CHAPTER 8

8. ENVIRONMENTAL IMPACT ASSESSMENT

8.1 Project Description

8.1.1 Background of the Project

Many of the municipalities, even major cities, in the Central Plateau Area of Guatemala have poor water supply services. The average coverage of water supply services in the plateau area, outside Guatemala City, was estimated at 69% in 1988, the average service period being less than 12 hours/day. The main water sources are springs and the service population in most of these municipalities have outgrown the capacity of the springs. In 1993, 31 out of 96 municipalities had a shortage of water supply, and this number is projected to increase to 42 municipalities by 2010 if new supply sources are not developed. Further, it is expected that the existing water source will be replaced with groundwater in the future. However, groundwater development faces several technical and economic problems due to the topographical and hydrogeological features of the Central Plateau Area.

With this background, the Government of the Republic of Guatemala requested the Japanese Government, in January of 1990, to cooperate in formulating a water supply source development plan focusing on groundwater development.

8.1.2 Objectives of the Project

The objectives of the project are:

1) To formulate a water supply plan for the prioritized municipalities by conducting a feasibility study.

2) To implement the water supply plan in the selected 10 municipalities based on the results of the feasibility study.

3) To conduct technology transfer to the counterpart personnel during the course of the feasibility study and implementation of the project.

8.1.3 Implementing Organization

The implementing organization is the Instituto de Fomento Municipal de Guatemala (INFOM: Municipal Development Institute of Guatemala).

8.1.4 Service Population and Project Scale

The service population and the scale of the project for the selected 10 municipalities are shown in Table 9.1.1 and 9.1.2. This water supply plan is made under the following basic concepts.

1) The target year is the year 2010.

2) The water supply service area and the service population in the year 2010 shall be restricted to the municipal city area and its population.

3) The scope of the project basically entails groundwater development and construction of conveyance facilities up to the existing reservoir. In addition, the project also includes improvement of the distribution facilities in the municipality of San Juan Comalapa, and the construction of reservoirs in 8 municipalities.

Table 8.1.1 Water Production in 1994 and Production Shortage in 2010

No.	Municipality	Population in 2010	Planned daily Supply Per Capita (l/c/d)	Water Demand in 2010 (m3/day)	Water Production in 1994				Max. Cap. of Existing Sources in 2010				Production Shortage in 2010 (m3/day)	Capacity of New Well (m3/day)	Number of Required Well *
					Natural Flow Spring	Pumped up Spring Water	Wells	Total (m3/day)	Natural Flow Spring	8-hour Pumping from Spring	24-hour Pumping from Wells	Total (m3/day)			
Gu 2	San Jose Pinula	19,970	155	3,095	-	-	821	821	-	-	818	818	-2,277	2,920	1 (0)
Gu 8	San Pedro Sacatepequez	10,140	155	1,572	-	122	98	220	-	-	294	294	-1,278	1,745	1 (0)
Sa11	Santa Maria de Jesus	14,890	155	2,308	-	-	173	173	-	-	691	691	-1,617	3,041	1 (0)
Ch 3	San Martin Jilotepeque	11,968	155	1,855	605	-	259	864	-	-	518	518	-1,337	2,186	1 (0)
Ch 4	San Juan Comalapa	19,408	155	3,008	371	27	112	510	371	144	539	1,054	-1,954	985	2 (1)
So 1	Solola	30,960	155	4,799	2,627	-	-	2,627	2,627	-	-	2,627	-2,172	1,909	2 (1)
So 4	Santa Lucia Utatlan	4,773	106	506	162	-	-	162	162	-	-	162	-344	821	1 (0)
To 5	Momostenango	16,740	155	2,595	346	294	-	640	346	294	-	640	-1,955	1,089	2 (1)
Qu18	San Francisco la Union	2,561	106	271	-	4	-	4	-	-	-	0	-271	821	1 (1)
Qu21	Genova	7,267	106	770	267	-	-	267	-	-	-	0	-770	1,365	1 (0)

* ( ) shows actual required number of well

Table 8.1.2 Project Facilities

No.	Municipality	Well			Transmission Pipe					Specified	Distribution pipe				Required
		Pumping Rate		Pumping Level	Elevation Difference	Pipe Diameter	* Distance	Head Loss	Flow Velocity	Pump Head (A)+(B)+(C)	Pipe Diameter	Distance	Head Loss	Flow Velocity	Additional Tank Vol.
		l/s	GPM	m	m	mm	m	m	m/s	m	mm	m	m	m/s	m3
Gu 2	San Jose Pinula	26.4	420	25	80	150	1,200	31.13	1.490	136.13	-	-	-	-	300
Gu 8	San Pedro Sacatepequez	14.8	230	60	40	150	1,200	10.66	0.840	110.66	-	-	-	-	-
Sa11	Santa Maria de Jesus	18.7	300	175	120	150	1,000	13.70	1.060	308.70	-	-	-	-	540
Ch 3	San Martin Jilotepeque	15.5	250	95	50	150	1,300	12.58	0.880	157.58	-	-	-	-	-
Ch 4	San Juan Comalapa No. 1	11.3	180	105	60	150	1,100	5.93	0.640	170.93	150	3,315	-	-	-
	San Juan Comalapa No. 2	11.3	180	105	80	150	1,200	6.47	0.640	191.47	100	4,455	-	-	270
So 1	Solola No. 1	12.6	200	100	0	150	30	0.20	0.710	100.20	150	2,500	59.50	1.430	1,040
	Solola No. 2	12.6	200	100	-20	150	1,100	7.25	0.710	87.25	-	-	-	-	-
So 4	Santa Lucia Utatlan	4.0	60	140	80	100	900	5.11	0.510	225.11	100	1,000	20.49	1.020	169
To 5	Momostenango No. 1	11.3	180	140	80	150	800	4.31	0.640	224.31	-	-	-	-	-
	Momostenango No. 2	11.3	180	140	80	150	1,200	6.47	0.640	226.47	-	-	-	-	180
Qu18	San Francisco la Union	3.1	50	180	100	100	1,000	3.54	0.390	283.54	-	-	-	-	90
Qu21	Genova	8.9	140	120	50	150	1,000	3.46	0.500	173.46	100	800	19.97	2.270	130

* Distance from well to distribution tank

8.2 Project Site Description

The existing social and natural environmental conditions and the present situation in the project sites that contribute to environmental pollution are detailed in Table 8.2.1.

8.2.1 Social Environment

(1) General

Twenty-one Maya groups live in Guatemala, mainly in the central highlands and northern parts of the country.

The ten prioritized municipalities are located in the central highland and the majority of the population is indigenous (Quiché, Kakchiquel, Kekchí and Mam - 60 to 100%), except for the population of San José Pinula where the majority is of European descent.

Each group has its own Maya idiom, but the main languages spoken in these municipalities are Spanish, El Quiché (S.F. La Unión and Momostenango), Kakchiquel (S.P. Sacatepéquez - 98%, Sololá and S.L. Utatlán), Kekchí and Mam (Génova - 60%).

In the rural area, there are generally more indigenous people than European descendants, who are concentrated in the urban areas. The percentage of indigenous people in the total population is lower in urban areas than the average ratio in the whole municipality.

Indigenous people still practice their traditional ways. The life style, standard of living and economic status of the indigenous people and European descendants greatly differ.

The majority of the population are Christians, although tribal religious practices still prevail. Catholics make up 40 to 90% and protestants 15 to 60% of the population (Table 8.2.2).

Christian holidays and festivals are often celebrated, indicating the extensive influence of Christianity on the peoples' lives. For example, only less than 1% of the population divorce, and birth control measures were pretty difficult to implement (mean family number is 7 - 12 members/family).

The education system in Guatemala has recently progressed. Now there are schools for primary and secondary education. Nevertheless, only a small percent of children can go to school, especially girls, in the central highland area (Table 8.2.3). Consequently, the indigenous people have very few job opportunities.

The main industry in the 10 municipalities is agriculture. Recently, however, a variety of industries, and consequently occupation, have been established in the urban area, particularly in S.P. Sacatepéquez where fabrics are manufactured and marketed in Guatemala City.

The average income in each municipality is not very high and varies widely from 400 to 1,200 Q/month.

As previously mentioned, only a small percent of the girls in the central highland get educated and there are also few jobs for them. Consequently, most of these girls follow their mothers' footsteps.

Most of the girls in the municipalities marry young, from 14 to 23 years old (18 - 20 years old is the average marrying age).

Women in these municipalities only started working recently, and they are usually employed in government offices: 15 women in Sololá, 70 in Comalapa, 15 in S.L. Utatlán, 40% of the total population of women in Momostenango and 50 in Génova. Only a few hold important jobs or positions however.

The mean salary of women is very low, ranging from 380 to 750 Q/month.

(2) Public facility service

1) Electric condition

Almost all of the urban areas of these municipalities are commonly supplied with electricity; about 100% of households are connected to the electric line. The average percentage of households in the rural areas and the entirety of Guatemala receiving this service ranges from 18 to 79% (1992 - 1993) and 49%, respectively.

Although the electric fee is very high (15 to 80 Q/month in the sites), people pay for it.

With the exception of Guatemala and S.P. Sacatepéquez, electric services for the municipalities are controlled by INDE, a partly government and privately operated institution. INDE cuts the electricity of those who do not pay their bills.

2) Telecommunication and radio

A telephone system has been developed in the last 6 years. Except for Guatemala City, however (where private lines have been installed in 20% of the area), only a few private lines have been installed in these prioritized municipalities.

Generally, people use public and community telephones, telegrams and radios, although only a few of these facilities are installed. S.F. La Unión is not equipped with a telephone system; people are therefore, largely dependent on telegrams, which can be sent from the post office (open 2 days a week), for outside communication.

GUATEL offices offer public telephone services in several municipalities.

GUATEL offices work in:	S.J. Pinula, S.P. Sacatepéquez, S.J. Comalapa, Sololá and Momostenango
Office not established in:	S.M. de Jesús, S.M. Jilotepéquez, S.L. Utatlán, S.F. La Unión and Génova

3) Mailing system

All of the municipalities are established with a post office; however, some are only open several days a week. Mailing system is not well developed, and delivery in the rural areas is not especially systematized. People, therefore, independently deliver and collect their mails and parcels.

4) Transportation and road

Road transportation is the main means of transportation in Guatemala. People usually use buses for transport and even shipment of agricultural products and domestic animals; the latter is usually loaded on the roof of the bus.

Only the central part of the municipal urban areas are paved, mainly with stones and a few with asphalt or concrete.

On special occasions, e.g., market days, people use pick-up trucks. These pick-up trucks are usually fully loaded with people and agricultural products.

S.J. Pinula, S.P. Sacatepéquez, Sololá and Momostenango are considered to have good road conditions. Génova is considered to have quite good road conditions while S.M. de Jesús is rated with fairly good, S.J. Comalapa, S.M. Jilotepeque and S.L. Utatlán with poor to fair, and S.F. La Unión with poor road conditions.

5) Waste collection

The municipalities have no waste collection services, except for a few areas where the services have just begun. Waste collected in these areas however are discarded in abandoned areas and not to a specified disposal site.

(3) Public sanitation

1) Water supply

Fifteen to 77% of the total households are supplied with potable water by the water systems in these municipalities. Supply services, however, are limited to the urban areas.

The water supply sources in these municipalities for drinking and domestic use are springs and deep wells, although the amount is not enough (Table 8.2.4).

Due to shortage in supply sources, the supply time is limited. The shortest is 1.5 hours every 2 days in S.M. de Jesús and the longest is 12 hours a day in Sololá. The supply amount ranges from 28 liters per capita per day (l/c/d) (S.F. La Unión) to 126 l/c/d (S.J. Comalapa).

To cope with the supply shortage, the residents dig their own private shallow wells or use water from private springs or rivers (Table 8.3.2). In Génova, about 25% of the households have their own shallow wells (200).

The residents pay water charges ranging from 0.6 (Génova) to 10 (S.M. de Jesús) Q/month. They also indicate willingness to pay more in the future if the water supply service level is upgraded.

2) Sewer and sanitary systems

Fifty (S.M. de Jesús) to 100% (Génova) of the households in the municipal urban areas, except S.F. La Unión, are connected to sewer systems. The 3 types of sewer systems are mentioned in 8.3.3.

About 25% (Momostenango) to 75% (Sololá) of houses have flush toilets, and the rest still use the pit latrines.

The sewer systems drain the wastewater of these municipalities directly into rivers, streams and lakes without any treatment, except in S.J. Comalapa and Sololá, which are equipped with simple wastewater treatment plants.

The plant in Comalapa, however, only treats wastewater during the day, while the plant in Sololá only treats less than half of the total amount of wastewater discharged into its waters.

This untreated wastewater condition seriously pollutes the waters of the 10 municipalities.

3) Health care

Health care conditions in these areas are still very poor. There are only a few public and private hospitals. The municipalities, however, are equipped with at least one health center, although without a resident doctor. Some of

these centers are only open once a week (Table 8.2.5).

4) Diseases

The common diseases in this area are acute diarrhea, respiratory infections, intestinal infections and skin diseases.

Only a low percentage of mortalities caused by these diseases are recorded, especially diarrhea in children, which people know is mainly caused by insanitary water. Intestinal infections are also caused by lack of potable water.

A high percentage of the children in several municipalities are presently observed to be malnourished. The improvement of the quality of water used in these areas for drinking and domestic purposes will significantly reduce the prevalence of the aforementioned diseases.

8.2.2 Natural Environment

(1) Topography

The land area of Guatemala is naturally divided into 3 regions: the coastal plains of the south, the Central Plateau, and the forestal plains of the north. The areas around the project sites are situated in the Central Plateau.

The Central Plateau Area, occupying about one tenth of the country, is composed of groups of mountainous highlands and intramountain basins with elevations ranging from 800 to 2,400 meters above sea level. The project sites are mainly located in the intramountain basins, except the municipalities of Santa María de Jesús, Sololá and Génova.

The municipality of Santa María de Jesús is situated on the flat plain (Sabana Grande) enclosed by mountains with steep slopes. This flat plain is presumably formed from an old crater lake filled up with the Quaternary volcanic rocks of Volcan de Agua and alluvial deposits. The municipality of Sololá is situated on a flat plateau with an elevation ranging from 2,300 to 2,400 meters above sea level, extending to the northern caldera wall of Lake Atitlán. The municipality of Genóva is situated on a flat plain on the foot of Quaternary volcanoes, with an elevation ranging from 300 to 400 meters above sea level.

The river system originating from the central mountain belt and flows into the Caribbean Sea (Río Pixcayá, Río Las Vacas, and Río Los Plátanos) has relatively gentle flow, while those flowing into the Pacific Ocean (Río Samala, Río Coyolalate, Río Guacalate, and Río Acuacapa) generally have rapid flow. Most of the rivers are severely contaminated with untreated sewage and waste discharge.

(2) Geology/Hydrogeology

The project sites are composed mainly of the Tertiary volcanic and Quaternary volcanic rock groups.

The Tertiary volcanic group is composed of basaltic to rhyolitic lava flows, pyroclastic flows, tuffbreccias and tuffs, and clastic sediments such as tuffaceous sandstone and mudstone. The thickness of this group varies by place depending on its origin and the places of volcanic eruption. Rocks of this group are in part highly fractured and form local water-bearing zones (lower aquifer). The Quaternary volcanic group is divided into 3 sub-groups: Pleistocene volcanic (Qp), Holocene volcanic (Qv), and alluvial deposits (Qa).

Pleistocene volcanic layer in the concerned area is composed mainly of pumice sediments, (fall deposits and pyroclastic flow types) which are generally solidified and partially contain lake deposits. The area is extensively but thinly overlain, a few to 30 meters, by these Pleistocene volcanic layer (Qp), which is intercalated with the upper aquifers of springs and shallow wells.

Holocene volcanic layer (Qv) is composed of basaltic to andesitic lava flows, pyroclastic flows, volcanic mud flows (lahare deposits), and volcanic ashes. The areas of Santa María de Jesús and Génova consist of these Holocene volcanic layers (Qv).

The main aquifers being targeted for groundwater development in the project sites are the lower aquifer of Tertiary volcanic rocks and the upper aquifer of Quaternary volcanic rocks (Santa María de Jesús and Génova).

The characteristics of these aquifers were determined based on the test well drilling and pumping test, and are shown in Table 8.2.6.

The waters of springs and shallow wells originate from the shallow aquifers of pleistocene pumice sediments in the project sites. However, the groundwater development potential of the shallow aquifer is generally low because it is a thinly sedimented layer with highly diversified lighological facies and seasonal fluctuation in water table.

(3) Meteorology

The average, maximum and minimum temperatures and annual rainfall in the project sites are shown below.

	Annual Rainfall (mm)	Temperature (°C)		
		Average	Maximum	Minimum
Guatemala	1,200	18.3	24.4	14.4
Chimaltenango	970	16.3	22.6	9.5
Quetzaltenango	840	13.3	21.7	5.8
Flores Costa Cuca	3,600	24.5	30.1	18.9

The rainy season usually begins in May and terminates in October. The monthly rainfall peaks twice, in June and September.

(4) Land Use Features

The land use pattern in most of these municipal areas are similar. Municipal towns are basically characterized by a "plaza" downtown, along with churches and public offices and are surrounded by commercial stores. Many villages are sporadically spread in the town proper.

Principally, the municipalities are surrounded with agricultural lands (mini-farms) and pasture or shrubberies.

As for land use conditions in the municipality of San Pedro Sacatepéquez, agriculture, including vegetable cultivation and horticulture, is predominant. The cultivated crops are sent to more profitable markets in Guatemala City.

Coffee is also a valuable product in Guatemala and is cultivated in large plantations in Génova.

(5) Water Resources

The rivers and streams flowing in the project sites are tertiary or smaller tributaries. The flow rate of the rivers in the dry season is extremely reduced and severely polluted by untreated sewage and waste discharge. Therefore, the main water supply source in the project sites is groundwater from springs, shallow wells, and deep wells (boreholes).

The present water use conditions and the groundwater development potential in each project site are shown in Table 8.2.1

Table 8.2.1 Site Description (1)

Municipality: **San José Pinula**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q1.00/month/connection payment - Q15.00/month/service in the future
	Existing water supply facilities and electrical conditions and so on	- Water sources: 3 wells capacity of 17.772 l/sec - Distribution systems: 2 tanks (concrete 750 m3) combination system by gravity supply from tanks and direct supply from well Number of house connection: 1,557 - Road and electricity: Good conditions
	Present sanitary conditions public facility services and sewerage, etc.	- Health center: 1, Public clinic: 2, Private clinic: 2 - Sewerage system exists in the central part, but sewage is discharged into the river without any treatment - Public facility service: Quite good
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area and its surroundings are situated on a plateau consisting of the pumice sediments of the pleistocene volcanic - There is a fault system, but there are neither alluvial clay beds nor swamps
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quantity and quality, precipitation	- Groundwater: Present use-787 m3/day, pH 6.2, EC 92μ℧. Total potential of groundwater development in the area is about 6,912 m3/day - Spring: 2 springs for local use, pH 6.0, EC 220μ℧. Precipitation 1,650 mm
	Existence of rare animals and plants, and their habitats	No existence of precious animals and plants
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- Some implementation for improvement of the existing sewerage is on-going - Construction works of new distribution tank is on-going, which can be used in this project

Table 8.2.1 Site Description (2)

Municipality: **Sololá**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Water supply conditions: 12 hrs/day supply, 113.94 l/c/d - Water tariff: Q 3.25/connection/month - Willingness for G/W development is very high due to waterborne disease etc.
	Existing water supply facilities and electrical conditions and so on	- Water sources: 2 springs of capacity of 30.4 l/sec - Distribution systems: 2 concrete tanks (590 m3) perfectly gravity supply system Number of house connection: 1,449 - Road and electricity: Good condition
	Present sanitary conditions public facility services and sewerage, etc.	- Public service: Quite good condition - Sewerage system: In the urban area - Waste water: Directly to Atitlan Lake - Treatment plant: Under construction - Many schools and high attendance rate
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area and its surroundings is situated on a flat Plateau consisting of pumiceous volcanic materials of the Pleistocene and the Tertiary volcanic - There is a fault system, but there are neither alluvial clay deposits nor swamps
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quantity and quality, precipitation	- Groundwater: Estimated potential of groundwater development in the area is 6,871 m3/day - Spring: 2 springs for domestic use capacity 30.4 l/sec, pH 6.0, EC 10 μU 1 spring for agricultural use - Precipitation 1,081 mm
	Existence of precious animals and plants, and their inhabitable areas etc.	- Main fish in the lake: Black-bass
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- Some implementation for improvement of the existing sewerage is on-going - Construction is a request for well construction project, which is still being considered by INFOM

Table 8.2.1 Site Description (3)

Municipality: **Momostenango**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Water supply condition: 3 hrs/day in dry season, 68.58 l/c/d - Water tariff: Q3/connection/month - Willingness to pay and municipal financial capacity are both high
	Existing water supply facilities and electrical conditions and so on	- Water sources: 2 springs of capacity of 14.2 l/sec, 1 spring by pumping-up, other on by gravity - Distribution systems: Two concrete tanks (700 m3), Number of house connections: 600 - Road and electricity: Good condition
	Present sanitary conditions public facility services and sewerage, etc.	- Public service: Quite good - Sewerage system: For 200 houses, directly to river: 400, house permeable type toilet - Electricity: Ca. 100% in urban area (Q30 - Q40/month) - Community telephone: 4 GUATEL offices - Post office: delivery men
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area and its surroundings are situated on the mountainous high land consisting of the tertiary volcanic rocks - There are many faults, but there are neither alluvial clay deposits nor swamps
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Estimated potential of groundwater development is 5,511 m3/day - Spring: 2 springs, capacity of 14.2 l/s, pH 6.5, EC 94 μU Precipitation 1,341 mm
	Existence of precious animals and plants, and their inhabitable areas etc.	Plantation of pine trees
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- There is a hot spring (48.1°C, pH 6.5, EC 94 μU) that is well used by the inhabitants of the area

Table 8.2.1 Site Description (4)

Municipality: **San Pedro Sacatepéquez**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q1.50/connection/month, 14 hrs/day, 45.55 l/c/d - Professional workers with high income, there is high probability to pay more for the water service
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 well (6.4 l/sec), 3 springs (4.24 l/s) of gravity type, 3 collection tanks - Distribution systems: Two concrete tanks (850 m3), 1,625 connections - Road and electricity: Good condition
	Present sanitary conditions public facility services and sewerage, etc.	- Sewerage system: 70% in urban; in rural area permeable type toilet - Coliform bacteria were found in both water house connection and in public faucets - Public service: It seems to be quite good, but there is no rubbish collection
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area and its surroundings are situated in the mountainous high land consisting of the Tertiary and Quaternary volcanic - There are faults and swamps, but no thick alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Present use 98 m3/day, pH 6.3, EC 149 μU Estimated potentiality for G/D 1,470 m3/day - Spring: 3 springs for domestic (4.24 l/s, pH 6.5, EC 114 μU) Many springs for agricultural use - Precipitation 1,032 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	- There is a kind of oak trees in the mountain side, but they are not precious
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		An improvement of existing sewerage system is recommended

Table 8.2.1 Site Description (5)

Municipality: **Santa María de Jesús**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Water supply condition: 1.5 hrs/4 days, 35.43 l/c/d - Water tariff: Q10/connection/month - Women feel that is a hard work to carry water from public faucet
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 well (6.0 l/sec), 2 springs (1.5 l/s) of gravity type - Distribution systems: 1 tank (240 m3) - Roads and transportation: Fairly good condition
	Present sanitary conditions public facility services and sewerage, etc.	- Sewerage system: Only in the central part - Public service: Fairly good - Diarrhea and intestinal disease by parasite often occur - School attendance: very low
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area is located on the foot of the Volcano de Agua and the project site is located in the alluvial plain surrounded by mountains, that can be considered to be an old semi-closed water area, so that, alluvial clay beds may be existing
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Present use (394 m3/day, pH 7.0, EC 328 μ℧ Estimated capacity of groundwater development 2,160 m3/day - Spring: 2 springs (1.5 l/s) - Precipitation 1,229 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	Negligible
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		

Table 8.2.1 Site Description (6)

Municipality: **San Juan Comalapa**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q2.00/month/service, (4 hrs/day, 126.24 l/c/d - If service is improved, the people are willing to pay for it. Their willingness to pay is very high
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 well (5.80 l/sec), 2 springs (34.00 l/s) by gravity and pumping up - Distribution systems: 3 concrete tanks (1,420 m3), 1,164 connections - Roads condition: Poor-Fair, Electricity: Good condition
	Present sanitary conditions public facility services and sewerage, etc.	- Sanitary conditions: looks very good - Sewerage system with treatment system exist - Rubbish is not found in the town; Public service: good - Hospitals, schools, post offices, market, etc. Peoples activity looks very high
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The city area and its surroundings are situated on the mesas in the intramountain basin (Río Pixcaya), consisting of the Tertiary volcanic and pumiceous materials of the Pleistocene volcanic - There are faults but not alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Present use 167/day, pH 6.5 EC 120 μ℧ Estimated potentiality of groundwater development 3,240 m3/day - Spring: present use 1,689 m3/day, pH 6.0, EC 140 μ℧ - Precipitation 1,414 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	- There were found many pine trees
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		

Table 8.2.1 Site Description (7)

Municipality: **San Martín Jilotepeque**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q2.50/month/service, (5.5 hrs/day, 103.44 l/c/d - Q10.00/month/service could be paid in the future
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 well (18.90 l/sec), 3 springs by gravity (fair amount) - Distribution systems: 1 concrete tank (600 m3), 1,300 connections - Road condition: Poor-Fair - Electricity: Good condition
	Present sanitary conditions public facility services and sewerage, etc.	
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The area is situated on the mesas in the intramountain basin (Río Pixcaya), consisting of the Tertiary volcanic and the pumiceous volcanic material of the Pleistocene - There are faults, but not thick alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Present use 641 m3/day, pH 7.0 EC 167 μU Estimated potentiality of groundwater development 2,808 m3/day - Spring and river: Urgent use only in dry season - Precipitation 1,272 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	None
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- There is a strong request for additional well construction project financed and supervised by INFOM

Table 8.2.1 Site Description (8)

Municipality: **San Francisco La Unión**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q5.00/month/service, 1 hr/2 days, 27.94 l/c/d
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 spring (see pages) of 0.51 l/sec capacity by pumping-up - Distribution systems: 2 concrete tanks (55 m3) - Road condition: Poor - Electricity: Good condition - House connection 102 (100% in urban) - Public faucet: non; many houses have both private well and water service
	Present sanitary conditions public facility services and sewerage, etc.	- Public service: Poor - Sewerage system: Non exist
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The area is situated on the cuestas in the intramountain basin of Río Samala system consisting of the Tertiary volcanic and the pumiceous volcanic materials of the Pleistocene - There are faults but not thick alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Estimated potentiality of groundwater development 1,403 m3/day - Spring: Present use 48 m3/day, pH 6.5, EC 127μ℧ (Water intake from seepage) - Precipitation 843 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	None
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- There is a strong request for improving the very poor conditions of present water supply by groundwater development

Table 8.2.1 Site Description (9)

Municipality: **Genóva**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q0.6/month/service, 2 hrs/day, 54.20 l/c/d - Until Q15.00/month could be paid
	Existing water supply facilities and electrical conditions and so on	- Water sources: 1 spring of 3.03 l/sec capacity by gravity type - Distribution systems: 12 concrete tank (140 m3), 358 connections
	Present sanitary conditions public facility services and sewerage, etc.	- Public service: Quite good - Sewerage system exist in the central part (80%) but, without any treatment
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The area is located on a foot of quaternary volcano consisting of andesitic to basaltic lava flows and pyroclastic of the Holocene - There is no thick alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Estimated potentiality of groundwater development 12,960 m3/day - Spring: Present use 206 m3/day, pH 6.0, EC 89 μ℧ - Precipitation: 3,640 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	No existence of precious species. There are plantations of coffee and rubber trees
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- The water resources of spring type are mostly occupied by the owners of private farms

Table 8.2.1 Site Description (10)

Municipality: **Santa Lucía Utatlán**		Site description
Social Environment	Present situation/willingness to pay O/M by municipal inhabitants	- Q3.00/month/service, 1 hr/2 days, 39.22 l/c/d - Available financial resources
	Existing water supply facilities and electrical conditions and so on	- Water sources: 3 springs of 1.88 l/sec capacity by gravity type - Distribution systems: 3 concrete tanks (90 m3), 149 connections - Road condition: Poor-Fair - Electricity: Good
	Present sanitary conditions public facility services and sewerage, etc.	
Natural Environment	Topographical and geological aspect. (Existence of steep slope, alluvial clay beds, swamps, and faults)	- The area is located on the mesas in the intramountain basin of Rio Quiscab consisting of the Tertiary volcanic and the pumice deposits of the Pleistocene volcanic - There are many faults but there are no alluvial deposits
	Present condition of water resources (groundwater, spring, lake and river water) in terms of quality and quantity, precipitation, etc.	- Groundwater: Estimated potential of development 2,160 m3/day, pH 6.0, EC 82 - 108 µ℧ (very limited seepage type) - Precipitation: 1,341 mm/year
	Existence of precious animals and plants, and their inhabitable areas etc.	None
Environmental Pollution	Present situation for the problems of environmental pollution	None
	Countermeasures/compensations for above problems	None
Remarks		- There is a strong request for groundwater development due to the existing poor water source of spring (very limited seepage type)

Table 8.2.2 Breakdown of Religious Groups in the Ten Municipalities (%)
(by interview)

Municipality	Catholic	Protestant	Others
S.J. Pinula	80	15	5
S.P. Sacatepéquez	75	25	0
S.M. de Jesús	85	15	0
S.M. Jilotepéque	-	-	-
S.J. Comalapa	85	15	0
Sololá	65	35	0
S.L. Utatlán	55	40	5
Momostenango	80	15	5
S.F. La Unión	80	20	0
Génova	40	60	0

Table 8.2.3 Educational Situation in the Ten Municipalities

Municipality	No. of Schools				No. of Students			
	Primary		Secondary		Secondary		University	
	Public	Private	Public	Private	Girl	Boy	Girl	Boy
S.J. Pinula	-	-	-	-	-	-	-	-
S.P. Sacatepéquez	8	3	0	3	40	60	5	15
S.M. de Jesús	-	-	-	-	3	5	0	0
S.M. Jilotepeque	-	-	-	-	-	-	-	-
S.J. Comalapa	-	-	-	-	15	20	2	6
Sololá	ca.56	4	3	4	20	40	0.5	2
S.L. Utatlán	-	-	-	-	15	85	0	1
Momostenango	1	4	1	1	40	60	-	-
S.F. La Unión	4	1	0	1	10	20	-	-
Génova	24	2	0	3	60	40	0	0

Table 8.2.4 Water Supply Condition in the Ten Municipalities

Municipality	Water Source	House Connect. (houses)	Supplying Period (hr)	Water Supply Volume (lts/p/d)	Water Charge (Q/connect./ month)
S.J. Pinula	W-4[1)]	1,557	4	69.8	1.0
S.P. Sacatepéquez	S-3 W-1	-	8 - 16	45.6	1.5
S.M. de Jesús	S-2 W-1	780	1.5/5 days	35.4	10.0
S.M. Jilotepéque	S-3 W-1	1,300	5.5	117.0	2.5
S.J. Comalapa	S-2 W-1	1,164	4	126.2	2.0
Sololá	S-2	1,149	12	113.9	3.25
S.L. Utatlán	S-4	149	1/2 days	85.3	3.0
Momostenango	S-2	600	3 - 12	68.6	3.0
S.F. La Unión	S-1	100	1/2 days	27.9	5.0
Génova	S-7	358	2	54.2	0.6

1) W - Well, S - Spring

Table 8.2.5 Number of Hospitals, Clinics, Health Centers and Pharmacies in the Ten Municipalities (by interview)

Municipality	Hospital		Clinic		Health Center	Pharmacy
	Public	Private	Public	Private		
S.J. Pinula	0	0	2	9	1	8
S.P. Sacatepéquez	-	-	-	-	-	-
S.M. de Jesús	0	0	0	0	0	0
S.J. Comalapa	0	1	0	4	1	9
Sololá	1	1	1	5	1	10
S.L. Utatlán	0	0	0	0	1	4
Momostenango	1	0	0	4	1	5
S.F. La Unión	0	0	0	0	1	2
Génova	0	0	0	0	1	0

Table 8.2.6 Results of Pumping Test

Nobre de Pozo (Well Name)	San Jose Pinula	S.P.Saca-tepequez	S.Maria de Jesus	S.M.Jilo-tepeque	San Joan Comalapa	Solola	Santa Lu. Utatlan	Momoste-naogo	S.F.la Union	Genova
1. Profundidad (Well depth) (m)	180	250	212	196	215	170	199	183	190	152
2. Longitud de rejilla (Total Screen Length) (m)	79.27	60.97	81.68	82.32	100.6	48.78	43.91	59.9	100.5	51.82
3. Formation del Aquifero principal (Formation of Main Aquifer)	Tv	Tv	Qv	Tv	Tv	Tv	Tv	Tv	Tv	Qv
4. Fecfa de Bombeo (Pumping Test Date)	Oct. 5 1994	Oct. 7 1994	Nov. 2 1994	Oct.28 1994	Nov.30 1994	Nov.19 1994	Nov.25 1994	Dec. 8 1994	—	Dec.11 1994
5. Nivel estatico de Agua (Static Water Level) (G.L.-m)	6.84	43.71	163.16	80.35	28.94	71.63	131.54	53.50	—	29.85
6. Caudal (GPM)	495	320	282	401	250	390	162	200		201
(Pumping Rate) (m³/day)	2698	1744	1537	2185	1363	2125	883	1090		1096
7. Abatimiento (Drawdown) (m)	11.9	67.29	3.53	9.63	156.4	54.86	9.13	70.3	—	88.36
8. Capacidad Especifica : C.F. (Specific Capacity : Sc)(m³/day/m)	227	26	435	227	8.7	39.7	96.7	15.5	—	12.4
9. Transmisibilidad (Transmissivity) (m³/day) a. Theis	299	33	150	510	5.51	25.22	228	15.43	—	10.74
b. Jacob	180	37	612	333	5.31	25.09	359	7.12	—	9.55
c. Recuperacion (Recovery)	190	68	937	834	7.34	35.35	538	8.67	—	15.42
Promedio(Average)	223	46	567	559	6.05	28.55	375	10.41	—	11.99

8.3 Environmental Impact Evaluation

In order to duly consider the environmental impacts of the groundwater development project, an Initial Environmental Examination (IEE) was conducted in the 10 prioritized municipalities during Phase I of the Study. The IEE results are summarized in Table 8.3.1.

Based on the IEE results, the following environmental surveys were conducted in the 10 municipalities for Environmental Impact Assessment.

a. Present condition and utilization of the shallow wells and springs located in the vicinity of the proposed boreholes.

b. Domestic sewage condition including quantity of sewage and physical analysis.

c. The effects of noise, ground vibrations, etc., generated by project related activities, on buildings and land use.

8.3.1 Impact on Shallow Wells and Springs (a.)

The following items were surveyed by area.

- Number of shallow wells and springs in the vicinity of the proposed boreholes
- Water right and utilization of shallow wells and springs
- Hydrogeological conditions such as aquifer characteristics, water level and water quality of shallow wells and springs

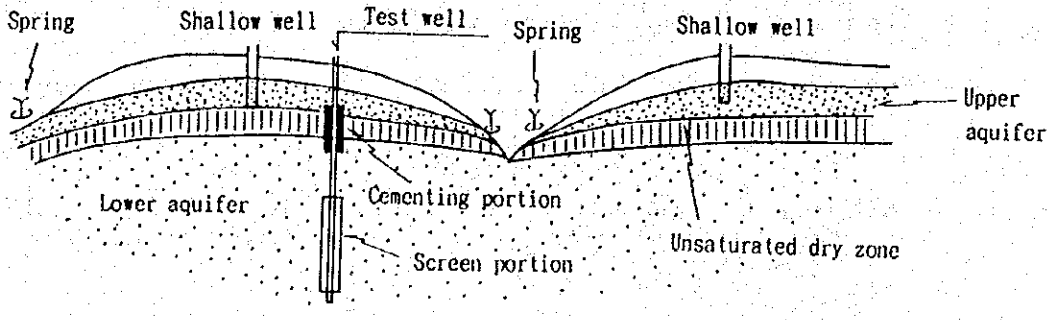
The results are summarized in Table 8.3.2. As shown in this table, there are many shallow wells and springs which are used for domestic and agricultural purposes. However, the construction of deep wells will not affect these shallow wells and springs due to the following hydrogeological conditions.

(a) The water of the existing shallow wells and springs in the areas are from the shallow (upper) aquifer which consists of alluvial deposits (Qa) and pumice sediments (Qp), and located at the weathered upper layer of Tertiary volcanic rocks.

(b) The screen of the deep wells are installed in lower aquifers which belong to the formation of Tertiary volcanic rocks (Qv). These lower aquifers are unconfined or semi-confined aquifers.

(c) An unsaturated dry zone separates the upper and lower aquifers.

(d) Groundwater will leak from the upper aquifer to the lower aquifer through the unsaturated dry zone, but artificial leakage can be mostly prevented by cementing, as illustrated below.



8.3.2 Impact on Domestic Sewage (b.)

The residents of the 10 municipalities were interviewed on the function and condition of existing sewers for domestic waste, in order to evaluate the impacts on the quality and quantity of domestic sewage.

(1) Present situation of sewer system

Quite a high percentage of households in nine out of ten municipalities have sewer systems (50 - 100%), except in S.F. La Unión.

These sewer systems are grouped into three types: Type-1: the sewer system for human and domestic wastewater, Type-2: the combined system for rainwater and domestic wastewater, and Type-3: the separate system for human/domestic wastewater and rainwater. Type-3 is found only in S.P. Sacatepéquez (Table 8.3.3).

The exact number of households with flush toilets is not clear, and it is also unknown whether supplied water or stored water (hauled water) is used for flushing. However, since Guatemalan houses have the shower and toilet together in one room, it is probably safe to assume that the number of households with showers would be the same as the number of households with flush toilets. Génova, however, is an exception, as 25% of the households are only installed with flush toilets. These flush toilets are connected to the sewers.

Except in S.J. Comalapa and Sololá, these sewer systems have no sewage treatment systems, thereby directly discharging collected sewage into streams, rivers and lakes, and consequently polluting surface water.

The plant in Comalapa was built by INFOM in 1982 and is only operated during the day. Sewage is therefore left to flow directly into the river untreated at night. Even though the sewage amount at night is insignificant, raw sewage discharge may still seriously pollute river water.

The plant in Sololá was completed at the end of 1994. However, this plant is intended to treat only half of the total sewage amount from Sololá municipality. The other half will be treated by another plant, which is still being planned.

Since the pollution of the water of Lake Atitlán is becoming a matter of concern, the sewer treatment project in Sololá should be immediately carried out.

(2) Sewage quality and quantity

Information on sewage quality was obtained by interview (% of households and population in the municipal urban area) to obtain the component ratios of sewage, which are generally made up of wastewater from toilets, kitchens, bathrooms and private and public washing places.

A large percentage of this sewage type is covered by waste water from kitchens and private and public washing places (56 - 100%). Wastewater drained through sewer systems of several municipalities usually contain rainwater (Table 8.3.3).

S.F. La Unión has no sewer system. Therefore, waste from kitchens, washing places and showers are either naturally drained into rivers or infiltrate the ground. Human excreta is excluded here, however, because the residents in this municipality still use pit latrines.

The amount of sewage can be generally estimated as nearly equal to the amount of water domestically used. The municipality, however, has no records on the amount of water domestically used due to the absence of water meters, and the fact that residents pay water fees according to the number of taps installed in the house.

During the study period, the consumption rate of domestic water was measured in order to evaluate the sewage quantity in San José Pinula (in August and December) and Sololá (three kinds of monthly readings: from February to December, daily readings from 30 November to 20 December and readings on 30 November and 21 December were obtained), where water meter systems are installed.

Several houses were selected for the measurement, and these houses were categorized into three types.

Type-1: houses with a single tap
Type-2: houses equipped with multiple taps including tap for shower

Type-3: houses equipped with multiple taps including the one for the toilet

Measurements carried out in August, the rainy season, showed that the mean water consumption of Type I is the lowest at 50 ℓ/c/d, compared to Type II which has 146 ℓ/c/d. Measurements in the dry season did not significantly vary as the mean water consumption rate of the houses ranged from 138 - 198 (Tables 8.3.4 - 5).

Water consumption in Sololá, hardly showed any significant differences either by season or house type. The mean of all readings was 144 lts/p/d (Table 8.3.5).

Although the consumption rate was only measured in two municipalities, the amount obtained was a lot greater than assumed, mainly because the value used to represent the number of family members using 1 connection was an estimate. Actual observations show that more than 1 family may use 1 connection. Therefore, the actual value, as well as the water supply volume, may probably be smaller than the value recorded.

Consumption amount of domestic water, therefore, was considered equal to the supplied water amount.

Sewage amount is consequently roughly considered to be equal to the supplied water amount.

Supply amount, and the sewage drained through the sewer system is estimated within a range of 50 to 100 percent, varying mainly by the type of toilet. In municipalities without drain systems, the percentage is regarded as zero. The present sewage amount and increased sewage amount is tabulated in Table 8.3.6 and 8.3.7. Sewage amount after water supply amount is increased is estimated using the same factors used in the estimation for the present sewage amount. In the present sewage amount estimation, the population, percentage of households connected to the sewer system and other factors were determined based on the interview results listed in Table 8.3.3.

The same estimation was tried for 2010, assuming that the population growth rate will be as estimated and all municipalities are equipped with sewer systems (Table 8.3.8)

In the urban areas of the ten municipalities, most of the rivers and streams are heavily polluted with sewage discharged from sewer systems without any treatment.

The amount of sewage discharged through the sewer systems will increase in accordance with the increase in water supply amount, even if the percentage of households equipped with faucets is as the present. The estimation is 1.1 (S.M. Jilotepéque) to 4.6 (S.M. de Jesús) times larger than the present amount after water supply amount is

increased.

Estimations for 2010 showed that the amount will be 1.5 (S.M. Jilotepéque) to 12.3 (S.M. de Jesús) times larger than the present.

Conclusively, sewage will be the most influential pollutant in the future. The pollution load, however, is observed to be improportionate to how progressive the polluted condition is in the area.

Pollution load is obtained by multiplying the sewage amount by the concentration of pollutants. Hence, an increase in water supply amount will not significantly affect pollution load.

Increase in population, however, may affect pollution load to a considerable extent.

8.3.3 Influence of the Construction Noise, Land Vibration, etc. (c.)

The effects of drilling noise and mud flow on populated areas were determined by interviewing residents living in the neighborhood of drilling sites in San José Pinula, San Martín Jilotepeque, San Francisco La Unión and Génova. The drilling sites are located within the town boundary of these municipalities.

None of the residents complained about the drilling activities, including drilling works carried out at night using a diesel engine generator. There were no complaints on mud either, because the drilling mud was mostly circulated in a closed system between mud pit and borehole, and any excess was properly drained.

The residents only complained about the wasteful use of water during well development works and pumping test.

It is concluded, therefore that the groundwater development project will not in any way adversely affect the living environment, as drilling works are presumed to have no serious impacts.

Land subsidence, which usually results from over pumping, will not occur because the wells will be drilled mostly in geological areas of volcanic formations without thick clay beds. Land subsidence is only possible if groundwater development is carried out in areas with wide and thick alluvial deposits, especially of clayey materials.

Table 8.3.1 Initial Environmental Impact Evaluation

		Items env. impact.	Eval.	Background/Remarks
Social Environment	1	Resettlements	D	Construction of new wells and transmission pipes can be implemented outside of residential area
	2	Economic activity	D	"
	3	Infrastructure	D	"
	4	Disturbance of community area	D	"
	5	Historical spots and cultural property	D	"
	6	Water right and right of common	B	The impact of the project on the existing adjacent dug wells and springs outside of Muni./City should be taken into consideration.
	7	Health and sanitation	D	Improvement can evidently be expected by the implementation of the project.
	8	Abandonments	D	Nothing will be abandoned from the implementation of the project.
	9	Disaster (risk)	D	Construction of new transmission pipes will mostly be carried out along the existing roads
Natural Environment	10	Topography and geology	D	Refer to item (9). There are no important topographical and geological features
	11	Land erosion	D	Refer to item (9)
	12	Groundwater, spring and perched water	B	The impact of the project on the existing dug wells and springs in surrounding areas should be taken into consideration.
	13	Swamp, lake, river	C	Impact from the sewage increase should be considered.
	14	Beach sea area	D	The project sites are located in the intramountain basins
	15	Animals and plants	D	New transmission pipes are constructed in the sub-ground; there are no precious animals and plants.
	16	Meteorology	D	Big scale disturbance or deforestation is not carried-out in the implementation of the project.
	17	Landscape	D	Same as item (16)
Environmental Pollution	18	Air pollution	D	Every well will be operated with Submersible motor pumps.
	19	Water pollution	D	Mud (muddy water) for well drilling is used in a closed circulatory plant
	20	Soil pollution	D	Same as item (19)
	21	Noise/lands vibration	C	The actual drilling works in Phase II should be considered
	22	Land subsidence	C	The project sites are not composed of alluvial deposits with thick clay beds
	23	Offensive odor	D	This item will not evolve due to the implementation of the project

Evaluation: A: Big/serious impacts can be considered
B: Some impact can be considered
C: Not evident, but consideration is necessary
D: No environmental impact

Table 8.3.2 Existing Shallow Wells and Springs

Municipality	Shallow wells						Springs			
	Number	W/Level (GL-m)	Well depth (m)	W/Quality	W/Right	Water Use	Number	W/Quality	W/Right	Water Use
S. J. Pinula	3	3–25	–	Poor *–1	Private	Agriculture–1 Bathing and washing–2	8	Poor	Public	Bathing & washing
S. P. Sacatepéquez	10	1–10	2.6–9	Good	Private	Agriculture–2 Domestic use–8	10	Good–7 Poor–3	Public–5 Private–5	W/S for city–5 Agriculture–3 Domestic use–2
S. M. de Jesús	0	–	–	–	–	–	0 *–2	–	–	–
S. M. Jilotepeque	3	3–20	6–22	Good–2 Poor–1	Private	Domestic use–2 for supplementary use–1	5	Good	Public–4 Private–1	Domestic use
S. J. Comalapa	26	3.6–10	4–12	Quite–good	Private	Agriculture–2 Domestic use–24	1	Quite–good	Public & private	Washing Drinking & domestic use
Sololá	3*–3	0.6–26	1.6–28	Quite–good	Private	Agriculture–1 Drinking & domestic use–1 Washing, bathing & cleaning–1	3	Quite–good	Public–3	Drinking & domestic use Agriculture
S. L. Utatlán	4	8.5–14.5	10–17	Good–1 *–4 Quite–good–3	Private	Drinking & domestic use–4	2	Good–2	Public–1 Private–1	Drinking Washing & domestic use
Momostenango	15<	3–16	6.5–18	Good & Quite–good	Private	Drinking & domestic use	1	Quite–good	Public	Drinking
S. F. La Unión	8	5–18	9–22	Quite–good	Private	Drinking & domestic use–8	2	Quite–good	Public	Drinking, washing & domestic use
					Public	Only drinking–1				
Génova	200	5–10	7–15	Quite–good	Private	Drinking & domestic use	0	–	–	–

*–1: Good – Potable, quite good – after boiling, poor – not used for drinking
*–2: A spring that was once used is now depleted
*–3: A spring was used until 1993, now it is depleted
*–4: 2% of population suffer stomach problems every month; 25% of which are children suffering diarrhea

Table 8.3.3 Condition of Existing Sewer System and Sewage in Ten Municipalities

Municipality	Households with Sewer Connection (%)	Type of Sewer System *-1	Population with Public Water for Washing & Bathing (%)	Population with Private Water for Washing & Kitchen use (%)	Population with Private Water for Washing, Kitchen use & B/Shower (%)	Sewage Quality	Sewage Treatment Plant
S. J. Pinula	95	Type-2	15	85	70	Waste Water from Toilet, W/K, B/Shower and Rain water	No
S. P. Sacatepéquez	90	Type-3	5	95	40	Waste Water from Toilet, W/K and B/Shower	No
S. M. de Jesús	50	Type-1	3 *-2	70	0	Waste Water from Toilet and W/K	No
S. M. Jilotepeque	80	Type-2	10	68	60	Waste Water from Toilet, W/K, B/Shower and Rain water	No
S. J. Comalapa	75 *-3	Type-1	25	75	75	Waste Water from Toilet, W/K, B/Shower and Rain Water	Filtration, treating 40% of the total amount of sewage
Sololá	85	Type-2	12	80	35	Waste water from Toilet, W/K, B/Shower and Rain Water	Filtration, treating half of the total amount of sewage
S. L. Utatlán	100	Type-1	30	70	50	Waste Water from Toilet, W/K and B/Shower	No
Momostenango	80	Type-1	50	50	25	Waste Water from Toilet, W/K and B/Shower	No
S. F. la Unión	0	-	16	40	4	-	-
Génova	100 *-4	Type-2	50 (0) *-5	75	50	Waste Water from Toilet, W/K, B/Shower and Rain water	No

*-1: Type-1: Sewer system only for human and domestic wastewater
Type-2: Combined sewer system for human and domestic waste and rain water
Type-3: Separate system for human and domestic wastewater from rain water
*-2: People go to rivers to bathe
*-3: 40% of the households in the urban area are connected to the private sewer system
*-4: 75% connected to toilet

Table 8.3.4 Amount of Water Consumption in S.J. Pinula

December, 1994

		Person/ Family	November (20 days)		Mean (lts./p/d)	
			(m3)	(ℓ/c/d)	Each Type	All
Type-I	House-1	8	12	75	138	156
	House-2	6	24	200		
Type-II	House-1	8	34	212	198	
	House-2	3	11	183		
Type-III	House-1	9	27	150	134	
	House-2	12	28	117		

Table 8.3.5 Amount of Water Consumption in Sololá

February - November, 1994

		Person/ Family	Mean Consumption (ℓ/c/d)			Mean (all) (ℓ/c/d)
			1	2	3	
Type-I	House-1	9	78	111	134	
	House-2	2	-	207	-	
	House-3	10	56	62	56	
	House-4	7	72	79	81	
	House-5	8	108	103	94	
	House-6	5	150	207	172	
	House-7	10	210	271	260	
Type-II	House-1	4	204	155	218	
Type-III	House-1	12	155	169	156	
Mean (ℓ/c/d)			129	152	146	144

Note: 1 Calculation based on monthly reading, from February to November 1994
2 Calculation based on daily readings in November 1994
3 Calculation based on readings on Nov. 30 and Dec. 20, 1994

Table 8.3.6 Estimated Sewage Amount Drained Sewer Systems in the 10 Municipalities in 1994

Municipality	Urban Population	Supplied Volume (ℓ/c/d)	Total Supplied Volume (m3/day)	Households with Sewer Connections (%)	Population using water for Washing, Kitchen use and B/shower (%)	Wastewater from Washing, Kitchen, B/Shower and Toilet (m3/day)*-1	Population connected to Sewer System not for Human Waste (%)*-2	Wastewater without Human Waste (m3/day)	Total Amount of Waste water (m3/day)
S. J. Pinula	11,277	69.81	787	95	70	551	25	198	749
S. P. Sacatepéquez	7,652	45.53	348	90	40	139	50	174	313
S. M. de Jesús	11,107	35.43	394	50	0	0	50	187	187
S. M. Jilotepeque	9,236	116.98	1,080	80	60	648	20	216	864
S. J. Comalapa	14,710	126.24	1,857	75	75	1,393	0	0	1,393
Sololá	15,254	113.94	1,738	85	35	608	50	868	1,476
S. L. Utatlán	2,176	39.22	85	100	50	43	50	43	86
Momostenango	10,390	68.58	713	80	25	178	55	392	570
S. F. la Unión	1,707	27.94	48	0	0	0	0	0	0
Génova	3,800	54.20	206	100	75	154	25	52	206

*1: Percentage of toilets connected to sewer system is regarded to be the same as the number of showers

Table 8.3.7 Estimated Sewage Amount through Sewer Systems after Water Supply is Increased

Municipality	Urban Population	Supplied Volume (ℓ/c/d)	Total Supplied Volume (m3/day)	Wastewater from Washing, Kitchen, B/Shower and Toilet (m3/day)	Wastewater without Human Waste (m3/day)	Total Amount of Wastewater (m3/day)	Rate of Sewage Amount after/freshet (Times)
S. J. Pinula	11,277	155	1,748	1,224	437	1,661	2.2
S. P. Sacatepéquez	7,652	155	1,186	474	593	1,067	3.4
S. M. de Jesús	11,107	155	1,722	0	861	861	4.6
S. M. Jilotepeque	9,236	106	979	587	196	783	1.1
S. J. Comalapa	14,710	155	2,280	1,710	0	1,710	1.2
Sololá	15,254	155	2,364	827	1,181	2,008	1.4
S. L. Utatlán	2,176	106	231	116	116	232	2.7
Momostenango	10,390	155	1,610	403	887	1,290	2.3
S. F. la Unión	1,707	106	181	0	0	0	–
Génova	3,800	106	403	302	101	403	2.0

Note: Based on the assumption that the population and other factors are the same as those used in 1994

Table 8.3.8 Estimated Sewage Amount drained in Sewer Systems after Water Supply Volume is increased in 2010

Municipality	Urban Population	Supplied Volume (ℓ/c/d)	Total Supplied Volume (m3/day)	Increased Rate of Wastewater from 1994 (Times) *-1
S.J.Pinula	19,970	155	3,095	4.1
S.P.Sacatepéquez	10,140	155	1,572	5.0
S.M.de Jesús	14,890	155	2,308	12.3
S.M.Jilotepeque	11,986	106	1,271	1.5
S.J.Comalapa	19,408	155	3,008	2.2
Sololá	30,960	155	4,799	3.3
S.L.Utatlán	4,773	106	506	5.9
Momostenango	16,740	155	2,595	4.6
S.F.la Unión	2,561	106	271	-
Génova	7,267	106	770	3.7

*-1 These are estimated assuming that 100% of the households are connected to sewer systems and all houses are equipped with connections in the kitchen, for washing, in the B/shower and flush toilets.

CHAPTER 9

9. WATER SUPPLY PROJECT FOR THE 10 MUNICIPALITIES

9.1 Project Formulation

9.1.1 Groundwater as Supplemental Supply Source

Based on the study on groundwater development potential in the areas in and around the 10 municipalities discussed in Chapter 7, and the water demand projection discussed in Chapter 4, a plan to develop groundwater as a supplementary supply source was established as one part of the Study.

The development plan in terms of development amount was made under the following basic concepts.

a. Target year is the year 2010.

b. The amount to be developed in each municipality is basically the difference between the water demand in 2010 and the amount supplied as of 1994, as tabulated in Table 9.1.1 with the exception of the following items c, d and e.

c. The existing supply sources with deteriorating raw water quality due to accelerated contamination will be replaced with groundwater. Therefore, the amount from existing sources will not be taken into account (San Martín Jilotepeque).

d. New wells will be constructed to replace existing production wells that are almost depleted. Therefore, the production amount of the existing wells will not be taken into account (San Francisco la Unión).

e. Increase in spring intake, in addition to groundwater development, was taken into consideration in places not fully utilizing spring source capacity due to the need for pump energy conservation (San Juan Comalapa). This consideration is also based on the fact that the development of a greater amount of groundwater is not cost effective.

Groundwater development in the 10 municipalities will be carried out with due consideration of their respective estimated potential to ensure a long-term safe pumping.

9.1.2 Supply Facility Construction Plan

The scope of the water supply facility construction work in the 10 municipalities was initially limited to the following points:

a. construction of borehole wells and installation of pumps, and

b. construction of a conveyance system connecting constructed wells to existing distribution tanks.

A detailed survey on existing facilities condition, however, has revealed that the above mentioned scope will not suffice for the improvement of the water supply service level in some municipalities, regardless of the development of a new water source, due mainly to the limited capacity of the distribution tank. Distribution tanks of greater capacity will be constructed therefore to increase the unit supply amount effectively.

Reservoirs will be constructed beside the existing tanks of 8 municipalities to ensure an 8 hour-supply capacity (the existing tanks in the remaining 2 municipalities are capacious).

The initial number of wells planned for construction was markedly reduced because the test drilling wells were more productive than expected. The effective use of the test wells will satisfy the demand of the 7 municipalities in 2010.

A well must be constructed in each of the municipalities of San Juan Comalapa, Sololá and Momostenango, in addition to the utilization of the test well. Another well is required for San Francisco la Unión, where the test well failed in terms of production.

The planned facilities in the 10 municipalities are tabulated in Table 9.1.2, and the basic layout is presented in Fig. 9.1.1 to 9.1.10.

9.1.3 Facility Construction Cost

The total construction cost for the planned facilities in the 10 municipalities was estimated at about 4 million US$. With the inclusion of administrative/engineering expenses and a price contingency of about 10%, the project cost was estimated at about 4.8 million US$.

The project cost for each of the facilities is shown below.

Total Project Cost (Unit = US$)

Item	Foreign Cost	Local Cost	Total
Construction Cost	2,564,005	1,430,333	3,994,338
Administration and Engineering Cost	230,760	128,729	359,489
Sub-Total	2,794,765	1,559,062	4,353,827
Price contingencies	153,840	286,066	439,906
Total	2,948,605	1,845,128	4,793,733

Project Cost of the 10 Municipalities (Unit = US$)

Municipality	Foreign Cost	Local cost	Total
San José Pinula	167,335	150,513	317,848
San Pedro Sacatepéquez	153,398	30,375	183,773
Santa María de Jesús	176,775	243,100	419,875
San Martin Jilotepeque	166,145	32,137	198,282
San Juan Comalapa	1,014,225	365,844	1,380,069
Sololá	465,109	544,262	1,009,371
Santa Lucía Utatlán	167,380	109,773	277,153
Momostenango	301,311	168,276	469,587
San Francisco la Unión	127,205	104,850	232,055
Génova	209,723	95,997	305,720
Total	2,948,606	1,845,127	4,793,733

The conditions used for cost estimation are as follows.

a. Cost estimation was carried out in December 1994.

b. Fixed exchange rate for US dollar to local currency (Quetzal):

US$1.00 = Q5.75

c. The cost of the following is to be estimated in US dollar and local currency:

Foreign currency portion

- Submersible motor pumps, other pumps and accessories
- Control panels
- Casings and screens
- Ductile cast iron pipes and specials
- Engineering cost for foreign consultants (foreign consultancy services)

Local currency portion

- Drilling work for the wells
- Labour force
- Cement, sand, gravel
- Reinforcement bars
- Fuel, oil, etc.
- Engineering cost (local consultancy services)

d. Contingency is 8% of foreign currency portion and 20% of the local currency portion in consideration of conversion rate fluctuation.

Table 9.1.1 Water Production in 1994 and Production Shortage in 2010

No.	Municipality	Population in 2010	Planned daily Supply Per Capita (l/c/d)	Water Demand in 2010 (m3/day)	Water Production in 1994				Max. Cap. of Existing Sources in 2010				Production Shortage in 2010 (m3/day)	Capacity of New Well (m3/day)	Number of Required Well *
					Natural Flow Spring	Pumped up Spring Water	Wells	Total (m3/day)	Natural Flow Spring	8-hour Pumping from Spring	24-hour Pumping from Wells	Total (m3/day)			
Gu 2	San Jose Pinula	19,970	155	3,095	-	-	821	821	-	-	818	818	-2,277	2,920	1 (0)
Gu 8	San Pedro Sacatepequez	10,140	155	1,572	-	122	98	220	-	-	294	294	-1,278	1,745	1 (0)
Sal1	Santa Maria de Jesus	14,890	155	2,308	-	-	173	173	-	-	691	691	-1,617	3,041	1 (0)
Ch 3	San Martin Jilotepeque	11,968	155	1,855	605	-	259	864	-	-	518	518	-1,337	2,186	1 (0)
Ch 4	San Juan Comalapa	19,408	155	3,008	371	27	112	510	371	144	539	1,054	-1,954	985	2 (1)
So 1	Solola	30,960	155	4,799	2,627	-	-	2,627	2,627	-	-	2,627	-2,172	1,909	2 (1)
So 4	Santa Lucia Utatlan	4,773	106	506	162	-	-	162	162	-	-	162	-344	821	1 (0)
To 5	Momostenango	16,740	155	2,595	346	294	-	640	346	294	-	640	-1,955	1,089	2 (1)
Qu18	San Francisco la Union	2,561	106	271	-	4	-	4	-	-	-	0	-271	821	1 (1)
Qu21	Genova	7,267	106	770	267	-	-	267	-	-	-	0	-770	1,365	1 (0)

* ( ) shows actual required number of well

Table 9.1.2 Project Facilities

No.	Municipality	Well			Transmission Pipe					Specified	Distribution pipe				Required
		Pumping Rate		Pumping Level	Elevation Difference	Pipe Diameter	* Distance	Head Loss	Flow Velocity	Pump Head (A)+(B)+(C)	Pipe Diameter	Distance	Head Loss	Flow Velocity	Additional Tank Vol.
		l/s	GPM	m	m	mm	m	m	m/s	m	mm	m	m	m/s	m3
Gu 2	San Jose Pinula	26.4	420	25	80	150	1,200	31.13	1.490	136.13	-	-	-	-	300
Gu 8	San Pedro Sacatepequez	14.8	230	60	40	150	1,200	10.66	0.840	110.66	-	-	-	-	-
Sa11	Santa Maria de Jesus	18.7	300	175	120	150	1,000	13.70	1.060	308.70	-	-	-	-	540
Ch 3	San Martin Jilotepeque	15.5	250	95	50	150	1,300	12.58	0.880	157.58	-	-	-	-	-
Ch 4	San Juan Comalapa No.1	11.3	180	105	60	150	1,100	5.93	0.640	170.93	150	3,315	-	-	-
	San Juan Comalapa No.2	11.3	180	105	80	150	1,200	6.47	0.640	191.47	100	4,455	-	-	270
So 1	Solola No.1	12.6	200	100	0	150	30	0.20	0.710	100.20	150	2,500	59.50	1.430	1,040
	Solola No.2	12.6	200	100	-20	150	1,100	7.25	0.710	87.25	-	-	-	-	-
So 4	Santa Lucia Utatlan	4.0	60	140	80	100	900	5.11	0.510	225.11	100	1,000	20.49	1.020	169
To 5	Momostenango No.1	11.3	180	140	80	150	800	4.31	0.640	224.31	-	-	-	-	-
	Momostenango No.2	11.3	180	140	80	150	1,200	6.47	0.640	226.47	-	-	-	-	180
Qu18	San Francisco la Union	3.1	50	180	100	100	1,000	3.54	0.390	283.54	-	-	-	-	90
Qu21	Genova	8.9	140	120	50	150	1,000	3.46	0.500	173.46	100	800	19.97	2.270	130

* Distance from well to distribution tank

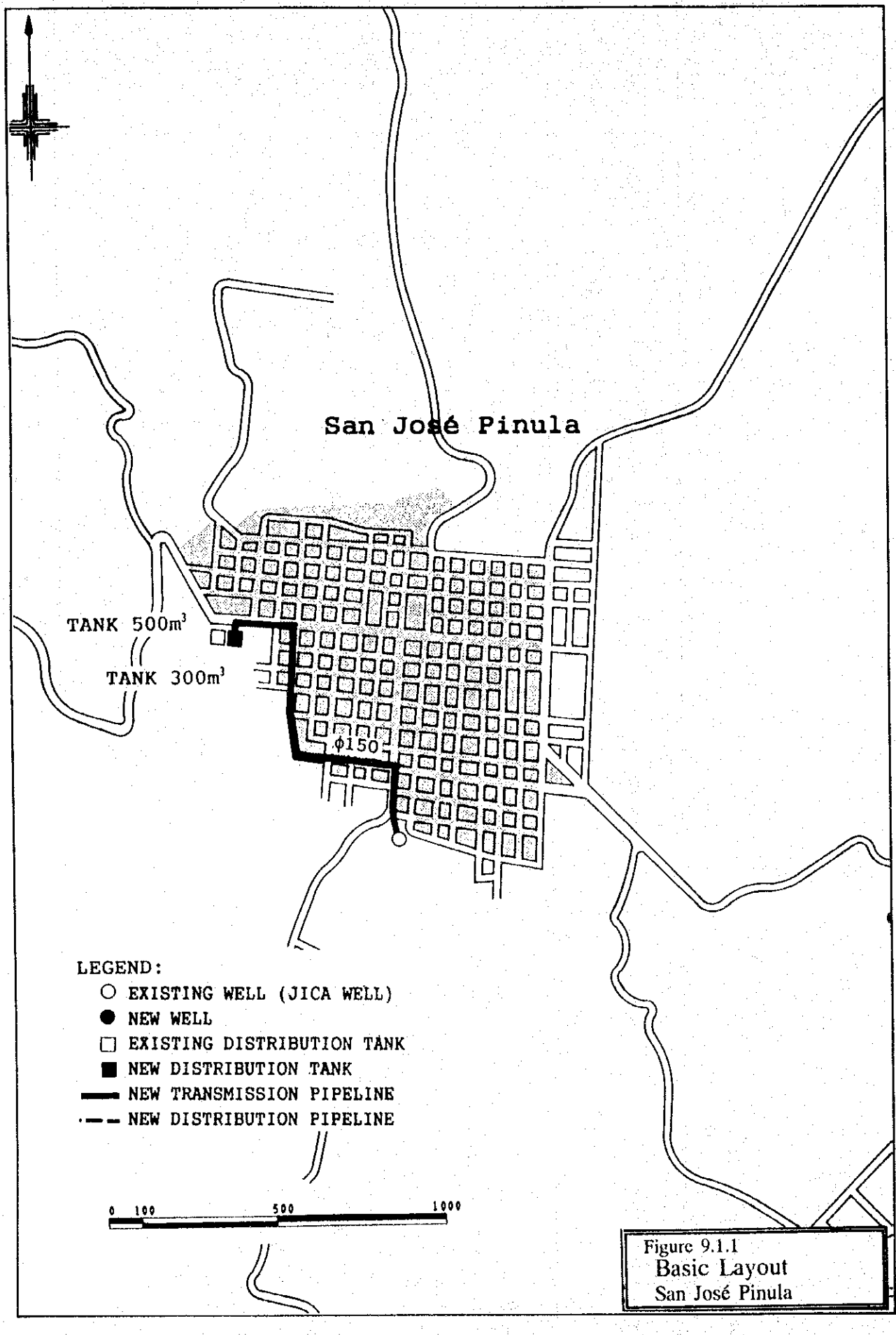


Figure 9.1.1
Basic Layout
San José Pinula

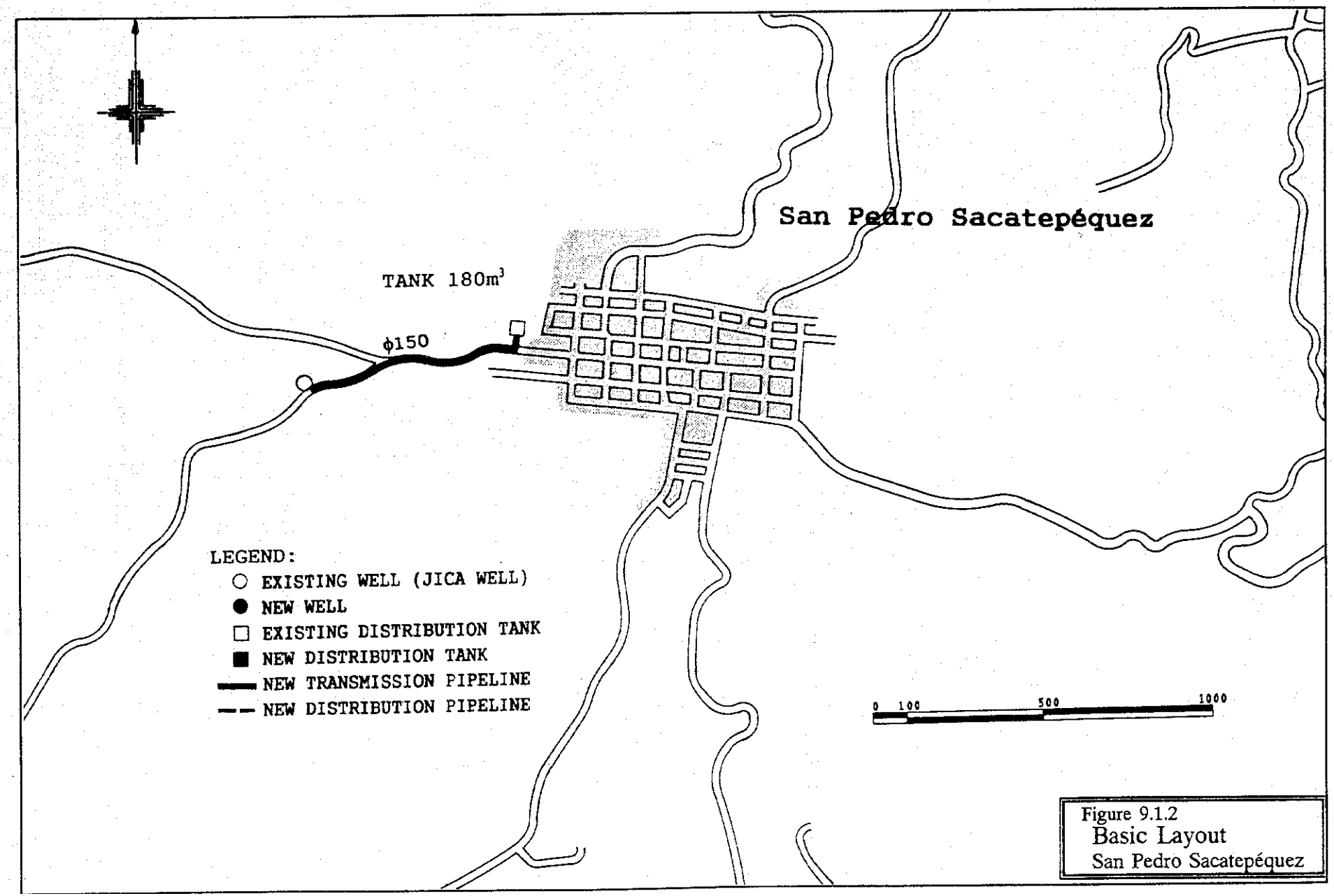


Figure 9.1.2
Basic Layout
San Pedro Sacatepéquez

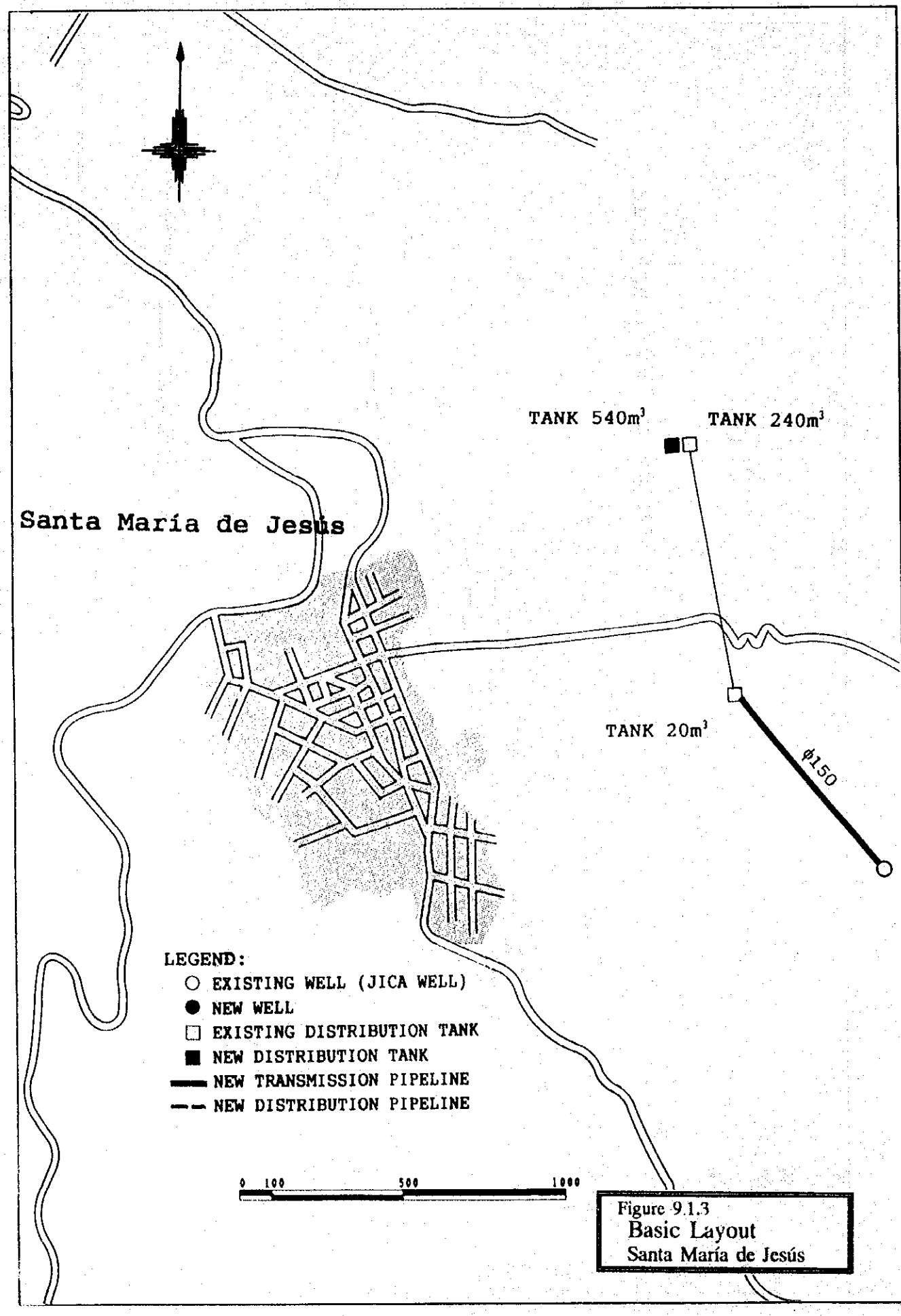


Figure 9.1.3
Basic Layout
Santa María de Jesús

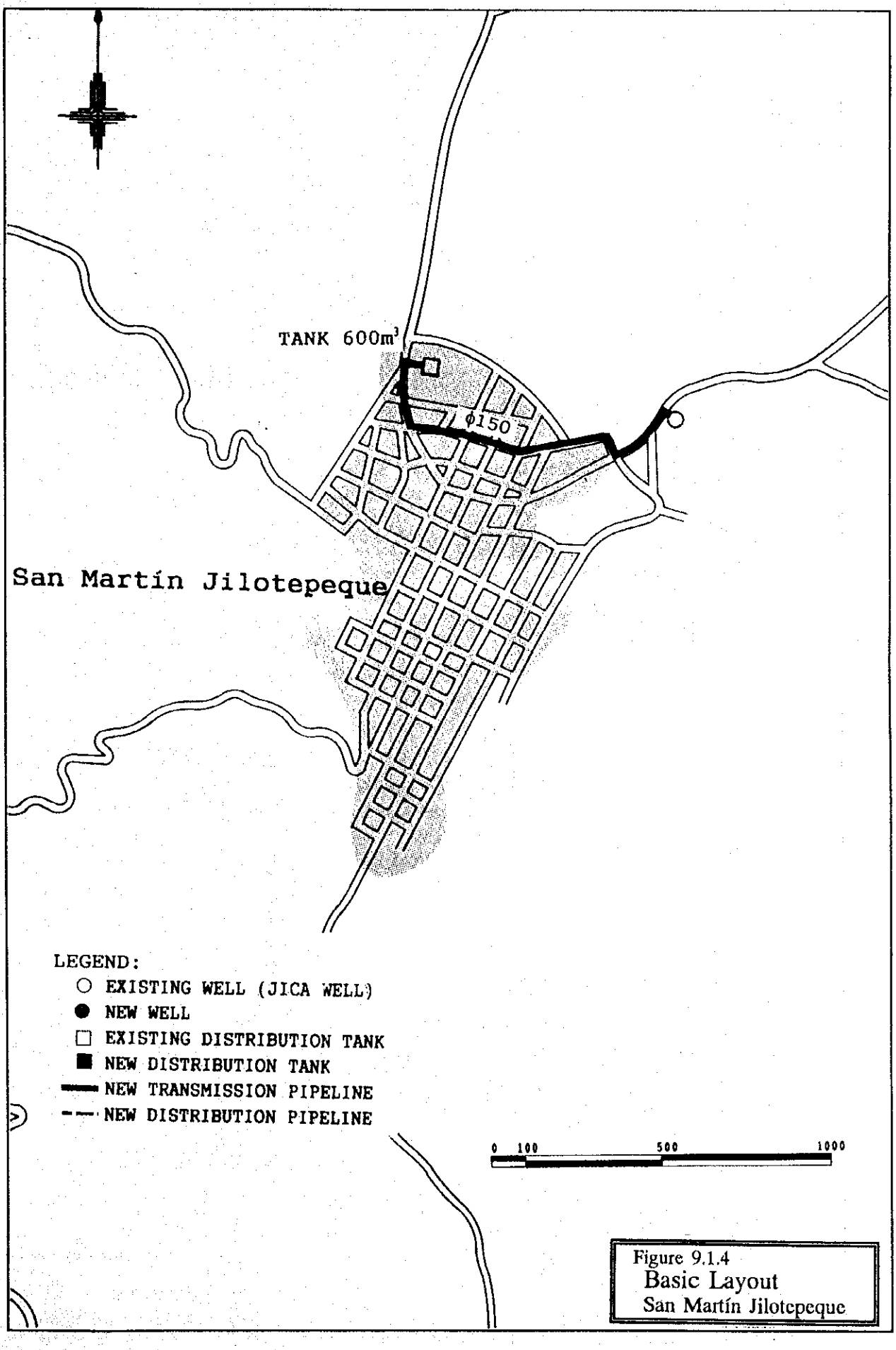


Figure 9.1.4
Basic Layout
San Martín Jilotepeque

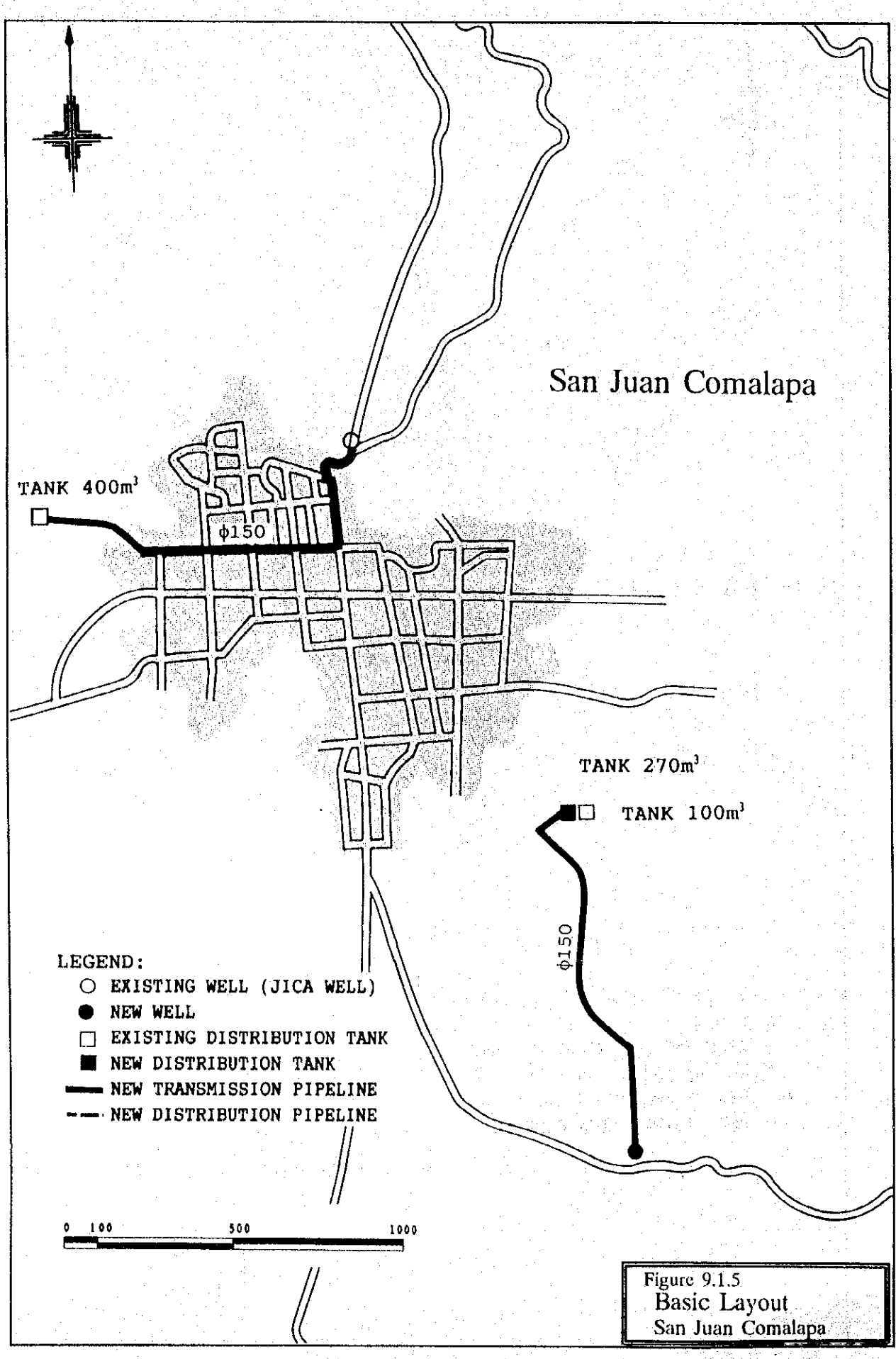


Figure 9.1.5
Basic Layout
San Juan Comalapa

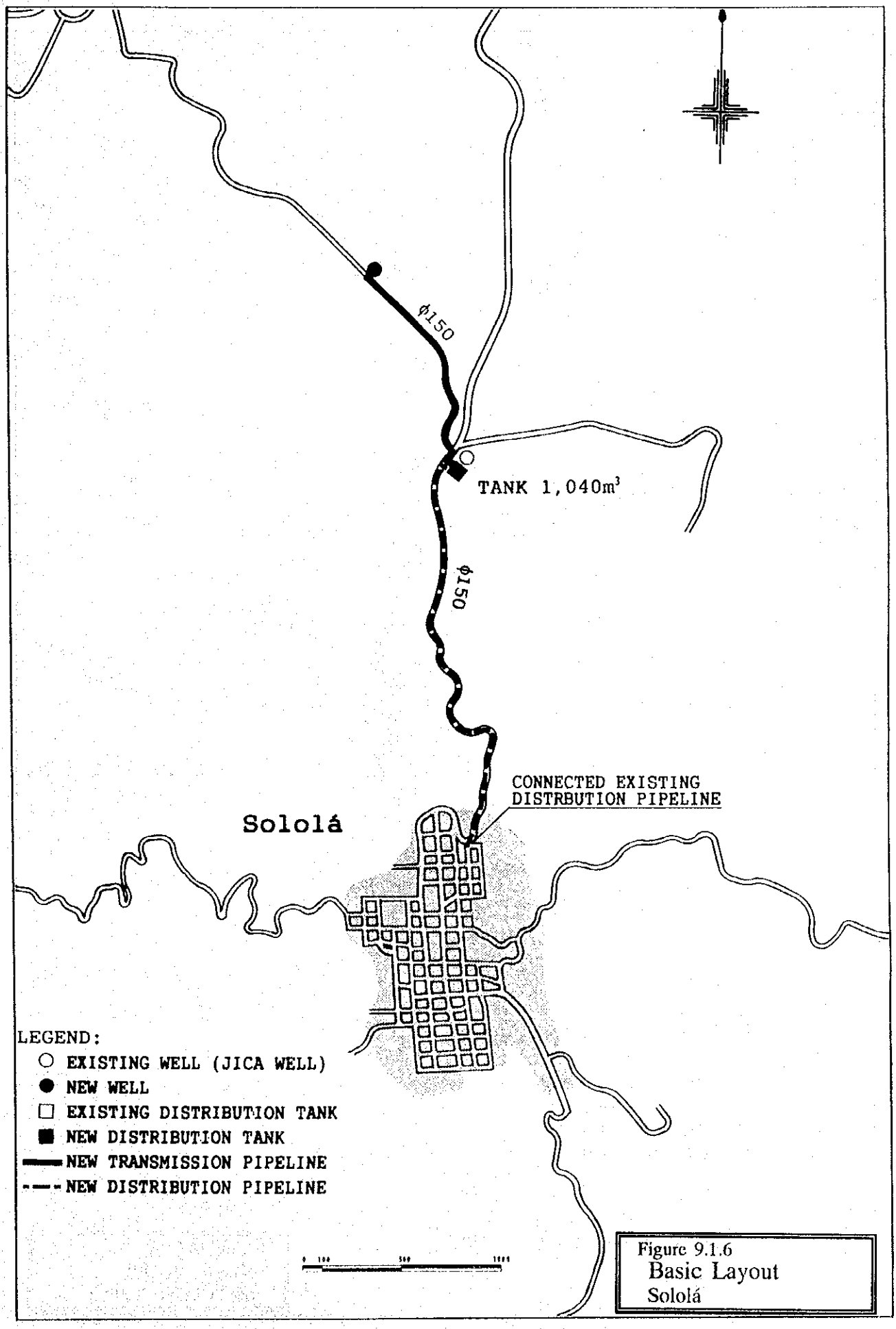


Figure 9.1.6
Basic Layout
Sololá

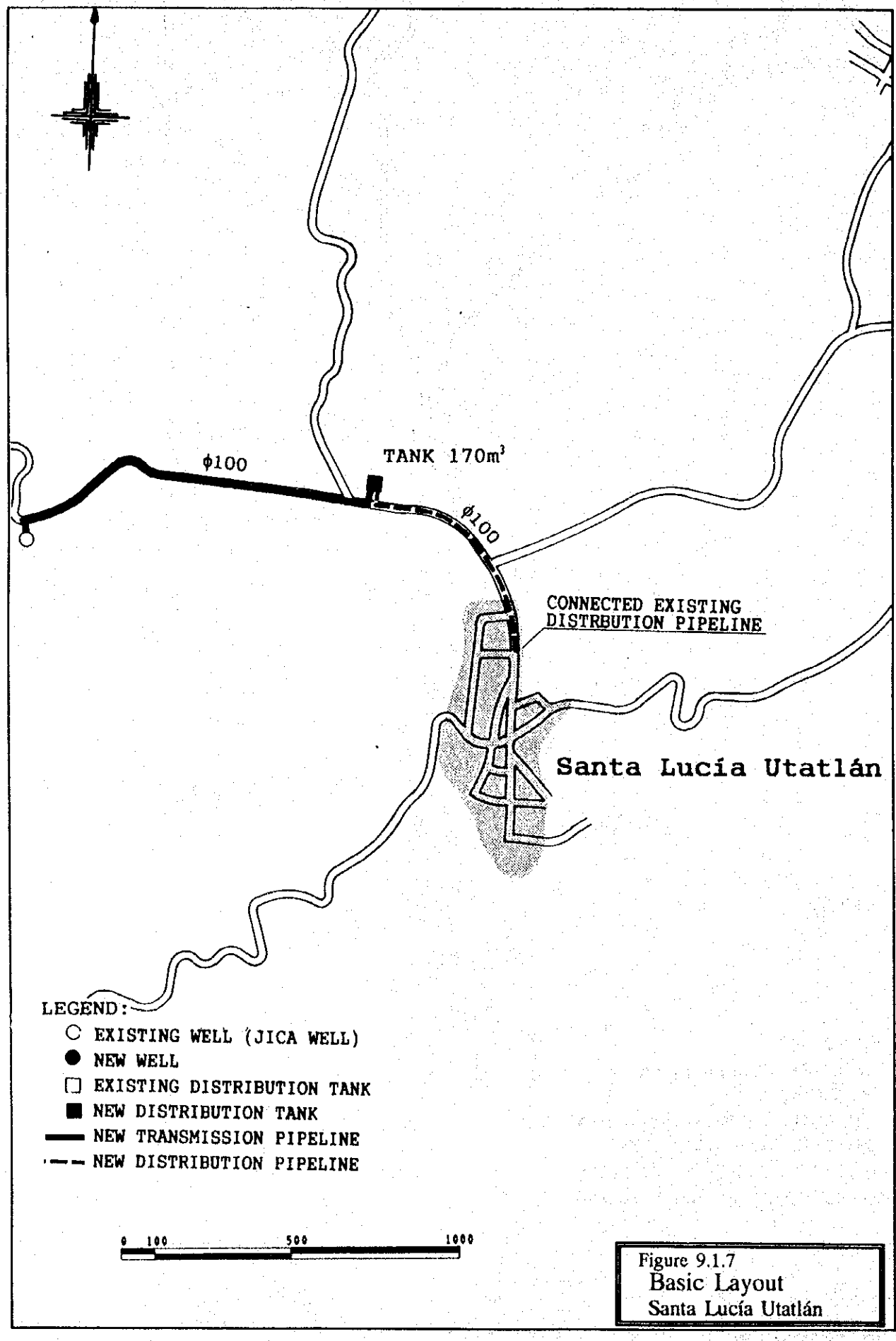


Figure 9.1.7
Basic Layout
Santa Lucía Utatlán

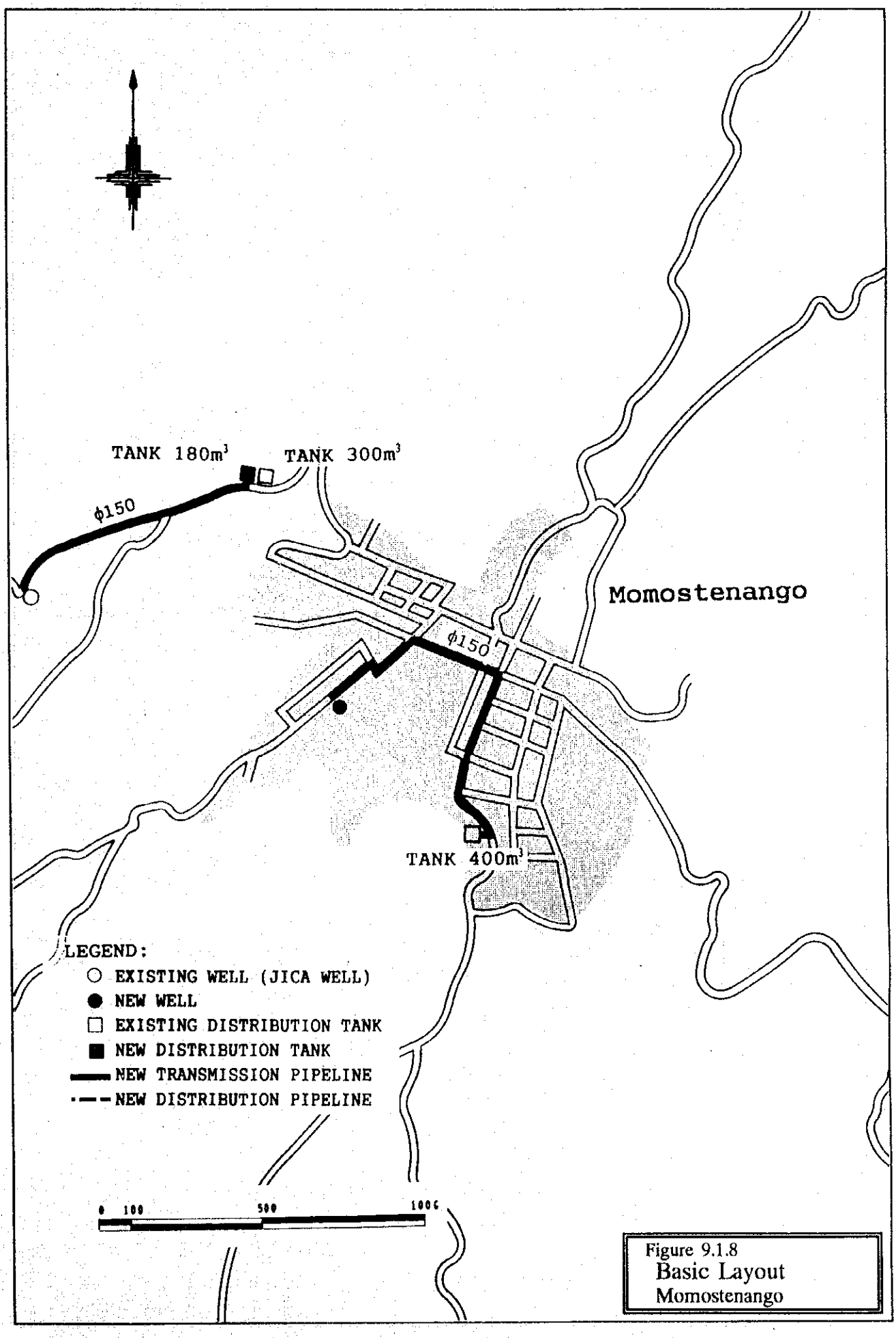


Figure 9.1.8
Basic Layout
Momostenango

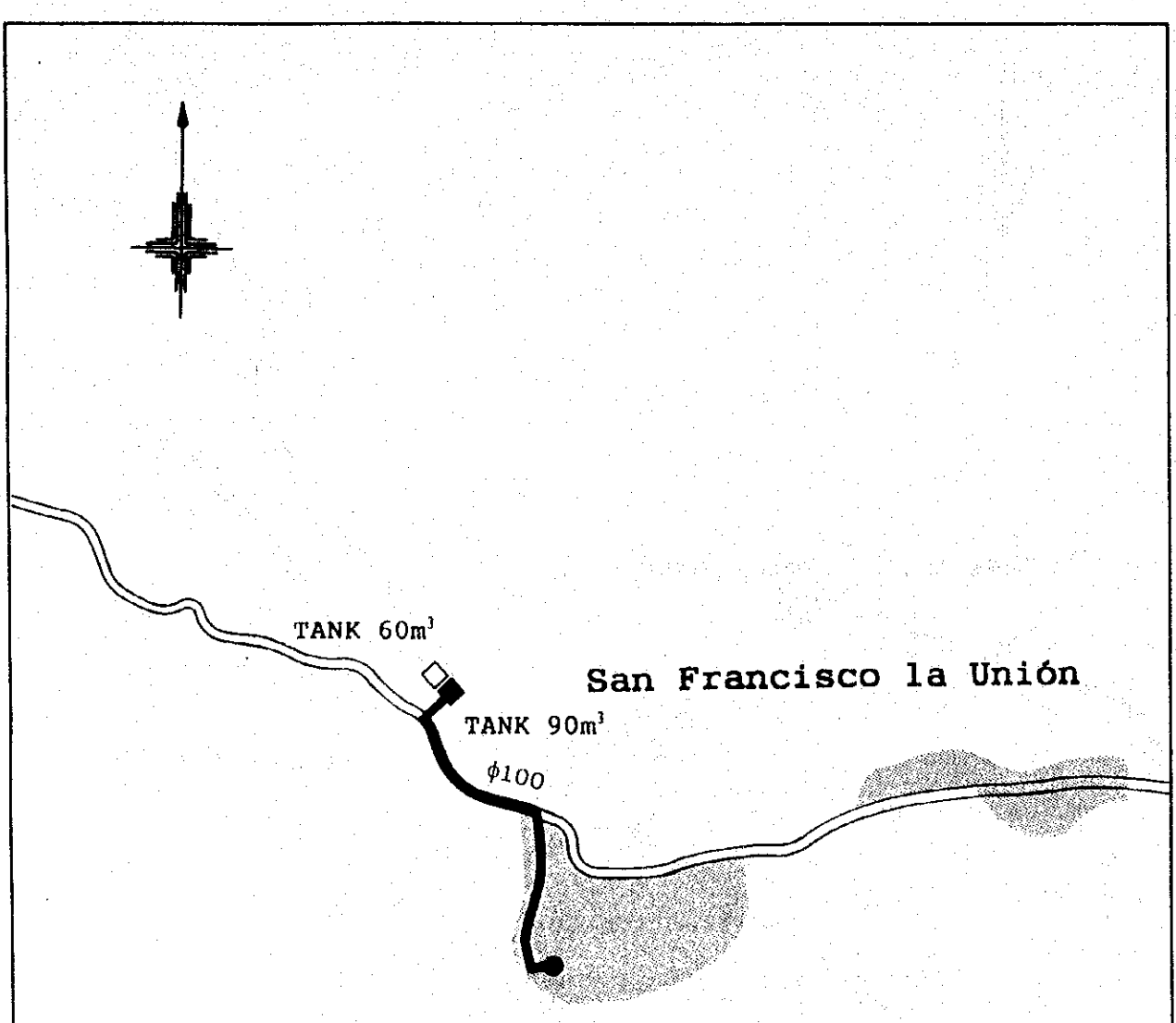


Figure 9.1.9
Basic Layout
San Francisco la Uninón

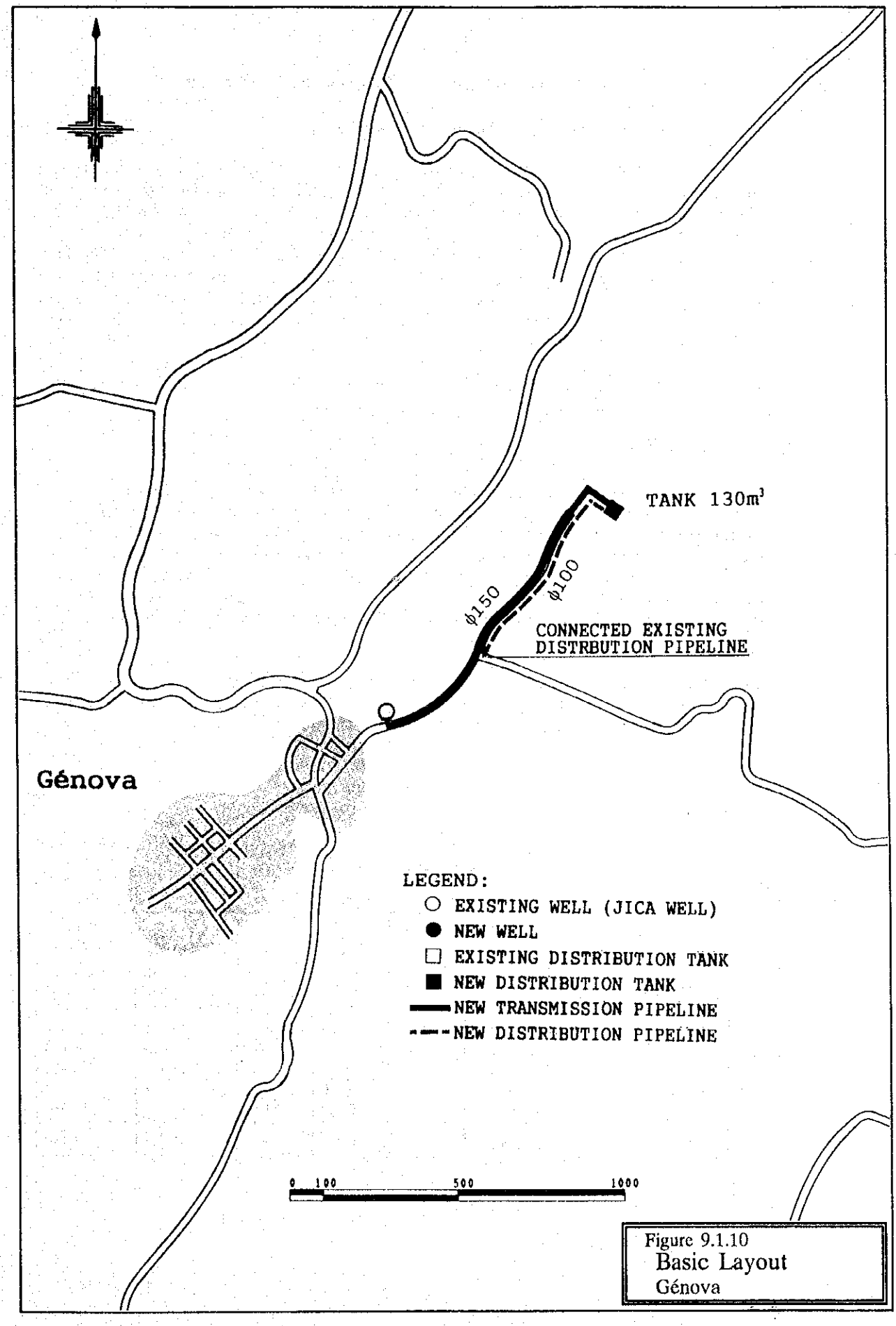


Figure 9.1.10
Basic Layout
Génova

9.2 Operation and Maintenance of Supply Facilities

9.2.1 Operation and Maintenance Plan

The operation and maintenance of new supply facilities in each of the 10 municipalities will be managed by one skilled operator and an assistant. The operator is responsible for the daily operation of pumping facilities and the periodical inspection of all facilities, including their adjustment, repair and replacement. Aside from being the subordinate of the operator, the assistant is also responsible for accounting and for the collection of water charges.

INFOM is responsible for the training of the persons assigned to these posts.

9.2.2 Operation and Maintenance Cost

The operation cost mainly covers the electricity cost for pump operation, chlorine and personnel expenses. Maintenance cost includes cost for repair and replacement of pumping equipment and occasionally the partial replacement of distribution pipes. Electricity cost was calculated based on a unit cost of Q0.6 per 1 KWH and in accordance with the estimated power required for each system by municipality.

The maintenance cost was set at 10 percent of the cost of the pumping equipment. The total operation and maintenance cost by municipality is presented below.

Operation and Maintenance Cost for the 10 Municipalities

(Unit = Q)

No.	Municipality	Operation Cost			Mainte. Cost	Total	
		Electr.C.	Chlor.C.	Man.C.		Q/Month	Q/Year
Gu 2	San José Pinula	18,643	279	2,000	1,374	22,296	267,552
Gu 8	San Pedro Sacatepéquez	9,951	141	2,000	886	12,978	155,736
Sa11	Santa María de Jesús	31,328	208	2,000	2,452	35,988	431,856
Ch 3	San Martín Jilotepeque	9,952	140	2,000	959	13,051	156,612
Ch 4	San Juan Comalapa	9,821	271	2,000	1,044	13,136	157,632
So 1	Sololá	7,137	432	2,000	1,005	10,574	126,888
So 4	Santa Lucía Utatlán	5,000	46	2,000	944	7,990	95,880
To 5	Momostenango	12,380	234	2,000	1,063	15,677	188,124
Qu18	San Francisco la Unión	5,022	24	2,000	918	7,964	95,568
Qu21	Génova	10,023	69	2,000	1,018	13,110	157,320
	Total	119,257	1,844	20,000	11,663	152,764	1,833,168

9.3 Project Evaluation

9.3.1 General

Conceptually, evaluation of a water supply project can be conducted from the financial and economic viewpoints. Financial evaluation refers to the incremental revenues and costs of the water supply operating entity (municipal government in this Project) which occur as a result of the Project implementation. On the other hand, economic evaluation considers the effects of the improved water supply on the society at large.

On the cost side, implementation of a water supply project requires the following types of costs. First, initial investment costs are needed for the construction of the necessary water supply facilities. Then, once these facilities are constructed, recurrent costs are incurred for their proper operation and maintenance. Finally, components of water supply facilities need to be replaced, depending on their useful lives, during the assumed life of the Project, thereby originating the replacement costs. Details of these costs are presented in the Main Report as Section 9.1.3 Cost for Facilities Construction and Section 9.2.2 Operation and Maintenance Cost.

Financial benefits refer to the incremental revenues that the municipal government can collect by implementing the Project. Incremental revenues depend on the level of water charges, on the willingness-to-pay and ability-to-pay of water users, on the number of water users, and on the ability of the municipal government to collect the water charges.

Economic benefits from improved water supply, as considered in this Project, are reductions in medical expenses, reduction in fire damages, and appreciation in the value of the land. Low quality drinking water may cause diarrhea and cholera, which require additional medical treatment expenses, but these are preventable expenses. Occurrence of fire turned out to be insignificant in the communities of the Project, but it is considered as a distinct risk in such town as Santa María de Jesús, where fences around houses are made of easily combustible materials such as corn stalks and bamboos. And, there is no doubt that the value of urban land goes up when the plot is serviced with drinking water supply, thereby increasing the asset value of land owners, while simultaneously augmenting the value of social infrastructure.

9.3.2 Interview Surveys

For purposes of the Project evaluation, interview surveys were conducted with municipal authorities, community residents, and health care professionals.

(1) Municipalities

Authorities in the selected ten municipalities were interviewed to obtain data on population, number of water connections, and the water charges. These data are crucial to estimate the revenues from the Project.

Municipal authorities were also requested to provide data on the number and average value of urban houses. These data were needed to estimate the fire prevention benefits, and land value appreciation benefits.

(2) Residents

A sample of residents of the selected ten communities were interviewed to estimate their willingness-to-pay for improved drinking water supply services. This required the community residents to imagine a hypothetical improved situation, which turned out to be too difficult for some people. Therefore, the following decisions were made.

- When municipal authorities claimed to have conducted a survey, formal or informal, on the willingness-to-pay of the community residents for improved drinking water supply services, the figures provided by the municipality were taken as the basis for revenue estimation (for example San José Pinula and Sololá).

- Greater reliance was placed on responses given by residents who were considered as knowledgeable about community matters, such as school teachers and a representative of a Drinking Water Commitee (Momostenango).

(3) Health centers

Health care professionals (doctors and/or nurses) were interviewed to obtain their opinions and statistical data on the incidence of water transmitted diseases (diarrhea, skin rash). Also requested were data on the treatment costs of the said diseases.

9.3.3 Survey Results

Tabulations of interview surveys gave the following results.

(1) Willingness-to-Pay (WTP)

Community	WTP Estimated by Municipality (Q/month)	WTP Expressed by Residents (Q/month)
San José Pinula	10-15	10-15
San Pedro Sacatepéquez	15	5-17
Santa María de Jesús	10	10
San Martín Jilotepeque	10	10
San Juan Comalapa	3-5	5
Sololá	12-40	12-40
Santa Lucía Utatlán	10	15-30
Momostenango	6	As needed
San Francisco La Unión	10-15	10-25
Génova	5	5

Municipal authorities in San José Pinula and Sololá conducted surveys of their own residents, which were assumed to be the WTP of these two communities for improved drinking water supply services. In Momostenango, the president of the Potable Water Committee promised to convince its 600 members to pay the water supply service fee required for the proper operation and maintenance of water supply facilities, if the Committee had access to well founded information on the monthly charges necessary for such a purpose. Therefore, the upper bound of the willingness to pay in Momostenango was assumed to be Q.40 per household per month, which was the highest level found in the survey of the 10 communities.

In San Martín Jilotepeque, water rates were increased to Q.10 per month in August 1994, without the promised improvement in drinking water supply services. This caused a widespread indignation among residents who considered demanding municipal authorities to return to the former water rate of Q.2.50 per month. However, since community residents had already accepted the water rate of Q.10 per month, this fee was taken as their willingness to pay.

In general, the WTP estimated by municipal authorities was lower than the one expressed by community residents. This was, perhaps, a reflection of the political risk which such a decision may have on the popularity of the Mayor who is elected by popular vote. In case of discrepancy in the WTP of a community, two revenue estimations were calculated, one as the lower bound and the other as the upper bound.

(2) Incidence of water transmitted diseases

The incidence of water transmitted diseases, mainly diarrhea, is shown in the table below. The medical treatment cost of diarrhea for the Ministry of Public Health and Social Welfare, according to some doctors,

ranged between Q.25 and Q.30 per case, whereby the value of Q.30 per case was assumed for benefit estimation.

Community	Incidence of Water Transmitted Diseases (% of Patients)
San José Pinula	31.28
San Pedro Sacatepéquez	16.13
Santa María de Jesús	60.00 (rainy season)
San Martín Jilotepeque	12.00
San Juan Comalapa	22.22
Sololá	9.52
Santa Lucía Utatlán	10.00
Momostenango	31.59
San Francisco La Unión	25.00
Génova	30.00

Hard statistics were not always available. Some health care centers had in file monthly records of patients and disease causes, while others relied on the memory of their professional staff. In any event, the high incidence of diseases caused by insufficient or low quality drinking water was quite obvious.

(3) Average value of a house

Municipal authorities were requested to estimate the average value of an urban house in their communities. Results were as follows.

Community	Average Value of a House (Q.)
San José Pinula	60,000
San Pedro Sacatepéquez	60,000
Santa María de Jesús	35,000
San Martín Jilotepeque	35,000
San Juan Comalapa	25,000
Sololá	40,000
Santa Lucía Utatlán	15,000
Momostenango	20,000
San Francisco La Unión	8,000
Génova	15,000

These values were understood to jointly include the value of the land and the value of the house.

9.3.4 Assumptions for the Project Evaluation

1) Table 9.3.1 shows, for each community, the basic data used in the Project evaluation, including the base population (1994), the yearly population growth rate, the average family size, the average value of a house and land, the lower and upper bounds of the willingness-to-pay for drinking water supply services,

and the incidence of diarrhea.

2) For revenue estimation, the Project was assumed to supply drinking water to 100% of households in the urban areas of the target communities. In other words, water supply services currently existing in the target communities were deemed as intermittent and negligible in volume. Hence, existing water supply services were deemed as grossly inadequate to apply the water service charges indicated by the willingness-to-pay survey, which assumed satisfactory service for water users.

3) Municipal governments were assumed to collect 80% of billings for water service charges determined on the basis of the willingness-to-pay survey.

4) The number of households in a given community in a given year was assumed to be a function of its 1994 population, and the community specific population growth rate and average family size.

5) Each family was assumed to live in an independent house, and the value of a dwelling was assumed to be divided equally between the house and the land.

6) Fire prevention benefits were assumed to amount to 0.5% of the community specific average value of a house.

7) Land appreciation benefits were assumed to amount to 2% of the community specific average value of a plot of land.

8) Diarrhea prevention benefits were estimated on the basis of the assumed 30% of the population resorting to health centers, the community specific incidence of diarrhea among the patients, and a treatment cost of Q.30 per case of diarrhea (savings for the Ministry of Public Health), assuming that the diarrhea strikes once a month during the six-month period of the rainy season.

9) The useful life of the Project was assumed to be 30 years, setting 2010 as the target year.

10) Market prices were used in the estimation of economic benefits because of the following two reasons: (a) the labor input of the Project comprised a small proportion of total costs and consisted mostly of skilled labor, whose valuation is usually assumed to reflect marginal productivity, and (b) price distortion of traded goods was slight, as indicated by the Standard Conversion Factor (SCF=0.97) which was calculated as follows.

SCF=(Import+Export)/(Import+Import Tax)+(Export-Export Tax)

Standard Conversion Factor of Guatemala

Unit: US$1,000

Year	Export	Export Tax	Import	Import Tax
1989	2,159,079	9,873	4,195,202	74,964
1990	1,162,970	836	1,648,799	97,455
1991	1,202,194	327	1,851,254	123,782
1992	1,295,291	109	2,462,757	213,764
Total	5,819,534	11,145	10,158,012	509,964

SCF = 0.969725227
SCF = Standard Conversion Factor

Source: 1) Banco de Guatemala, Boletín Estadístico, Enero-Febrero-Marzo 1994
2) Instituto Nacional de Estadística, Anuario de Comercio Exterior 1992

9.3.5 Evaluation Results

(1) Financial Evaluation

Cash flows (CF) were calculated for the Project and for each municipality, on the basis of estimated revenues and costs presented as Table 9.3.2 and Tables 9.3.2a to 9.3.2j. Cash flows served to determine the evaluation indices for this Project, that is, the financial internal rates of return (FIRR) for each municipality and for the Project, which are summarized below.

Municipality/Project	FIRR (%)
San José Pinula-high WTP	6.52
San Pedro Sacatepéquez-high WTP	9.31
Santa María de Jesús-high WTP	No solution
San Martín Jilotepeque-high WTP	7.40
San Juan Comalapa-high WTP	No solution
Sololá-low WTP	2.60
Sololá-high WTP	18.83
Santa Lucía Utatlán-high WTP	3.68
Momostenango-high WTP	27.43
San Francisco La Unión-high WTP	No solution
Génova-high WTP	No solution
The Project	6.56

Financially, the Project is feasible only if revenues are estimated with the upper bound willingness-to-pay. Further, the Project should be implemented using a very favorable soft financing scheme, since the FIRR is a modest 6.56%. The overall Project feasibility implies the need for a unifying entity. This is because, individually, only six of the selected ten municipalities showed positive levels of

FIRR. Then, the unifying body could resort to cross subsidization among municipalities so as to make the Project feasible.

Of the four municipalities where the FIRR could not be calculated, three (Santa María de Jesús, San Francisco La Unión and Génova) had negative cash flows during the whole Project life. The reasons, however, were different. Negative cash flows in San Francisco La Unión and Génova were basically due to the small number of households. On the other hand, in Santa María de Jesús, the costs were unusually high due to the hilly topography, which required wells to be located in distant lowlands, thereby incurring high investment cost and high operation cost of the water distribution system.

San Juan Comalapa had positive cash flows during some years of the Project life, despite a low WTP, but the surplus of revenues over expenditures were too small to permit calculation of the FIRR.

(2) Economic Evaluation

The economic benefits of the Project were estimated in terms of savings of the Ministry of Public Health and Social Welfare in medical treatment expenses of diarrhea, reduction in fire damages, and land value appreciation. These estimated benefits and costs are also presented as cash flows (CF), for the Project and for each municipality in Table 9.3.3 and Tables 9.3.3a to 9.3.3j. The relevant evaluation indices, namely,the economic internal rates of return (EIRR) are summarized below.

Municipality/Project	EIRR (%)
San José Pinula	96.75
San Pedro Sacatepéquez	100.01
Santa María de Jesús	42.01
San Martín Jilotepeque	89.04
San Juan Comalapa	13.19
Sololá	26.28
Santa Lucía Utatlán	No solution
Momostenango	24.36
San Francisco La Unión	No solution
Génova	8.01
The Project	30.45

The value of the EIRR at 30.45% indicates a significant positive impact of the Project on the society. Still, EIRR could not be calculated in Santa Lucía Utatlán, despite the cash flow being positive during some years of the Project life, and in San Francisco La Unión, where the cash flow was negative during the whole Project life. The insufficient or negative cash flows in these two

municipalities were due to a combination of small number of households and low value of dwellings.

The largest impact came from land appreciation benefits. This indicates that the impacts would be larger in municipalities where the land value is already high, which are due either to the proximity to Guatemala City (San José Pinula, San Pedro Sacatepéquez) or to a favorable location on a main road (Sololá).

9.3.6 Sensitivity Analysis

(1) Financial Rates of Return

Sensitivity analysis was conducted under two scenarios, one with a 10% reduction in revenues, and the other with a 10% increase in costs. Results of sensitivity analysis are summarized below.

Municipality/Project	FIRR (%)		
	Base Case	Revenues (-10%)	Costs (+10%)
San José Pinula	6.52	3.97	
San Pedro Sacatepéquez	9.31	6.45	
Santa María de Jesús	No sol.	No sol.	
San Martin Jilotepeque	7.40	4.61	4.88
San Juan Comalapa	No sol.	No sol.	No sol.
Sololá	18.83	16.90	17.08
Santa Lucía Utatlán	3.68	2.08	2.23
Momostenango	27.43	24.22	24.51
San Francisco la Unión	No sol.	No sol.	No sol.
Génova	No sol.	No sol.	No sol.
The Project	6.56	4.80	4.97

The above table shows that the Project is slightly more sensitive to a 10% reduction in revenues than to a 10% increase in costs. This remark is also valid for all municipalities.

The FIRR of the Project decreased by around 25% in response to either a 10% decrease in revenues or a 10% increase in costs. Municipalities more sensitive than the Project were San José Pinula, San Pedro Sacatepéquez, San Martín Jilotepeque and Santa Lucía Utatlán. On the other hand, Sololá and Momostenango were quite insensitive, showing only around a 10% reduction in the values of FIRR in response to either a 10% decrease in revenues or a 10% increase in costs.

It is understood that collection of water charges is a truly difficult task facing the water supply operating entity. Therefore, an additional sensitivity analysis was conducted by assuming a 70% collection rate, instead of the initially assumed 80% of billings. As a result, the Project

FIRR declined from 6.56% to 4.34%, that is, a 10% reduction in collection rate caused a 35% decline in the FIRR of the Project. Taking the municipalities individually, only Sololá and Momostenango were less sensitive to reduced collection rates than the Project as a whole. Details are shown below.

Municipality/Project	Base Case FIRR (%)	
	Bill Collection Rates	
	80%	70%
San José Pinula	6.52	3.26
San Pedro Sacatepéquez	9.31	5.68
Santa María de Jesús	No sol.	No sol.
San Martín Jilotepeque	7.40	3.85
San Juan Comalapa	No sol.	No sol.
Sololá	18.83	16.41
Santa Lucía Utatlán	3.68	1.65
Momostenango	27.43	23.41
San Francisco la Unión	No sol.	No sol.
Génova	No sol.	No sol.
The Project	6.56	4.34

(2) Economic Rates of Return

Sensitivity analysis was conducted under two scenarios, one with a 10% reduction in economic benefits, and the other with a 10% increase in costs. Results of sensitivity analysis are summarized below.

Municipality/Project	EIRR (%)		
	Base Case	Benefits	Costs
		(-10%)	(+10%)
San josé Pinula	96.75	86.03	87.00
San Pedro Sacatepéquez	100.01	89.33	90.37
Santa María de Jesús	42.01	36.22	36.75
San Martín Jilotepeque	89.04	78.91	79.83
San Juan Comalapa	13.19	11.55	11.70
Sololá	26.28	23.73	23.97
Santa Lucía Utatlán	No sol.	No sol.	No sol.
Momostenango	24.36	21.42	21.69
San Francisco la Unión	No sol.	No sol.	No sol.
Génova	8.01	6.06	6.25
The Project	30.45	26.98	27.29

The above table shows that the Project is slightly more sensitive to a 10% reduction in benefits than to a 10% increase in costs. This remark is also valid for all municipalities.

The EIRR of the Project decreased by around 10% in response to either a 10% reduction in benefits or a 10% increase in costs. Only Génova was significantly more sensitive than the Project with about 25% decrease in EIRR in response to a 10% reduction in benefits or a 10% increase in costs. Municipalities slightly more sensitive than the Project were Santa María de Jesús, San Juan Comalapa and Momostenango.

The largest impact of the Project on the society came from land value appreciation benefits. Therefore, an additional sensitivity analysis was conducted by assuming different rates of land appreciation benefits depending on muncipalities. Specifically, instead of the initially assumed 2% of the value of the land for all muncipalities, a 5% value appreciation was assumed for San José Pinula and San Pedro Sacatepéquez (municipalities near Guatemala City), and 3% for Sololá (located on a main road). As a result, the EIRR of the Project increased from 30.45% to 44.92%.

9.3.7 Overall Evaluation and Suggestions

(1) General

The people in the Study Area face a critical shortage of drinking water supply, which is presumed to continue into the foreseeable future. Due to the lack of appropriate surface water sources, the goal of the Project is to satisfy the water demand up to the year 2010 through the development of new groundwater sources. The beneficiary population in the target year is estimated at around 139,000 persons or 23,500 households.

The choice of groundwater as new water sources is reasonable, since test drillings showed that the Study Area is endowed with groundwater of good quality, requiring only chlorination prior to distribution. The development of these new water sources will permit regular distribution of good quality drinking water, instead of the extremely irregular water supply service prevailing at present.

The FIRR of the Project may not be fully convincing at 6.56%, but the benefits of the Project on the society far outweigh this concern as indicated by the 30.45% EIRR. There is no question that the ten communities included in the Project are in dire need for improved supply of drinking water. Therefore, the Project should be urgently implemented, especially if soft loans or grants can be obtained for financing the initial investments.

However, a great deal of caution is required in the Project implementation. This is because revenues in some municipalities are insufficient to cover even the operation and maintenance costs. Suggestions on ways to overcome this situation are presented below.

(a) Executing Unit of the Project within INFOM

As already mentioned elsewhere, if an administrative unit is set up within INFOM for the Project execution, it will become the unifying entity of the ten municipalities. Then, it will be possible to implement a cross subsidy scheme among the ten municipalities, whereby financially weaker municipalities would be subsidized by financially stronger municipalities within the Project.

In reality, implementation of the cross subsidy scheme would be quite difficult. In addition to administrative difficulties, there is a question of fairness, since none of the ten municipalities is sufficiently well-off as to subsidize other communities.

(b) Firm Commitment to Use Other Revenues

Alternative local revenue sources of municipalities are virtually non-existent. An analysis of municipal budgets showed that both current income and capital income depend heavily on subsidies or transfers from the Central Government. Current income subsidies come as transfers from the Finance Ministry (15% to 40% of current income), while the capital income subsidies (95% to 99% of capital income) come as transfers from the Central Government, based on a Constitutional provision to return 8% of current income of the Central Government to municipalities through INFOM. Altogether, the subsidies for current income and for capital income amounted to between 60% and 93% of the total municipal budget.

Whether or not to use these subsidies for drinking water supply is a decision to be made by each municipality. Yet, using these subsidies to finance water suplly costs may be the only option available in the immediate future. Hence, it would be acceptable in the short-run, but over the long-run, water users in each municipality should be able to finance at least the operation and maintenance costs of their own drinking water supply service.

(c) Self-sustaining Water Supply Service

As illustrated in the above description, the ten municipalities are financially weak in terms of independent local revenue sources. This situation is exacerbated by the general perception existing in Guatemala that drinking water should be supplied free of charge. This perception of drinking water as a basic necessity exists, to some extent, in most countries, but it is particularly strong in Guatemala. To make matters worse, drinking water supply is a service provided by municipalities, where mayors are elected by popular vote, thereby making it politically difficult to make the financially correct decision of increasing water charges in step with rising costs.

This perception needs to be changed. The general public

must be made perfectly aware of the costs involved in securing water sources and supplying safe drinking water through appropriate distribution facilities. Paying for all these costs through the properly set water charges will ultimately benefit the consumers themselves, since cost recovery will make continued improvements possible in water supply facilities. Conversely, low water charges that do not cover the costs will only accomplish the perpetuation of less-than-satisfactory water supply service.

Consequently, revenue shortfalls can be covered by government subsidies in the short-run, but water charges in the long-run should ideally cover all costs. To get water users to pay the appropriate water charges, a well organized and long-term public education campaign is necessary. This education campaign should encompass children and adults, formal and informal education systems, and should resort to systematic use of the mass media.

At the same time, the ten municipalities should do their utmost to improve management and operation of their drinking water supply services. One aspect of great potential impact refers to the installation of water meters for the measurement of actual water consumption by each user. The installation of water meters should be combined with the adoption of a water service rate, which ideally will be structured as increasing blocks, that is, as water consumption increases, so does the water service charge.

If an increasing block rate structure is difficult to be implemented, a simpler water rate structure should be adopted on the basis of a basic charge in combination with excess consumption charge. The basic charge should be low and, accordingly, entitle water consumers to use a relatively low volume of water per month. Still, this low volume may be enough for a great deal of households.

Either water rate structure will allow a better correlation between consumption of and payment for water. In other words, fairness will be achieved, as high volume consumers will have to pay more, and viceversa. This will be quite a contrasting change from the current practice of unmetered consumption, whereby a "title" holder has the right to consume so much water per month (e.g. 30,000 liters per month), without much regard for actual consumption. Fairness is expected to induce good will among consumers, who may be more willing to pay for water services. Then, municipal finance will improve with respect to water supply service, thereby contributing to the probability of success of the Project.

An additional benefit of the increasing block rate structure is the conservation effect, as unit price of water will be higher as the consumption increases. This will necessarily compel water consumers to use water more rationally than under the presently prevailing unmetered consumption.

(2) Required Water Charges

To be fair, residents of each community should pay the costs associated with the drinking water supply service in their own community. These costs are divided into Operation and Maintenance Costs on one side, and Investment and Replacement Costs on the other. These costs are specific to each community, as water supply facilities were designed according to the characteristics of each community. Further, the monthly water service charges for each family is inversely proportional to the population size or the number of households in the community. Hence, a community with a small population is in disadvantage, as the monthly water service charges to be borne by each household are relatively high.

Operation and Maintenace Costs are incurred daily, and are easily estimated on a monthly or yearly basis. On the other hand, Investment Costs are incurred initially, followed by periodic Replacement Costs of diverse components at the end of their useful lives, thereby requiring conversion into yearly or monthly costs. Then, the monthly charges to cover Investment Costs could be properly allocated among the community residents.

Therefore, in order to estimate the monthly charges for investment costs, Annual Equivalent Costs were initially calculated by applying the Capital Recovery Factor at 10% interest rate to the estimated investment costs. The Capital Recovery Factor is given by the following formula.

$$CRF = [i(1+i)^n] / [(1+i)^n - 1]$$

where,

CRF: Capital Recovery Factor
i: interest rate
n: number of year

The resulting monthly water service charges per household by municipality are shown below.

Municipality	Required Water Charges (Q/fam./mo.)		
	O & M	Investmet	Total
San Jose Pinula	15 (0%)	11	26(+73%)
San Pedro Sacatepéquez	13 (-24%)	9	22(+29%)
Santa María de Jesús	23 (+130%)	13	36(+260%)
San Martín Jilotepeque	8 (-20%)	6	14(+40%)
San Juan Comalapa	7 (+40%)	32	39(+680%)
Sololá	7 (-83%)	31	38(-5%)
Santa Lucía Utatlán	29 (-3%)	49	78(+160%)
Momostenango	11 (-73%)	16	27(-33%)
San Francisco La Unión	39 (+56%)	56	95(+280%)
Génova	24 (+380%)	27	51(+920%)

Note: The percentage in parentheses (%) indicates the change over the upper bound willingness-to-pay.

When the total water charges indicated above were applied, the resulting financial rate of return of the Project was 16.71%. The FIRR values by municipality are shown below.

Municipality/Project	FIRR (%)
San Jose Pinula	21.17
San Pedro Sacatepéquez	16.79
Santa María de Jesús	16.22
San Martín Jilotepeque	16.79
San Juan Comalapa	12.96
Sololá	17.87
Santa Lucía Utatlán	20.49
Momostenango	16.80
San Francisco La Unión	15.47
Génova	20.46
The Project	16.71

Further, sensitivity analysis indicated that these FIRR values were quite insensitive either to a 10% decrease in revenues or a 10% increase in costs. As a matter of fact, only in San Pedro Sacatepéquez and Santa María de Jesús the FIRR values decreased by around 20% in response to a 10% reduction in revenues or a 10% increase in costs, while responses of the remaining municipalities fluctuated between 10% and 15%.

In summary, the required total water charges per month may be too heavy a financial burden for households in such small municipalities as Santa Lucía Utatlán, San Francisco La Unión and Génova. Municipal authorities in these small communities will almost inevitably have to use part of the subsidies from the Central Government to ease the financial burden on the community residents. However, if the Project is expected to be successfully implemented, municipal

authorities in all communities should truly strive to educate their own residents, and convince water users to pay, at the very least, the operation and maintenance costs of their own drinking water supply service.

Table 9.3.1 Basic Data for the Project Evaluation
Cuadro 9.3.1 Datos Basicos para la Evaluacion del Proyecto

Community	Population Growth Rate (%)	Population in 1994 (Persons)	Population in 2010 (Persons)	Household Size (Persons)	WTP LowerBound (Q/month)	WTP Upper Bound (Q/month)	AverageValue of a House (Q)	Diarrea Incidence (%)
San Jose Pinula	3.64	11,277	19,970	6.1	10	15	60,000	31.28
San Pedro Sacatepequez	1.78	7,652	10,140	5.8	5	17	60,000	16.13
Santa Maria de Jesus	1.85	11,107	14,890	5.6	10	10	35,000	60.00
San Martin Jilotepeque	1.63	5,482	7,103	4.2	10	10	35,000	12.00
San Juan Comalapa	1.75	14,710	19,408	5.6	3	5	25,000	22.22
Solola	4.52	15,254	30,960	7.6	12	40	40,000	9.52
Santa Lucia Utatlan	5.03	2,176	4,773	6.3	10	30	15,000	10.00
Momostenango	3.03	10,390	16,740	5.7	6	40	20,000	31.59
San Francisco La Union	2.57	1,707	2,561	6.7	10	25	8,000	25.00
Genova	4.14	3,800	7,267	5.4	5	5	15,000	30.00

Table 9.3.2 The Project Incremental Revenues and Costs
Cuadro 9.3.2 Ingresos y Costos Incrementales del Proyecto

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	97,714	16,824	0	0	26,365	0	26,365	-26,365	-26,365
1999	100,536	17,287	1,323	3,141	0	1,835	1,835	-512	1,306
2000	103,453	17,765	1,363	3,244	0	1,835	1,835	-472	1,409
2001	106,468	18,258	1,403	3,352	0	1,835	1,835	-432	1,517
2002	109,585	18,768	1,445	3,463	0	1,835	1,835	-390	1,628
2003	112,809	19,294	1,489	3,579	0	1,835	1,835	-346	1,744
2004	116,142	19,837	1,534	3,699	0	1,835	1,835	-301	1,864
2005	119,590	20,398	1,580	3,823	0	1,835	1,835	-255	1,988
2006	123,157	20,978	1,629	3,952	0	1,835	1,835	-206	2,117
2007	126,846	21,577	1,679	4,086	0	1,835	1,835	-156	2,251
2008	130,664	22,196	1,730	4,225	1,696	1,835	3,531	-1,801	694
2009	134,614	22,836	1,784	4,369	0	1,835	1,835	-51	2,534
2010-2027	138,703	23,497	1,839	4,519	0	1,835	1,835	4	2,684

FIRR = 0.0656

Table 9.3.2a San Jose Pinula Incremental Revenues and Costs
Cuadro 9.3.2a Ingresos y Costos Incrementales de San Jose Pinula

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	13,011	2,133	0	0	1,748	0	1,748	-1,748	-1,748
1999	13,485	2,211	212	318	0	268	268	-56	50
2000	13,975	2,291	220	330	0	268	268	-48	62
2001	14,484	2,374	228	342	0	268	268	-40	74
2002	15,011	2,461	236	354	0	268	268	-32	86
2003	15,558	2,550	245	367	0	268	268	-23	99
2004	16,124	2,643	254	381	0	268	268	-14	113
2005	16,711	2,740	263	394	0	268	268	-5	126
2006	17,319	2,839	273	409	0	268	268	5	141
2007	17,950	2,943	282	424	0	268	268	14	156
2008	18,603	3,050	293	439	158	268	426	-133	13
2009	19,280	3,161	303	455	0	268	268	35	187
2010-2927	19,982	3,276	314	472	0	268	268	46	204

Table 9.3.2b San Pedro Sacatepequez Incremental Revenues and Costs
Cuadro 9.3.2b Ingresos y Costos Incrementales de San Pedro Sacatepequez

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	8,212	1,416	0	0	1,011	0	1,011	-1,011	-1,011
1999	8,358	1,441	69	235	0	156	156	-87	- 79
2000	8,507	1,467	70	239	0	156	156	-86	83
2001	8,658	1,493	72	244	0	156	156	-84	88
2002	8,812	1,519	73	248	0	156	156	-83	92
2003	8,969	1,546	74	252	0	156	156	-82	96
2004	9,129	1,574	76	257	0	156	156	-80	101
2005	9,292	1,602	77	261	0	156	156	-79	105
2006	9,457	1,630	78	266	0	156	156	-78	110
2007	9,625	1,660	80	271	0	156	156	-76	115
2008	9,797	1,689	81	276	102	156	258	-177	18
2009	9,971	1,719	83	281	0	156	156	-73	125
2010-2027	10,148	1,750	84	286	0	156	156	-72	130

FIRR = 0.0931

Table 9.3.2c Santa Maria de Jesus Incremental Revenues and Costs
Cuadro 9.3.2c Ingresos y Costos Incrementales de Santa Maria de Jesus

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	11,952	2,134	0	0	2,309	0	2,309	-2,309	-2,309
1999	12,173	2,174	209	209	0	432	432	-223	-223
2000	12,398	2,214	213	213	0	432	432	-219	-219
2001	12,628	2,255	216	216	0	432	432	-216	-216
2002	12,861	2,297	220	220	0	432	432	-212	-212
2003	13,099	2,339	225	225	0	432	432	-207	-207
2004	13,342	2,382	229	229	0	432	432	-203	-203
2005	13,588	2,426	233	233	0	432	432	-199	-199
2006	13,840	2,471	237	237	0	432	432	-195	-195
2007	14,096	2,517	242	242	0	432	432	-190	-190
2008	14,357	2,564	246	246	281	432	713	-467	-467
2009	14,622	2,611	251	251	0	432	432	-181	-181
2010-2027	14,893	2,659	255	255	0	432	432	-177	-177

FIRR = No solution

Table 9.3.2d San Martin Jilotepeque Incremental Revenues and Costs
Cuadro 9.3.2d Ingresos y Costos Incrementales de San Martin Jilotepeque

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	9,853	2,346	0	0	1,091	0	1,091	-1,091	-1,091
1999	10,014	2,384	229	229	0	157	157	72	- 72
2000	10,177	2,423	233	233	0	157	157	76	76
2001	10,343	2,463	236	236	0	157	157	79	79
2002	10,511	2,503	240	240	0	157	157	83	83
2003	10,683	2,543	244	244	0	157	157	87	87
2004	10,857	2,585	248	248	0	157	157	91	91
2005	11,034	2,627	252	252	0	157	157	95	95
2006	11,214	2,670	256	256	0	157	157	99	99
2007	11,396	2,713	260	260	0	157	157	103	103
2008	11,582	2,758	265	265	110	157	267	-2	-2
2009	11,771	2,803	269	269	0	157	157	112	112
2010-2027	11,963	2,848	273	273	0	157	157	116	116

FIRR = 0.074

Table 9.3.2e San Juan Comalapa Incremental Revenues and Costs
Cuadro 9.3.2e Ingresos y Costos Incrementales de San Juan Comalapa

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	15,767	2,816	0	0	7,590	0	7,590	-7,590	-7,590
1999	16,043	2,865	83	138	0	158	158	-75	-20
2000	16,324	2,915	84	140	0	158	158	-74	-18
2001	16,609	2,966	85	142	0	158	158	-73	-16
2002	16,900	3,018	87	145	0	158	158	-71	-13
2003	17,196	3,071	88	147	0	158	158	-70	-11
2004	17,497	3,124	90	150	0	158	158	-68	-8
2005	17,803	3,179	92	153	0	158	158	-66	-5
2006	18,114	3,235	93	155	0	158	158	-65	-3
2007	18,431	3,291	95	158	0	158	158	-63	-0
2008	18,754	3,349	96	161	240	158	398	-302	-237
2009	19,082	3,408	98	164	0	158	158	-60	6
2010-2026	19,416	3,467	100	166	0	158	158	-58	8

FIRR = No solution

Table 9.3.2f Solola Incremental Revenues and Costs
Cuadro 9.3.2f Ingresos y Costos Incrementales de Solola

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	18,205	2,395	0	0	5,552	0	5,552	-5,552	-5,552
1999	19,028	2,504	288	961	0	127	127	161	-834
2000	19,888	2,617	301	1,005	0	127	127	174	878
2001	20,787	2,735	315	1,050	0	127	127	188	923
2002	21,726	2,859	329	1,098	0	127	127	202	971
2003	22,708	2,988	344	1,147	0	127	127	217	1,020
2004	23,735	3,123	360	1,199	0	127	127	233	1,072
2005	24,808	3,264	376	1,253	0	127	127	249	1,126
2006	25,929	3,412	393	1,310	0	127	127	266	1,183
2007	27,101	3,566	411	1,369	0	127	127	284	1,242
2008	28,326	3,727	429	1,431	231	127	358	71	1,073
2009	29,606	3,896	449	1,496	0	127	127	322	1,369
2010-2027	30,944	4,072	469	1,563	0	127	127	342	1,436

FIRR = 0.026 0.1883

Table 9.3.2g Santa Lucia Utatlan Incremental Revenues and Costs
Cuadro 9.3.2g Ingresos y Costos Incrementales de Santa Lucia Utatlan

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	2,648	420	0	0	1,524	0	1,524	-1,524	-1,524
1999	2,781	441	42	127	0	96	96	-54	31
2000	2,921	464	45	134	0	96	96	-51	38
2001	3,068	487	47	140	0	96	96	-49	44
2002	3,222	511	49	147	0	96	96	-47	51
2003	3,384	537	52	155	0	96	96	-44	59
2004	3,555	564	54	162	0	96	96	-42	66
2005	3,733	593	57	171	0	96	96	-39	75
2006	3,921	622	60	179	0	96	96	-36	83
2007	4,118	654	63	188	0	96	96	-33	92
2008	4,326	687	66	198	108	96	204	-138	-6
2009	4,543	721	69	208	0	96	96	-27	112
2010-2027	4,772	757	73	218	0	96	96	-23	122

FIRR = 0.0368

Table 9.3.2h Momostenango Incremental Revenues and Costs
Cuadro 9.3.2h Ingresos y Costos Incrementales de Momostenango

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	11,708	2,054	0	0	2,583	0	2,583	-2,583	-2,583
1999	12,063	2,116	122	813	0	188	188	-66	-625
2000	12,428	2,180	126	837	0	188	188	-62	649
2001	12,805	2,246	129	863	0	188	188	-59	675
2002	13,193	2,315	133	889	0	188	188	-55	701
2003	13,593	2,385	137	916	0	188	188	-51	728
2004	14,004	2,457	142	943	0	188	188	-46	755
2005	14,429	2,531	146	972	0	188	188	-42	784
2006	14,866	2,608	150	1,001	0	188	188	-38	813
2007	15,316	2,687	155	1,032	0	188	188	-33	844
2008	15,780	2,769	159	1,063	244	188	432	-273	631
2009	16,259	2,852	164	1,095	0	188	188	-24	907
2010-2027	16,751	2,939	169	1,128	0	188	188	-19	940

FIRR = 0.2743

Table 9.3.2i San Francisco La Union Incremental Revenues and Costs
Cuadro 9.3.2i Ingresos y Costos Incrementales de San Francisco La Union

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	1,889	282	0	0	1,276	0	1,276	-1,276	-1,276
1999	1,938	289	28	69	0	96	96	-68	-27
2000	1,987	297	28	71	0	96	96	-68	-25
2001	2,038	304	29	73	0	96	96	-67	-23
2002	2,091	312	30	75	0	96	96	-66	-21
2003	2,145	320	31	77	0	96	96	-65	-19
2004	2,200	328	32	79	0	96	96	-64	-17
2005	2,256	337	32	81	0	96	96	-64	-15
2006	2,314	345	33	83	0	96	96	-63	-13
2007	2,374	354	34	85	0	96	96	-62	-11
2008	2,435	363	35	87	105	96	201	-166	-114
2009	2,497	373	36	89	0	96	96	-60	-7
2010-2027	2,562	382	37	92	0	96	96	-59	-4

FIRR = No solution

Table 9.3.2j Genova Incremental Revenues and Costs
Cuadro 9.3.2j Ingresos y Costos Incrementales de Genova

Year	Population (Persons)	Hholds. (Number)	Low WTP (1,000Q)	High WTP (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	Low CF (1,000Q)	High CF (1,000Q)
1998	4,469	828	0	0	1,681	0	1,681	-1,681	-1,681
1999	4,654	862	41	41	0	157	157	-116	-116
2000	4,847	898	43	43	0	157	157	-114	-114
2001	5,047	935	45	45	0	157	157	-112	-112
2002	5,256	973	47	47	0	157	157	-110	-110
2003	5,474	1,014	49	49	0	157	157	-108	-108
2004	5,701	1,056	51	51	0	157	157	-106	-106
2005	5,937	1,099	53	53	0	157	157	-104	-104
2006	6,182	1,145	55	55	0	157	157	-102	-102
2007	6,438	1,192	57	57	0	157	157	-100	-100
2008	6,705	1,242	60	60	117	157	274	-214	-214
2009	6,982	1,293	62	62	0	157	157	-95	-95
2010-2027	7,272	1,347	65	65	0	157	157	-92	-92

FIRR = No solution

Table 9.3.3 Economic Benefits of the Project
Cuadro 9.3.3 Beneficios Economicos del Proyecto

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	97,714	16,824	597,996	0	0	0	0	26,365	0	26,365	-26,365
1999	100,536	17,287	614,583	1,536	6,146	1,373	9,055	0	1,835	1,835	7,220
2000	103,453	17,765	631,708	1,579	6,317	1,409	9,305	0	1,835	1,835	7,470
2001	106,468	18,258	649,390	1,623	6,494	1,447	9,564	0	1,835	1,835	7,729
2002	109,585	18,768	667,650	1,669	6,676	1,485	9,831	0	1,835	1,835	7,996
2003	112,809	19,294	686,508	1,716	6,865	1,525	10,107	0	1,835	1,835	8,272
2004	116,142	19,837	705,987	1,765	7,060	1,567	10,391	0	1,835	1,835	8,556
2005	119,590	20,398	726,109	1,815	7,261	1,609	10,685	0	1,835	1,835	8,850
2006	123,157	20,978	746,899	1,867	7,469	1,653	10,989	0	1,835	1,835	9,154
2007	126,846	21,577	768,380	1,921	7,684	1,698	11,303	0	1,835	1,835	9,468
2008	130,664	22,196	790,579	1,976	7,906	1,744	11,627	1,696	1,835	3,531	8,096
2009	134,614	22,836	813,522	2,034	8,135	1,792	11,961	0	1,835	1,835	10,126
2010-2027	138,703	23,497	837,235	2,093	8,372	1,842	12,307	0	1,835	1,835	10,472

EIRR = 0.304500

Table 9.3.3a San Jose Pinula Economic Benefits
Cuadro 9.3.3a Beneficios Economicos de San Jose Pinula

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	13,011	2,133	127,977	0	0	0	0	1,748	0	1,748	-1,748
1999	13,485	2,211	132,635	332	1,326	228	1,886	0	268	268	1,618
2000	13,975	2,291	137,463	344	1,375	236	1,954	0	268	268	1,686
2001	14,484	2,374	142,467	356	1,425	245	2,025	0	268	268	1,757
2002	15,011	2,461	147,653	369	1,477	254	2,099	0	268	268	1,831
2003	15,558	2,550	153,027	383	1,530	263	2,176	0	268	268	1,908
2004	16,124	2,643	158,598	396	1,586	272	2,255	0	268	268	1,987
2005	16,711	2,740	164,371	411	1,644	282	2,337	0	268	268	2,069
2006	17,319	2,839	170,354	426	1,704	293	2,422	0	268	268	2,154
2007	17,950	2,943	176,554	441	1,766	303	2,510	0	268	268	2,242
2008	18,603	3,050	182,981	457	1,830	314	2,601	158	268	426	2,175
2009	19,280	3,161	189,642	474	1,896	326	2,696	0	268	268	2,428
2010-2027	19,982	3,276	196,544	491	1,965	338	2,794	0	268	268	2,526

EIRR = 0.9675

Table 9.3.3b San Pedro Sacatepequez Economic Benefits
Cuadro 9.3.3b Beneficios Economicos de San Pedro Sacatepequez

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	8,212	1,416	84,952	0	0	0	0	1,011	0	1,011	-1,011
1999	8,358	1,441	86,464	216	865	73	1,154	0	156	-156	998
2000	8,507	1,467	88,003	220	880	74	1,174	0	156	156	1,018
2001	8,658	1,493	89,569	224	896	75	1,195	0	156	156	1,039
2002	8,812	1,519	91,164	228	912	77	1,216	0	156	156	1,060
2003	8,969	1,546	92,786	232	928	78	1,238	0	156	156	1,082
2004	9,129	1,574	94,438	236	944	80	1,260	0	156	156	1,104
2005	9,292	1,602	96,119	240	961	81	1,282	0	156	156	1,126
2006	9,457	1,630	97,830	245	978	82	1,305	0	156	156	1,149
2007	9,625	1,660	99,571	249	996	84	1,328	0	156	156	1,172
2008	9,797	1,689	101,344	253	1,013	85	1,352	102	156	258	1,094
2009	9,971	1,719	103,148	258	1,031	87	1,376	0	156	156	1,220
2010-2027	10,148	1,750	104,979	262	1,050	88	1,401	0	156	156	1,245

EIRR = 1.0001

Table 9.3.3c Santa Maria de Jesus Economic Benefits
Cuadro 9.3.3c Beneficios Economicos de Santa Maria de Jesus

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	11,952	2,134	74,700	0	0	0	0	2,309	0	2,309	-2,309
1999	12,173	2,174	76,082	190	761	394	1,345	0	432	432	913
2000	12,398	2,214	77,489	194	775	402	1,370	0	432	432	938
2001	12,628	2,255	78,923	197	789	409	1,396	0	432	432	964
2002	12,861	2,297	80,383	201	804	417	1,421	0	432	432	989
2003	13,099	2,339	81,870	205	819	424	1,448	0	432	432	1,016
2004	13,342	2,382	83,385	208	834	432	1,475	0	432	432	1,043
2005	13,588	2,426	84,927	212	849	440	1,502	0	432	432	1,070
2006	13,840	2,471	86,499	216	865	448	1,530	0	432	432	1,098
2007	14,096	2,517	88,099	220	881	457	1,558	0	432	432	1,126
2008	14,357	2,564	89,729	224	897	465	1,587	281	432	713	874
2009	14,622	2,611	91,389	228	914	474	1,616	0	432	432	1,184
2010-2027	14,893	2,659	93,081	233	931	483	1,646	0	432	432	1,214

EIRR = 0.4201

Table 9.3.3d San Martin Jilotepeque Economic Benefits
Cuadro 9.3.3d Beneficios Economicos de San Martin Jilotepeque

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	9,853	2,346	82,108	0	0	0	0	1,091	0	1,091	-1,091
1999	10,014	2,384	83,447	209	834	65	1,108	0	157	-157	951
2000	10,177	2,423	84,807	212	848	66	1,126	0	157	157	969
2001	10,343	2,463	86,189	215	862	67	1,144	0	157	157	987
2002	10,511	2,503	87,594	219	876	68	1,163	0	157	157	1,006
2003	10,683	2,543	89,022	223	890	69	1,182	0	157	157	1,025
2004	10,857	2,585	90,473	226	905	70	1,201	0	157	157	1,044
2005	11,034	2,627	91,948	230	919	71	1,221	0	157	157	1,064
2006	11,214	2,670	93,446	234	934	73	1,241	0	157	157	1,084
2007	11,396	2,713	94,970	237	950	74	1,261	0	157	157	1,104
2008	11,582	2,758	96,518	241	965	75	1,282	110	157	267	1,015
2009	11,771	2,803	98,091	245	981	76	1,302	0	157	157	1,145
2010-2027	11,963	2,848	99,692	249	997	78	1,324	0	157	157	1,167

EIRR = 0.8904

Table 9.3.3e San Juan Comalapa Economic Benefits
Cuadro 9.3.3e Beneficios Economicos de San Juan Comalapa

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	15,767	2,816	70,388	0	0	0	0	7,590	0	7,590	-7,590
1999	16,043	2,865	71,620	179	716	192	1,088	0	158	158	930
2000	16,324	2,915	72,874	182	729	196	1,107	0	158	158	949
2001	16,609	2,966	74,149	185	741	199	1,126	0	158	158	968
2002	16,900	3,018	75,446	189	754	203	1,146	0	158	158	988
2003	17,196	3,071	76,767	192	768	206	1,166	0	158	158	1,008
2004	17,497	3,124	78,110	195	781	210	1,186	0	158	158	1,028
2005	17,803	3,179	79,477	199	795	214	1,207	0	158	158	1,049
2006	18,114	3,235	80,868	202	809	217	1,228	0	158	158	1,070
2007	18,431	3,291	82,283	206	823	221	1,250	0	158	158	1,092
2008	18,754	3,349	83,723	209	837	225	1,272	240	158	398	874
2009	19,082	3,408	85,188	213	852	229	1,294	0	158	158	1,136
2010-2027	19,416	3,467	86,679	217	867	233	1,316	0	158	158	1,158

EIRR = 0.1319

Table 9.3.3f Solola Economic Benefits
Cuadro 9.3.3f Beneficios Economicos de Solola

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	18,205	2,395	95,816	0	0	0	0	5,552	0	5,552	-5,552
1999	19,028	2,504	100,147	250	1,001	98	1,350	0	127	127	1,223
2000	19,888	2,617	104,673	262	1,047	102	1,411	0	127	127	1,284
2001	20,787	2,735	109,405	274	1,094	107	1,474	0	127	127	1,347
2002	21,726	2,859	114,350	286	1,143	112	1,541	0	127	127	1,414
2003	22,708	2,988	119,518	299	1,195	117	1,611	0	127	127	1,484
2004	23,735	3,123	124,920	312	1,249	122	1,684	0	127	127	1,557
2005	24,808	3,264	130,567	326	1,306	128	1,760	0	127	127	1,633
2006	25,929	3,412	136,468	341	1,365	133	1,839	0	127	127	1,712
2007	27,101	3,566	142,637	357	1,426	139	1,922	0	127	127	1,795
2008	28,326	3,727	149,084	373	1,491	146	2,009	231	127	358	1,651
2009	29,606	3,896	155,823	390	1,558	152	2,100	0	127	127	1,973
2010-2027	30,944	4,072	162,863	407	1,629	159	2,195	0	127	127	2,068

EIRR = 0.2628

Table 9.3.3g Santa Lucia Utatlan Economic Benefits
Cuadro 9.3.3g Beneficios Economicos de Santa Lucia Utatlan

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	2,648	420	6,305	0	0	0	0	1,524	0	1,524	-1,524
1999	2,781	441	6,622	17	66	15	98	0	96	96	2
2000	2,921	464	6,955	17	70	16	103	0	96	96	7
2001	3,068	487	7,305	18	73	17	108	0	96	96	12
2002	3,222	511	7,672	19	77	17	113	0	96	96	17
2003	3,384	537	8,058	20	81	18	119	0	96	96	23
2004	3,555	564	8,463	21	85	19	125	0	96	96	29
2005	3,733	593	8,889	22	89	20	131	0	96	96	35
2006	3,921	622	9,336	23	93	21	138	0	96	96	42
2007	4,118	654	9,806	25	98	22	145	0	96	96	49
2008	4,326	687	10,299	26	103	23	152	108	96	204	-52
2009	4,543	721	10,817	27	108	25	160	0	96	96	64
2010-2027	4,772	757	11,362	28	114	26	168	0	96	96	72

EIRR = No solution

Table 9.3.3h Momostenango Economic Benefits
Cuadro 9.3.3h Beneficios Economicos de Momostenango

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	11,708	2,054	41,081	0	0	0	0	2,583	0	2,583	-2,583
1999	12,063	2,116	42,325	106	423	206	735	0	188	- 188	547
2000	12,428	2,180	43,608	109	436	212	757	0	188	188	569
2001	12,805	2,246	44,929	112	449	218	780	0	188	188	592
2002	13,193	2,315	46,291	116	463	225	804	0	188	188	616
2003	13,593	2,385	47,693	119	477	232	828	0	188	188	640
2004	14,004	2,457	49,138	123	491	239	853	0	188	188	665
2005	14,429	2,531	50,627	127	506	246	879	0	188	188	691
2006	14,866	2,608	52,161	130	522	254	906	0	188	188	718
2007	15,316	2,687	53,742	134	537	261	933	0	188	188	745
2008	15,780	2,769	55,370	138	554	269	961	244	188	432	529
2009	16,259	2,852	57,048	143	570	277	990	0	188	188	802
2010-2027	16,751	2,939	58,775	147	588	286	1,020	0	188	188	832

EIRR = 0.2436

Table 9.3.3i San Francisco La Union Economic Benefits
Cuadro 9.3.3i Beneficios Economicos de San Francisco La Union

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	1,889	282	2,256	0	0	0	0	1,276	0	1,276	-1,276
1999	1,938	289	2,313	6	23	26	55	0	96	96	-41
2000	1,987	297	2,373	6	24	27	56	0	96	96	-40
2001	2,038	304	2,434	6	24	28	58	0	96	96	-38
2002	2,091	312	2,496	6	25	28	59	0	96	96	-37
2003	2,145	320	2,561	6	26	29	61	0	96	96	-35
2004	2,200	328	2,626	7	26	30	63	0	96	96	-33
2005	2,256	337	2,694	7	27	30	64	0	96	96	-32
2006	2,314	345	2,763	7	28	31	66	0	96	96	-30
2007	2,374	354	2,834	7	28	32	67	0	96	96	-29
2008	2,435	363	2,907	7	29	33	69	105	96	201	-132
2009	2,497	373	2,982	7	30	34	71	0	96	96	-25
2010-2027	2,562	382	3,059	8	31	35	73	0	96	96	-23

EIRR = No solution

Table 9.3.3j Genova Economic Benefits
Cuadro 9.3.3j Beneficios Economicos de Genova

Year	Population (Persons)	Houses (Number)	House&Land (1,000Q)	Fire Prev (1,000Q)	Land App (1,000Q)	Diarrea (1,000Q)	EconBenef (1,000Q)	Inv&Repl (1,000Q)	O&M (1,000Q)	TotalCost (1,000Q)	CashFlow (1,000Q)
1998	4,469	828	12,414	0	0	0	0	1,681	0	1,681	-1,681
1999	4,654	862	12,928	32	129	75	237	0	157	157	80
2000	4,847	898	13,463	34	135	79	247	0	157	157	90
2001	5,047	935	14,020	35	140	82	257	0	157	157	100
2002	5,256	973	14,601	37	146	85	268	0	157	157	111
2003	5,474	1,014	15,205	38	152	89	279	0	157	157	122
2004	5,701	1,056	15,835	40	158	92	290	0	157	157	133
2005	5,937	1,099	16,490	41	165	96	302	0	157	157	145
2006	6,182	1,145	17,173	43	172	100	315	0	157	157	158
2007	6,438	1,192	17,884	45	179	104	328	0	157	157	171
2008	6,705	1,242	18,624	47	186	109	341	117	157	274	67
2009	6,982	1,293	19,396	48	194	113	356	0	157	157	199
2010-2027	7,272	1,347	20,200	51	202	118	370	0	157	157	213

EIRR = 0.0801