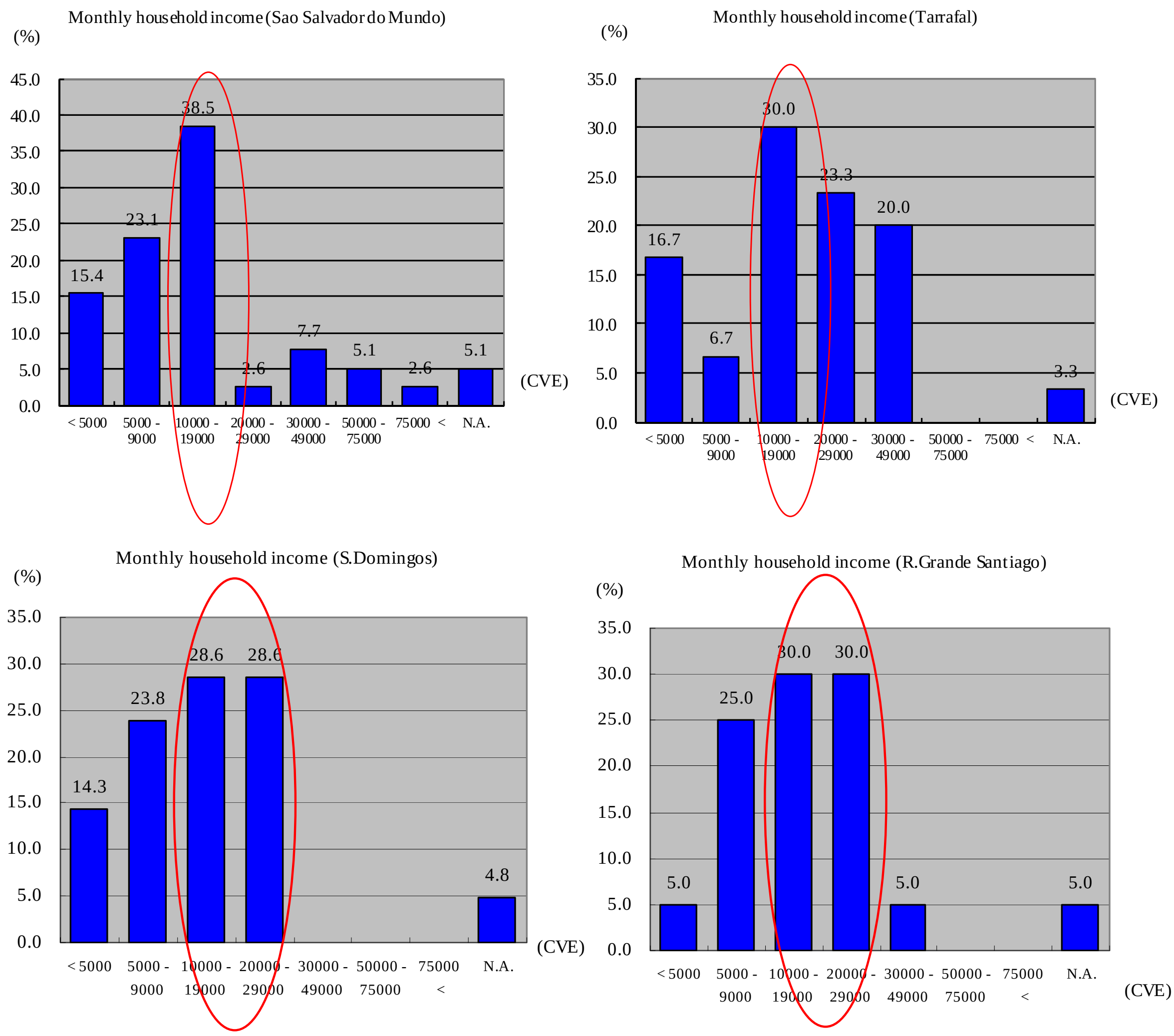
Although our analysis depends only on the result of this socio-economic survey due to a lack of national statistics on household income, it is assumed that the level of monthly household income in Praia Municipality is more than double in comparison to other municipalities[4].



Source: Socio-economic Survey by the JICA Study Team

<u>Figure 2.6-1(1): Household income level by SAASs</u>

[4] In general, it needs to be considered that it is not necessarily easy to receive responses on monthly household income and spending corresponding to the real situation. Meanwhile, the result of this socio-economic survey seemed to comparatively reflect the real situation, since the answer is chosen by the income classes which classified income level into 7 classes.



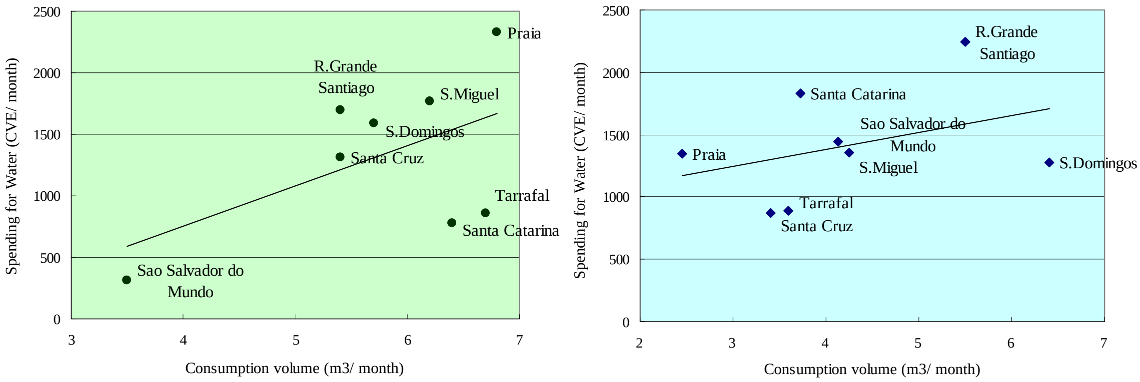
Source: Socio-economic Survey by the JICA Study Team

Figure 2.6-1(2): Household income level by SAASs

(2) Differences of Monthly Consumption in Piped Water

Total monthly household consumption and total monthly household spending for water by municipalities are shown in Figure 2.6-2.

In case of piped water, total monthly household consumption is between 5-7 m^3 except for Sao Salvador do Mundo Municipality. Although the households in Praia Municipality consume the largest quantity of water, the households in Tarrafal, Santa Catarina and Sao Miguel also utilize a similar amount of piped water in a month and there are no large differences between these municipalities.



Source: Socio-economic Survey by the JICA Study Team

Figure 2.6-2: Household spending for water and household consumption volume by SAASs

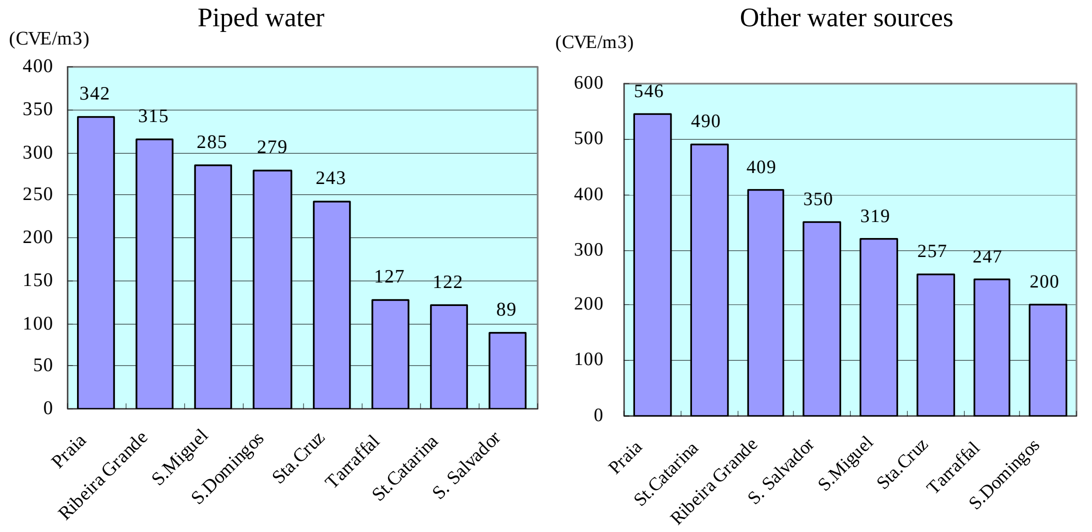
(3) Differences of Monthly Spending in Piped Water

The households in Praia municipality spend, on a monthly basis, the largest amount of money for water among all municipalities in case of piped water. By contrast, the total household spending in Tarrafal, Santa Catarina and Sao Salvador do Mundo are relatively low. Notably, the households in Tarrafal and Santa Catarina spend less money for water than the households in Praia municipality, despite the total monthly consumption volumes being largely similar among these municipalities.

(4) Spending for Water per Cubic Meter

In case of potable water, the monthly household spending per cubic meter in Praia municipality is 342 CVE/ m^3, which is the most expensive unit price. This unit spending is nearly four times higher than 89 CVE/ m^3 in Sao Salvador do Mundo, the lowest unit price (Figure 2.6-3). In particular, the unit spending per cubic meter in Tarrafal, Santa Catarina and Sao Salvador do Mundo stays at a low level because the water tariff rate of these municipalities is lower than that of other municipalities.

In the case of other water sources, the highest spending per cubic meter is 546 CVE/ m^3 in Praia municipality, followed by Santa Catarina at 490 CVE/ m^3 and Ribeira Grande at 409 CVE/ m^3. In comparison to potable water, all units spending per cubic meter of other resources are high except for Sao Domingos. The possible reasons are that: (1) the O&M cost of water supply by using water trucks, particularly fuel cost, are relatively higher than that of potable water, (2) the transportation cost is simply imposed on the water tariff rate without any adjustments, for instance, by cross-subsidy of profits between different types of water supply.



Source: Socio-economic Survey by the JICA Study Team

Figure 2.6-3: Household spending for water per m^3 by SAASs

(5) Water Tariff Rate and Willingness to Pay

In terms of people's willingness to pay, 80-88% of the total responses preferred the lowest water tariff rate between 200-350 CVE/m^3 except for Praia and Santa Catarina municipalities, as described in section 2.7. So, the result can be interpreted that only 10-12% of the total responses are willing to pay a higher water tariff rate from the range of 200-350 CVE/m^3 in most municipalities. Praia and Santa Catarina municipalities have the largest and second largest cities, respectively; the difference in the willingness to pay could be closely related to the level of household income.

(6) Household Spending Level

The study preliminary estimated what percentage of households spend money on water in the total monthly household income using the maximum value of income classes[5]. The result indicates that the monthly spending in Sao Domingos, Ribeira Grande and Sao Miguel is more than 5% of monthly household income, both in cases of potable water and other resources.

International experience suggests that monthly spending on water has to be less than 3-5% of monthly household income. It could be assumed that the monthly household spending for water in the abovementioned municipalities exceeded this empirical level. The result, however,

[5] For the estimation, the maximum value of monthly household income in each income class is selected for the calculation. For instance, 75,000CVE in the income class of "50,000 – 75,000 CVE" was adopted for the calculation. The calculation was made on what percentage is shared by monthly household spending for water to 75,000 CVE as a maximum value in the income class.

could be dealt with only as a reference for this section, because: (1) it needs to be noted that poor people probably consume less than the average amount of monthly consumption and spend less money on water purchases than the average in general, and (2) the number of domestic respondents in the socio-economic survey is limited to 300 samples.

Table 2.6-5: Household spending for water and household income level by municipality

		South			North				
		S.Domingos	Ribeira Grande	Pria	Sta.Cruz	S.Miguel	St.Catarina	S. Salvador	Tarrafal
Piped water									
Average household spending for water (CVE/ month)		1,589	1,700	2,328	1,314	1,766	780	313	853
Monthly income class (CVE)	Adopted income value								
< 5,000	5,000	31.8%	34.0%	46.6%	26.3%	35.3%	15.6%	6.3%	17.1%
5,000 - 9,000	9,000	17.7%	18.9%	25.9%	14.6%	19.6%	8.7%	3.5%	9.5%
10,000 - 19,000	19,000	8.4%	8.9%	12.3%	6.9%	9.3%	4.1%	1.6%	4.5%
20,000 - 29,000	29,000	5.5%	5.9%	8.0%	4.5%	6.1%	2.7%	1.1%	2.9%
30,000 - 49,000	49,000	3.2%	3.5%	4.8%	2.7%	3.6%	1.6%	0.6%	1.7%
50,000 - 75,000	75,000	2.1%	2.3%	3.1%	1.8%	2.4%	1.0%	0.4%	1.1%
Other water resources									
Average household spending for water (CVE/ month)		1,280	2,249	1,343	873	1,354	1,828	1,447	889
Monthly income class (CVE)	Adopted income value								
< 5,000	5,000	25.6%	45.0%	26.9%	17.5%	27.1%	36.6%	28.9%	17.8%
5,000 - 9,000	9,000	14.2%	25.0%	14.9%	9.7%	15.0%	20.3%	16.1%	9.9%
10,000 - 19,000	19,000	6.7%	11.8%	7.1%	4.6%	7.1%	9.6%	7.6%	4.7%
20,000 - 29,000	29,000	4.4%	7.8%	4.6%	3.0%	4.7%	6.3%	5.0%	3.1%
30,000 - 49,000	49,000	2.6%	4.6%	2.7%	1.8%	2.8%	3.7%	3.0%	1.8%
50,000 - 75,000	75,000	1.7%	3.0%	1.8%	1.2%	1.8%	2.4%	1.9%	1.2%

--- the monthly household spending for water which exceeds 5% of monthly household income

Source: Socio-economic survey by the JICA Study Team

2.6.4 Main Principles for Water Tariff Setting

In water tariff rate setting, the following principles need to be secured in general[6]: (1) beneficiaries-pay principle, (2) profitable price level recovering cost (initial cost, O&M cost), (3) affordable price system, (4) pro-poor price system integrated with governmental subsidy. Because principle (2) contradicts principles (3) and (4) in some cases, the appropriate measures

[6] JICA (2005) "Basic Study on Enhancement of Installation of Public-Private Partnership in Development Projects in Less Developed Countries"

such as subsidies, tax exemptions and so on are taken by the government and municipalities in usual cases. Therefore, the right combination balance of these principles is required.

It is crucial to consider the differences in levels of household income and affordability to pay, and regional disparities on average monthly household spending for water per cubic meter in the water tariff rate setting. If the water supply systems in the south and the north are integrated into one system in future in accordance with the optional orientation by GoCV, it could be a common case to adopt the same water pricing system for water provided from the same system. On the other hand, it could not be desirable to set the same water tariff both in Praia and other municipalities from a viewpoint of people’s affordability to pay and sustainability of waterworks, because the household income level of Praia municipality is remarkably higher than other municipalities. International experience shows that monthly spending for water is expected to be less than 3-5% of monthly household income; therefore, it is essential to pay careful attention to this issue in setting water tariff rates.

2.7 Result of Socio-Economical Analysis

2.7.1 Water Consumption

Under this analysis, the fieldwork covered the identification of the households and tourist, industrial and public facilities to be surveyed, in order to obtain a representative sample.

Table 2.7-1: Number of Samples in the Municipalities

Municipalities	Year 2008			Nº. Samples			
	Total	Male	Female	House	Hotel	Industry	Public Blds
Tarrafal	22,453	9,873	12,580	30	1	1	1
Santa Catarina	46,866	21,055	25,811	50	2	2	2
São Salvador Mundo	10,560	4,698	5,862	20	0	1	1
Santa Cruz	28,989	13,518	15,471	30	2	2	2
São Lourenço Orgãos	8,961	4,187	4,774	20	0	1	1
Praia	123,741	60,318	63,423	80	12	10	10
Ribeira Grande de Santiago	9,639	4,482	5,157	20	1	1	1
São Domingos	14,230	6,834	7,396	20	1	1	1
São Miguel	17,291	7,514	9,777	30	1	1	1
Total	**282,730**	**132,479**	**150,251**	**300**	**20**	**20**	**20**

The classes "lower", "middle" and "upper" used in the analysis were defined as associated with the following levels of expenses per family unit:

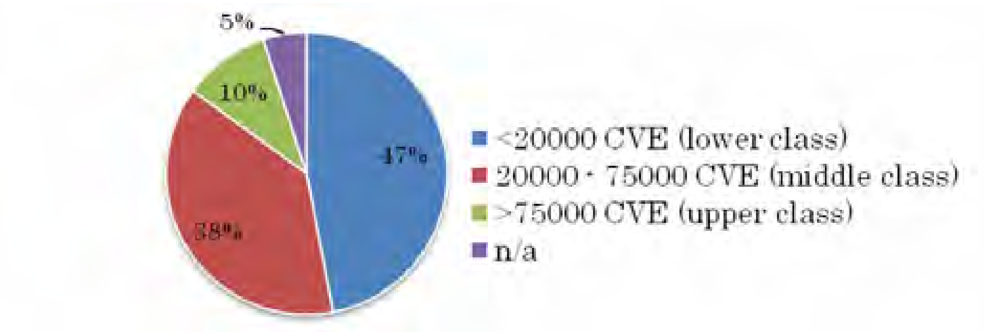
- Lower: up to19,000 CVE/month
- Middle: from 20,000 to 75,000 CVE/month

- Upper: more than 75,000 CVE/month

2.7.2 Households

(1) Households' Monthly Income

In the group of about 300 households surveyed, about 21% have incomes between 20,000 and 29,000 CVE. The total percentage of those with incomes between 20,000 and 75,000 CVE (middle class) is about 38%, about 10% of those with incomes above 75,000 CVE (upper class). About 47% have incomes of 19,000 CVE or below (lower class).



Source: Socio-economic Survey by the JICA Study Team

Figure 2.7-1: Household Monthly Income

(2) Costs and Water Consumption

The monthly mean amount spent by households on public water supply is about 1,400 CVE, with a minimum of 72 CVE and a maximum of about 8,000 CVE.

The monthly mean amount spent by households on water consumption from other sources is also about 1,400 CVE, with a minimum of 100 CVE and a maximum of about 4,900 CVE.

Mean water consumption from the public supply network is about 6.0 m^3/month. The highest mean values (about 6.0 m^3/month or higher) occur in Praia (6.8 m^3/month), Tarrafal (6.7 m^3/month), Santa Catarina (6.4 m^3/month) and São Miguel (6.2 m^3/month). The lowest mean value was recorded in São Salvador do Mundo (3.5 m^3/month).

Relating this mean water consumption with the families' mean size, we can obtain the following capitations (per person, l/day and m^3/month):

Table 2.7-2: Average Household Water Consumption from Public Water Supply

Municipality	Average Household Water Consumption	
	(m^3/month/person)	(l/day/person)
Tarrafal	1.4	46.6
Santa Catarina	1.2	40.0
Santa Cruz	0.9	30.0
Praia	1.5	50.0
S. Domingos	1.0	33.3
S. Miguel	1.1	36.6
São Salvador do Mundo	0.7	23.3
Ribeira Grande de Santiago	0.9	30.0

Source: Socio-economic Survey by the JICA Study Team

The monthly mean consumption of water from other sources is about 4.0 m^3. The highest mean values (more than 5.0 m^3/month) are recorded in São Domingos (6.4 m^3/month) and Ribeira Grande de Santiago (5.4 m^3/month). The lowest mean values (less than 3.0 m^3/month) were recorded in Santa Cruz (2.5 m^3/month).

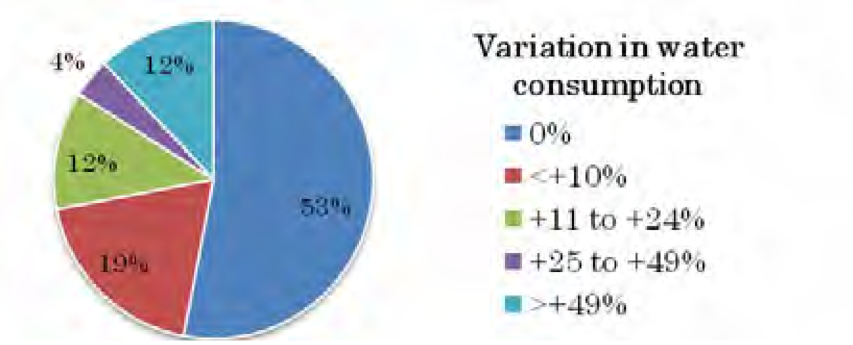
Relating this mean water consumption with the families' mean size we can obtain the following capitations (per person, l/day and m^3/month):

Table 2.7-3: Average Household Water Consumption from Other Sources

Municipality	Average Household Water Consumption	
	(m^3/month/person)	(l/day/person)
Tarrafal	0.8	26.6
Santa Catarina	0.7	23.3
Santa Cruz	0.5	16.6
Praia	0.5	16.6
S. Domingos	1.1	36.6
S. Miguel	0.8	26.6
São Salvador do Mundo	0.8	26.6
Ribeira Grande de Santiago	0.9	30.0

Source: Socio-economic Survey by the JICA Study Team

The answer to the question "Do you think that at certain times of the year home water consumption increases?" indicates that most people (about 53%) believe that there is no variation in water consumption throughout the year. About 19% responded that these variations are less than 10% and 12% indicated that variations are between 11% and 24%.



Source: Socio-economic Survey by the JICA Study Team

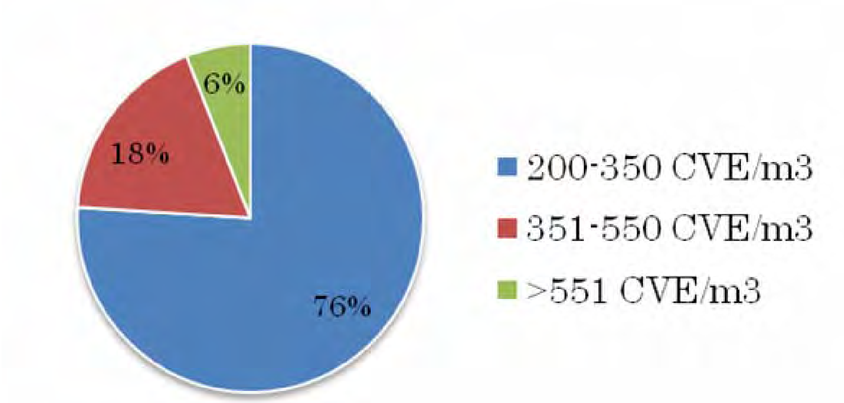
Figure 2.7-2: Percentage of people who believe there are variations in water consumption

The answer to the question "If there were no limitations on water supply, do you consider that the actual total consumption would be …" indicates a trend towards an increase in mean water consumption of about 16%. This could be explained by the fact that the current situation is so restrictive in terms of access to water, that a greater availability of water would, of course, increase consumption.

(3) Ability and Willingness to Pay for Water Tariff

The great majority of respondents (about 71%) are receptive to pay more for the water if the service is to improve.

The great majority of respondents that are receptive to paying more for the water (about 76%) are receptive to paying the lowest suggested tariff for water (200 to 350 CVE/m^3). This fraction is over 70% in all municipalities, except Praia, where about 61% are willing to pay this tariff. Only about 18% showed willingness to pay the next lowest tariff (351 to 550 CVE/m^3).



Source: Socio-economic Survey by the JICA Study Team

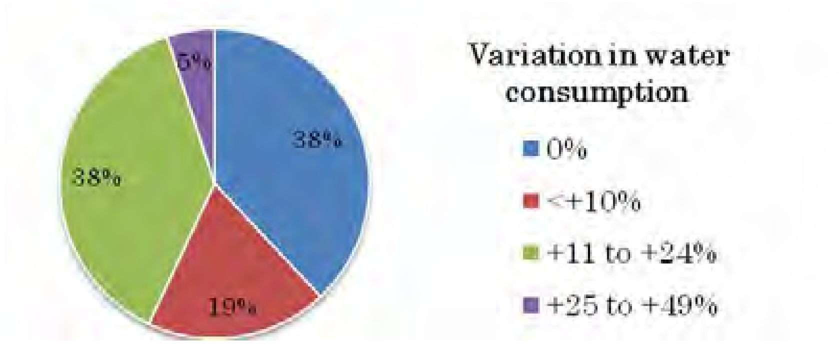
Figure 2.7-3: Willingness to Pay for Water Tariff

2.7.3 Industry

In all the industries surveyed, the monthly consumption of tap water varies from a minimum of 0.5 m^3/month (in Santa Cruz) and a maximum of 300 m^3/month (in Praia). The mean value is about 90.0m^3/month.

The mean consumption of water from other sources is about 280 m^3/month. The minimum value is 0.5 m^3/month (in Santa Cruz) and a maximum of 2,700 m^3/month (Águas de Cabo Verde, in Praia).

The answer to the question "Do you think that at certain times of the year the water consumption increases in your facility?" indicates that about 62% of the industries consider that there are variations in water consumption throughout the year. About 19% responded that these variations are less than 10%. About 38% responded that these variations are between 11% and 24% and about 5% indicated variations between 25% and 49%.



Source: Socio-economic Survey by the JICA Study Team

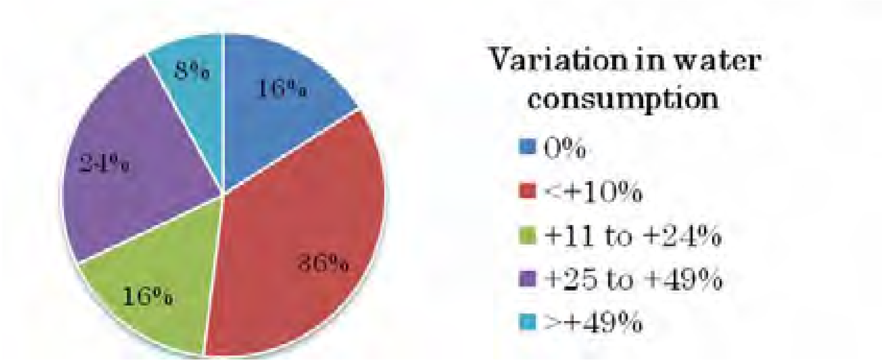
Figure 2.7-4: Percentage of people who believe there are variations in water consumption

2.7.4 Public Facilities

In the facilities surveyed, tap water consumption varies from a minimum of 2.0 m^3/month (Youth Center in São Miguel) and a maximum of 2,700 m^3/month (Hospital Agostinho Neto, Praia). The mean value is about 150m^3/month.

The mean consumption of water from other sources is 470 m^3/month. The minimum value is about 2.0 m^3/month (ING in Praia) and the maximum is about 2,400 m^3/month (Santa Catarina Hospital, with a self-use well).

The answer to the question "Do you think that at certain times of the year water consumption increases in your facility?" indicates that a significant majority of the respondents believe that there are variations in water consumption throughout the year. About 36% responded that these variations are less than 10%. About 16% responded that these variations are between 11% and 24% and about 24% indicated that variations are between 25% and 49%.



Source: Socio-economic Survey by the JICA Study Team

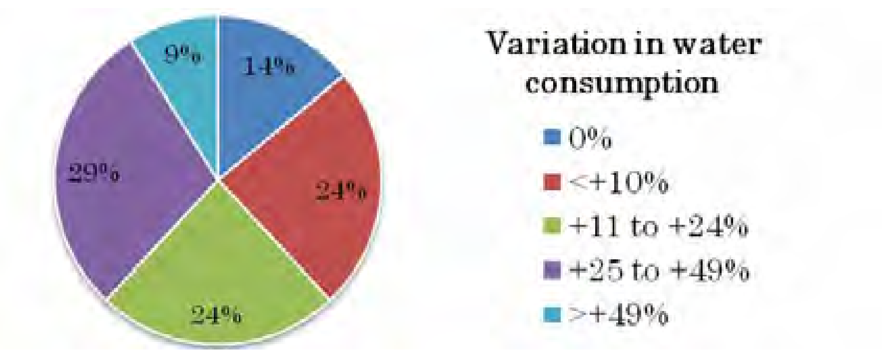
Figure 2.7-5: Percentage of people who believe there are variations in water consumption

2.7.5 Hotel

In the group of 21 hotels surveyed, monthly consumption of tap water varies from a minimum of 9.0 m^3 (in Praia) and a maximum of 450 m^3 (also in Praia). The monthly mean value is about 84.0m^3.

The average consumption of water from other sources is about 200 m^3/month. The minimum value is 0.5 m^3/month (in Santa Cruz) and the maximum is 1,200 m^3/month (in Praia).

The answer to the question "Do you think that at certain times of the year water consumption increases in your hotel?" indicates that a significant majority of respondents (86%) considers that there are variations in water consumption throughout the year. About 24% responded that these variations are less than 10%. About 24% responded that these variations are between 11% and 24% and about 29% indicated variations between 25% and 49%.



Source: Socio-economic Survey by the JICA Study Team

Figure 2.7-6: Percentage of people who believe there are variations in water consumption

2.8 Assistance by Donors

2.8.1 Japanese Government

The Japanese Government signed an Exchange of Notes in 2009 for the first yen loan project co-financed with the African Development Bank to strengthen the capacity of energy generation and transmission in Santiago Island. Since 1999, Japan has aided several grant projects such as construction of Mindelo fishing port in Sao Vicente Island, extension of Port Infrastructure in Praia in addition to continuous food aid. Prior to the presnt F/S survey in Santiago Island, Japanese government has contributed since 2002, 2 grant-aid projects of drinking water supply to construct the related facilites, to procure materials and equipment for surveying groundwater, administration vehicles as well as trainings for capacity building of SAASs and sanitary awareness program of users in rural area.

2.8.2 Other Donors

In Santiago Island there is not a Master Plan of Water Supply and Sewerage of the Cape Verdean government though the Cape Verde Government Millennium Development Goal requires improving the service of the potable water supply to more communities in wider areas. There is a certain number of donor projects ongoing with different concepts but they are limited to an area only within the territory of a municipality. All of the donors are aware of the importance of coordination among themselves to harmoniously develop a potable water supply and sanitation system and organize the “Sector Group of Water and Sanitation”, whose members are donors and concerned governmental institutions of Cape Verde, chaired by the European Union Representative Office in Praia to discuss and exchange information about the indicators and priority means for sector reform, intentions and objectives of new projects and budget assistance programs in the water sector on a bimonthly basis. The first meeting was held on 24th November 2010. Types of water infrastructures for which donors are contributing: Desalination Plant equipment and accessories, Water Reservoir construction, Water Transmission Pipelines, Dam for Irrigation, and Improvement of urban water distribution networks, Improvement of management of SAAS and ELECTRA, etc.

Other than donors’ activities, it is important to mention a concession scheme legally approved by Decree-Law No. 36/2008 of 10 November 2008. The concession company is named CAIS. It is owned by the Cape Verde Government (10%) and an Italian company (90%) and is entitled to be a public works exclusive concession as a BOT (Built, Operate and Transfer) scheme, especially in charge of production of desalinated water to be supplied to municipalities of the interior of Santiago; Santa Catarina, Santa Cruz, São Miguel and São Salvador do Mundo. CAIS intends to install one desalination plant with a capacity of 3,500m^3/day at Calheta de Sao

Miguel, and another with a capacity of 1,000 m^3/day at Pedra Badejo in the Municipality of Santa Cruz where the quality of actual potable water is not appropriate for drinking. The official agreement with concerned authorities is actually suspended due to the proposed high price of desalinated water.
Assistance by Donors is shown in Figure 2.8-1

(1) World Bank

The World Bank is proceeding with the project in the Water and Energy Sectors in Santiago Island. The project includes the working program for future institutional/restructuring of ELECTRA and the preparation of the "Reestablishment and Reform of Water and Electricity Sectors" project.

Besides energy generation, a desalination plant will have a production capacity of 5,000 m^3/day with an extension of the factory facilities at Palmarejo-Praia and a water reservoir of 3,000 m^3 to increase the capacity of the supply for the city of Praia. The project details shall be described in the Project Appraisal Document by 18 March 2010, and a complete feasibility study will be finished by September 10th, 2010. A desalination plant of 5,000 m^3/day is expected to be realized within several years.

(2) African Development Bank

AfDB has a grant project for the on-going study of ground water resource mobilization under a national-level strategy in collaboration with INGRH.

(3) European Union

The European Union finance scheme is aimed at increasing water household connections by the distribution network in the city of Praia in collaboration with the OPEC Fund for International Development (OFID). The European Union thinks that water issue in Cape Verde will not be solved unless there is a responsible government entity.

(4) Spanish Cooperation

The Spanish Cooperation shall finance the installation of desalination equipment for an additional production capacity of 5,000 m^3/day inside the existing ELECTRA plant, which was funded formerly by Spanish Cooperation. The installation work is expected to be completed by the end of 2010. The Spanish cooperation has given the fund for a water reservoir constructed in 2010 in the Municipality of Ribeira Grande de Santiago, whose capacity is 1,000 m^3.

(5) Portuguese Cooperation

The Portugal Cooperation applies a tied-loan due to the urgency of the project, based on the G-G agreement, for three irrigation dams, namely 1) Salinero Dam - Municipality of Ribeira Grande de Santiago, 2) Faveta Dam - Municipality of Sao Salvador do Mundo, 3) Saquinho Dam - Municipality of Santa Catarina. The collected water shall be used solely for agricultural purposes by "gota-a-gota" drip-feeding irrigation piping networks.

(6) French Cooperation

The French Development Agency (ADF) approved in 2008 a loan budget allocation of 10 million Euros for the implementation of the project for the reinforcement of the potable water supply in the Municipality of Santa Catarina and drainage of the city of Assomada in addition to the improvement of the management of SAAS. ADF outlined the improvement of the distribution network such as repairs to existing pipelines and introducing a remote management system to control the operation of pumps. Nevertheless, ADF project will reinforce the additional production capacity with only 521 m^3/day. Therefore the French Cooperation considers that the groundwater resouce is not sufficient to supply drinking water to meet future demand of Santa Catarina municipality even though ADF achieves the current program to strengthen water production capacity and reduce the rate of unbilled water.

(7) Luxembourg Cooperation

Lux-Development recently completed the grant project "Indicative Cooperation Program (PIC) Phase 2", in the Municipality of Sao Domingos that started in 2007 and which comprises of facilities such as pipelines, pump station, water reservoir, rehabilitation and enhancement of existing distribution network, private bathroom, septic tanks and a sewerage system. Lux-Development has received a request for the construction of desalination plant from the Municipality of Sao Domingos and it is considered as one of possible components for future cooperation.

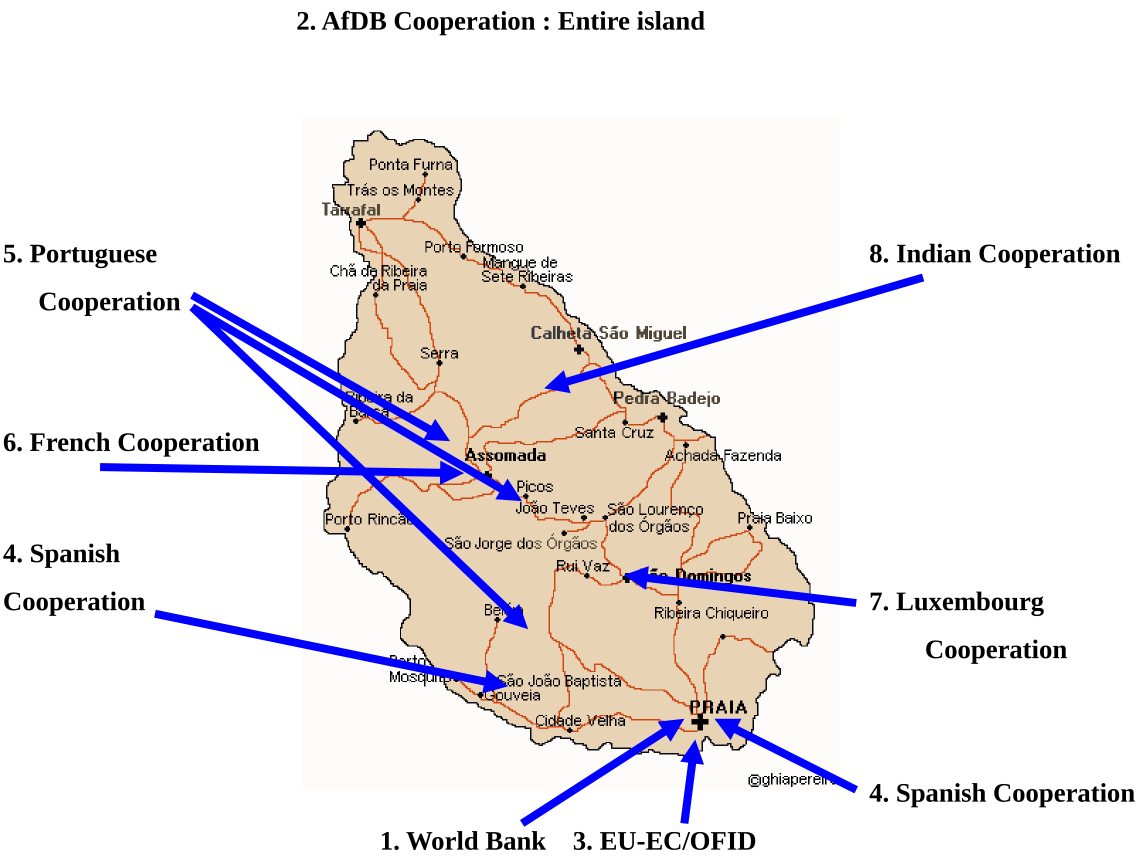
(8) Indian Cooperation

The finance from the Indian government is to be used to construct the water transmission pipeline from the Sao Miguel desalination plant of the concession company CAIS to the city of Assomada, covering a distance of about 18 km. But this financing is not yet confirmed. The size of the pipe corresponds to a volume of 3,500 m^3/day of water production. The above-mentioned explanations are summarized in the table below.

Table 2.8-1: Assistance by Other Donors

No.	Donor	Project	Capacity	Location	Status
1	Japan	Groundwater Development in Santiago Island	350 m^3/d	6 municipality 23 communes	2009
2	World Bank	Desalination Plant	5,000 m^3/d	Praia	2012
3	AfDB	Ground Water Resources	Strategy	Entire Island	On-going
4	EU-EC/OFID	Distribution Network	—	Praia	On-going
5	Spain	Desalination Equipment	5,000 m^3/d	Praia, Ribeira Grande	2010
6	Portugal	3 Irrigation Dams	—	SC, SSDM, RGDS	2010
7	France	Distribution Network, Sewerage	521 m^3/d	Santa Catarina	2010
8	Luxembourg	Distribution, Reservoir, etc.	—	Sao Domingos	Completed 2009
9	India	Transmission Pipeline	18 km	Sao Miguel to Assomada	Expected 2011

Source: MTIE

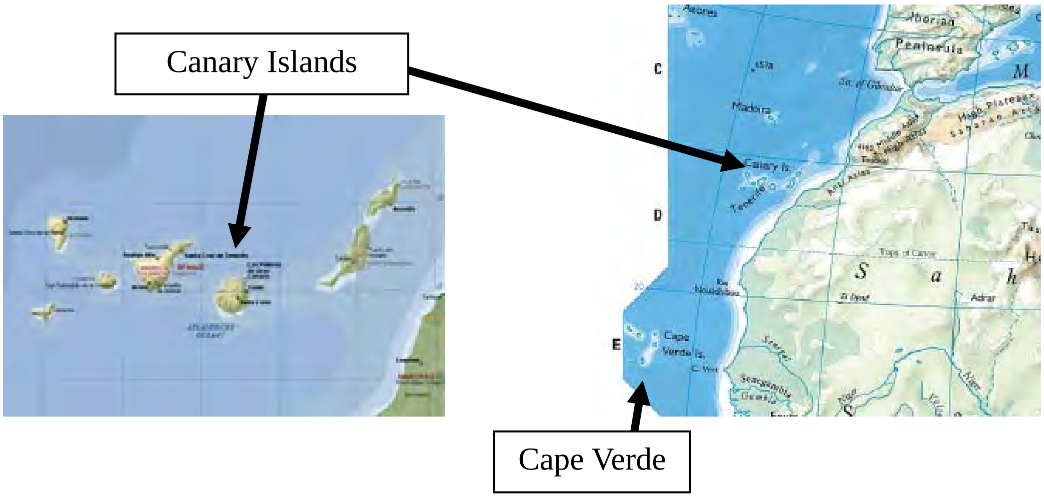


Source: JICA Study Team

Figure 2.8-1: Assistance by Donors

2.9 Reference Survey in Canary Islands

The Canary Islands, Spain, locate in the Atlantic Ocean, and around 1,000 km south of Spain and several hundred kilometers from Morocco, which consist of 7 major islands. Due to the islands geographical location, the islands' climate is subtropical and similar to Cape Verde.



The Canary Islands had the same water issues as Cape Verde due to the almost equal climate conditions. The Gran Canaria, main island of Canary Islands, has 400,000 population, is one of important island in this area. Many tourists from Europe visit these islands, and the tourism industry is one of important industries. Fresh water is required for not only habitants but also tourism, agriculture and fishery industries, etc.

With regards to water resources, ground water is not enough and its salinity is rather high. Therefore seawater and brackish water desalination technologies have been applied from more than 30 years ago. As the result, many desalination facilities are in operation in these islands. Most of all desalination process, such as RO membrane, Multi-stage Flash (MSF), Multi-effect Distillation (MED), Vapor Compression Distillation (VCD), Electro Dialysis (ED), etc. are used Due to its cheaper cost and long time operation experiences, RO technology is now widely applied in these islands.

Scheduled flights are operated between Lisbon and Praia, some of which stop over Gran Canary (city of Las Palmas). Therefore the study team visited Gran Canary on the way to Praia from Japan, and collected useful data for this study on RO plant operation. The survey topics are briefly described below:

<u>Reference Facility 1 : Northern part of the island</u>

The capacity is same as F/S study (5,000 m^3/day). Plant started from June 2010. The purpose is to produce irrigation water with EU drinking water specification. Boron is monitored.

The actual operation data in middle of August, 2010 is as follows:

Sea water intake	: Beach well intake
Sea Water	
TDS	: 38,000-38,500 ppm
Boron	: 4.5 - 5.5 ppm
pH	: 7.7
Temperature	: 23-27 deg C
Recovery Ratio	: 45%
Desalinated Water	
Product water quantity	: 5,000 m^3/day
Product water quality	: 270-300 micro siemens/cm (around 150 ppm)
Boron content	: 0.6 - 0.8 ppm
RO operating pressure	: 62bar
RO membrane	: Japanese product, Polyamide-spiral membrane

Reference Facility 2 : Eastern part of the island

The capacity is 2,500 m^3/day. Plant started 2002, and is operated with partially wind power. The major purpose is to produce irrigation water. Desalinated water is sold to farmers with the price much less than 1 Euro/m^3. Power consumption is currently 4.1 kWh/m^3 including sea water intake and transmission of product water to reservoir neraby. RO system has energy recovery device supplied by American company.

The actual operation data in middle of November, 2010 is as follows:

Sea water intake	: Beach well intake
Sea Water	
TDS	: 38,000 mg/l
Desalinated Water	
Product water quantity	: 2,500 m^3/day
Product water quality	: 800 micro siemens/cm (around 500 ppm)
RO membrane	: Japan and USA, Polyamide-spiral membrane

Reference Facility 3 : Southern part of the island, high recovery rate type

This facility is owned and operated by the electric power generation company in the island.

Open sea water is supplied to this desalination plant. The difference of this plant from other standard plants is that this plant adopts higher recovery system. Originally plant is designed with standard recovery of 40%., and after several years operation, additional RO unit (Bank 2) is attached at Brine from original desalination plant (Bank 1) for producing more fresh water, then total product water is increased up to 55%.recovery.

This type can produce higher desalinated water with same intake and pretreatment for fresh sea water. Bank 1 unit produces 19,000 m^3/day (Intake is 47,500 m^3/day) Bank 2 unit produces 7,300 m^3/day of water respectively. RO membrane is Polyamide-spiral made in Japan.

Other topics

1. Operation and maintenance

Since the Canary Islands have been industrialized and modernized its infrastructure including logistics system, most of industrial materials and goods are easily delivered and obtained as well as EU countries. Operation and maintenance tools and materials for desalination facilities are also available in the islands by frequent connection with EU countries.

On the other hands, those tools are not easily available in Cape Verde and/or rather difficult access to EU countries. It is recommended that necessary spare parts and tools might be stored inside of Santiago island, Cape Verde.

2. Irrigation water

Maximum salinity of irrigation water for various fruits and vegetable are specified. The followings are typical allowable salinity in TDS. Ground water in Canary Island is over these limitation. This is why farmers have to get desalinated water for their irrigation.

Tomato : 1,500 micro siemens/cm (around 800 mg/l)l

Water melon : 800 micro siemens/cm (around 500 mg/l)

Papaya : 800 micro siemens/cm (around 500 mg/l)

Banana : 400 micro siemens/cm (around 250 mg/l)

Chapter 3. Basic Plan Development

Chapter 3. Basic Plan Development

3.1 Basic Conditions for Planning

3.1.1 Level of Population in 2020

The distribution of the population among the municipalities in Santiago Island is very disproportionate. The data presented by INE (Institute Nacionale de Estatisticas) indicates the distribution of the population in 2012 and 2020 as per following Table 3.1-1. Over the last few years, the asymmetry of the population between urban areas and rural areas has increased due to the migration of the rural population to urban centers. It is especially obvious towards the city of Praia.

Table 3.1-1: Population Distribution in Santiago Island (year 2012-2020)

Municipality	2012		2020				
	Total	%	Total	% Urban	Urban	% Rural	Rural
Tarrafal	24,663	8.05	28,577	34.0	9,716	66.0	18,861
Santa Catarina	50,332	16.43	58,321	32.0	18,663	68.0	39,658
São Salvador do Mundo	11,355	3.71	13,157	13.5	1,776	86.5	11,381
Santa Cruz	31,157	10.17	36,102	40.0	14,441	60.0	21,661
São Lourenço dos Orgaos	9,626	3.14	11,154	20.0	2,231	80.0	8,923
Praia	136,339	44.51	157,978	98.5	155,609	1.5	2,370
Ribeira Grande de Santiago	9,664	3.15	11,562	15.1	1,748	84.9	9,814
São Domingos	14,957	4.88	17,331	16.0	2,773	84.0	14,558
São Miguel	18,242	5.95	21,137	35.0	7,398	65.0	13,739
Total (Santiago Island)	306,335	100.00	355,319	304.1	214,355	595.9	140,965

Source: Instituto nacional de Estatistica / Resultado de Revisão das Projecções Demograficas 2000-2020

3.1.2 Levels of Water Consumption 2020

(1) House use by INGRH estimation

Based on the data from the "*National Vision on Water, Life and Environment in 2025*" by INGRH (2000), the average consumption of drinking water in the years 1996-1997 for people connected to the network was estimated at 50 liters/person/day for those with household connections, and 15 liters/person/day for users of fountains. Refer to Table 3.1-2 and Table 3.1-3. The horizons of water consumption per person in the years 2010 and 2020 are predicted as per the same Table.

Table 3.1-2: Water Consumption per Person in Urban Areas (by INGRH)

Year	Urban			
	% Coverage by Public Pipe	Consumption l / person / day	% Coverage by Fountain	Consumption l / person / day
1996-1997	—	50	—	15
2010	90	100	10	25
2020	100	150	—	(note)

(Note) During the discussion with INGRH, consumption in 2020 by persons who are not connected by pipelines is corrected to 50 liters/person/day in urban areas and rural areas.

Source: Study team

Table 3.1-3: Water Consumption per Person in Rural Areas (by INGRH)

Year	Rural			
	% Coverage by Public Pipe	Consumption l / person / day	% Coverage by Fountain	Consumption l / person / day
1996-1997	—	—	—	15 (7-25)
2010	20	50	80	25
2020	25	80	75	50

Source: Study team

Apart from the above target figure, INGRH and SAAS staff indicate the following pipe connection ratio and targeted leakage ratio in Table 3.1-4 and Table 3.1-5, respectively..

Table 3.1-4: Targeted Pipeline Connection Ratio by Each Municipality

year	South			North					
	Praia	Ribeira Grande	Sao Domingos	Tarrafal	Sao Miguel	SS do Mundo	Santa Catarina	Santa Cruz	Sao Lourenco
2007	47.3%	10.9%	9.9%	64.1%	53.7%	15.4%	48.8%	76.9%	43.9%
2020	99.0%	90.0%	90.0%	95.0%	90.0%	80.0%	95.0%	95.0%	90.0%

Source: INGRH & SAAS

Table 3.1-5: Targeted Pipeline Leakage Ratio by Each Municipality

year	South			North					
	Praia	Ribeira Grande	Sao Domingos	Tarrafal	Sao Miguel	SS do Mundo	Santa Catarina	Santa Cruz	Sao Lourenco
2007	24%	20%	10%	24%	16%	20%	28%	28%	10%
2020	15%	15%	15%	15%	15%	15%	15%	15%	15%

Source: INGRH & SAAS

(2) House use by PAGIRH estimation

Furthermore, water needs in the year 2020 have been assumed in the *"Action Plan and Integrated Management of Water Resources (PAGIRH)"* based on the following parameters:

1) Assumptions of Population Growth

The basic assumption is that population growth will remain similar to the current average of 2.5% per annum. This actually corresponds to projections of population growth estimated by the Instituto Nacional de Estatística (INE) for 2020. The rural population tends to decline slightly because of the strong flow into urban areas.

2) Assumptions of Water Consumption per Capita

It is estimated that in 2007, as per Table 3.1-6, the average water consumption per person per day for house use was 60 liters in urban areas and 25 liters in rural areas. Also it is estimated that public consumption was 20 liters in urban areas and 5 liters in rural areas.

The PAGIRH assumed that between 2015 and 2020 daily consumption per person for house use will increase to 120 from 60 liters in urban areas and to 55 from 25 liters in rural areas, while public consumption in urban areas will increase to 25 from 20 liters and in rural areas to 10 from 5 liters per day.

Table 3.1-6: Projection of Water Consumption per Person

	Actual (2007)		2015-2020	
	Urban (liter/day)	Rural (liter/day)	Urban (liter/day)	Rural (liter/day)
House Use	60	25	120	55
Public Consumption	20	5	25	10

Source: PAGIRH

(3) Tourism use by PAGIRH estimation

As per Table 3.1-7, the assumption is given based on 20% growth above the current industrial level by 2015, and afterward around 10% until 2020.

The average daily water consumption per tourist was set at 200 liters in 2007, 250 liters in 2010, 370 liters in 2015 and 400 liters in 2020. Under these assumptions, in 2020, the water needs of the tourism sector will amount to approximately 3.4 million m^3 per year.

Table 3.1-7: Requirement of Potable Water for Temporary Population (Tourists) 2007-2020

	2007	2010	2015	2020
Temporary Population (Tourist) / year	1,559,808.4	2,312,116.0	4,455,607.0	8,586,262.0
Temporary Population (Tourist) / day	4,273.4	6,334.6	12,207.1	23,524.0
Consumption / person (liter)	200	250	370	400
Total / day (m^3)	854.7	1,583.6	4,516.6	9,409.6
Total / year (m^3)	311,961.7	578,029.0	1,648,574.6	3,434,504.8

Source: PAGIRH

Tourism-related figures are introduced as per Table 3.1-8 according to the tourism development department of MTIE. Bed numbers for tourists in 2008 in Santiago Island were 1,150. Based on this data and annual growth, the number of beds in 2020 is estimated to be 4,600. These 4,600 beds in Santiago Island are allocated to each community for this study as per Table 3.1-10.

Table 3.1-8: Tourist forecast (unit: beds)

	2008	2010	2015	2020
Nation total	11,420	14,111	28,383	57,088 (note 1)
Sal island	5,838	--	--	--
Santiago island	1,150	--	--	4,600 (note 2)
Other island	4,432	--	--	--

Source: Tourism development department of MTIE

Note 1: According to the tourism development department, growth per annum is estimated to be 15%. Data is introduced only up to 2015; 2020 is calculated using 15% per annum growth used by the study team.

Note 2: According to the tourism development department, 15% growth per annum is rather optimistic, so 12% per annual is applied by the study team.

(4) Conclusion for the study

As per above paragraphs 1, 2 and 3, several estimations are presented by different organizations. Referring to these data and overall opinion by related organizations and persons, the study team concluded the consumption volume for each category is as per Table 3.1-9.

Table 3.1-9: Water consumption for the study

	Urban(*) (liter/day/person)	Rural(*) (liter/day/person)
With public pipeline connection	150	80
Without public pipeline connection	50	50
For hotel use	300	300

(*) Definition of "Urban" and "Rural" is based on the Instituto nacional de Estatistica.

Source: Study team

3.1.3 Required production capacity

Based on the estimated growth of the population in 2020 in section 3.1.1, and growth of water consumption per person in 2020 in section 3.1.2, the daily consumption of potable water by residents in each municipality is estimated as per Table 3.1-10 without considering the seasonal variation of the population. Consumption by tourists from foreign countries with a 40% peak factor and some industrial usages are considered. Leakage, non-payment water, and administrative usage are also considered according to the previous Table 3.1-5. Industrial usage is estimated through interviews in each municipality.

So, the required capacity of water is calculated to be 47,848 m^3/day, which includes 47,492 m^3/day (refer to item "C" in Table 3.1-10) for inhabitants, tourists and industry and 356 m^3/day (refer to item "j" in Table 3.1-10) for seasonal peak demand especially hotel use.

After consideration of leakage, etc., the necessary production capacity is estimated to be 56,229 m^3/day (refer to item "E" in Table 3.1-10).

Table 3.1-10: Water demand and necessary production quantity in 2020 (m^3/day)

1. Deamand (year 2020)

items		South			South total	North						North total	Total	data source
		Praia	Ribeira Grande	Sao Domingos		Tarrafal	Sao Miguel	SS do Mundo	Santa Catarina	Santa Cruz	Sao Lourenco			
a. Target Year (2020) Population (person)		157,978	11,562	17,331	186,871	28,577	21,137	13,157	58,321	36,102	11,154	168,448	355,319	Institute Nacional de Estatistica (INE)
a1	- Urban	155,609	1,746	2,772	160,127	9,717	7,398	1,776	18,663	14,441	2,231	54,226	214,353	INE
a2	- Rural	2,369	9,816	14,559	26,744	18,860	13,739	11,381	39,658	21,661	8,923	114,222	140,966	INE
b. Overall Pipeline Service Coverage (%)		99.0%	90.0%	90.0%		95.0%	90.0%	80.0%	95.0%	95.0%	90.0%			Steering Committee (SAAS)
	in 2007	47.3%	10.9%	9.9%		64.1%	53.7%	15.4%	48.8%	76.9%	43.9%			INE
c. Served Population	Connection ratio in Urban, data by INGRH : 100 %													
c1 =a x b	Overall population served by pipe network	156,398	10,406	15,598	182,402	27,148	19,023	10,526	55,405	34,297	10,039	156,438	338,839	Connection ratio (Urban Total)
c2 = a1xConnection ratio (%)	- Urban, with pipe connection	155,609	1,746	2,772	160,127	9,717	7,398	1,776	18,663	14,441	2,231	54,226	214,353	100%
c3 = c1-c2	- Rural, with pipe connection	789	8,660	12,826	22,275	17,431	11,625	8,750	36,742	19,856	7,808	102,212	124,486	Connection ratio (Rural Total)
c4 = a-c1	Overall population, NOT served by pipe	1,580	1,156	1,733	4,469	1,429	2,114	2,631	2,916	1,805	1,115	12,011	16,480	88%
c5 = a1-c2	- Urban, without pipe connection	0	0	0	0	0	0	0	0	0	0	0	0	
c6 = a2-c3	- Rural, without pipe connection	1,580	1,156	1,733	4,469	1,429	2,114	2,631	2,916	1,805	1,115	12,011	16,480	
d. Per-Capita Average Demand (litter/person/day)														
d1	- Urban, with pipe connection	150	150	150		150	150	150	150	150	150			INGRH
d2	- Rural, with pipe connection	80	80	80		80	80	80	80	80	80			INGRH
d3	- Urban, without pipe connection	50	50	50		50	50	50	50	50	50			INGRH
d4	- Rural, without pipe connection	50	50	50		50	50	50	50	50	50			INGRH
e. Domestic demand (m3/day)														
e1 = c2 x d1	- Urban, with pipe connection	23,341	262	416	24,019	1458	1110	266	2799	2166	335	8,134	32,153	
e2 = c3 x d2	- Rural, with pipe connection	63	693	1026	1,782	1394	930	700	2939	1588	625	8,177	9,959	
e3 = c5 x d3	- Urban, without pipe connection	0	0	0	0	0	0	0	0	0	0	0	0	
e4 = c6 x d4	- Rural, without pipe connection	79	58	87	223	71	106	132	146	90	56	601	824	
A. = e1+e2+e3+e4	Domestic Demand (m3/day)	23,483	1,012	1,529	26,024	2,923	2,145	1,098	5,885	3,845	1,015	16,911	42,936	
f. Tourism Demand														
f1	Number of Beds (beds)	2,400	100	100	2,600	200	100	0	500	200	0	1,000	3,600	MTIE(Tourism dept) + Study team
f2	Expected Average Occupancy	70%	70%	70%		70%	70%	70%	70%	70%	70%			Study team
f3	Per-Capita Demand (litter/bed/day)	300	300	300		300	300	300	300	300	300			MTIE(Tourism dept) + Study team
f = f1 x f2 x f3	Tourism Sub total (m3/d)	504	21	21	546	42	21	0	105	42	0	210	756	
g. Industries, office, hospital, others (m3/day)		3,000	0	50	3,050	50	100	0	500	100	0	750	3,800	MTIE(Industry dept) + Study team
B = f + g	Non-Domestic Demand (m3/day)	3,504	21	71	3,596	92	121	0	605	142	0	960	4,556	
C = A + B	Total Net Water Demand (m3/day)	26,987	1,033	1,600	29,620	3,015	2,266	1,098	6,490	3,987	1,015	17,871	47,492	
h.	Leakage Ratio (%)	15	15	15		15	15	15	15	15	15		15	Steering Committee (SAAS)
	NOW	24	20	10		24	16	20	28	28	10		24	SAAS
D = C /(100% - h%)	Day Average Demand (m3/day)	31,750	1,216	1,882	34,848	3,548	2,666	1,292	7,635	4,690	1,194	21,025	55,873	
i.	Seasonal Peak Factor (Tourism)	1.4	1.4	1.4		1.4	1.4	1.4	1.4	1.4	1.4			Study team
j. f x (i-1) / (100%-h%)	Seasonal Additional Demand (m3/day)	237	10	10	257	20	10	0	49	20	0	99	356	
E = D + j	Daily Maximum Demand (m3/day)	31,987	1,226	1,892	35,105	3,567	2,676	1,292	7,684	4,710	1,194	21,124	**56,229**	
		57%	2%	3%	62%	6%	5%	2%	14%	8%	2%	38%	100%	

2. Existing plant, including planned plant

	Praia	Ribeira Grande	Sao Domingos	South total	Tarrafal	Sao Miguel	SS do Mundo	Santa Catarina	Santa Cruz	Sao Lourenco	North total	Total
Existing Desalination Plant	5,000	(Palmarejo)		5,000					0		0	5,000
Planned plant									(Achada Ponta)			
by Spanish fund	5,000	(Palmarejo)		5,000							0	5,000
by World Bank fund	5,000	(Palmarejo)		5,000							0	5,000
Total				15,000							0	**15,000**

3. Necessary additional plant (1-2)

	Praia	Ribeira Grande	Sao Domingos	South total	Tarrafal	Sao Miguel	SS do Mundo	Santa Catarina	Santa Cruz	Sao Lourenco	North total	Total
Detail figure (m3/d)				20,105							21,124	41,229
Round figure (m3/d)				**20,000**							**20,000**	**40,000**

Source: Study team

3.2 Basic Planning

3.2.1 F/S Project Areas

All municipalities in Santiago Island in Table 3.2-1are the object area. Water shall be delivered to the main reservoir near the object municipality

In this study, for estimation of the F/S Project production capacity, a water supply project established by other donors is not considered, except one comprehensively planned. In later stages, after any other donor's project has become more certain, their capacity shall be deducted from this F/S project capacity.

Table 3.2-1: Object municipalities

Municipality	Abbreviation in Fig 3.3-1
Praia	--
Ribeira Grande de Santiago	RbGr
São Domingos	SDmg
São Miguel	SMG
Santa Catarina	SCtr
Santa Cruz	SCRZ
São Salvador do Mundo	SSdM
São Lourenço dos Orgaos	SLdO
Tarrafal	TRFL

Source: Study team

3.2.2 Facility Planning

(1) Required production capacity

As per section 3.1.3, the required production capacity for the entire island is 56,229 m^3/day. Regarding the F/S Project capacity, the following step is considered.

- Required production capacity in 2020 : 56,229 m^3/day (round figure 55,000 m^3/d)
- Existing Desalination Capacity in 2010 : 5,000 m^3/day, in Praia

(note) Two (2) units of 1,200 m^3/day are planned to be transferred to another island. Therefore, only the 5,000 m^3/d plant is considered. Also, the 500 m^3/d plant in Santa Cruz is not considered due to a small production capacity

- Comprehensively planned expansion plant : 5,000 m^3/day by Spanish government
  : 5,000 m^3/day by World Bank
- Additional capacity for total demand : 40,000 m^3/day (55,000 – 5,000 x 3 units)

(2) Water quality

In Cape Verde, no water quality standard exists. Although the Ministry of Health of Cape Verde is drafting standards, this work has not yet been completed. Basically, they follow WHO guidelines. Therefore, this F/S will also follow WHO guidelines for water quality. Table 3.2-2 shows the key part of WHO guidelines for drinking water quality for this F/S. The maximum salinity of potable water will be 1,000 mg/l in TDS (Total Dissolved Solids) and 0.5 mg/l of Boron, etc.

Table 3.2-2: Part of drinking water quality standard (WHO, USA, EU and Japan)

Item	WHO	USA	EU	Japan
1. Inorganics				
Aluminum	0.2	0.05 ~ 0.2	0.2	0.2
Ammonia	1.5		0.5	
Antimony	0.005	0.006	0.005	0.002
Arsenic	0.01	0.05	0.01	0.01
Asbestos	U	7 (Mil./L)		
Barium	0.7	2		
Beryllium	NAD	0.004		
Boron	0.5		1	1
Cadmium	0.003	0.005	0.005	0.01
Chloride	250	250	250	200
pH	―	6.5 ~ 8.5	6.5 ~ 9.5	5.8 ~ 8.6
Selenium	0.01	0.05	0.01	0.01
Silver	U	0.01		
Sodium	200		200	200
Sulfate	250	250	250	
Tin	U			
Total Dissolved Solids	1000	500		500 ~ 200
Uranium	0.002	0.03		0.002
Zinc	3	5		1
Thallium		0.002		
2. Organics				
Carbon tetrachloride	0.002	0.005		0.002

(note 1) Unit: mg/l except where specified.

(note 2) 0.5 mg/l of Boron in WHO guidelines is a provisional figure

(note 3) In the EU standard, TDS is not stated, but 2,500 μ S/cm at 20 deg C is regulated.

Source: Ministry of Health, Labor and Welfare, Japan: www.mhlw.go.jp/shingi/2002/11/s1108-5g.html

(3) Mixture or utilization of ground water

1) A mixture of ground water was studied in phase 1 in 2009, and the situation found in Cape Verde was as follows:
   - According to government policy, ground water will be utilized for irrigation purposes after completion of an adequate network for desalinated water.
   - For reducing Boron concentration in the product water, mixture of ground water to RO desalinated water was studied. But as per Figure 4.1-2, Boron content is estimated

to be 0.9 mg/l which means almost 1.8 times of limited figure (0.5 mg/l). For getting 0.5 mg/l or less, almost same amount of ground water is necessary. This is not met the above government policy.

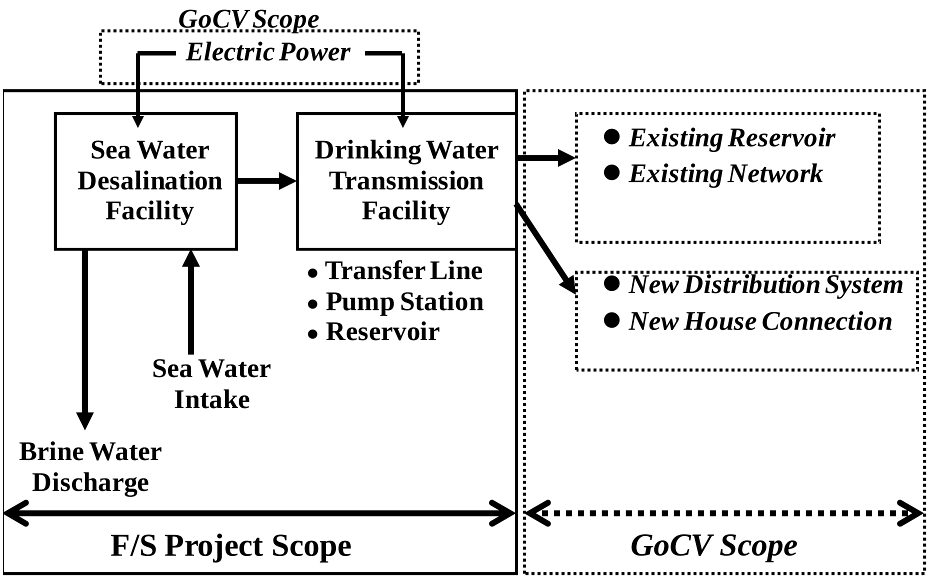
2) Therefore, this study concluded as follows:
   - Only seawater is utilized as a water resource for this study
   - For the study, ground water is not used for mixing with desalinated seawater

(4) Water supply network

Figure 3.2-1 shows the concept of the F/S Project, which includes the following facilities:

1) New water production facility at a suitable place
2) Transmission pipe line from desalination plant to the reservoirs for municipalities in question

The necessary distribution pipe line from reservoirs to each user (house) is not included.



Source: Study team

Figure 3.2-1: Concept of water supply system

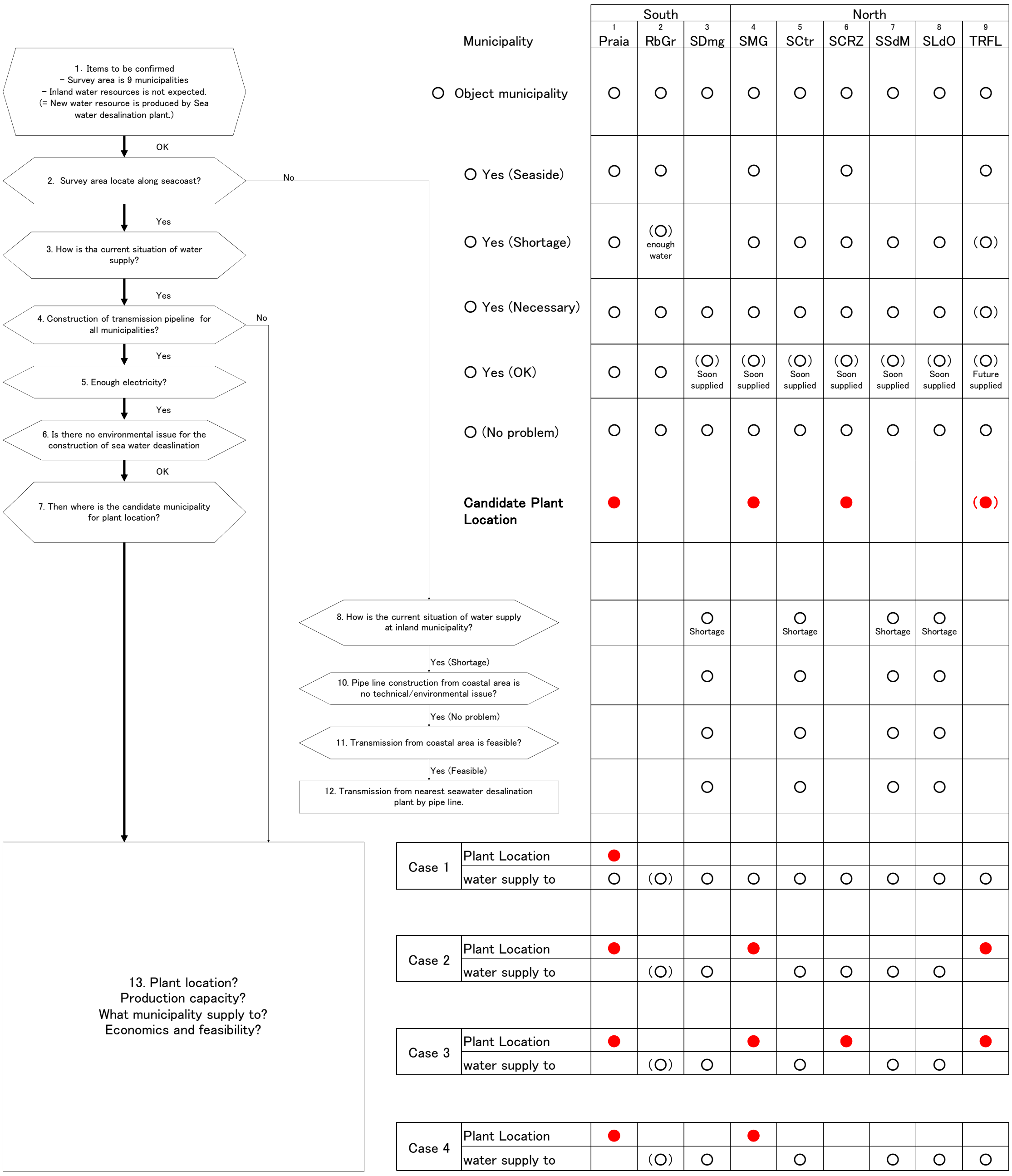
3.3 F/S Project Selection

3.3.1 Selection of the F/S Project

(Note) In section 3.3.1, only Cases 1, 2 and 3 are compared for "conclusion in phase 1 in 2009". Later on, during further study in phase 2 from April 2010, Case 4 came up and was studied. The outline of Case 4 is introduced in section 3.3.2.

(1) Selection flow

Based on the F/S Project selection criteria, which were agreed with GoCV in an inception meeting, the situation regarding each commune is reviewed accordingly. The study result is introduced in Figure 3.3-1.



Source: Study team

Figure 3.3-1: F/S Project selection criteria

Then, the following three (3) cases were nominated as candidate F/S Project formations in the phase 1 stage in February, 2010:

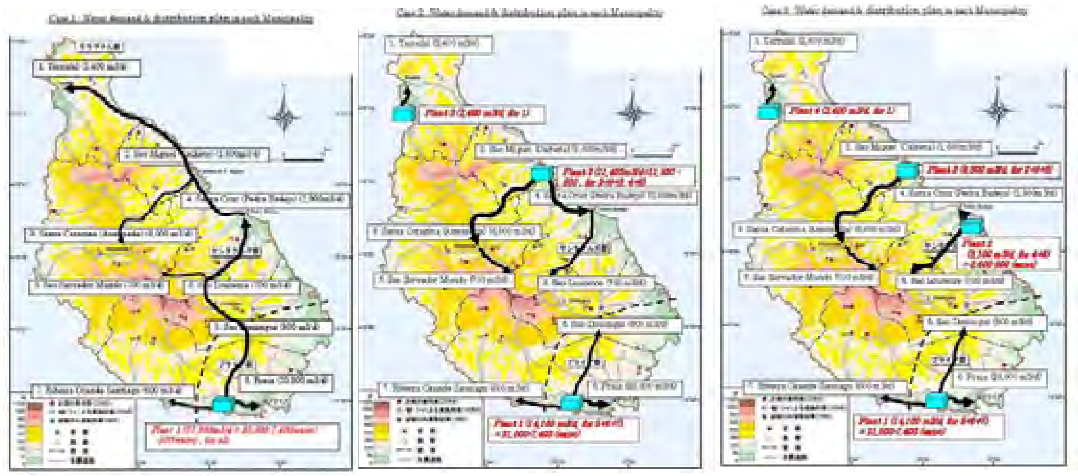
Case 1: One desalination plant at Praia; distribution of its water to all municipalities by transmission pipeline.

Case 2: Three plants at Praia, Sao Miguel and Tarrafal; distribution of their water to nearby municipalities by transmission pipeline.

Case 3: Four plants at Praia, Sao Miguel, Santa Cruz and Tarrafal; distribution of their water to near municipalities respectively by transmission pipeline.

Advantages and disadvantages of each case are as per the following section (2)-(4).

Case 1 ***Case 2*** ***Case 3***



Source: Study team

Figure 3.3-2: Candidate cases

(2) Case 1

- Expected Advantages

1) Lower construction cost for desalination plant

2) Centralized operation and management

- Disadvantages

1) Higher construction cost for transmission pipeline

2) Higher pump station cost

3) Responsibilities between ELECTRA (water producer) and municipalities (water distributors) need to be solved.

4) Risk of water leak and loss

5) Risk of one water production facility

(3) Case 2

- Expected Advantages

  1) Lower construction cost for transmission pipeline

  2) Lower pump station cost

  3) Job creation in local municipalities

  4) Lower conflict between ELECTRA and other municipalities

  5) Risk of decentralization from one water supplier

- Disadvantages

  1) Higher construction cost for desalination plants

  2) More people required for operation and maintenance

  3) More training costs for operators

(4) Case 3

- Expected Advantages

  1) Lower construction cost for transmission pipeline

  2) Lower pump station cost

  3) Job creation in local municipalities

  4) Less conflict between ELECTRA and other municipalities

  5) Risk of decentralization from one water supplier

  6) Easier to adjust if another donor's project comes up

- Disadvantages

  1) Higher construction cost for desalination plants

  2) More people required for operation and maintenance

  3) More training cost for operator

(5) Comparison

Since the system design is still at a preliminary stage, only a relative comparison among the three cases is conducted from the viewpoints of construction cost, operation and maintenance cost, and EIA (Environmental Impact Assessment) cost.

The construction cost of Case 2 is estimated to be 77% of Case 1, and Case 3 is 74% of Case 1.

3.3.2 Further study results and F/S Project image for feasibility study

(1) Case 4

In phase 2, which started from April 2010, the above cases were further studied and discussed. Finally, the Government of Cape Verde and the JICA Study Team agreed on Case 4, which is a similar development to cases 2 and 3. The outline of Case 4 is introduced in Figure 3.3-3. This plan was confirmed at the 3rd Steering Committee in June 2010.

Figure 3.3-3: Case 4 project outline

The following connection pipeline, pump stations and reservoirs will be constructed

Connection Pipeline From	To	Reservoir Capacity (m^3)	Pump Stations
Southern part			
Palmarejo	Praia	5,000 x 2	1
(Palmarejo)	Porto Mosquito	200	1
(Palmarejo)	Ribeira Chiquero	2,000	2
Ribeira Chiqueco	Sao Domingos	1,000	1
Northen part			
Calheta	Sao Miguel	7,000	1
Sao Miguel	Santa Cruz	3,000	-
Sao Miguel	Tarrafal	2,000	1
Sao Miguel	Assomada	5,000	5
Santa Cruz	Sao Lourenco	600	1
Assomada	Sao Salvador	600	1
Loop (Note)			
Sao Salvador	Sao Lourenco	-	1
Sao Domingo	Sao Lourenco	-	1

Note: This is optional. If necessary, these loops shall be studied in projects other than the JICA F/S project.

(2) Advantages of Case 4

Most of the advantages are the same as cases 2 and 3. Other major advantages are,

1) The two or three northern plants are all located at one plant, which makes for a centralized operation in the northern area.

2) In the southern area, no large amount of water transmission from Praia is necessary because of the newly created northern plant.

3) The northern plant is separated from the southern plant. Therefore, even if negotiations with another donor are under way, operations at the southern plant will not be affected by any negotiations.

4) Because of the same size of the dual plants, in case of an accident at one of the plants, the other plant can act as a back up.

3.4 Summary of F/S Project

3.4.1 Scope of F/S Project

The major items for further study are summarized as follows:

(1) Raw water:

Only sea water is used as a water resource. Ground water is not used for drinking water in this F/S Project.

(2) Desalination plant:

Two (2) plants with an RO membrane process,

at Palmarejo for southern municipalities

at Calheta for northern municipalities

(3) Transmission pipe line:

Included. From desalination plant to main reservoirs for each municipality.

(4) Power Electricity:

Available from the public grid. A private power plant will not be constructed.

3.4.2 Major items prepared by GoCV

The following items are outside of the scope of the F/S project.

(1) Land acquisition/preparation for the project

(2) Distribution network:

From main reservoirs to each use-point shall be prepared by GoCV.

(3) Environmental Impact Assessment (EIA) cost

(4) Consultancy costs for further project development, such as detailed design, selection of plant contractor, etc.

(5) Pre-operational costs, such as interest fees during construction, training fees for new operators, legal costs, etc.

Chapter 4. Project Feasibility Study

Chapter 4. Project Feasibility Study

4.1 Conceptual Design of Facility

4.1.1 Design Conditions and Basic Specifications – Seawater desalination facility

(1) Water Quality

1) Raw water fed to desalination plant

Raw sea water quality for the design base of the new desalination facility is set by referring to the quality of intake well water currently used in the existing desalination plants. The results of analysis of well water samples collected at Palmarejo and Santa Cruz during the JICA team's 3rd site survey period (from 11 May, 2010 though 11 July, 2010) show salinity of 38,000 mg/l and 31,000 mg/l in TDS (Total Dissolved Solids) as per Table 4.1-1. The details of this data are introduced in Table 2.5-6 and Table 2.5-8.

Table 4.1-1: Key data of sea water at candidate facility construction site

Location	Beach well near plant		Open sea near candidate site		
	Praia	St. Cruz	Praia	Sao Miguel	Tarrafal
TDS (mg/l)	38,000	31,000	41,000 ~ 42,000	39,000 ~ 40,000	38,000
Chloride (mg/l)	20,000 ~ 21,000	17,000 ~ 19,000	23,000 ~ 25,000	20,000	21,000
Boron (mg/l)	4 - 5	3	5	5	5
Temperature (deg C)	15.1 – 15.2	23.6 – 24.0	24.6 – 25.1	26.7	26.3-26.4
pH (--)	7.7 – 7.8	7.5	8.2	8.2	8.2

Source: Study team

The ion balance was studied, with a consideration of around 38,000 mg/l in TDS and 20,000 mg/l of chloride. As a result, key data for raw sea water for the system design is set as follows:

TDS : 37,800 mg/l
Boron : 5 mg/l
Temperature : 20 deg C
pH : 7.8

Other ion data than collected/analyzed ion are assumed by referring to the actual analysed data in Table 2.5-8 and seawater data around the Cape Verde.

2) Product water from desalination plant

As per Section 3.2.2, water shall be treated in order to meet WHO (World Health Organization) drinking water guidelines. The following items are especially taken into consideration:

TDS	: less than 1,000 mg/l
Chloride (Cl^-)	: 250 mg/l
Boron (B)	: 0.5 mg/l *(note)*
pH	: 6.5-9.5 (based on EU standard, due to no indication in WHO)

note: Boron content

The boron content in drinking water in this study is set to be 0.5 mg/l based on WHO guidelines third edition, 2008. The drinking water quality committee in WHO, at its meeting on 9-13 November 2009, recommended revising the boron guideline value to 2.4 mg/l. The revised guideline value and Summary Statement will be incorporated into the Guidelines for drinking-water quality, 4th edition, which will be published in 2011.

Further, the Water Code of the Republic of Cape Verde established by the Decree Law no. 8/2004 of 02/23/2004, B. O. no. 6 – it is hereby declared that the boron content in drinking water is consented to be no greater than 1mg/l by the Ministry of Health in Cape Verde on July 29th 2010.

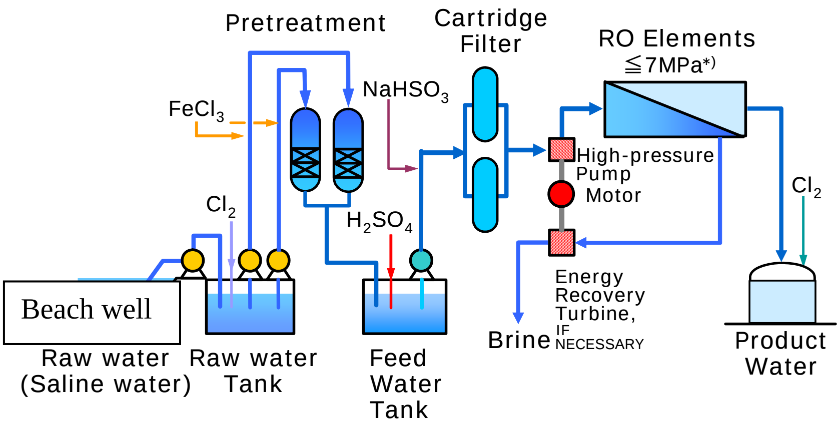
Thus, this regulation is expected to be revised, but the basic stance of this study follows the rules/data in operation at the time of developing the Interim Report in June 2010. Therefore this study adopts a double stage RO system.

When the boron content in drinking water is revised as per above, the RO system should be reviewed accordingly in the detail design phase of the project.

(2) Desalination Facility

1) Basic process

The concept flow of an RO desalination facility is shown in Figure 4.1-1, which consists of a sea water intake system, pre-treatment system, RO system, post treatment system, RO membrane cleaning system and chemical injection system. In this study, raw sea water is collected from a beach well, instead of the open sea, and concentrated brine water will be discharged to the open sea, which is far from the intake point. In the post-treatment system, pH adjustment, hardness adjustment and disinfection, etc., are considered. After then, water will be transmitted to each reservoir. A detailed flow is outlined in section 4.1.3.



Source: Study team

Figure 4.1-1: Basic flow of desalination facility

2) Unit Production Capacity

Production capacity from each unit is planned at 5,000 m^3/day.

This is a popular size, and the existing plant at Palmarejo and the plants planned in near future, funded by the Spanish fund and World Bank fund, are also 5,000 m^3/day.

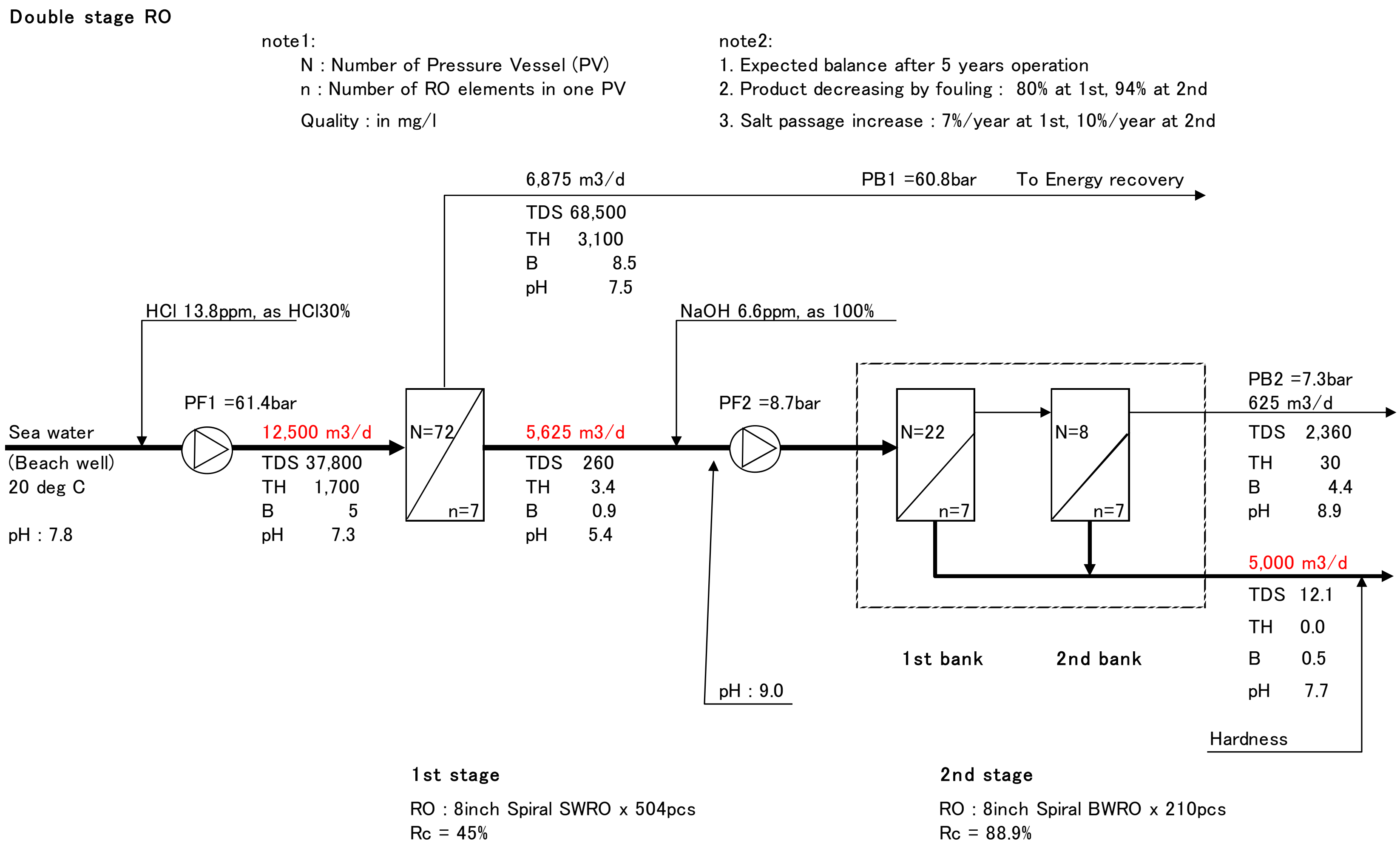
3) Double stage RO system

From the viewpoint of boron concentration in the water produced from sea water desalination, the water quality from a single-stage RO system does not satisfy WHO standards. Therefore, product water is again fed to an additional RO system and desalinated again by this system, i.e., a double stage RO process is adopted. Recovery at the 1st stage (sea water desalination) is 45% and at the 2nd stage (brackish water desalination) is 88.9%; total recovery is 40%.

Brine from the 1st stage will be discharged into the open sea after passing through an energy recovery device, and Brine from the 2nd stage is also discharged into sea because of its high boron concentration.

A rough material balance is as per Figure 4.1-2.

(note) For reducing Boron concentration in the product water, mixing with underground water was studied, but as per section 3.2.2(3), this process needs big amount of ground water and not met with Government policy. Therefore, double stage RO process is adopted in this study.



Source: Study team

Figure 4.1-2: Expected material balance at RO desalination system (Product: 5,000m³/d)

4) Product water tank

The product water tank capacity at the plant site is planned for 1/3 day production quantity.

5) Other necessary equipment, such as electric receiving equipment, chemical dosing unit, cleaning device, system control room, etc., will be prepared accordingly.

(3) Operation time

The system is designed for 24-hours-a-day and 365-days-a-year operation.

(4) Electricity

Electricity is sourced from the nearby public electric grid.

4.1.2 Design Conditions and Basic Specifications - Water Transmission Facility

(1) Transmission pipelines

The potable water produced by desalination facilities will be transferred to the main reservoirs located near each city by a combined pumping and gravity system. Because of the escarped relief of Santiago Island, there will be an area with high water pressure. In order to optimize the design requirements and the installation cost, two types of pipe material shall be selected as follows: Ductile iron with internal cement lining (DICL) for high-pressure force mains and high-density polyethylene (HDPE) for all other transmission lines. The pipeline will be buried in the ground as much as possible, around 1 meter deep, and the pipeline will be equipped with sectional valves, air valves, washout valves, fire hydrants, an anti-water hammer system, a data transmission fibre optic line and warning voice tape.

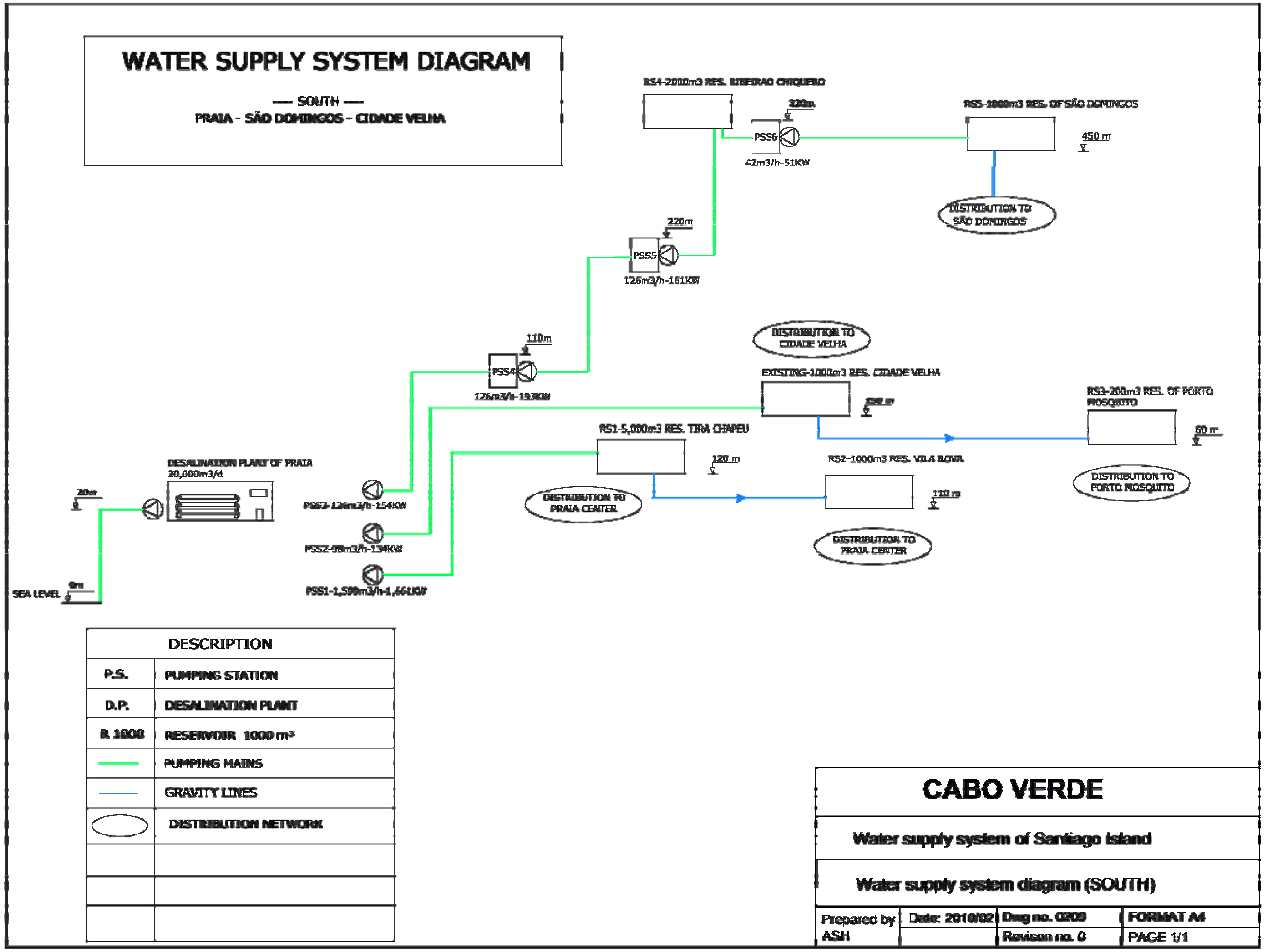
(2) Pumping stations

The pumping stations are basically connected to reservoirs. In order to ease and optimize the operation and maintenance of this equipment, the pumps and motors shall be of a similar type as much as possible. No booster-type pumping stations are considered in the proposed network system. Full automation for operations shall not be adopted for easy operation and maintenance. Level indicators installed in reservoirs will control the pumping stations.

(3) Reservoirs

The reservoirs are the square-shaped, reinforced concrete type and shall be composed of regular modules of 1,000m^3. The reservoirs will be located on elevated hills; this will enable the distribution of water by gravity through connections to existing distribution networks. Their capacity will be calculated to deal with a continuous supply and also be able to face peak demands. Extras connections to the reservoirs to supply potable water trucks could be considered in areas where the existing network is not sufficient to distribute the water to each house.

Two water supply system diagrams, in the south and north, are shown in figures 4.1-3 and 4.1-4, respectively.



Source: Study team

Figure 4.1-3: Water supply system diagram (South)