DOMINICAN REPUBLIC

INSTITUTO NACIONAL DE AGUAS POTABLES

Y ALCANTARILLADOS

THE STUDY ON GROUNDWATER DEVELOPMENT PROJECT IN THE WESTERN REGION DOMINICAN REPUBLIC

VOLUME I

SUMMARY

AUGUST 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION MAP OF PROJECT AREA

MONTE CRISTI

DAJABON

HAITI REPUBLIC

PROJECT AREA

CORDILLERA CENTRAL

ELIAS PIÑA

SIERRA DE NEIBA

INDEPENDENCIA

SIERRA DE BAORUCO

REPUBLICA DOMINICANA

SANTIAGO

SANTO DOMINGO

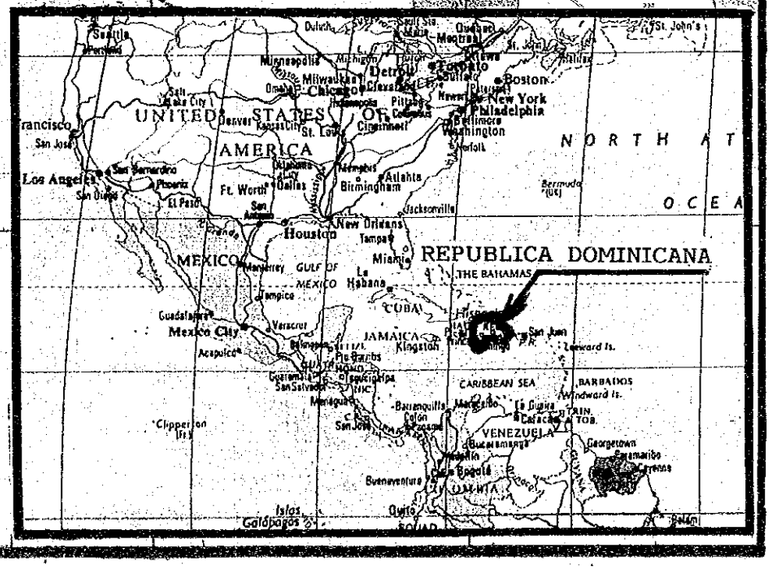
SAN CRISTOBAL

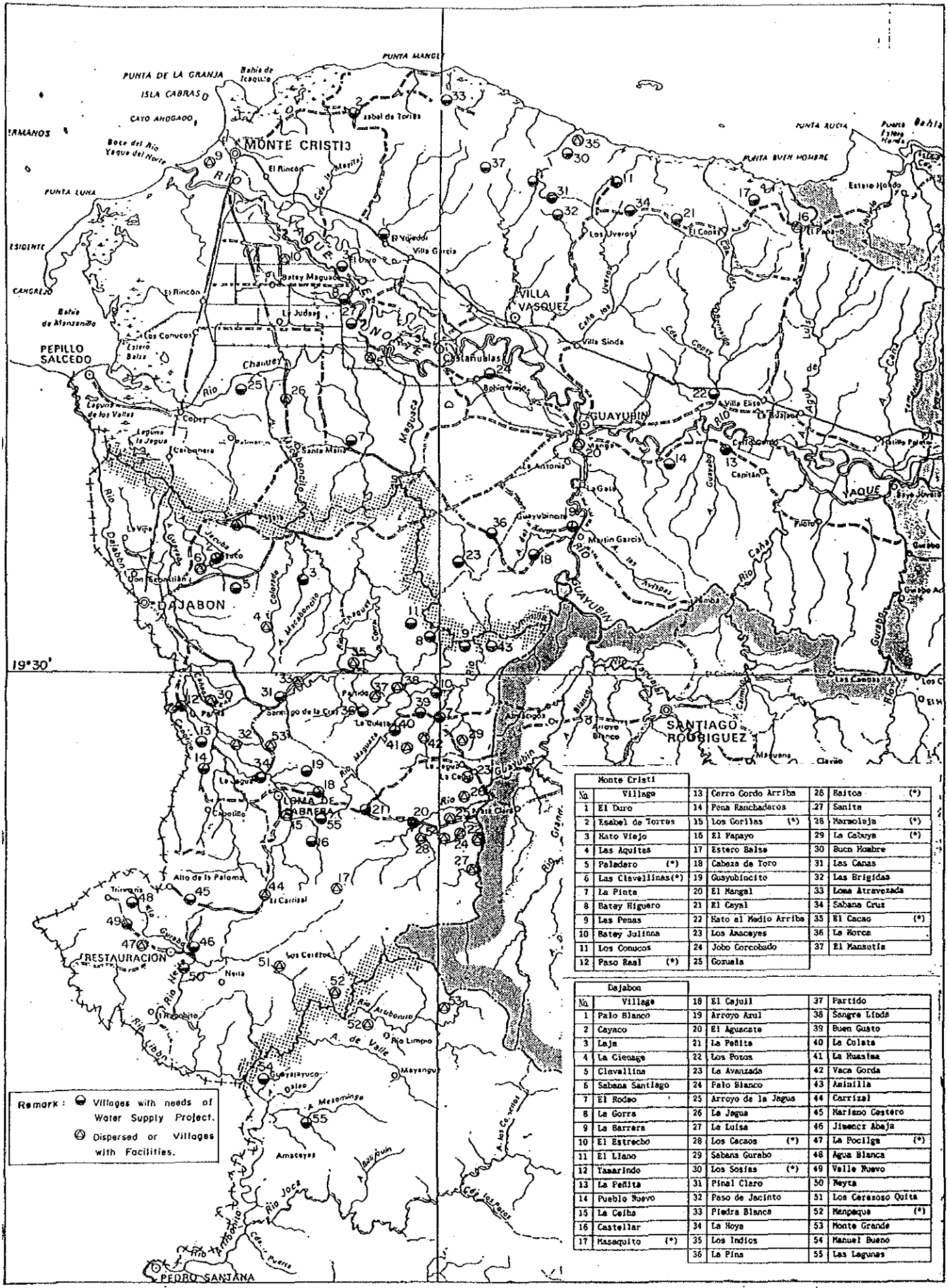
LA ROMANA

BARAHONA

0 10 20 30 40km

SCALE 1 : 500,000



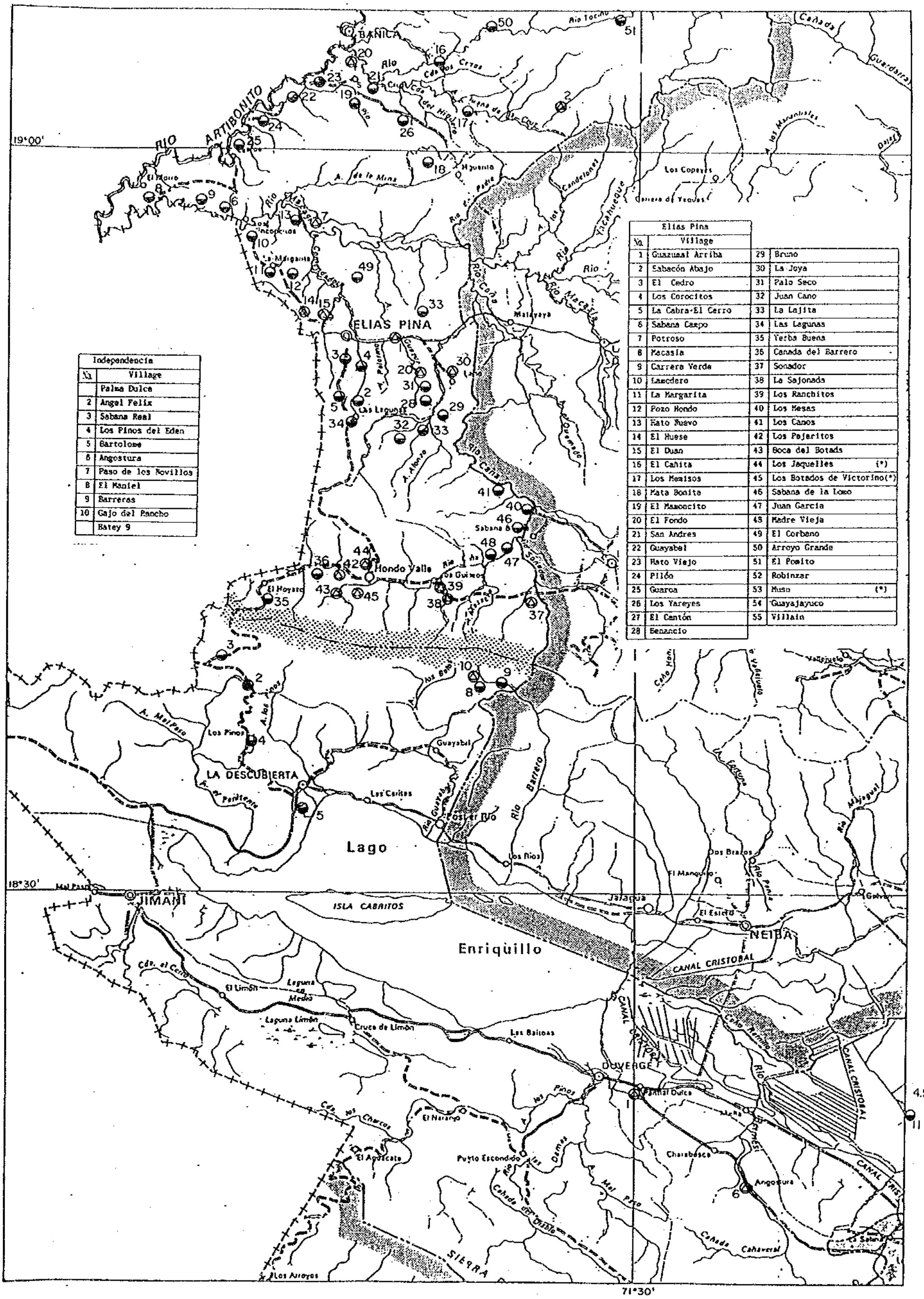


Monte Cristi					
№	Village	13	Cerro Gordo Arriba	26	Baitos (*)
1	El Duro	14	Pena Ranchaderos	27	Sanita
2	Esabel de Torres	15	Los Gorilas (*)	28	Manzoleja (*)
3	Hato Viejo	16	El Papayo	29	La Cabaya (*)
4	Las Aquitas	17	Estero Balse	30	Buen Hombre
5	Paladero (*)	18	Cabeza de Toro	31	Las Canas
6	Las Clavellinas(*)	19	Guayubincito	32	Las Brigidas
7	La Pinta	20	El Mangal	33	Loma Atravezada
8	Batey Higuero	21	El Cayal	34	Sabana Cruz
9	Las Penas	22	Hato al Medio Arriba	35	El Cacao (*)
10	Batey Julinna	23	Los Anaceyes	36	La Horca
11	Los Conucos	24	Jobo Corcobado	37	El Mansutia
12	Paso Real (*)	25	Gozuela		

Dajabon					
№	Village	18	El Cajuil	37	Partido
1	Palo Blanco	19	Arroyo Azul	38	Sangre Linda
2	Cayaco	20	El Aguacate	39	Buen Gusto
3	Laja	21	La Penita	40	La Culata
4	La Cienaga	22	Los Pozos	41	La Ruanina
5	Clavellina	23	La Avanzada	42	Vaca Gorda
6	Sabana Santiago	24	Palo Blanco	43	Aminilla
7	El Rodeo	25	Arroyo de la Jagua	44	Carrizal
8	La Gorra	26	La Jagua	45	Mariano Castero
9	La Barrera	27	La Luisa	46	Jimenez Abaja
10	El Estrecho	28	Los Cacaos (*)	47	La Pocilga (*)
11	El Llano	29	Sabana Gurabo	48	Agua Blanca
12	Tamarindo	30	Los Sosias (*)	49	Valle Nuevo
13	La Penita	31	Final Claro	50	Neyta
14	Pueblo Nuevo	32	Paso de Jacinto	51	Los Cerezoso Quita
15	La Ceiba	33	Piedra Blanca	52	Manpaque (*)
16	Castellar	34	La Hoya	53	Monte Grande
17	Masequito (*)	35	Los Indios	54	Manuel Bueno
		36	La Pina	55	Las Lagunas

Villages Location Map (1/2)

0 5 10 15 km



Independencia	
No.	Village
	Palma Dulce
2	Angel Felix
3	Sabana Real
4	Los Pinos del Eden
5	Bartolome
6	Angostura
7	Paso de los Novillos
8	El Maniel
9	Barreras
10	Gajo del Pancho
	Batey 9

Elias Pina			
No.	Village		
1	Guazumal Arriba	29	Bruno
2	Sabacón Abajo	30	La Joya
3	El Cedro	31	Palo Seco
4	Los Corocitos	32	Juan Cano
5	La Cabra-El Cerro	33	La Lajita
6	Sabana Campo	34	Las Lagunas
7	Potroso	35	Yerba Buena
8	Macasia	36	Canada del Barrero
9	Carrera Yerda	37	Sonador
10	Lamedero	38	La Sajonada
11	La Margarita	39	Los Ranchitos
12	Pozo Hondo	40	Los Mesas
13	Hato Nuevo	41	Los Canos
14	El Huese	42	Los Pajeritos
15	El Duan	43	Boca del Botads
16	El Cañita	44	Los Jaquelles (*)
17	Los Memisos	45	Los Botados de Victorino(*)
18	Mata Bonita	46	Sabana de la Lomo
19	El Mamoncito	47	Juan Garcia
20	El Fondo	48	Madre Vieja
21	San Andres	49	El Corbano
22	Guayabal	50	Arroyo Grande
23	Hato Viejo	51	El Pomito
24	Pilón	52	Robinzar
25	Guaroa	53	Muso (*)
26	Los Yareyes	54	Guayajayuco
27	El Cantón	55	Villain
28	Benancio		

Villages Location Map (2/2)

0 5 10 15km

TABLE OF CONTENTS

SUMMARY

1. Preface

1.1 This Report is prepared based on the "Scope of Work for the Study on the Groundwater Development Project in the Western Region of the Dominican Republic", agreed upon between the Institute Nacional de Aguas Potables y Alcantarillados (INAPA) and Japan International Cooperation Agency (JICA) on February 13, 1990.

1.2 The objectives of the Study are to evaluate the potentiality of groundwater resources and to prepare a groundwater development plan, including a rural water supply plan for 158 villages, in four western provinces of the Dominican Republic, namely Monte Cristi, Dajabon, Elias Pina, and Independencia.

2. Present Conditions

2.1 The proposed Project area covers four administrative provinces, namely Monte Cristi, Dajabon, Elias Piña and Independencia. There are situated along the frontier with the Republic of Haiti, and cover 6,527 km^2, which corresponds to 13.4% of the total surface area of the country. The proposed Project Area accounts for 4.4% of the overall population according to the 1981 Population Census. The population of each province is shown below:

Province	Population 1981 Census	1990 Estimate
Monte Cristi	82,891	92,678
Dajabon	56,926	64,123
Elias Pina	65,727	72,651
Independencia	46,882	43,077
Total	252,425	272,529

2.2 The proposed Project Area shows rich topographic variations ranging from low areas of 40 m below sea level to mountain plateaus of more than 2,000 m. There are large regional differences not only in hydrological and meteorological conditions, but also in socioeconomic conditions.

Being restricted by physical and socioeconomic conditions, the level of water supply to the area residents reveals wide regional differences.

2.3 The general conditions of water supply service of the 4 provinces are as follows:

Monte Cristi Province

- Hand pump wells and wind pump wells are provided to the main villages of the northern mountain area. However, the groundwater is too salty for drinking, whereby it is used only for miscellaneous purposes. Drinking water is distributed by tank lorries, in addition to rain water stored by the area residents.
- The water sources of the central lowland area of the Yaque del Norte river basin are the branch rivers of Yaque del Norte, namely Guayubin, and La Cana. The river water is purified in the treatment plant of the water supply system. However, a part of the villages relies on hand pump wells.
- The water sources of the eastern area of the Yaque del Norte left bank river basin are Guayubin, Inajo, and Cana rivers. The surface water is purified in the treatment plant of the water supply system. The downstream areas, on the other hand, get their water supply from hand pump wells and from the nearest irrigation canal.
  However, the groundwater along the border with Dajabon Province is too salty for drinking.
  The Salcedo Lake is the water of source for the Pepillo Salcedo water supply system.

Dajabon Province

- The areas in and around Dajabon City get their drinking water from the modern water supply system which uses the Dajabon River as the water source.
- The towns located in the hills and plateaus in the center and south of the province get good quality water service through the water supply system, which uses Maguaca, Capotillo and Neita rivers as water sources.

Elias Pina Province

- The Comendador area gets its water from the water supply system which uses the Las Carreras Canal as water source. Hand pump wells are also used.

- The Pedro Santana area, located in the northwest of the Province, has a water supply system which pumps up surface water from the Artibonito River. In Sabana Cruz and Higuerito areas near the Pedro Santana area, groundwater-based water supply system services are provided through house connections.

Independencia Province

- There are 8 water supply systems by house connection in the northern bank area of Lake Enriquillo. Water sources are springs with abundant water existing in the alluvial fan formed in the south of Neiba Mountains. Water is taken either directly from springs or from rivers where spring water flows in.
- The southern bank basin of Lake Enriquillo uses abundant groundwater or spring water to service water through 6 water supply systems. In the western area of the southern bank, water is serviced by the Jimani water supply system, which uses the Jimani Canal as water source. However, the canal's water has become increasingly turbid in recent years, and the area is confronted with problems of rising water treatment expenses.

2.4 The service population of the 4 western provinces is estimated to be approximately 54%, excluding the population using the hand and wind pump wells. However, the service population of the rural area is only 16% approximately.

The systematic water service for the area, by INAPA, has taken place along the easily accessible trunk roads. On the other hand, in hard-to-reach inland villages, the difficulty to secure water during the dry season aggravates the village tendency to be depopulated due to population migration to urban areas.

Based on these circumstances, development and stable supply of safe water for domestic use will satisfy an old and strong demand of the residents, and will contribute to stabilize and improve living conditions of the local residents.

Furthermore, provision of water supply will contribute to decrease the population migration to urban areas and the resulting disintegration of rural villages. The ensuing favorable effects will consist of activation of regional production, and prevention of population concentration in urban areas. The development of water supply for domestic use in this area, therefore, is regionally and nationally of extreme importance.

3. The Project

3.1 The Project comprises the following components:

Groundwater Resources Development Plan
Water Resources Development Plan
Water Production/Supply Plan
Facility/Equipment Plan
Operation/Maintenance Plan

3.2 The Project area is divided into 8 hydrogeological provinces, according to the recharge mechanism and the geological structure of the aquifers in the area. Each hydrogeological province shows various groundwater characteristics, especially when examining the existing recharge storage conditions, development potential and potential volume. Nevertheless, except for a local area restricted by hydrogeological, climatic and geographic conditions, the groundwater development potential is assessed to be high and adequate enough to solve the serious shortage of domestic water in the Project Area.

- The recharge storage of groundwater in Cordillera Septentional (Hydrogeological Province Ⅰ) is low and high content values of SO_4 and Cl have been observed. Groundwater development potential is estimated to be low.

- The left bank area of Rio Macasia, the central part of Elias Piña Province, (Hydrogeological Province Ⅴ-2) shows a low quantity of water recharge too, and development potential is comparatively low.

- Development of living water supply in the surrounding areas of Lago Enriquillo (Hydrogeological Province Ⅵ, Ⅶ, Ⅷ) is not urgently required as a water supply system is serviced, using water springs as a water source. Besides, these areas are excluded from the Groundwater Development Plan together with the aforementioned Ⅰ and Ⅴ2 hydrogeological provinces.

- The hydrogeological provinces where groundwater development is available were determined based on the results of test well drilling operations.

- The Groundwater Development Plan was settled on, and the required depth of the designed wells required pump heads and safety yield were evaluated in accordance with the specific characters of groundwater in the respective provinces.

- The Groundwater Development is intended for the area ranging south of the Northern Mountains (I) and north of Rio Macasia left band area (V -2) in the Elias Piña Province.

- Groundwater in the Province II , that is the flood plain of Rio Yaque del Norte, is of unconfined type and stored in a relatively shallow place. Province IV chiefly consists of weathering zone or fissure zone located on basement rocks, where groundwater of high water quality is likely to be developed.

- Groundwater in the Province IV is briefly storaged in a weathering zone and/or structured zone of the basement rocks, where groundwater of higher quality is likely to be developed.
  Groundwater of both Province II , IV and northern part of VI will be targeted by the Groundwater Development Plan.

- Provinces III -1, 2, 3 are inferred to be very promising areas on a qualitative and quantitative viewpoint, followed by Provinces III -4 and IV -1.

- The summary of aquifer properties of each hydrogeological province is presented below;

No.	Hydrogeological Province Name	Yield Capacity (l/min)		Depth of Aquifer (m)	Kind of Aquifer
I	Cordillera Septentrional	Lack of available aquifer within 150 m in depth		–	×
II	Llano de Rio Yaque del Norte	Q = 100	partly Q ≧ 500	< 60	* Unconfined
III$_1$	Sur del Yaque del Norte	Q = 100		60 ~ 90	* Confined
III$_2$	Sur del Yaque del Norte	Q ≧ 100	partly Q ≧ 1000	60 ~ 90	* Confined
III$_3$	Sur del Yaque del Norte	Q = 300	partly Q ≧ 500	60 ~ 120	* Confined
III$_4$	Sur del Yaque del Norte	20 > Q ≧ 5,	partly Q ≧ 300~500	30 ~ 60	* Confined
IV$_1$	Cordillera Central	60 > Q ≧ 10		30 ~ 60	* Unconfined
IV$_2$	Cordillera Central (north)	Lack of high available aquifer up to the basement situated at 90 m in depth		70	* Unconfined
IV$_2$	Cordillera Central (south)	Lack of high available aquifer up to the basement situated at 60 m in depth		70	* Unconfined
IV$_3$	Cordillera Central	20 > Q ≧ 5		–	(Surface Water)
V$_1$	Valle de San Juan	20 > Q ≧ 5,	partly Q ≧ 300~500	50 - 70	Confined
V$_2$	Valle de San Juan	Lack of available aquifer within 120 m in depth		–	×
VI	Sierra de Neiba	20 > Q ≧ 5		50 - 70	* Unconfined
VII$_1$	Cuenca de Enriquillo	–		–	(Spring)
VII$_2$	Cuenca de Enriquillo	200 > Q ≧ 100,	partly Q ≧ 3000	80	Unconfined
VIII	Sierra de Baoruco	20 > Q ≧ 5		–	Unconfined

*Proposed groundwater development province

3.3 The Project Area is divided into seven (7) hydrological basins according to the distribution of the river systems.
The stream flow water development potentiality for the Project in the proposed area is concluded to be very low, because the surplus discharge water is estimated to exceed 10-hm3/year with 80% of return flow, however, more than 70% of the annual discharge is observed during the rainy season. It seems therefore impossible to implement an effective water supply service in absence of high dam facilities.

3.4 The rainfall amount and distribution in the Project Area vary locally and annually, however, a limited number of villages rely on rainwater only as a water source for domestic water use.

3.5 The water resources development will be carried out in the 158 villages proposed by INAPA. Accordingly, water development potentiality, present water supply circumstances and socio-economical conditions of each of the proposed villages were examined. The results are tabulated below:

Provinces	Disoluted Villages	Villages Covered by Existing Water Service System	Villages Requiring Water Supply Development	Total
Monte Cristi	8	5	24	37
Dajabon	5	23	27	55
Elias Piña	3	13	39	55
Independencia	2	4	5	11
Total	18	45	95	158

3.6 58 villages were selected, while the other villages were excluded due to the following conditions:

- Poor groundwater development potential
- Access conditions very poor
- Only mountain streams flow water is available
- Area covered by existing urban water supply systems
- Villages with less than 20 households
- Villages located in the Independencia Province

3.7 The water production and water supply plan were formulated in accordance with the following standards:

–	Target year	2000 year
–	Service Population	65,707 in 2000
–	Water Consumption	40~100 ℓ/day/cap. However, 15 ℓ/day/cap, for drinking water distributed by water wagon
–	Water Quality	Natural groundwater supply Reserved rain water purified

3.8 The design production water is estimated for every villages from the prospective demand in the year 2000. Two methods have been selected for the groundwater production, taking into consideration the design production water capacity per unit hour, the required lifting head, and the variation of the dynamic head of the groundwater: pumping up water by manual power, and pumping up water by electric motor by a generator.

3.9 Forty (40) villages are provided by 131 wells using a hand pump, seven (7) villages are provided by 7 wells with a submersible motor pump.
The proposed villages, beneficiary villages, and well numbers of each province are shown as follows:

		Handpump		Submersible Motor Pump	
Prefecture	Villages	Beneficiary Villages	Wells	Beneficiary Villages	Wells
Monte Cristi	19	2	5	6	6
Dajabon	21	20	72	1	1
Elias Piña	18	18	54		
Independencia	–	–		–	–
Total	58	40	131	7	7

3.10 In consideration of the present water shortage circumstances and dependable water resources conditions, the improvement of existing two reservoirs is proposed to catch and store the surface runoff water and to supply seven villages with domestic water.
Location of the proposed reservoirs, covered villages, and beneficiary population are presented below:

3.11 The present water supply status of the four villages,namely Isabel de Torres, Estero Balsa, Lom Atravezacla, and El Manantial, with a total

Reservoir Name	Covered Villages	Beneficiary Population
Las Brigada	Las Aguitas	692
	Buen Hombre	423
	Las Canas	245
	Las Brigada	95
Total		1,455
El Cayal	Los Conucos	483
	El Cayal	424
	Sabana Cruz	647
Total		1,554 persons

population of 1160, and located close to the Atlantic Ocean, is similar to the four mentioned villages.

A water transport system by water wagon is proposed for the said villages, however, the distributed water, which is a clean drinking water, will only amount to 15 ℓ/day per capita.

3.12 The proposed water supply system plan is devised in connection with the proposed water production systems.

The proposed water supply systems are shortly summarized below.

Production System	Water Supply System
Hand Pump (Type Ⅰ)	Water Transportation by the Beneficiary himself
Submersible Motor Pump (Type Ⅱ)	Elevated Water Tank –Communal Faucet – Water Transportation by the Beneficiary himself
Reservoir (Type Ⅲ)	Intake Water Pump – Sand Filter – Chlorination – Booster Pump Pipe Line– Elevated Water Tank – Communal Faucet – Water Transportation by the Beneficiary himself
Existing Water Production Plant Water Wagon (Type Ⅳ)	Drinking water – Transport – Communal Distribution Water Tank-Transportation by the Beneficiary himself

3.13 The facilities/equipment under the proposed Project are planned in accordance with the basic concept of water production and supply.

General features of the project facilities/equipment are presented in the Table below:

	Unit	No.	Specifications
Water Production Facility/Equipment			
Well	No.	138	Drilling Dia. 10 5/8', total length 11,130 m Casing pipe FRP, Dia. 6'
Hand Pump	Set	131	Bellows pump
Submersible motor pump	Set	7	Electric Motor 1.5 kw-5, 2.2 kw-2 Generator 7.7 KVA-6nos. 6.3 KVA-1no
Elevated Water Tank	No.	7	Reinforced Concrete 2.5×2.5×2-7 h^m
Accessories	Lump.	1	Generator/Control Building 7 Communal Faucet 25 Nos
Reservoir	No.	2	A=200×100 m at Normal Water Level, Intake Works
Filtration Plant	No.	2	Sand Filter, Chlorination plant, Booster Pump 69~73 m^3/day 3.7·5.5 kw
Pipeline	m	13,100	φ50~φ100
Accessories	Set	1	Reinforced Concrete, Water Tank, 4 nos, and Communal Faucet 17 Nos
Water Wagon	No.	2	8 m^3 Tank Lorry
Accessories	Lump.	4	Reinforced Concrete Water Tank 16 m^3~30 m^3
Ground Water Monitoring System			
Well	No.	7	
Water Level Recorder	Set	7	Groundwater Level Automatic Recorder One purchase and 6 Nos. donated by JICA
Miscellaneous	Lump.	1	Access Road 21 km, O/M Office Building 2 River Crossing 14 Nos. Travelling Work Shop Patrol Service Car

3.14 The implementation period was tentatively determined at 3 years including an 1-year preparation period. In the first year of the pre-project stage. The construction schedule is divided into 2 blocks so that the works completed in one year will realize 100% benefits within the following year. The proposed construction works and facilities for each year are presented in the table below.

I st Year (1993)	II nd Year (1994)	III rd Year (1995)
Land Acquisition	Access Roads Const/ Improvement Works	Water Production/ Distribution Works
Preliminary Works	Preliminary Works (Detailed Design/Survey) Well Production/Distribution Works Type I systems 50 Nos	Type I systems 81 Nos Type III system 1 Nos (El Cayal) Type IV systems 2 Nos O/M Facilities/Equipment Works (60%)
Detailed Design/ Survey	Type II system 7 Nos type III Sy6stem (Las Aquitas) 1 Nos O/M Facilities/Equipment Works (≒40%) Monitoring System (60%)	Monitoring System (40%) Spare Parts

3.15 Project cost consists of direct construction cost, land acquisition, O&M facilities and equipments, administration and engineering costs, physical and price contigencies.

Based on the constant prices of December 1991, total financial cost is estimated at RD$127,201 thousand, considering the future cost escalation estimated at 30% for local currency.

In addition to that, the Project cost includes the monitoring system cost at RD$2,780 thousand and spare parts cost at RD$1,705 thousand.

3.16 The disbursement schedule for the original plan in accordance with the tantative implementation schedule and Project cost is presented as follows:

Financial Year	1993	1994	1995	Total
RD$	7,371,863	60,101,274	59,728,170	127,201,000

3.17 Annual operation and maintenance costs consist of O/M staff salaries in INAPA's engagement, operator of the motorized pumps, fuels for the generator operating, fuels for the various vehicles intended for maintenance of project facilities, and chlorine and sand for the proposed reservoir water supply systems.

(Unit: 000 RD$)

		Foreign Currency Portion	Local Currency	Total
1	Water Production/Supply Systems	59,672	20,769	80,441
2	O/M Facilities/Equipment	3,650	684	4,334
3	Monitoring System	1,137	1,643	2,780
4	Access Roads	191	1,715	1,906
5	Preliminary Works	-	744	744
	Direct Construction Costs	64,650	25,555	90,205
6	Administration and Engineering	10,818	4,523	15,341
7	Land Acquisition	-	143	143
8	Spare Parts	1,705	-	1,705
9	Physical Contigencies	7,717	3,022	10,739
	Sub total	84,890	33,243	118,133
10	Price Contigencies	-	9,064	9,068
	Total	84,890	42,311	127,201

Expenses for general inspection and maintenance, repair of proposed Project facilities, and repair of equipments for O/M were excluded from the annual O/M cost because these required expenses are recommended to be borne by INAPA.

The required cost was estimated at RD$1,542,113, and the O/M cost to be borne by the beneficiaries, depending on each system requirement are shown below.

	RD$/m^3	RD$/Household/ Month
Manual Pump System	0.005	0.05
Motorized Pump System	0.881	12.3
Reservoir Water Supply System	8.91	58.1
Water Wagon System	6.34	18.1

* Excluding INAPA's expenses

Allocated capital cost per cubic meter of produced water in the proposed Project are presented in the following table.

	Total Cost RD$	Useful Life year	RD$/m3
Manual Pump System	83,018,339	15	28.8
Motorized Pump System	20,518,676	15	5.1
Reservoir Water Supply (Booster Pump) System	19,625,195	15	24.8
Water Wagon System	4,039,094	15	35.3
Total	107,201,304	15	14.9

* Excluding the required replacement cost

4. Project Justification

4.1 The total amount of water production was estimated at 1563 m3/day, and will be supplied to 25,630 beneficiaries, i.e., 7% of the total population of the Monte Cristi, Dajabon, Elias Piña, and Independencia in the target year.

4.2 The households, populations and villages covered by the proposed system, and the number of the proposed systems in the respective provinces are as follows:

		Monte Cristi	Dajabon	Elias Piña	Total
Manual Pump System					
	No. of Villages	2	20	18	40
	No. of Systems	5	72	54	131
	No. of Households	127	1,395	955	2,477
	Population	910	7,227	5,580	13,717
Motorized Pump System					
	No. of Villages	6	1	-	7
	No. of Systems	6	1	-	7
	No. of Households	1,523	94	-	1,617
	Population	7,364	377	-	7,741
Reservoir Filtration Booster Pump System					
	No. of Villages	7			7
	No. of Systems	2			2
	No. of Households	674			674
	Population	3,009			3,009
Water Wagon Distribution System					
	No. of Villages	4			4
	No. of Systems	2			2
	No. of Households	223			223
	Population	1,160			1,160
Total	No. of Villages	19	21	18	58
	No. of Systems	15	73	54	142
	No. of Households	2,547	1,486	955	4,991
	Population	12,443	7,604	5,580	25,627

4.3 According to the Report on Health Condition issued in 1990 by the Ministry of Public Health, the four provinces of Monte Cristi, Dajabon, Elias Piña, and Independencia accounted for 7.4% of reported cases of gastroenterities and 8.4% of reported cases of disentry of the country in 1987, while, the estimated

population of four provinces in 1987 was only 3.8% of the country. The incidence of gastroenterities and disentry is higher in the four provinces than in the whole country. In addition to above, and according to the results of the interview survey, 37% of all patients coming to rural hospitals and clinics are affected by gastrointestinal diseases.

4.4 There is no doubt that the supply of safe drinking water owing to the implementation of the proposed Project will result in a low incidence of water-borne and water-related diseases, leading to better health conditions, and therefore improving well-being of a more productive life.

4.5 The pilot water production/supply system was constructed by JICA in Palo Blanco, Dajabon Province. The system consist of a deeptube well equipped with a submersible motor pump operated by a diesel generator, an elevated tank, and public faucets.

The Palo Blanco residents decided on their own initiative to contribute RD$30 per family per month to the operation and maintenance of the water supply system, and 75 families participated to the contribution.

4.6 Provided the beneficiaries of each system devised in the proposed Project participate to the operation and maintenance expenses as the Palo Blanco residents did and that this operation will be well managed the collected fees will be sufficient enough to pay not only for the recurrent costs but a part of the replacement costs too.

4.7 However, given that some villages may be not able to shoulder the operation and maintenance costs, a subsidy would have to be provided by a governmental or nongovernmental organization.

Despite the willing participation of local residents, their responsibilities would be restricted to the operation and maintenance expenses. Accordingly, the government should be responsible for the investment and replacement costs of water production and supply facilities.

4.8 According to the socio-economical survey conducted in the proposed villages available water sources are generally located between 50 m and 950 m from the houses. After the implementation of the Project, the distance from the communal faucet to house decreases to an average of 200 m. The beneficiaries will therefore save time for water supplying and transportation. Time-saving arising from this Project will above all benefit to children and women. It will enable children to attend the school, and women to undertake

useful productive work and to attend some trainings to improve their social status.

4.9 Some villages in the northern part of Monte Cristi Province are dependent upon rainwater for the daily water use, and a typical family has to purchase general purpose water and drinking water to supplement the water shortage during the dry season. It can be assumed that such conditions are not only noticed in the northern villages of Monte Cristi but in all the proposed Project Area too.

5. Conclusion and Recommendations

5.1 Conclusion

The present conditions of living water supply provided to the agricultural and mountain villages of the 4 western provinces is inferred to be particularly grave leading to immigration of villages to other villages, dissolution of local communes and abandonment of land resources.

- A stable supply of purified in compliance with the water resources effectively developed and demand in water is expected to contribute largely not only to the improvement of living conditions stability and environment of local residents, but equally to be of interest to National Security.
  Accordingly, the execution of the current development works is regarded as a critical problem by the Government of Dominica.

- It was confirmed from the results of many survey related to groundwater development and conducted for the purpose of implementing the Present Development Project, that, except in a part of the object Area, development of groundwater will be able to cope with the demand in water of local residents.
  Effective storage and utilization of rain water will be implemented in partial areas where domestic water is urgently required, but located in regains of low groundwater potential.

- The present Project was devised to meet the different requirements of the 58 planed villages. Designed implementation of facilities is as follows:

  - Plan of Groundwater production and Supply: 47 villages
  - Plan of Storage and Purification of surface runoff water:

7 villages

- Purified Water Conveyance Plan: 4 villages

5.2 Recommendations

- In this project, the living water development and supply facilities are intended to meet the fundamental needs of local resident. These works for social development shall be executed under the responsibility of the Government.

- On the other hand, the economic standards of the beneficiary villages are considerably low, compared to the other regions. Admittedly, they may not be able to afford the initial capital cost of constructing the Project facilities. Consequently, the total amount of capital cost of the facilities must be funded with the help of the Government and charged to INAPA.

- INAPA should carry out the following measures to implement the Project as soon as possible.

  - Discussion with the Authorities concerned of the matter of raising funds.
  - Reinforcement and settlement of executive as well as O/M organization.
  - Improvement of the basic policy related to water supply of rural villages.

Besides, daily maintenance of domestic water and daily operation and maintenance of the facilities shall be performed by the beneficiary community. The cost for daily production and supply of domestic water shall be borne by the beneficiary community members. INAPA shall therefore take the following measures:

- to educate the beneficiaries to promote a self-inposed maintenance system
- to transfer techniques and give practical guidance in pursuit of an appropriate daily maintenance
- to raise the sense of responsibility and promote the self-support of daily O/M costs.

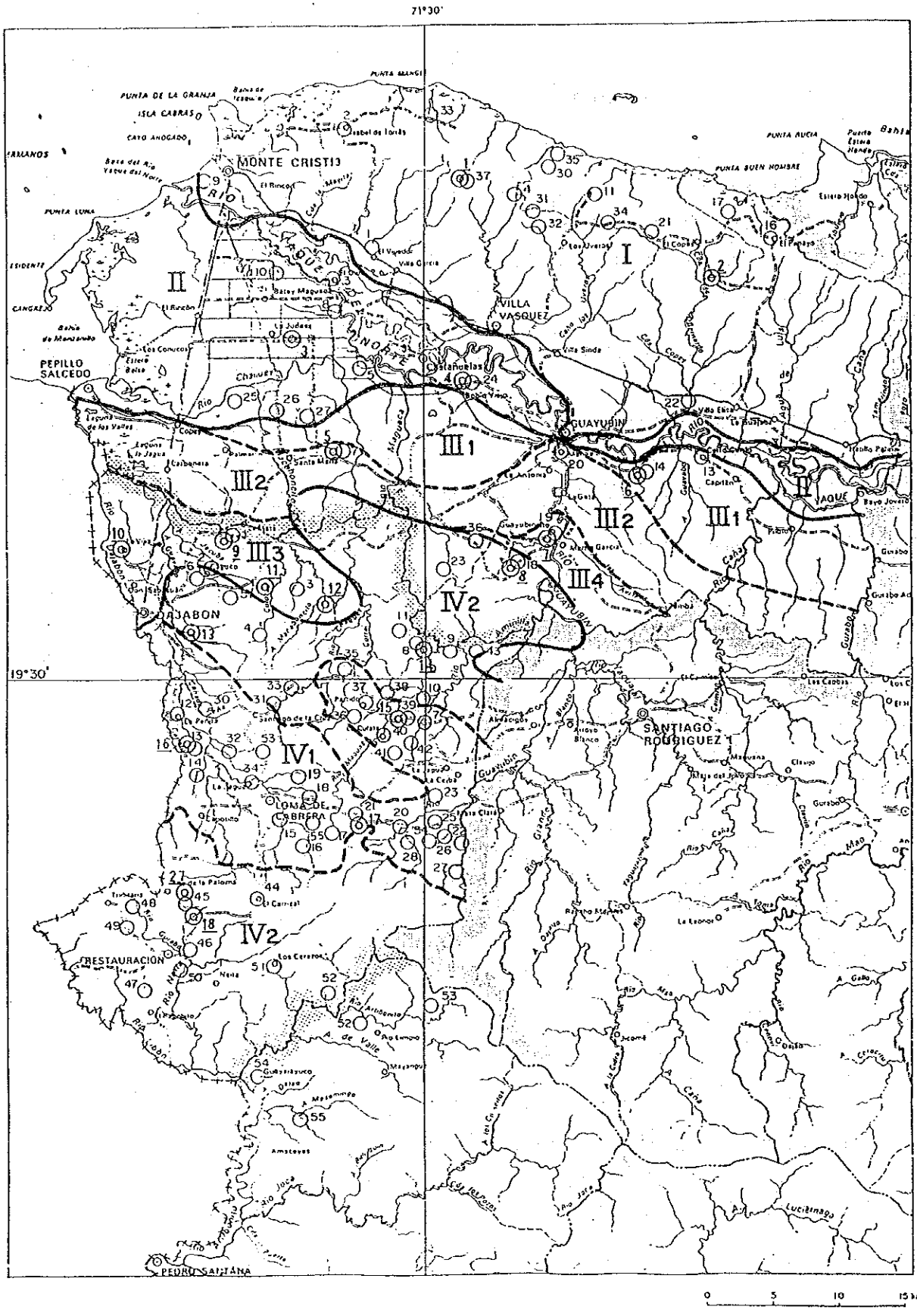


Fig. 1.1 Hydrogeological Province Map (1)

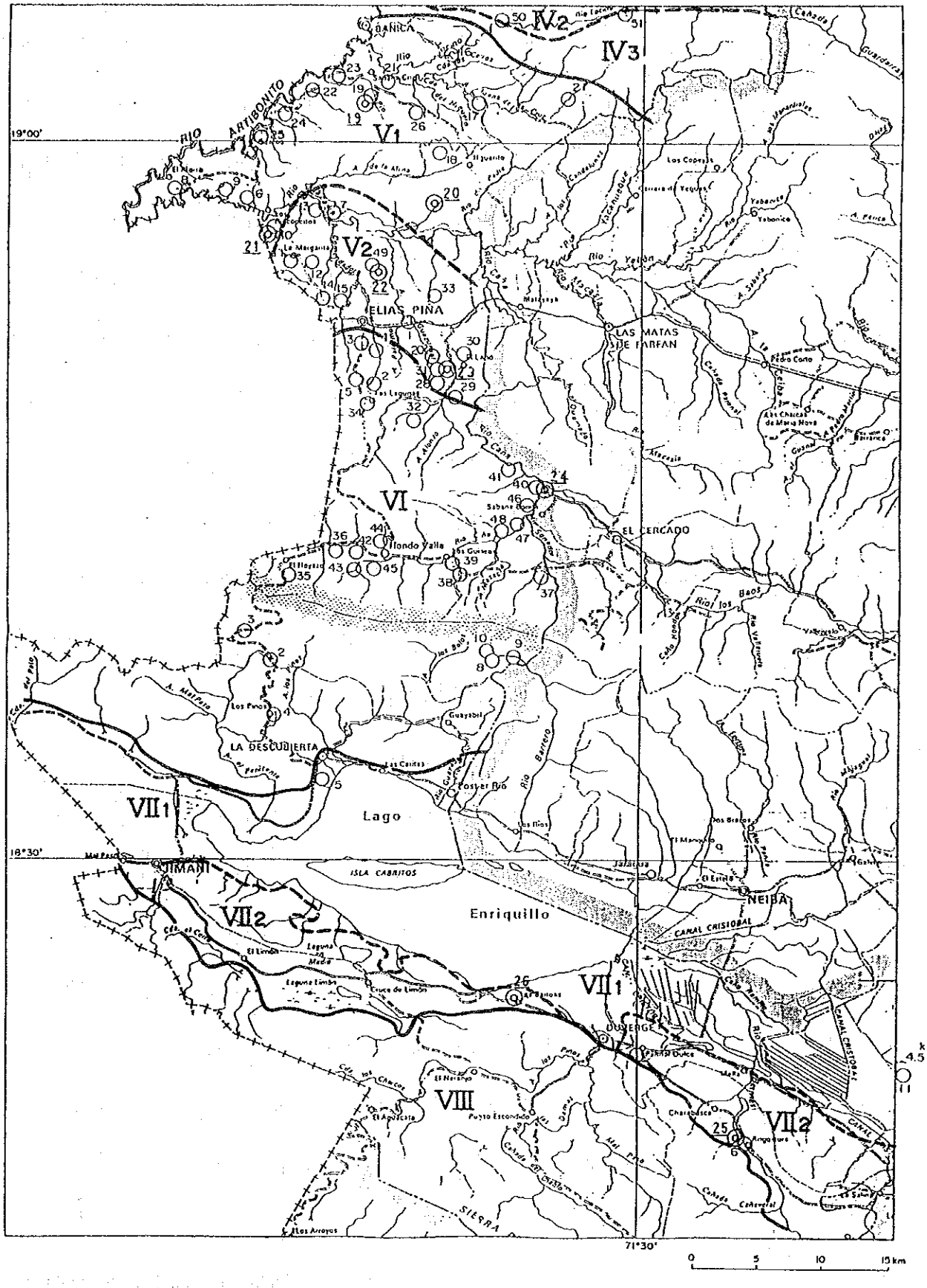


Fig. 1.2 Hydrogeological Province Map (2)

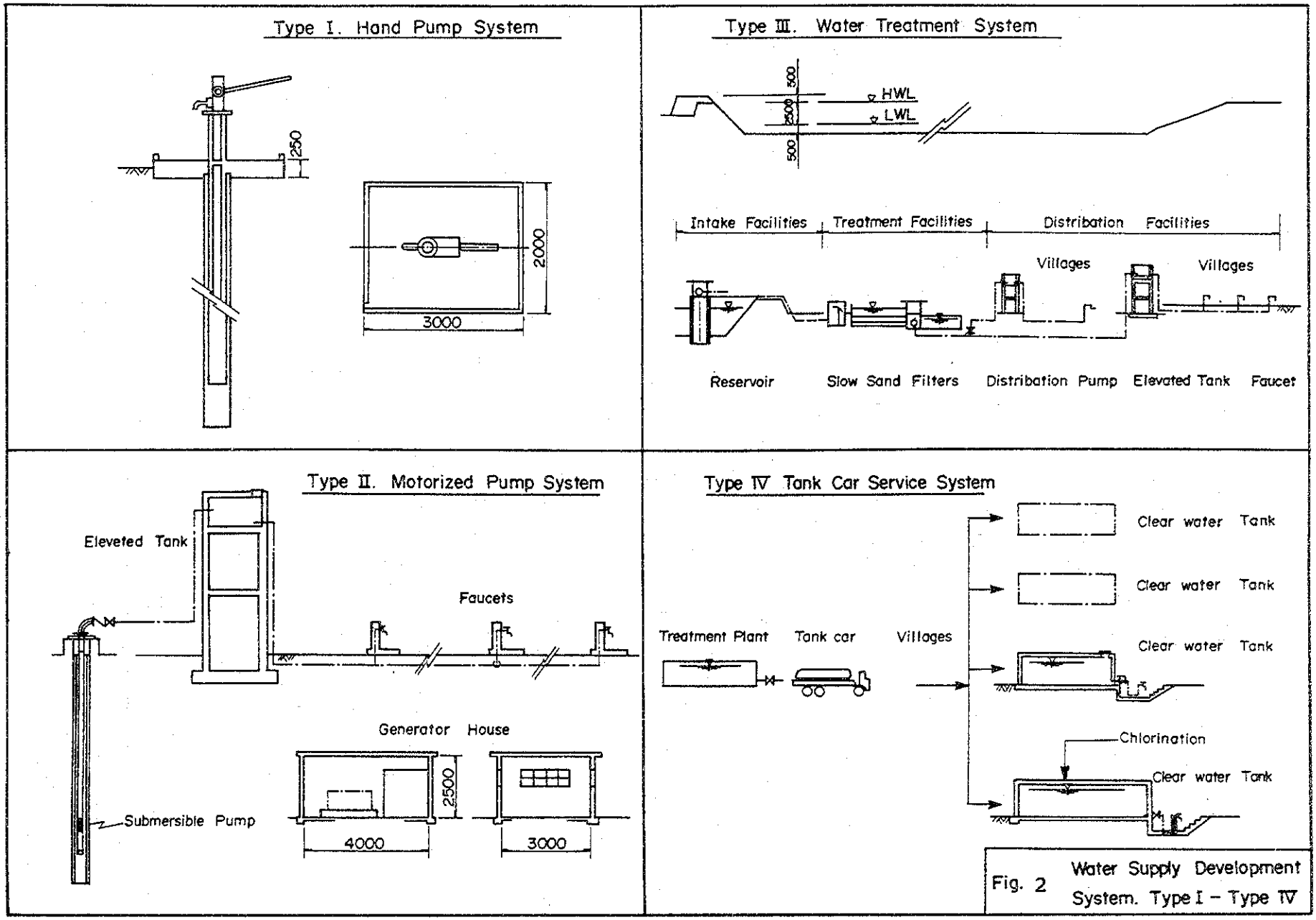


Fig. 2 Water Supply Development System. Type I – Type IV

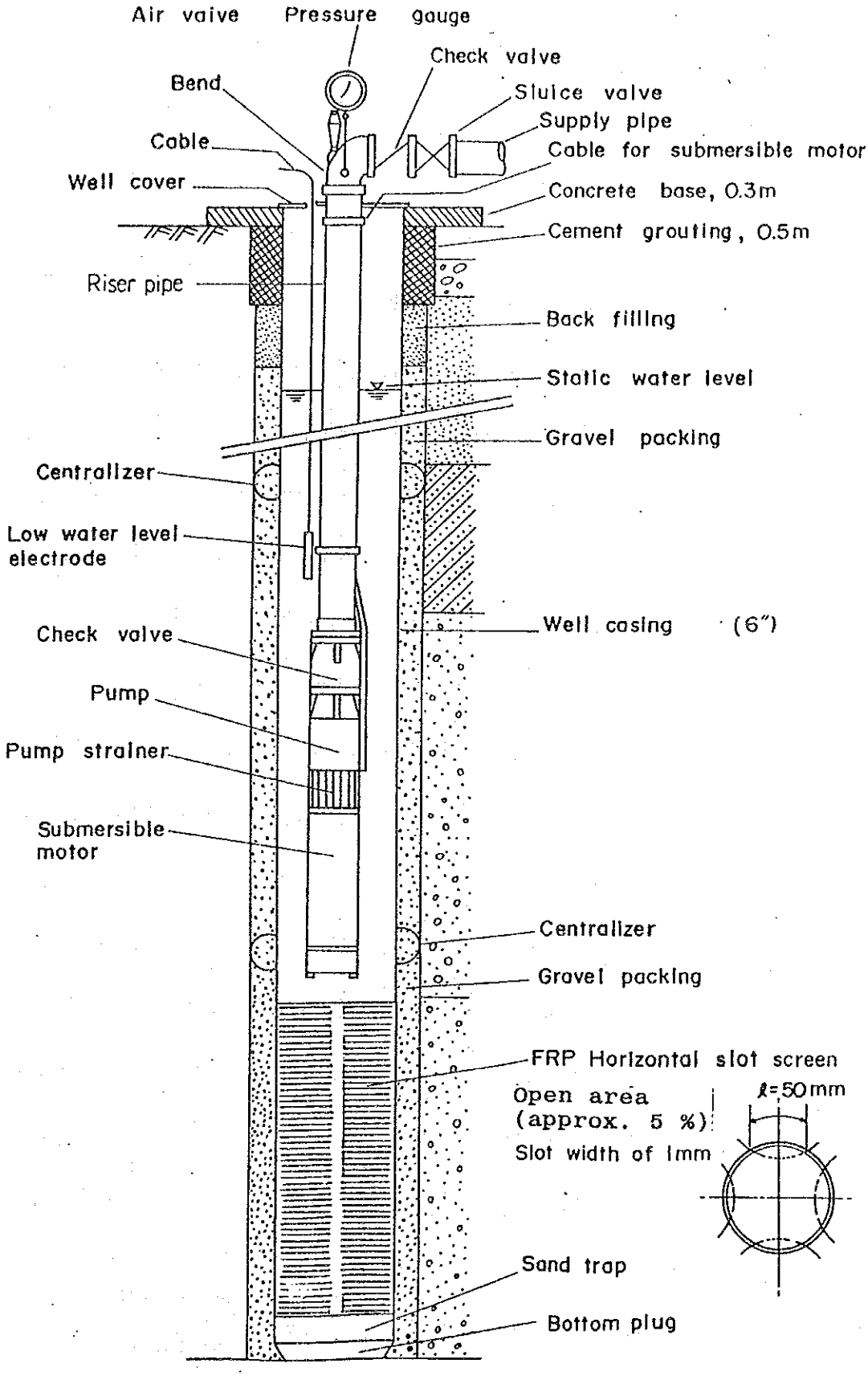


Fig. 3 Standard Design of the Well (Motorized Pump)

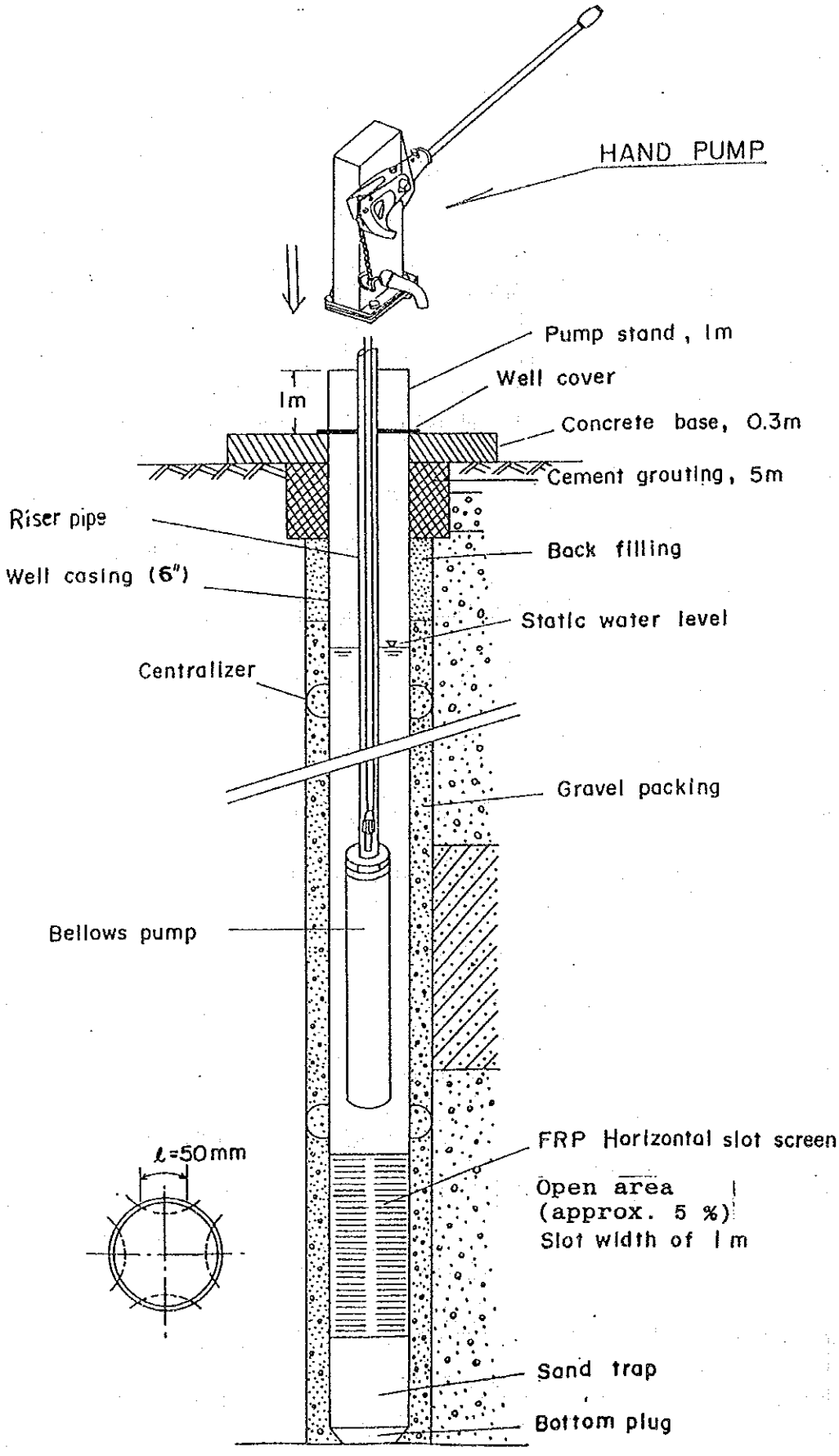
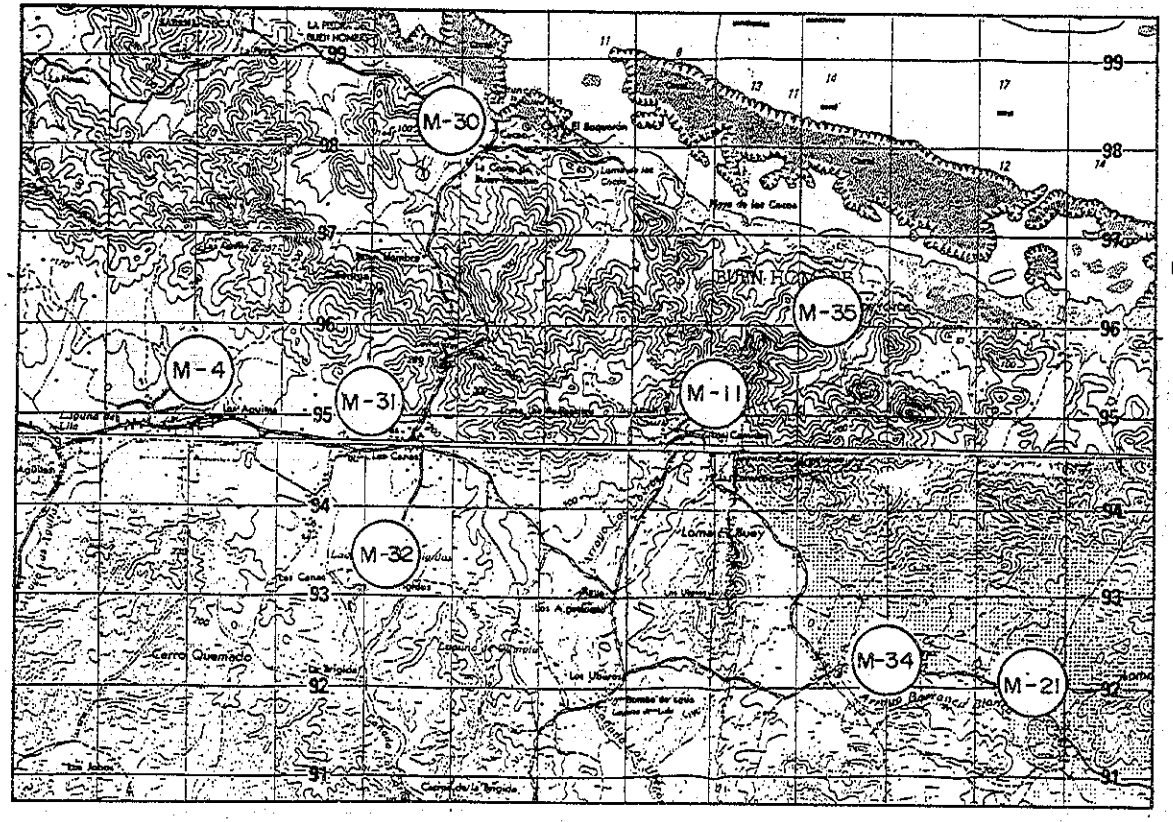
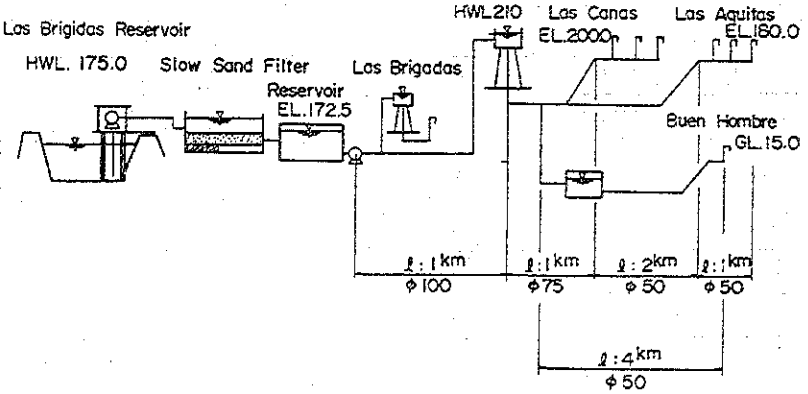


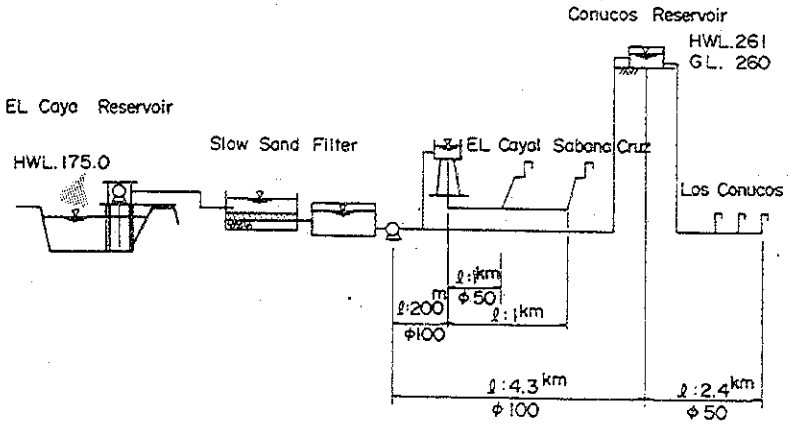
Fig. 4 Standard Design of the Well (Hand Pump)



Central Treatment Plant System Flow Chart



East Treatment Plant System Flow Chart



Northern Mountain Central					Northern Mountain East				
No.	Village	Household	Population	Demand	No.	Village	Household	Population	Demand
				ℓ/min					ℓ/min
4	Las Aquitas	153	692	23	11	Los Canucos	98	483	16
30	Buen Hombre	89	423	14	21	El Cayal	97	424	14
31	Las Canas	70	245	8	34	Sabana Cruz	148	647	21
32	Las Brigidas	19	95	3					
Total		331	1455	48 (69.0 m³/d)			343	1554	51 (73.0 m³/d)

Fig. 5 23 Type III Surface Water Treatment System

Table 1.1 Facility Plan 1/4

1. Type I : Hand pumps system G-I-1)

Flow Chart :

Borehole 1) Underground water level : over 40m
2) Household : over 20 → Hand pump → Inhabitant water supply

Monte Cristi														
		Basic Projection				Drilling						Situation		
No.	Village	Household	Population	Consumption	Demand	Depth	Diameter	Rig	Waterlevel	Wateryield	Number	Access	Test Drilling	Hydrogeol. Zone
3	Hato Viejo	32	150	40 ℓ/c/d	15 ℓ/min	70	10-5/8"	Percussion	20 -m	100 ℓ/min	2	Good	3 Las Aquas	II
27	Sanita	95	760	40	76	70	"	"	"	"	3	Good	3 Las Aquas	II
	Sub total: 2 villages	127	910		91						5			
Dajabon														
3	Laja	50	400	40	40	120	10-5/8"	Rotary & Percussion	40	100~200	4	Good	11 Esperon 12 Chacuey	III 3
5	Clarellina	102	418	40	42	100	"	R&P	40	100~200	4	Good	11 Esperon	III 3
8	La Gorra	131	642	60	32	100	"	"	40	10	6	Good	14 La Borra	IV 2
9	La Barrera	42	198	40	20	100	"	"	40	10	2	Good	14 La Borra	IV 2
10	El Estrecho	25	200	40	20	100	"	"	40	10	2	Good	14 La Borra	IV 2
11	El Clano	65	276	40	27	100	"	"	40	10	3	Good	14 La Borra	IV 2
13	La Peñita	89	388	40	39	80	"	"	20	10~15	4	Good	16 La Penita Abajo	IV 1
14	Pueblo Nuevo	65	243	40	24	80	"	"	20	10	2	Good	16 La Penita Abajo	IV 1
18	El Cajuil	78	390	40	39	80	"	"	20	10~20	4	Good	17 La Penita Arriba	IV 1
20	El Aquacate	57	312	40	31	80	"	"	20	10~20	3	Good	"	IV 1
21	La Peñita	69	374	40	37	80	"	"	20	10~20	4	Good	"	IV 1
23	La Avanzada	35	210	40	21	80	"	"	20	10~20	2	Good	"	IV 1
31	Pinal Claro	71	347	40	34	80	"	"	20	10~15	4	Good	15 Buen Gristo 16 Penita Abajo	IV 2
34	La Hoya	38	228	40	23	80	"	"	20	10~15	2	Good	16 Penita Abajo	IV 1
39	Buen Gusto	79	328	40	33	100	"	"	40	10	3	Good	14 La Gorra	IV 1
43	Aminilla	133	677	40	68	100	"	"	40	10	7	Good	18 Mariano 27 Cestero	IV 2
45	Mariano Cestero	95	570	40	56	80	"	"	40	10	6	Good	18 Mariano 27 Cestero	IV 2
49	Valle Nuevo	52	312	40	21	80	"	"	40	10	3	Good	18 Mariano 27 Cestero	IV 2
50	Neyta	32	192	40	19	80	"	"	40	10	2	Good	17 Penito Abajo	IV 2
55	Las Lagunas	87	522	40	52	80	"	"	40	10	5	Good	14 La Borra	IV 1
	Sub total: 20 villages	1,395	7,227		678						72			

Table 1.2 Facility Plan 2/4

Elias Pina

No.	Village	Basic Projection				Drilling						Situation		
		Household	Population	Consumption	Demand	Depth	Diameter	Rig	Waterlevel	Water Yield	Number	Access	Test Drilling	Hydrogeol. Zone
				ℓ/c/d	ℓ/min					ℓ/min				
6	Sabana Campo	30	180	40	18	80	10-5/8"	Percussion	40-m	10	2	Poor	21 Lamesdero	V 1
8	Macasia	115	690	40	69	80	〃	〃	40	10	7	Poor	21 Lamesdero	V 1
9	Carrera Verde	35	210	40	21	80	〃	〃	40	10	2	Poor	21 Lamesdero	V 1
10	Lamedero	35	210	15	8	80	〃	〃	40	10	2	Good	21 Lamesdero	V 1
19	El Mamoncito	55	313	40	32	80	〃	〃	40	10~20	2	Good	19 El Mamoncito	V 1
21	San Andrés	19	114	40	11	60	〃	〃	40	10~20	2	Poor	〃	
22	Guayabal	114	629	40	44	80	〃	〃	40	10~20	6	Good	〃	V 1
23	Hato Viejo	47	259	40	26	80	〃	〃	40	10~20	3	Good	〃	V 1
24	Pilón	50	300	40	30	80	〃	〃	40	10~20	3	Good	〃	V 1
25	Guaroa	36	216	40	21	80	〃	〃	40	10~20	2	Good	〃	V 1
26	Los Yareyes	60	332	40	33	80	〃	〃	40	10~20	3	Good	〃	V 1
32	Juan Cano	39	234	40	23	60	〃	〃	40	20	2	Good	24 Asiento Migael	V 1
36	Cañada del Banero	42	225	40	22	60	〃	〃	40	20	2	Good	〃	V 1
40	Los Mesas	40	240	40	8	60	〃	〃	40	20	2	Poor	〃	V 1
41	Los Caños	33	198	40	7	60	〃	〃	40	20	2	Poor	〃	V 1
46	Sabana dela Lomo	118	708	40	30	60	〃	〃	40	20	7	Poor	〃	V 1
47	Juan Garcia	33	198				〃	〃	40	20	2	Poor	〃	V 1
48	Madre Vieja	54	324	40	11	60	〃	〃	40	20	3	Poor	〃	V 1
Sub total: 18 villages		955	5,580		414						54			
Total: 40 villages		2,238	13,717		1,055						131			

Table 1.3 Facility Plan 3/4

2. Type II : Motorized Pump System G-I-2)

Flowchart :

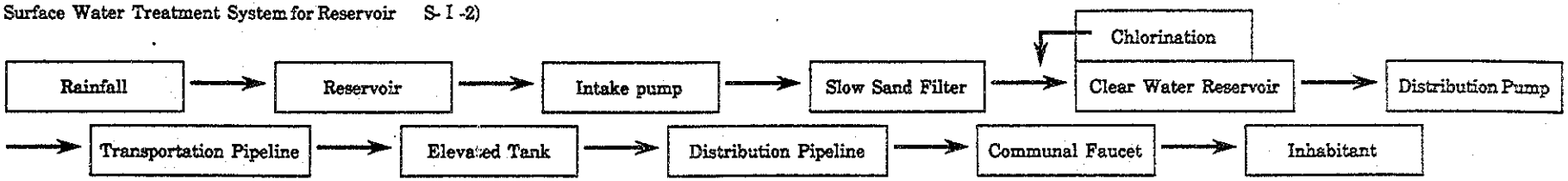
Borehold 1) Household: over 50
2) Water Yield: over 100 ℓ/min → Submersible Pump → Elevated Tank → Communal Faucet → Inhabitant

No.	Village	Basic Projection: Household	Population	Consumption ℓ/c/d	Demand ℓ/min	Drilling: Depth m	Diameter	Rig	Waterlevel -m	Water Yield ℓ/min	Facilities: Pump kw KVA	Elevated Tank m3	Faucet	Pipeline	Situation: Test Drilling	Hydrogeol. Zone
Monte Cristi																
7	La Pinra	156	680	100	56	80	10-5/8"	Percussion	20	100	1.5.10	30	3	φ50 500 φ75 100	5 La Pinta	III 2
8	Batey Higuero	501	2,253	100	187	80	"	"	20	300	2.2.10	100	5	φ75 200 φ100 600	3 Las Aquas	II
13	Cerro Gorob Arriba	98	431	100	36	80	"	"	20	100	1.5.10	20	3	φ50 1000	6 Ranchaduo	III 1
14	Penã Ranchaderas	97	432	100	36	80	"	"	20	100	1.5.10	20	3	φ50 500 φ75 100	6 Ranchaduo	III 1
24	Jabo Corcobado	471	2,068	60	86	80	"	"	30	100	2.2.10	50	5	φ50 500 φ75 1500 φ100 600	4 Jobo Corcobado	II
25	Gozuela	200	1,500	60	75	80	"	"	20	100	1.5.10	40	4	φ50 200 φ75 1100	3 Las Aquas	III 2
Sub Total: 6 villages		1,523	7,364		476							260	23	φ50 2700 φ75 3,000 φ100 1,200		
Dajabon																
2	Cayuco	94	377	60	16	80	10-5/8"	Rotary & percussion	40	100~200	1.5, 10	10	2	φ50 200	10 La Vigia	III 3
Sub Total: 1 village		94	377		16											
Total: 7 villages								Rotary & Percussion								
		1,617	7,741		492			Percussion	6				-			

Table 1.4 Facility Plan 4/4

3. Type Ⅲ : Surface Water Treatment System for Reservoir S-Ⅰ-2)

Flowchart :



Monte Cristi		Basic Projection				Intake Facilities			Treatment Plant				Distribution Facilities			
No.	Village	Household	Population	Consumption	Demand	Reservoire Volume			Capacity	Slow Sand Filter	Chlorinator	Clear Water Reservoir	Pump	Elevated tank	Faucet	Pipeline
4	Las Aquitas	153	692	40 ℓ/c/d	23 ℓ/min							4×4×2.5 m		– m³	4	φ100 1.0 km
30	Buen Hombre	89	423	"	14	50,000 m³	72 ℓ/min	0.4×2 kw	100 m³/d	8.0×3.2×2 m Basin	2 unit	40m³	3.7kw×2	24	3	φ75 1.0
31	Las Canas	70	245	"	8					Flow Velocity 4.0 m/d		R.T=9.6 Hour		–	1	φ50 2.2
32	Las Brigidas	19	95	"	3				"					4	1	
North Central: 4 villages		331	1,455		48 (69.0m³/d)										9	4.2 km
11	Las Canucos	98	483	40	16	50,000 m³	72 ℓ/min	0.4×2 kw	100 m³/d	8.0×3.2×2		40×40×2.5		10	3	φ100 4.5
21	El Cayal	97	424	"	14					Flow Velocity 4.0 m/d	2 unit	V=40m³	5.5kw×2	10	2	475 1.0 φ50 3.4
34	Sabana Cruz	148	647	"	21							R.T=9.6 Hour		–	3	–
North East: 3 villages		343	1,554		51 (73.0m³/d)										8	
Total: 7 villages		674	3,009		99 (142m³/d)										φ100 5.5 km φ75 2.0 φ50 5.6	13.1 km

4. Type Ⅳ : Tank Lorry Supply System S-Ⅰ-1)

Flowchart :

Monte Cristi		Basic Projection				Transportation System		
No.	Village	Household	Population	Consumption	Demand	Tank Vol.	Distance from Treatment Plant	Tank Lorry Unit
2	Isabel de Torres	72	311	15 ℓ/c/d	3.8, (5.6) ℓ/min m³/d	24 m³	Average 20 Kar	8 ton × 2 unit with pump
17	Estero Balsa	53	233	15	2.9, (4.2)	16	"	
33	Loma Afravezada	67	280	15	3.5, (5.0)	24	"	
37	El Mansutia	92	336	15	4.2, (6.0)	30	"	
Total; 4 villages		223	1,160		14.4, (20.8)	94