(2) Cropping Plan

1) Basic concept of the plan

The basic concept of the proposed cropping pattern is enumerated below.

- to increase the cropping rate by ensuring irrigation water throughout the year.
- to keep the production level of two basic crops; maize and kidney beans.
- to attempt to expand the cropping rate for vegetables to be exported with high profitability.
- to maintain the cropping area of tobacco.
- to avoid continuously harvesting the same crop.
- to crop maize or kidney beans in each section for maintaining soil fertility.
- to level labor distribution wherever possible and to utilize local labor.

2) Cropping pattern

The cropping pattern shown in Fig. 4.2.3-1 is proposed on the basis of the following rotation system according to the above basic concept.

4.2.4 Determination of Optimum Development Scale

(1) Water Resource Development

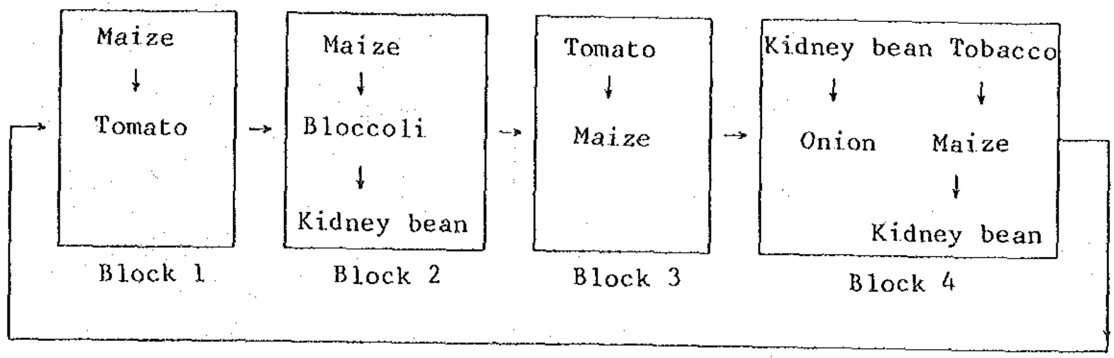
The volume of water resource required in the proposed area is about 1,026 mm/ha per year. Should irrigation area be set in 4,000 - 4,800 ha according to the cropping pattern shown in the preceding paragraph, a water resource volume of 41,000,000 - 49,300,000 m^3 must be developed (Table 4.2.4-1).

Table 4.2.4-1 Water Resources Development

(Unit : mm)

	Wet season (May - Oct.)	Dry season (Nov. - Apr.)	Total
① Water requirement	570	393	963
② Effective precipitation	475	0	475
③ Irrigation water requirement ① - ②	95	393	488
④ Water source development requirement ③ x 1/0.476	200	826	1,026

Item	Irrigation area	Water requirement	Required water resource development
1	4,000 ha	1,026 mm	41.04 MCM
2	4,350 ha	1,026 mm	44.63
3	4,800 ha	1,026 mm	49.28



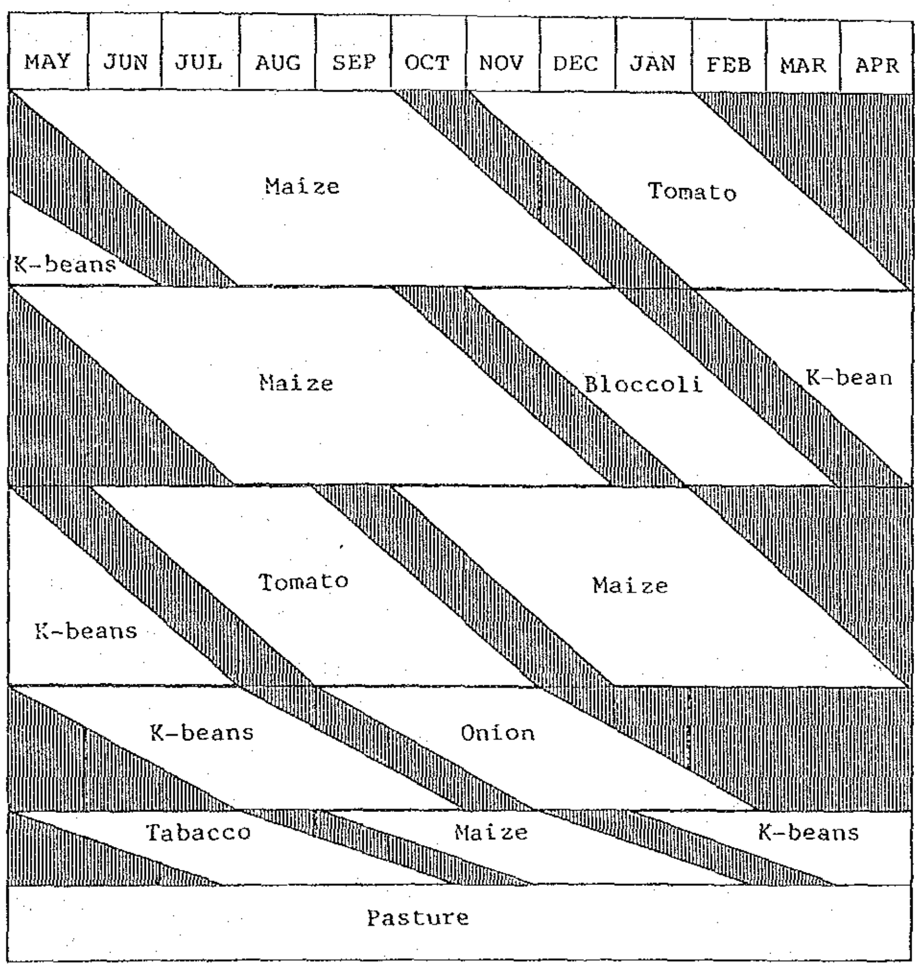


Fig. 4.2.3-1 Proposed Cropping Pattern

The water resource is developed on condition that ample river water in the wet season is stored for the dry season and groundwater is utilized.

(2) Potential of development water volume

1) Surface water

The Guirila River intended for the dam site has a small catchment area of 26 km^2, and the annual average runoff discharge is estimated 12 MCM. On the other hand, the Ostua River has a large annual average runoff discharge of 97 MCM enough to serve as a water resource river (Fig. 4.2.4-1).

Therefore, the Guirila dam is capable of storing the required water volume depending on water conducted from the Ostua River.

The relationship between driving water volume and canal capability from the Ostua River to the Guirila dam, canal capability of driving water in a necessary volume is 3.0 - 4.0 m^3/s (Fig. 4.1.2-4).

Irrigation area	Driving water capability
4,000 ha	3.0 m^3/s
4,350	3.0
4,800	4.0

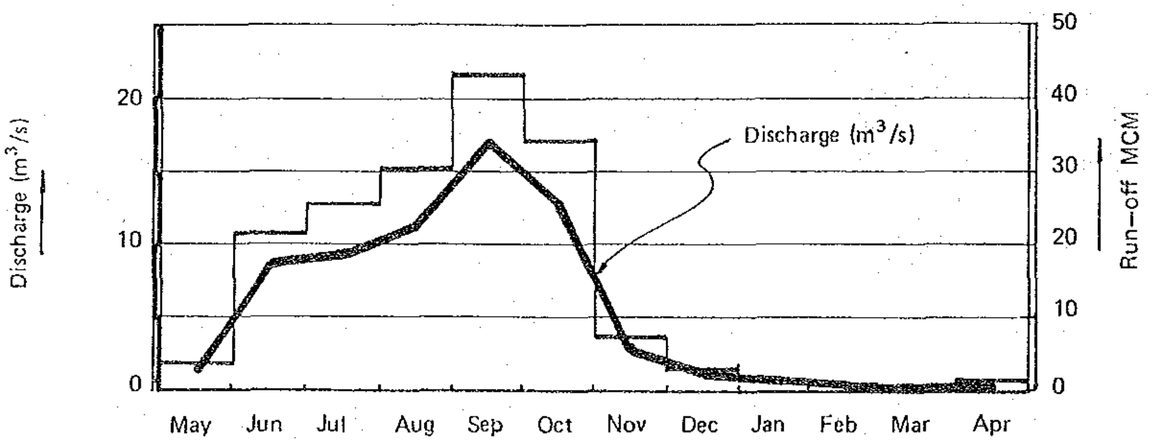


Fig. 4.2.4-1 Monthly Average Discharge of the Ostua River (Casa de Tablas)

The potential storage capacity of the Guirila dam varies with the driving capability from the Ostua River, and is 49,900,000 - 72,900,000 m^3 on the average per year, including inflow from the Guirila River (Table 4.2.4-2, Appendix 4.2.2).

Table 4.2.4-2 Guirila Dam Storage by Driving Canal

Annual dam inflow	Driving canal capability (m^3/s)				
	3.0	4.0	5.0	6.0	7.0
Average (MCM)	49.9	56.3	62.9	68.2	72.9
Maximum (MCM)	74.3	86.9	98.6	109.1	118.4
Minimum (MCM)	19.4	20.5	21.4	22.2	22.8

2) Groundwater resource

Groundwater has several features as water resource. Groundwater has two major advantages : the water resource is located so near the field that no water driving is necessary and, the water resource causes only a few intake and driving losses. However, dynamic water table is about 20 - 50 m under the ground level, or even deeper, and involves pumping. Briefly, groundwater requires purchase and maintenance cost of the indispensable pump. Adaptability of groundwater development depends on groundwater deposits and economy in development water cost in comparison with that of the dam.

Available groundwater volume may be estimated for the following two sectors from the results of electrical prospecting survey, pumping test, record of groundwater utilization, and field survey.

- Available groundwater: 5 MCM at Mojarritas sector
  8.4 MCM at San Pedro sector

- Coverage of groundwater irrigation
  Downstream Mojarritas River and around San Pedro River: about 800 ha

Therefore, for the purpose of the water resource plan intended for the whole plan area, water resource cannot depend only on groundwater and the development plan must be combined with the dam development plan.

(3) Study for Optimum Plan

1) Basic conditions and alternatives of the plan

The basic conditions of the plan is set as follows before studying the optimum plan.

a. Proposed irrigation area should be as wide as possible, including the present irrigation area, on condition that necessary water resource is ensured.

b. A reservoir, the main facility, should preferably be formed as low as possible in height in consideration of basement of dam site composed of tuff.

c. Cost of operation and maintenance is are borne to local beneficiaries, as a rule. Therefore, operation and maintenance cost necessary for the management of the project is limited to a minimum. The ratio of project cost, and operation and maintenance cost for irrigation projects in Guatemala is shown as follow.

	Government	Beneficiary
- Share of construction project cost	40%	60%
- Share of operation and maintenance cost	0%	100%

d. Facilities of Hoyo Lake irrigation project, etc. are effectively utilized.

e. Water resources are planned through comparative study of discharge, topography, geology, etc. and groundwater development is simultaneously studied. To determine the optimum plan, the following three alternatives are studied which have different conditions of irrigation area, kind of water resources, etc.

Case 1 :
Independent Guirila dam, irrigable area 4,800 ha
Case 2 :
Independent Guirila dam, irrigable area 4,350 ha
Case 3 :
Guirila dam and groundwater wells, irrigable area 4,800 ha(include groundwater irrigation area of 800 ha)

2) Base Year for Planning and Storage Capacity

Probability analysis on inflow to the Guirila dam (driving capability : 4.0 m^3/s) indicates that 1972 and 1977 in observation years for 15 years from 1967 -1987 fall in a draught year experienced once in a 30 -50 year period. Therefore, a plan is established that meets requirements of 13 years excluding 1972 and 1977 in the water resource capacity.

Table 4.2.4-3 shows water balance calculation for the above 15 observation years. Table 4.2.4-4 shows a required storage capacity by the water balance. Table 4.2.4-5 shows a storage capacity for each irrigation area.

Table 4.2.4-4 Required Storage Capacity (A = 4,800 ha)

Rank	Required reservoir storage	Year	Probability year	Remarks
	MCM		Year	
1	39.8	1972	10	Insufficient inflow in draught year
2	38.5	1977	8	- ditto -
3	37.7	1974	6	inflow _ Necessary reservoir storage

Refer to Appendix 4.2.1.

Table 4.2.4-5 Storage Capacity by Project Scale

Irrigable area	Required reservoir storage	Necessary driving capacity
4,800 ha	37.7 MCM	4.0 m^3/s
4,350 ha	33.8	3.0
4,000 ha	30.8	3.0

Referred to Appendix 4.2.1.

The greatest reservoir storage was registered in 1974, and is translated into 37.7 MCM, 33.8 MCM, and 30.8 MCM for irrigable area 4,800 ha, 4,350 ha, and 4,000 ha, respectively.

3) Comparison of alternatives

Three alternatives are proposed considering available reservoir storage, type of water resource, scale of benefited area, etc. and comparatively studied for technical feasibility, economy, and ease of operation and maintenance to obtain the optimum plan. Each case has the following features.

Table 4.2.4-3 Water Balance

[x1000 m3]

	Year	Driving Canal Capacity 3 m3/sec	4 m3/sec	5 m3/sec	6 m3/sec	7 m3/sec
IRRIGATION AREA: 4800 (ha)	1967	31468	31468	31468	31468	31468
	1968	30623	30623	30623	30623	30623
	1969	30995	30995	30995	31004	30995
	1970	32865	32592	32592	32673	32673
	1971	33551	33551	33551	33551	33551
	1972	39836	39835	39836	39836	39836
	1973	31255	31255	31255	31255	31255
	1974	37690	37690	37691	37691	37691
	1975	32515	32448	32448	32448	32448
	1976	34636	34549	34477	34477	34477
	1977	38478	38478	38478	38478	38478
	1978	21754	21754	21754	21754	21754
	1979	34486	34400	34314	34227	34209
	1980	30431	30432	30431	30431	30431
	1981	21479	21479	21479	21479	21479
	Year	3 m3/sec	4 m3/sec	5 m3/sec	6 m3/sec	7 m3/sec
IRRIGATION AREA: 4350 (ha)	1967	27963	27963	27963	27963	27963
	1968	27240	27240	27240	27240	27240
	1969	27157	27157	27157	27166	27157
	1970	29077	28904	28904	28885	28885
	1971	29667	29667	29667	29667	29667
	1972	35649	35648	35649	35649	35649
	1973	27632	27632	27632	27632	27632
	1974	33823	33823	33824	33824	33824
	1975	29052	28985	28985	28985	28985
	1976	30848	30761	30689	30689	30689
	1977	34295	34295	34295	34295	34295
	1978	18606	18606	18606	18606	18606
	1979	30683	30597	30511	30424	30406
	1980	26593	26594	26593	26593	26593
	1981	17960	17960	17960	17960	17960
	Year	3 m3/sec	4 m3/sec	5 m3/sec	6 m3/sec	7 m3/sec
IRRIGATION AREA: 4000 (ha)	1967	25237	25237	25237	25237	25237
	1968	24609	24609	24609	24609	24609
	1969	24172	24172	24172	24181	24172
	1970	26131	25958	25958	25939	25939
	1971	26738	26738	26738	26738	26738
	1972	32396	32395	32396	32396	32396
	1973	24814	24814	24814	24814	24814
	1974	30838	30838	30839	30839	30839
	1975	26381	26314	26314	26314	26314
	1976	27902	27815	27743	27743	27743
	1977	31077	31077	31077	31077	31077
	1978	16226	16226	16226	16226	16226
	1979	27737	27651	27565	27478	27460
	1980	23608	23609	23608	23608	23608
	1981	15325	15325	15325	15325	15325

$$V = \sum_{i=1}^{n} (Q_{in} - Q_{out})$$

where : V : Storage Volume

Qin : Inflow to Dam

Qout : Outflow from Dam

a. Case 1 (Independent Guirila Dam, benefited area 4,800 ha) (Fig. 4.2.4-2)

i. Benefited area (A = 4,800 ha)

Not only the present upland field is intended for irrigation, but also the agricultural land is positively converted that is used only as pasture.

ii. Water resource

Water of the Ostua River in the wet season is conducted into the Guirila dam and stored for the dry season. All benefited area depends solely on this dam.
The dam has a net reservoir storage capacity of 37.7 MCM and a dam height H 49 m (less than 50m)

iii. Canal system

Driving canal: length, L = 9.5 km,
canal capacity Q = 4.0 m^3/s (max)
Main canal : length, L = 41.2 km,
canal capacity Q = 3.28 m^3/s (max)

iv. Operation and maintenance

Operation and maintenance is simplified because irrigation water is taken out of a single water resource by gravity.

b. Case 2 (Independent Guirila Dam, benefited area 4,350 ha) (Fig. 4.2.4-3)

i. Benefited area (A = 4,350 ha)

The irrigation area intended by the project is limited only to the present upland field.

ii. Water resource

Water of the Ostua River is conducted into the Guirila Dam as in Case 1, however, the scale of the dam is reduced as benefited area is reduced (V = 33.8 MCM)

iii. Canal system

Driving canal: length L = 9.5 km,
canal capacity Q = 3.0 m^3/s (max)
Main canal : length L = 41.2 km,
canal capacity Q = 2.97 m^3/s (max)

iv. Operation and maintenance

Same as Case 1.

c. Case 3 (Guirila Dam and groundwater well, benefited area : 4,800 ha) (Fig. 4.2.4-4)

i. Benefited area (A = 4,800 ha)

The benefited area consists of the present upland field and a part of pasture to be converted into upland field.

ii. Water resource

Mojarritas sector and San Pedro sector can use groundwater as water resource, and the upland field of about 800 ha (including a part of pasture to be converted) depends for the water resource on wells.
The other upland field (4,000 ha) depends for the water resource on the Guirila Dam.
Case 3 requires the smallest dam size of three alternatives, as shown in Table 4.2.4-6. The ground water resource is obtained by 55 wells (including 33 new wells).

iii. Canal system

The benefited area by wells requires no canal to be newly installed because wells are strategically located in the Area. Therefore, Case 3 requires a shorter canal length than the others.

Driving canal: length L = 9.5 km,
canal capacity Q = 3.0 m^3/s
Main canal : length L = 36.5 km,
maximum canal capacity Q = 2.72 m^3/s

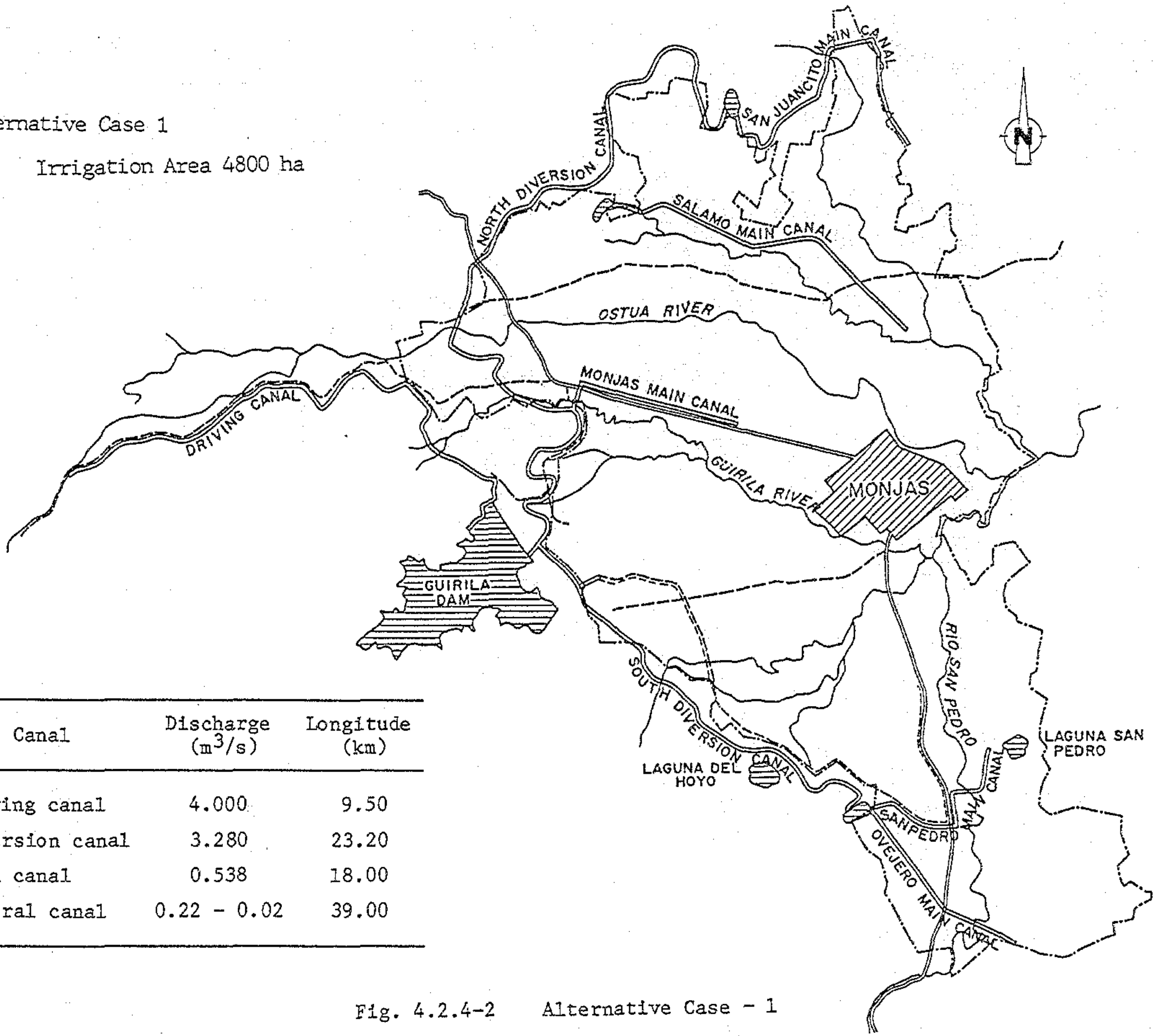
iv. Operation and maintenance

The operation and maintenance system is divided into 2 systems: the dam system and well system.

The above three cases are compared and listed in Table 4.2.4-6.

Alternative Case 1

Irrigation Area 4800 ha

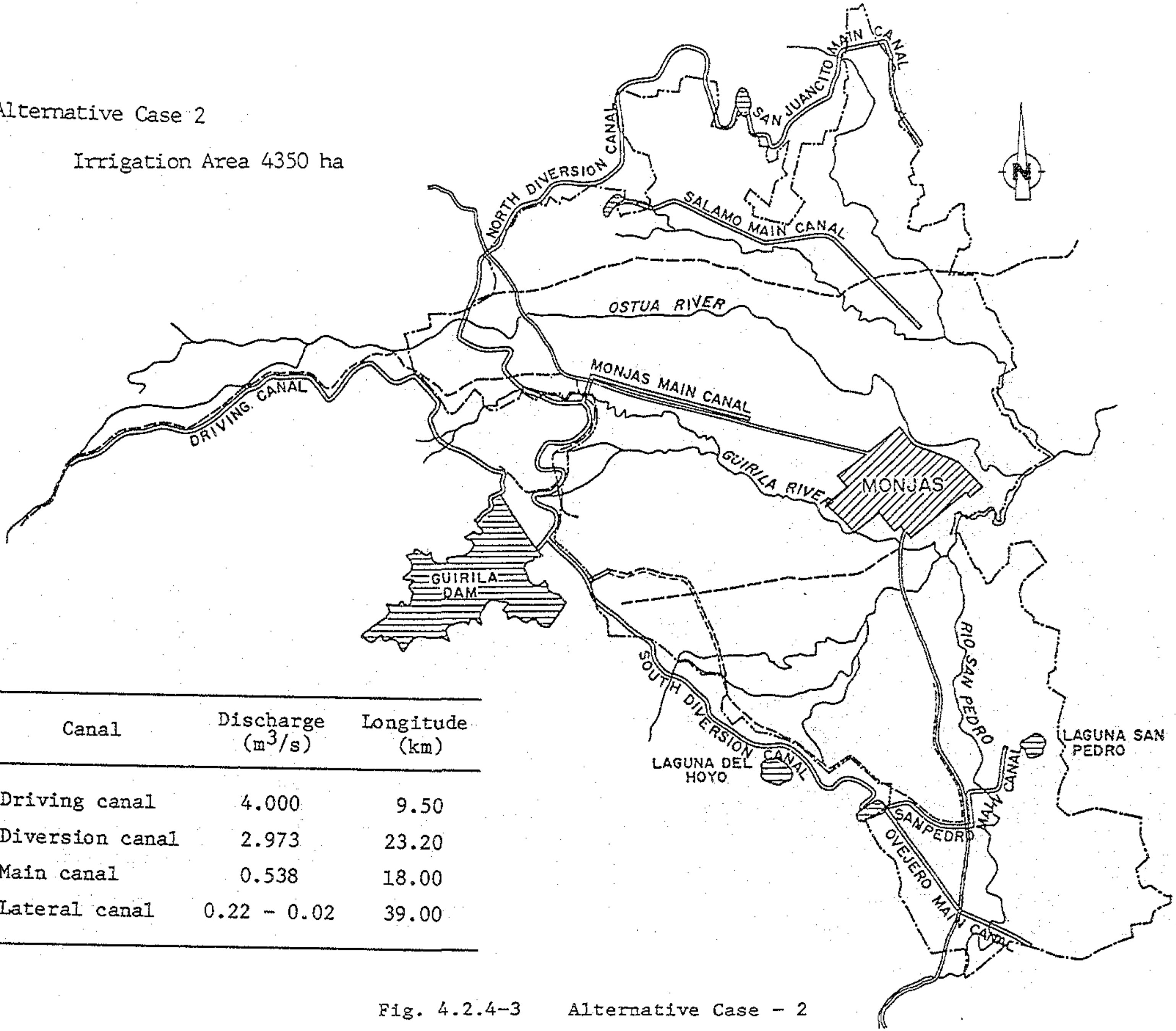


Canal	Discharge (m^3/s)	Longitude (km)
Driving canal	4.000	9.50
Diversion canal	3.280	23.20
Main canal	0.538	18.00
Lateral canal	0.22 - 0.02	39.00

Fig. 4.2.4-2 Alternative Case - 1

Alternative Case 2

Irrigation Area 4350 ha

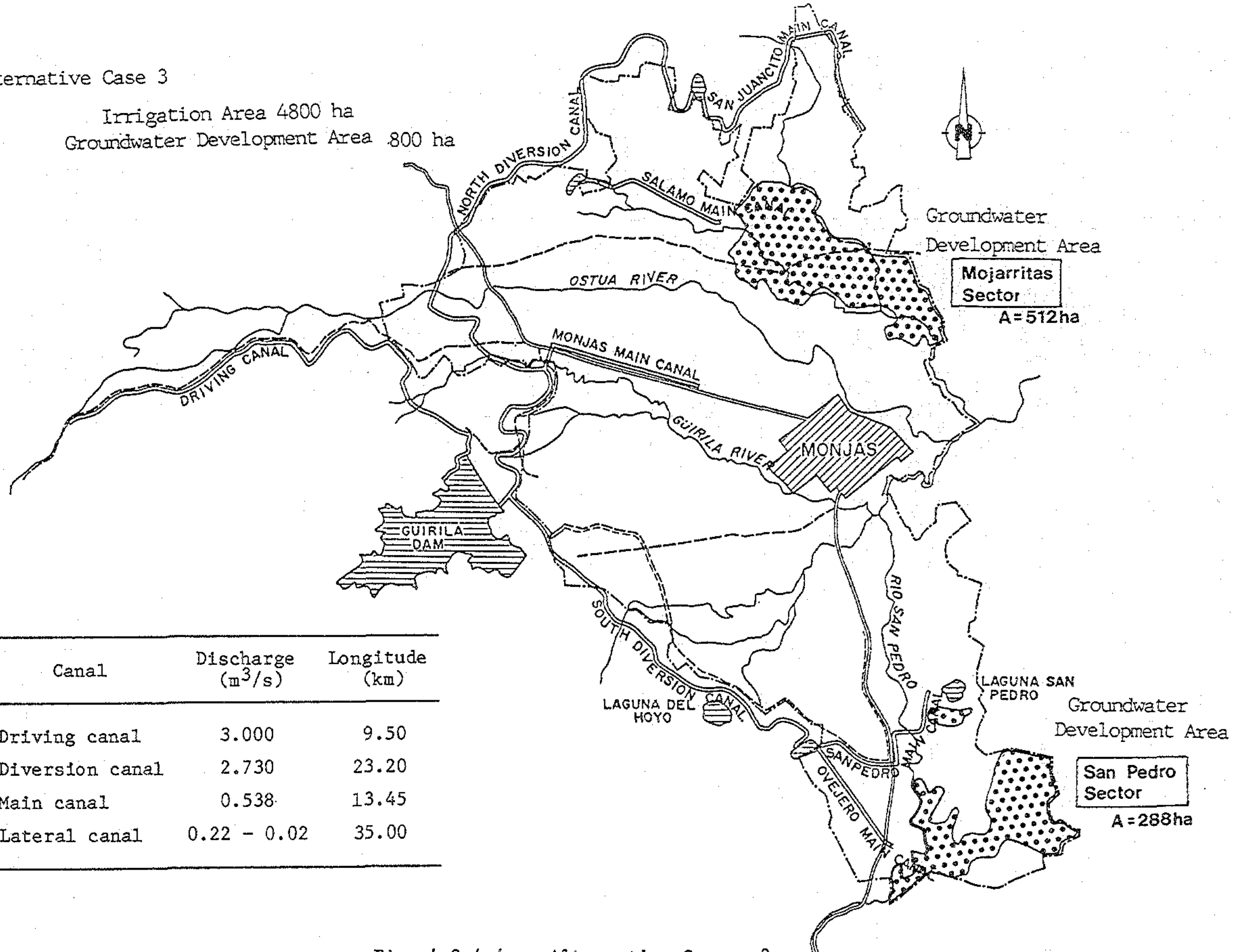


Canal	Discharge (m^3/s)	Longitude (km)
Driving canal	4.000	9.50
Diversion canal	2.973	23.20
Main canal	0.538	18.00
Lateral canal	0.22 - 0.02	39.00

Fig. 4.2.4-3 Alternative Case - 2

Alternative Case 3

Irrigation Area 4800 ha
Groundwater Development Area 800 ha



Canal	Discharge (m^3/s)	Longitude (km)
Driving canal	3.000	9.50
Diversion canal	2.730	23.20
Main canal	0.538	13.45
Lateral canal	0.22 - 0.02	35.00

Fig. 4.2.4-4 Alternative Case - 3

Table 4.2.4-6 Comparison of Alternative Plans

ALTERNATIVE PLAN	WATER RESOURCES	BENEFIT AREA (ha)		REQUIRED WATER (MCM)	REQUIRED GROUND WATER (MCM)	WATER RESOURCES FACILITIES: DAM: Available storage capacity (MCM)	DAM: Dam Hight (M)	DAM: Dam Volume (MCM)	Head Work (Set)	GROUNDWATER: Present Pumping-out (m3/s)	GROUNDWATER: Proposed Pumping-out (m3/s)	CANAL FACILITIES: CONDUCTION: Capacity (m3/s)	CONDUCTION: Length (km)	MAIN CANAL: Capacity (m3/s)	MAIN CANAL: Length (km)	MERIT	SUBJECT TO BE SETTLED	REMARKS
CASE 1	GUIRILA DAM	4,800	-Existing upland field and scattered pasture land to be changed to upland field.	4.928	--	3.770	49.0	2.64	1 Ostua River	--	--	4.0	9.5	3.28	41.2	-Monolithic water utilization system can be applied for the whole area. -Operation and maintenance system is simple and easy.	-Dam and driving canal scale will be larger than other two cases. -Construction cost will be high.	Refer to Fig.4.2.4-2
CASE 2	GUIRILA DAM	4,350	-Existing upland field	4.466	--	3.380	47.0	2.41	1 Ostua River	--	--	3.0	9.5	2.97	41.2	-Driving canal will be as large as main canal. -Operation and maintenance will be simple and easy.	-Groundwater irrigation area and a part of existing upland field will remain as is. -Benefit area is smaller than other two cases.	Refer to Fig.4.2.4-3
CASE 3	GUIRILA DAM AND GROUND WATER	4,800	-Existing upland field and Mojarritas and San Pedro areas where groundwater irrigation is practiced at present.	4.107	631 1)	3.080	45.5	2.24	1 Ostua River	0.18 2)	0.28 (0.46)	3.0	9.5	2.72	36.5	-Effective utilization of groundwater resources. -Driving canal will be as large as main canal.	-Rehabilitation of existing deep well will be necessary. -Operation and maintenance cost will be high due to electric charge. -Operation and maintenance system will be separated for dam and deep well.	Refer to Fig.4.2.4-4

*1 Present pumping discharge

$$V=\frac{49.284\text{MCM} \times 800 \times 0.476}{4{,}800\text{ha} \times 0.62} = 6.31 \text{ MCM}$$

*2 Volume of groundwater to be used

$$\left.\begin{array}{l} 8.4\ell/s \times 22 = 0.18 \\ 8.4\ell/s \times 33 = 0.28 \end{array}\right\} 0.46$$

4) Determination of optimum alternative plan

Cases 1, 2 and 3 have been studied for irrigable area, construction cost for water resources facilities , overall operation and maintenance, and profitability. On the basis of the above results Case 1 is determined as the optimum plan, which depends on the water resource solely on the Guirila dam and covers on irrigable area of 4,800 ha.

Case 1 has the following main advantages.

- A large irrigable area of 4,800 ha is covered, including pasture to be converted into upland field.

- A water requirement of 37.7 MCM (live capacity of reservoir: 39.6 MCM) is ensured depending on water introduced into the Guirila River from the Ostua River.

- Construction cost for water resources facilities per ha is least expensive than Case 2.

- Operation and maintenance is easy and least expensive.

- Hoyo Lake irrigation canals are effectively utilized.

- Case 3 (depending on the water resource partly on groundwater) requires high operation and maintenance cost which causes poor profitability.

Table 4.2.4-7 shows a list which evaluates each alternative.

Table 4.2.4-7 Evaluation of Alternative Plans

Item	Case 1	Case 2	Case 3	
1. Benefited area (ha)	4,800	4,350	4,800	
2. Main resource facilities	Surface water (dam only)	Surface water (dam only)	Surface water: 4,000 ha Ground water: 800 ha (2 types of water resource)	
3. Water resource facilities				
Dam height (m)	49	47	45.5	
reservoir storage (MCM)	37.7	33.8	30.8	
*Technical feasibility	feasible	feasible	feasible	
Well number of wells (Number)	-	-	New : 33 Existing: 22 } 55	
*Technical feasibility	-	-	feasible	
4. Water resource construction cost				
Dam construction cost (unit : Q 1000)	34,500	32,600	31,300	
Well and pump construction cost (unit : Q 1000)	-	-	3,040	
Total	34,500	32,600	34,340	
*Construction cost per unit area (Q/ha)	7,188	7,494	7,154	
5. Operation and maintenance cost (annual) 1/				
- Number of persons	73	73	73	
- Annual operation and maintenance cost (unit : Q 1000)				
Dam maintenance	655 (4,800ha)	653 (4,350ha)	645 (4,000ha)	
Well maintenance	-	-	436 (800ha)	
Total	664	653	1,081	
*Operation & maintenance cost per ha (Q/year)				
Dam maintenance	138	150	161	
Well maintenance	-	-	545	
Average	138	150	225	
Evaluation	regular	slightly expensive	extremely expensive	
6. Ratio of water cost to production cost 2/			Well	Average
Maize, %	5.5	5.9	18.1	8.7
Kidney beans, %	6.5	7.0	20.9	10.1
*Profit from maize (Q/ha)	14	7	-226	-37

Note 1/: refer to Appendix 4.1.2.(5)
2/: refer to Table A.4.1.2-8

(4) Irrigation Plan

1) Specifications of Plan

The plan, selected through the Study in the preceding subparagraph, is designed as in the following specifications.

a. Benefited area A = 4,800 ha

b. Water resource facilities

i. Driving canal
- Diversion weir: 1 unit
- Driving canal
  - length : 9.5 km
  - discharge: 4.0 m^3/s

ii. Reservoir
- Required reservoir storage: 37.7 MCM
- Live capacity of reservoir: 39.6 MCM
- Dam height: 49 m
- Dam volume: 2.64 MCM

c. Irrigation facilities

i. Diversion canal	:	length L = 23.2 km
		canal capacity Q = 0.62 - 3.28 m^3/s
ii. Main canal	:	length L = 18.0 km
		canal capacity Q = 0.54 m^3/s (average)
iii. Lateral canal	:	length L = 39.0 km
		canal capacity Q = 0.21 m^3/s (maximum)
iv. Regulating reservoir	:	3 places

2) Operation of Guirila Dam

The Guirila Dam is studied for dam operation for 15 years from 1967 to 1981. The study may be summarized as shown below. Fig.4.2.4-5 shows the operation water level of the dam.

a. The dam has a live capacity of reservoir of 39.6 MCM (required reservoir storage : 37.7 MCM) enough to fully irrigate the total area of 4,800 ha.

b. In the area of 4,800 ha which is irrigated depending on a driving capacity of 4.0 m^3/s max from the Ostua River to the Guirila dam, water runs short in a volume of about 25 MCM between January and April in 1972 and 1977. Water overflows in other 9 years. The surplus are sufficiently controllable by regulation of water introduced from the Ostua River.

c. In the draught years 1972 and 1977, reduced reservoir storage is still capable of supplying 35-40% of the total irrigation area.

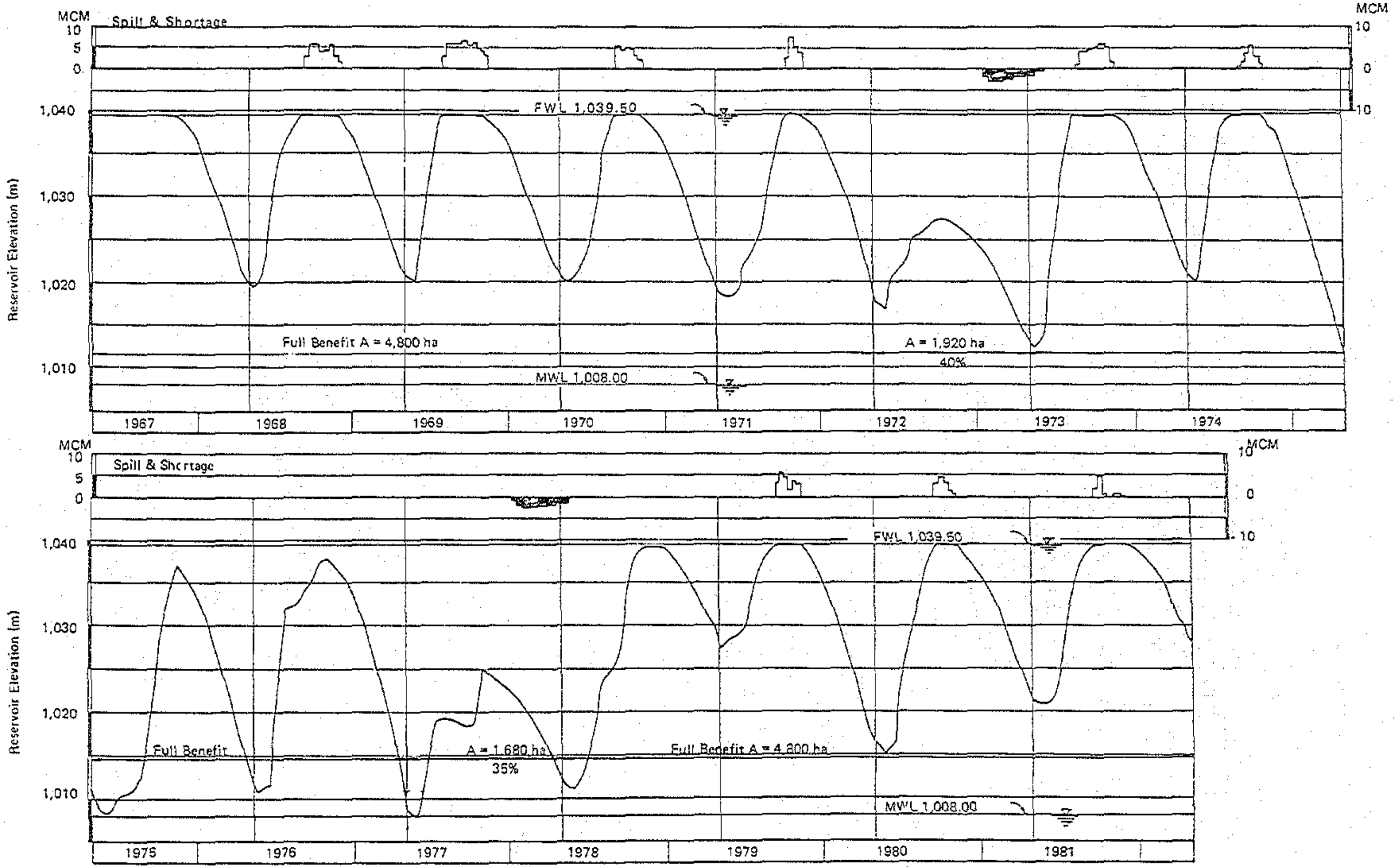


Fig. 4.2.4-5 Operation Water Level of Dam

d. The irrigable area is estimated as follows using the reservoir storage from the end of September to October as an index ; this period is the initial period of the dry season.

i. When a reservoir storage level is EL 1,036.9 m or more (reservoir storage : 34 MCM), the area of 4,800 ha is irrigable.

ii. When a reservoir storage level is lower than EL 1,036.9 m, an irrigable area is found in the following equation.

$$A = 4{,}800 \text{ ha} \times R$$

where, A = irrigable area
R = Coefficient of reservoir storage

$$= \frac{\text{reservoir storage at the end of September}}{\text{gross reservoir storage}} \times 100$$

4.3 Development Plan

4.3.1 Land Use Plan

The area to be irrigated is the existing upland field and a part of pasture to be converted into upland field, and covers a total area of 4,800 ha.

Existing upland field	4,350 ha
Pasture to be converted into upland field	450 ha
Total	4,800 ha

The pasture land is suitable for agriculture as classified into Class II or III but has not been used as upland field because of the shortage of irrigation water and imbalance of labor. However, the pasture has sufficient reasons to justify conversion by means of irrigation : ① farmers having pasture are of intention to convert their pasture into upland field for better profitability if irrigation water is insured, ② irrigation facilities are more efficiently utilized with conversion of pasture scattered in the upland field into upland field, and ③ the conversion conforms to the irrigation strategy of the Govenment to expand irrigation benefited area to a maximum.

Therefore, the land use plan converts about 450 ha out of 1,000 ha of pasture land into upland field ; the intended pasture is situated to the south of the Ostua River considering available irrigation water. Table 4.3.1-1 shows the proposed land use area and Fig. 4.3.1-1 shows the land use plan map.

Table 4.3.1-1 Proposed Land Use

Classification		Area (ha) Jutiapa Dep.	Jalapa Dep.	Total (ha)
Agricultural land	Upland field	715	3,635	4,350
	Converted field	31	419	450
	Sub Total	746	4,054	4,800
	Pasture	39	511	550
	Total	785	4,565	5,350
Forest		235	840	1,075
Residential area		5	365	370
Lakes and swamp		35	-	35
Others		65	235	300
Grand Total		1,125	6,005	7,130

A wide range of pasture located in the north of the Ostua River is remained in consideration of available irrigation water.

4.3.2 Irrigation Plan

(1) Benefited area and proposed rate of cropping

The cropping pattern and cultivation area of main crops in 4,800 ha of the benefited area are discussed in Chapter 4.2.3. The basic concept of the irrigation plan is to maintain production of maize and kidney beans which are basic crops, and to increase cropping of highly profitable export vegetables. As a result the proposed irrigation plan, local labor will be able to effectively utilize.

The proposed rate of cropping is performed based on farmer's intention survey, past records of representative farmers in the Hoyo Lake irrigation area, opinions of the agriculture extension adviser, etc. The basic rate of cropping is determined as shown below through several trial calculations (Table 4.3.2-1).

Fig. 4.3.1-1 Land Use Plan Map
Mapa del Uso Propuesto de la Tierra

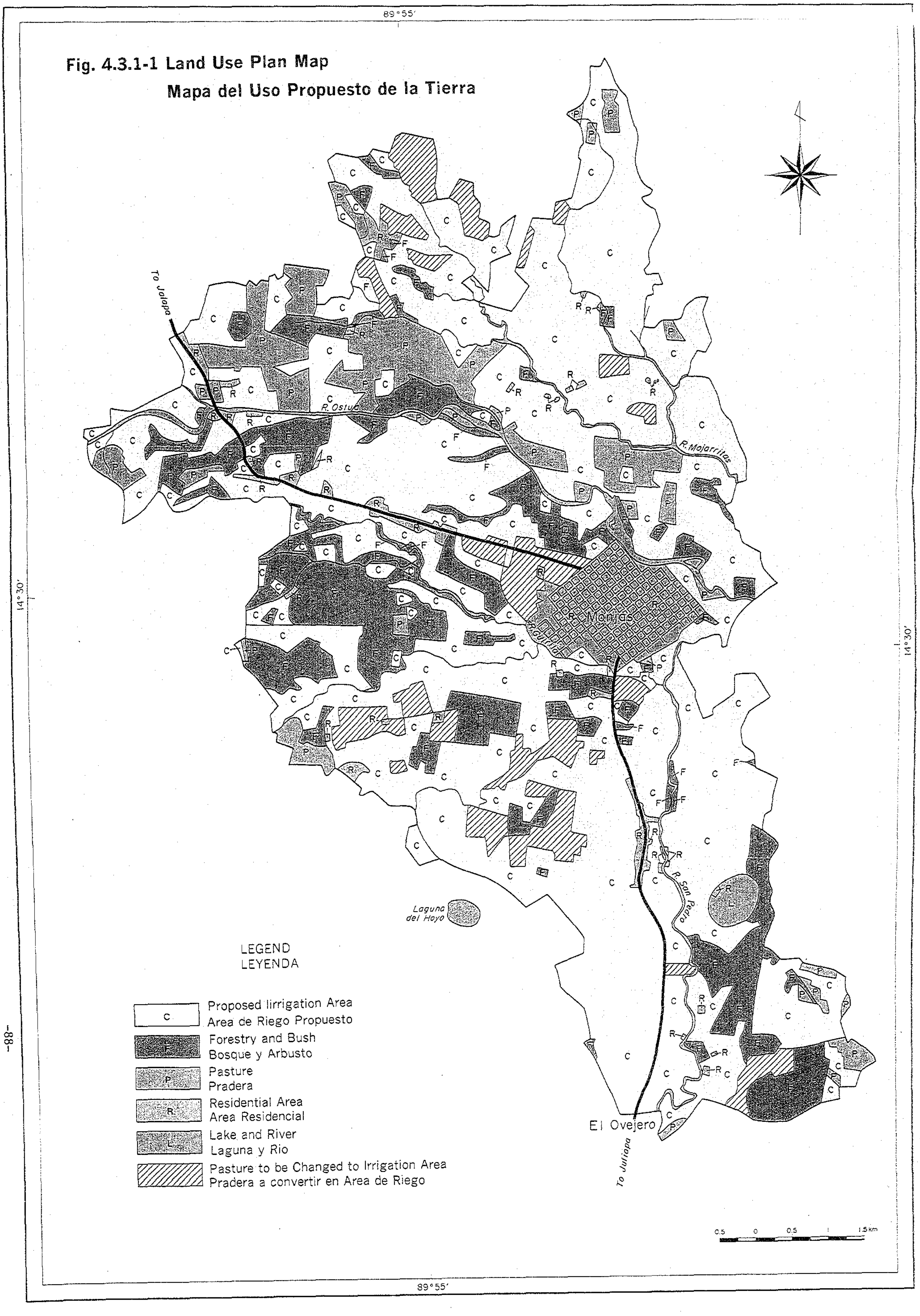


Table 4.3.2-1 Proposed Cropping Area

Class	Area	Crops	Cropping Area
1	1,200 ha	Maize + Tomatoes	2,400 ha
2	1,200	Maize+Broccoli+Kidney beans	3,600
3	1,200	Tomatoes + Maize	2,400
4	750	Kidney beans + Onion	1,500
5	450	Tobacco+Maize+Kidney beans	1,350
Total	4,800	(Total Irrigation Area)	11,250
Cropping Rate	(100)		(234)

Irrigation water requirement is calculated according to the above cropping pattern.

(2) Irrigation water requirement

1) Crop water requirement

a. Calculation of evapotranspiration

i. Evapotranspiration (ETo) is the basis of crop water requirement and calculated using meteorological data of La Ceibita meteorological station by Penman method (Table 4.3.2-2). The calculation is detailed in Table A.4.2.1-2.

Table 4.3.2-2 Evaporation by Penman Method

(Unit: mm)

Month	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Average
ETo	3.86	4.64	5.24	5.44	4.83	4.23	4.57	4.23	3.78	3.67	3.61	3.54	4.30

Evapotranspiration obtained by Penman method is in good agreement with evaporation obtained by the Pan Evaporation method and used as the irrigation standard of the Hoyo Lake irrigation project (Fig. 4.3.2-1).

ii. Calculation of crop water requirement

Crop water requirement (ET crop) is obtained in the following equation.

ET crop = Kc x ETo

Table 4.3.2-3 shows the result of the calculation.

Crop coefficient Kc is obtained, with reference made to FAO, Technical Paper No. 24, Crop Water Requirements, and is as shown in Table 4.3.2-4.

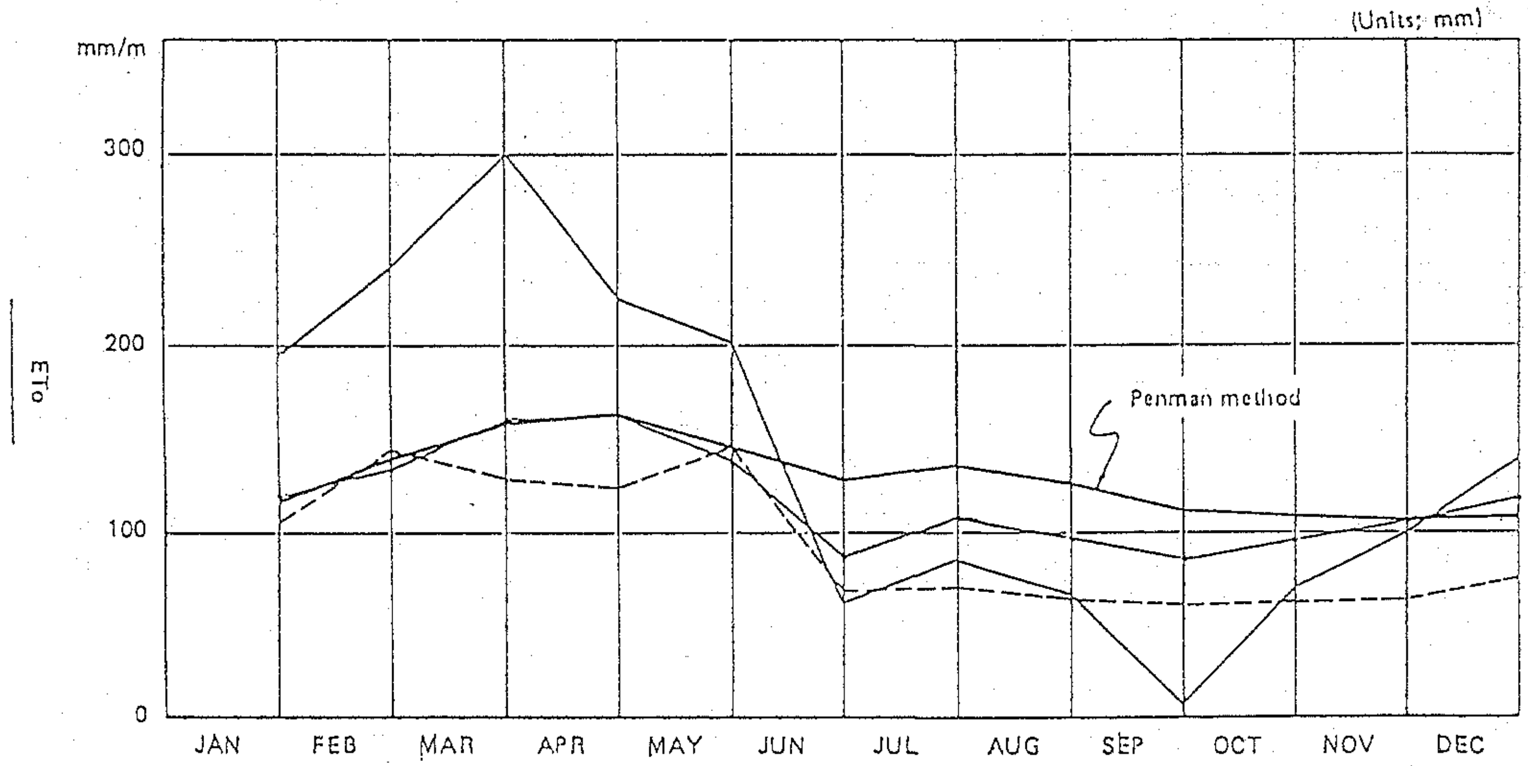
Fig. A.4.2.1-2 shows the detailed crop coefficient by cropping period.

Table 4.3.2-4 Crop Coefficient

Crops	Month	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Maize	I, II	0.40	0.48	0.66	0.87	1.04	0.98	0.88	0.68	-	-	-	-
"	III	-	-	-	-	-	0.47	0.65	0.82	0.94	0.98	0.89	0.68
"	IV	-	-	-	-	0.46	0.64	0.78	0.87	0.94	0.73	-	-
Tomato	I	-	-	-	-	-	-	0.46	0.64	0.81	0.93	1.03	0.89
"	II	-	0.43	0.62	0.79	0.92	1.03	0.89	-	-	-	-	-
Broccoli		-	-	-	-	-	-	0.54	0.77	0.81	0.93	0.93	-
Kidney beans	I	0.89	0.99	0.77	-	-	-	-	-	-	0.42	0.61	0.78
"	II	0.42	0.61	0.78	0.87	0.99	0.77	-	-	-	-	-	-
"	III	0.99	0.77	-	-	-	-	-	-	0.45	0.63	0.79	0.90
Tabacco		0.42	0.61	0.78	0.91	1.02	0.85	-	-	-	-	-	-
Onion		-	-	-	-	0.46	0.59	0.72	0.83	0.92	0.87	-	-

2) Calculation of irrigation water requirement

Irrigation water requirements are calculated on the basis of crop water requirement, effective rainfall, and irrigation efficiency. Irrigation continued in the dry season may result in hazardous salt deposits. Fortunately, the Area has not suffered from salt deposits but this plan allows for water requirements for desalinization. The reference value of effective rainfall and irrigation efficiency are shown below.



Penmman	115.8	138.3	157.3	163.1	144.9	127.0	137.1	127.0	113.5	110.0	108.3	106.3
Christiansen*	195.6	242.0	301.7	225.8	203.5	63.4	85.9	68.0	5.7	71.3	98.8	139.0
Evaporimetro*	116.3	132.2	160.6	162.0	137.3	85.5	106.9	95.5	85.5	95.5	101.5	118.7
Blaney-Criddle*	105.3	143.5	128.3	123.7	146.2	65.6	69.8	63.2	59.9	62.4	63.4	75.1

*Operation criteria of Hoyo Irrigation Project

Fig. 4.3.2-1 Evapotranspiration by Crops

Table 4.3.2-3 Monthly Crop Water Requirement

(Units; mm)

Crops	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Mean
Maize (I), (II)	57.9	60.7	90.1	109.9	117.7	107.7	95.3	72.2	-	-	-	-	711.5
" (III)	-	-	-	-	-	52.1	70.4	86.9	108.9	136.0	139.6	111.0	704.9
" (IV)	-	-	-	-	52.2	70.5	84.5	93.2	109.1	101.9	-	-	511.4
Tomato (I)	-	-	-	-	-	-	49.8	68.5	93.5	129.8	161.9	145.8	649.3
" (II)	-	55.1	84.5	100.2	104.4	113.2	96.8	-	-	-	-	-	554.2
Broccoli	-	-	-	-	-	-	58.7	82.3	93.7	129.2	146.7	-	510.6
Kidney bean (I)	129.0	125.7	105.0	-	-	-	-	-	-	59.1	96.4	127.2	642.4
" (II)	61.2	77.8	107.0	110.9	112.4	84.2	-	-	-	-	-	-	553.5
" (III)	143.5	97.1	-	-	-	-	-	-	52.2	88.5	124.9	146.6	652.8
Tabaco	61.2	77.8	107.5	115.4	115.4	93.3	-	-	-	-	-	-	570.6
Onion	-	-	-	-	51.8	64.9	78.3	88.0	106.5	120.7	-	-	510.2
Average	90.5	82.4	98.8	109.1	92.3	83.7	76.2	81.8	94.0	109.3	133.9	132.7	547.6
Total	452.8	494.2	494.1	436.4	553.9	585.9	533.8	491.1	563.9	765.2	669.5	530.6	6,571.4

a. Effective rainfall

Effective rainfall is determined according to Evaporation and Precipitation Method (U.S.D.A.), with reference made to available precipitation data, precipitation characteristics, records of the Hoyo Lake irrigation project area, etc. (Table 4.3.2-5).

Table 4.3.2-5 Effective Rainfall

(Unit: mm)

Month	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
Rainfall (1963-87)	106	187	157	148	169	94	13	2	1	1	7	19	927
Effective rainfall	60	90	90	90	90	55	0	0	0	0	0	0	475

Effective rainfall is estimated at 475 mm for 6 months in the wet season (May to October), which is about 50% of annual precipitation.

b. Irrigation efficiency

Irrigation efficiency is determined with reference made to FAO guideline taking into account topography, canal structure, distribution system, irrigation system, etc. Irrigation efficiency for each irrigation system is shown in Table 4.3.2-6.

Table 4.3.2-6 Irrigation Efficiency

Irrigation Method	Field Applica. Efficiency (Ea)	Distri. Efficiency (Eb)	Conveyance Efficiency (Ec)	Irrigation Efficiency (Ep)
Surface Irrigation (furrow)	0.60	0.90	0.85	0.46
Spray Irrigation (Sprinkler)	0.70	0.90	0.85	0.54

c. Leaching water requirement

Water requirement for desalinization is obtained in the following equation.

$$L_r = \frac{EC_w}{5EC_e - EC_w} \times \frac{1}{L_e}$$

where;

L_r = Leaching water requirement
ECe = Electric conductivity of saturation water within allowable range of yield reduction (mmho/cm)
Le = Leaching efficiency

The leaching water requirement for each crop is shown below, and detailed information is given in Appendix 4.2.1(7)

Crops	L_r
Maize	0.03
Broccoli	0.02
Tomatoes	0.02
Kidney beans	0.01
Onion	0.04
Tobacco	0.02

d. Irrigation water requirements

Irrigation water requirements are obtained for each crop from crop water requirement, effective rainfall, cropping area for each crop, and irrigation efficiency, using the following equation.

$$W.R. = \frac{A \times \text{Net ETcrop}}{1 - L_r} \times \frac{10}{Ep}$$

where;

A : irrigation area, (ha)
Net ET crop: ETo-Pe; net crop requirement
ETo: Crop water requirement, mm
Pe : Effective rainfall, mm
Ep : Irrigation efficiency
Lr : Leaching water requiement

Result of the calculation is shown in Table 4.3.2-7 and -8.

Water requirement dependent on water resource is 49.3 MCM per year (1,026 mm per ha), as obtained from the proposed benefited area of 4,800 ha and land use rate. The maximum water requirement Q is 3.28 m^3/s.

Table 4.3.2-7 Required Water

Date Mon.	10 Day	Water Requirement (MCM)		Water Requirement (m^3/s)	Irrigation Area (ha)	Unit Water Requirement (lit/sec/ha)
May	B	0.721		0.834	1,983	0.42
	M	0.539		0.624	2,067	0.30
	L	0.488		0.565	2,150	0.26
Jun	B	0.168		0.194	2,500	0.08
	M	0.140		0.162	2,851	0.06
	L	0.115		0.133	3,200	0.04
Jul	B	0.141		0.163	3,600	0.05
	M	0.209	9,603 MCM	0.242	4,000	0.06
	L	0.286	200 mm	0.331	4,400	0.08
Aug	B	0.409		0.473	4,400	0.11
	M	0.681		0.788	4,400	0.18
	L	0.623		0.721	4,400	0.16
Sep	B	0.748		0.866	4,267	0.20
	M	0.718		0.831	4,133	0.20
	L	0.526		0.609	4,000	0.15
Oct	B	1.060		1.227	3,734	0.33
	M	0.914		1.058	3,466	0.31
	L	1.117		1.293	3,200	0.40
Nov	B	2.297		2.659	3,466	0.77
	M	2.020		2.338	3,467	0.67
	L	1.982		2.294	3,600	0.64
Dec	B	2.003		2.318	3.600	0.64
	M	2.086		2.414	3,600	0.67
	L	2.355		2.726	3,600	0.76
Jan	B	2.501		2.895	3,650	0.79
	M	2.608	39,681 MCM	3.019	3,700	0.82
	L	2.834	826 mm	3.280	3,750	0.87
Feb	B	2.831		3.277	3,400	0.96
	M	2.636		3.051	3,050	1.00
	L	2.452		2.838	2,700	1.05
Mar	B	2.279		2.638	2,484	1.06
	M	2.055		2.378	2,266	1.05
	L	1.992		2.306	2,050	1.12
Apr	B	1.769		2.047	1,867	1.10
	M	1.603		1.855	1,683	1.10
	L	1.378		1.595	1,500	1.06
Total/ Average		49.284	49,284 MCM 1,026 mm		3,227	

Table 4.3.2-8 Required Water by Crops

(A = 4,800 ha)
(Units: MCM)

Date Mon.	10 Day	Maize (I) (1,200 ha)	Maize (II) (1,200 ha)	Maize (III) (1,200 ha)	Maize (IV) (450 ha)	Tomato (I) (1,200 ha)	Tomato (II) (1,200 ha)	Broccoli (1,200 ha)	Kindney Bean (I) (1,200 ha)	Kidney Bean (II) (750 ha)	Kidney Bean (III) (450 ha)	Tabaco (450 ha)	Onion (750 ha)	Total (MCM)
	B	0.003	0.003						0.537	0.003	0.173	0.002		0.721
May	M								0.426		0.113			0.539
	L								0.404	0.005	0.077	0.002		0.488
	B								0.154		0.014			0.168
Jun	M								0.140					0.140
	L								0.105	0.006		0.004		0.115
	B								0.061	0.050		0.030		0.141
Jul	M	0.018	0.018						0.007	0.103		0.063		0.209
	L	0.054	0.054				0.027			0.091		0.060		0.286
	B	0.107	0.107				0.056			0.084		0.055		0.409
Aug	M	0.200	0.200				0.105			0.105		0.071		0.681
	L	0.211	0.211				0.072			0.069		0.060		0.623
	B	0.278	0.278				0.069			0.074		0.049		0.748
Sep	M	0.260	0.260				0.102			0.057		0.039		0.718
	L	0.182	0.182				0.108			0.031		0.023		0.526
	B	0.370	0.370		0.001		0.245			0.044		0.030		1.060
Oct	M	0.325	0.325		0.019		0.209			0.010		0.010	0.016	0.914
	L	0.357	0.357	0.031	0.076		0.196						0.100	1.117
	B	0.491	0.491	0.241	0.214	0.047	0.436	0.048					0.329	2.297
Nov	M	0.374	0.374	0.342	0.250	0.094	0.088	0.110					0.388	2.020
	L	0.250	0.250	0.447	0.268	0.145		0.194					0.428	1.982
	B	0.147	0.147	0.550	0.248	0.223		0.291					0.397	2.003
Dec	M	0.065	0.065	0.656	0.230	0.322		0.386					0.362	2.086
	L			0.813	0.222	0.454		0.511					0.355	2.355
	B			0.881	0.194	0.582		0.518			0.017		0.309	2.501
Jan	M			0.930	0.157	0.707		0.523			0.035		0.256	2.608
	L			1.019	0.121	0.862		0.566			0.061		0.205	2.834
	B			1.017	0.079	0.883		0.551	0.051		0.104		0.146	2.831
Feb	M			0.913	0.034	0.858		0.496	0.107		0.157		0.071	2.636
	L			0.811		0.828		0.406	0.187		0.220			2.452
	B			0.682		0.739		0.276	0.295		0.287			2.279
Mar	M			0.529		0.604		0.133	0.439		0.350			2.055
	L			0.404		0.491			0.667		0.430			1.992
	B			0.238		0.311			0.824		0.396			1.769
Apr	M			0.103		0.133			0.999		0.368			1.603
	L								1.057		0.321			1.378
Total		3.692	3.692	10.607	2.113	8.283	1.713	5.009	6.460	0.732	3.123	0.498	3.362	49.284

Item	Discharge	Period
Maximum water requirement	3.280 m^3/sec	Late January
Maximum unit water requirement	1.12 lit/sec/ha	Late March

(3) Irrigation Method

1) Intake rate

The intake rate test was carried out at 8 points in the Study area to review the irrigation plan.

The result of the field intake rate test may be expressed with the basic intake rate, as shown below (Table 4.3.2-9).

Table 4.3.2-9 Basic Intake Rate

Location	Basic intake rate (mm/hr)
1. Hoyo irrigation project area	2.03
2. Ovejero (No. 1)	1.98
" (No. 2)	8.56
3. San Pedro (No. 1)	12.99
" (No. 2)	15.39
4. Guirila (No. 1)	5.96
" (No. 2)	10.18
5. San Antonio (No. 1)	4.51
" (No. 2)	11.26
6. Monjas (I)	1.09
7. Monjas (II) (No. 1)	0.73
" (No. 2)	2.86
8. Salamo	2.24
Average	6.14

The measuring point and intake test results are shown in Appendix 4.2.1(8).

2) Irrigation method

The irrigation method in the Area is planned considering natural conditions, agricultural management, and economic conditions as follows:

Furrow irrigation : 80%
Sprinkler irrigation : 20%

Irrigation method is determined for the following main reasons.

a. Topographical gradients and shape of farm plots are suitable for both surface irrigation and sprinkler irrigation but the basic intake rate (1 - 15 mm/hr) indicates that furrow irrigation is more suitable.

   Moreover, predominant east wind in the dry season has inverse influence on splinkler efficiency whereby splinkler irrigation is taken lower rate.

b. At present the irrigation area employs the following system, which is also taken into account.

   Furrow irrigation : 76%
   Sprinkler irrigation : 24%

c. The splinkler facilities requires a relatively high cost (about Q 10,000 for standard set).

d. Sprinkler irrigation is partly employed for agricultural management reasons, water control labor and work system in particular. The ratio of sprinkler irrigation is 20%, with the present rate taken into account.

(4) Irrigation water requirement, interval, and rotation blocks

Soils were sampled at the intake rate measuring point to analyze physical properties of soil such as specific gravity, porosity ratio, field capacity, and wilting point (Table A.3.2.5-4).

This analysis is accompanied by calculation of effective moisture content of each soil layer and total readily available moisture (TRAM) (Table 4.3.2-10).

Table 4.3.2-10 Total Readily Available Moisture

(Unit: mm)

Location	TRAM	
	Maize, Tobacco	Tomato, Onion, Broccoli etc.
1. Hoyo Lake Irrigation Project Area	78	39
2. Ovejero	70	35
3. San Pedro	46*	23*
4. Guirila	54	27
5. San Antonio	45*	23*
6. Monjas	64	32
7. Monjas	62	31
8. Mojarritas	68	34
9. Achiotes	66	33
Average	61	31
Average (Except 3.5)	66	33

As shown in Table 4.3.2-10, representative soil except that of points 3 and 5 has the TRAM value of 66 mm for maize and tobacco and 33 mm for tomatoes, and broccoli, etc.

Irrigation interval for each crop is obtained from the TRAM value and daily water requirements (Table 4.3.2-11).

Table 4.3.2-11 Irrigation Interval for Crops

Crops	TRAM (mm)	Max. daily water requirement (mm/day)	(Average)	Intervals (day)
Maize I,II	66	4.07		
Maize III	66	4.72	4.2	15
Maize IV	66	3.71		
Tomato I	33	5.73	4.8	7
Tomato II	33	3.83		
Broccoli	33	5.17		6
Kidney beans I	33	4.41		
Kidney beans II	33	3.85	4.5	7
Kidney beans III	33	5.27		
Tobacco	66	3.94		16
Onion	33	4.15		8
Average	33	4.5		7

Irrigation interval depends on crops and cropping time as shown above, and the mean value of daily water requirement in the growing period is about 90% of the maximum value. Irrigation interval may be regarded as 7 days in average. This value is in agreement with the value of guideline of the Hoyo Lake irrigation project.

A water requirement for each irrigation operation is 33 - 66 mm as indicated by the TRAM value. In normal operation, furrow irrigation and splinkler irrigation can cover an irrigation area of 1.4 -2.1 ha, and the rotation block (Arb) is found in the following calculation.

$$Arb = 1.4 \sim 2.1 \times 7 \doteqdot 10 - 15 \text{ ha}$$

The irrigation supply to tertiary canal in the rotation block has a capacity (qs) of 8.21 liter/s/ha.

(5) Water distribution plan

1) Irrigation system

Taking into consideration, topography, present river conditions, residential area and Hoyo Lake irrigation project area, the irrigation system is planned by dividing the benefited irrigation area into 10 blocks (Table 4.3.2-12).

Fig. 4.3.2-12 Water Distribution Block

Block	Division works	Area (ha)
- South diversion canal		
1. Hoyo Irrigation Area	16	923.6
2. San Pedro area	13	504.8
3. Ovejero area	11	394.8
4. Ovejero Pump area	4	145.0
5. Direct Supply area	6	201.8
Sub-total		2,170.0
- North Diversion Canal		
6. Monjas area	11	567.0
7. Salamo area	14	737.2
8. San Juancito area	10	560.0
9. Direct Supply area	24	695.8
Sub-total		2,560.0
- Driving Canal		
10. Direct Supply area	2	70.0
Sub-total		70.0
Total		4,800 ha
Average	111*	480 ha

* Division work for main and lateral canal are not included.

The main canal has a mean coverage area of 480 ha and each division work covers about 45 ha (3 rotation block).

Fig. 4.3.2-2 shows the main canal and water distribution.

2) Regulating reservoir plan

It is difficult to efficiently distribute water just in time in a long canal system. Therefore, a regulating reservoir is planned for each diversion canal end (the head of the main canal) to facilitate diversion control.

The regulating reservoir has the following functions.

- To store water for night time delivery,
- To regulate the time lag in canal flow,
- To store of waste and surplus water from upper stream of canal, and
- To regulate pumping water.

3) Unit water requirement

The unit water requirement by canal is determined according to the function of each canal.

Canals	Service area (ha)	Unit water requirement (lit/sec/ha)
Diversion canal	560 - 2,560	0.87
Main canal	average 480	1.12
Lateral canal	15 - 150	1.43
Tertiary canal	average 15	8.21

4.3.3 Reservoir Plan

(1) Scale of reservoir

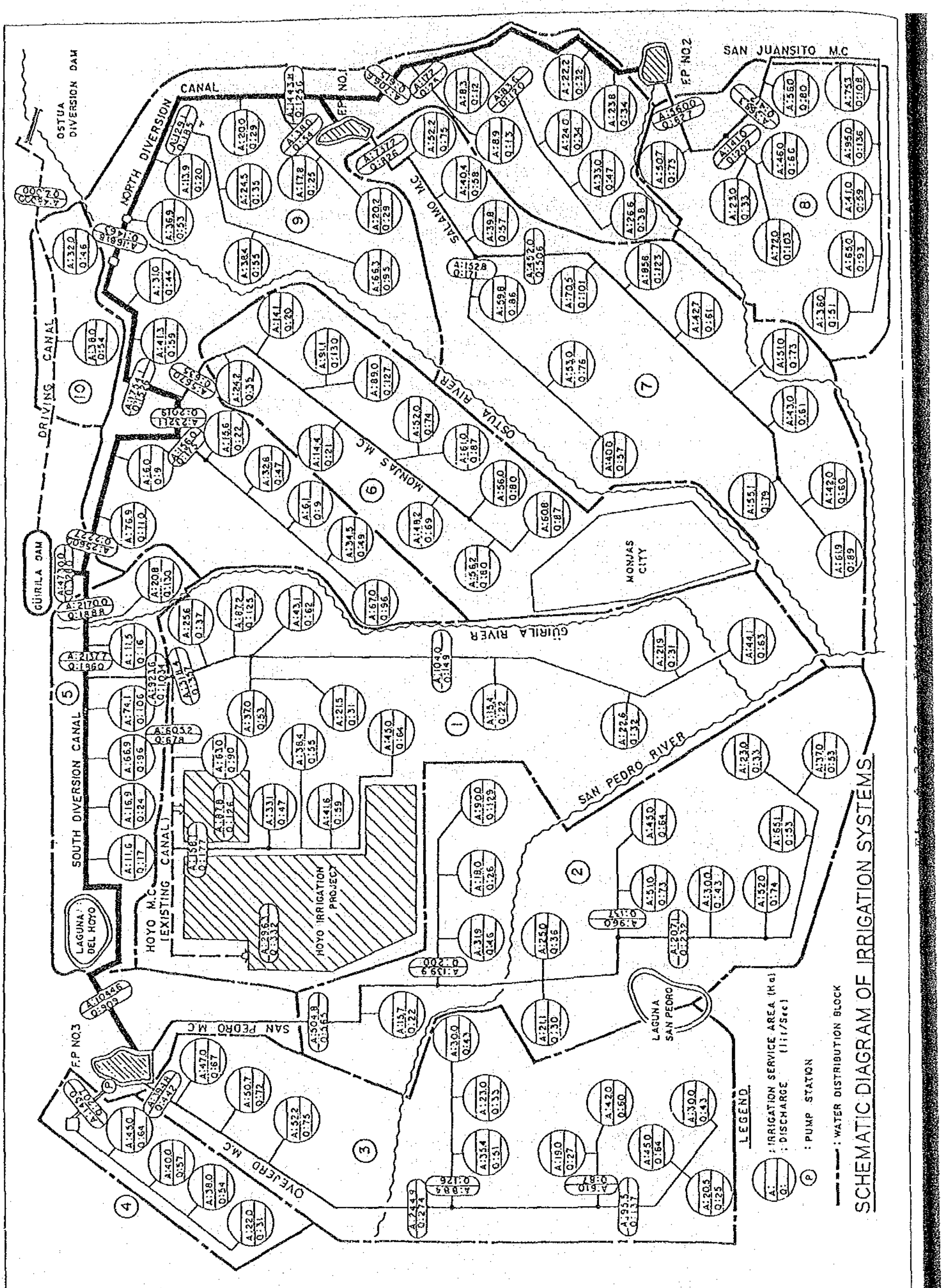
The scale of the reservoir in the Guirila dam site is shown in Chapter 4.2. The basic development concept and is designed as shown below according to the Height - Volume Curve shown in Appendix Fig. A.4.1.1-1.

<u>Catchment area</u>

Direct catchment area	26.0 km^2
Indirect catchment area	177.0 km^2

<u>Average annual runoff</u>

Direct catchment area	11.9 MCM
Indirect catchment area	96.7 MCM



SCHEMATIC DIAGRAM OF IRRIGATION SYSTEMS

Reservoir

Live capacity of reservoir 1/	39.6 MCM
Design sedimentation	1.3 MCM
Gross capacity of reservoir	40.9 MCM
Reservoir area in F.W.L.	2.05 km^2
Full water level (F.W.L.)	1,039.50 m
High water level (H.W.L.)	1,041.00 m
Dead water level (D.W.L.)	1,008.00 m
Usable water depth	39.50 m

Note : 1/ The live capacity of reservoir includes a 5% loss.

(2) Dam scale

1) Elevation of non-overflow crest

The elevation of non-overflow crest is calculated by the following method:

1 In case of full water level (1,039.50 m)

$Hf + hw + he + 1$

where, $hw + he < 1$, $Hf + 2$

2 In case of high water level (1,041.00 m)

$Hh + hw + 1$

Where, $hw < 1$, $Hh + 2$

where, Hf = full water level
Hh = high water level
hw = wave height in a reservoir generated by winds (m)
he = wave height in a reservoir generated by earthquakes (m)

a. Wave height (hw) generated by winds

Wave height in a reservoir generated by winds is applied to the SMB method with Saville method. According to the climatological data at the Study area for 10 year period, the average monthly wind velocity is not more than 2.0 m/sec. Therefore, the wave height generated by wind will be very low because of this wind velocity, but the designed wind velocity uses 20 m/sec velocity in consideration of the safety side for dam body. The distance between the opposite banks is 2,800 m from topographic map of scale 1 to 12,500. And the upstream slope is smooth. From the above data shown the wave height becomes to 1.50 m.

b. Wave height (he) generated by earthquakes

The earthquake wave height is obtained in the following equation.

$$he = \frac{1}{2} \cdot \frac{K\tau}{\pi} \sqrt{g \cdot Ho}$$

where, K : design seismic intensity, 0.12
τ : circle of seismic waves adopted by 1.0 second
Ho : water depth of reservoir in FWL
FWL 1,039.50 - EL 1,000 = 39.50 m
g : gravitational acceleration, 9.8 m/sec^2

$$he = \frac{1}{2} \times \frac{0.12}{3.14} \times \sqrt{9.8 \times 39.5}$$
$$= 0.38 \text{ m}$$

c. Determination of non-overflow crest

- In case of full water level (FWL 1,039.50 m)

$$hw + he = 1.50 + 0.38 = 1.88 > 1.0$$

Therefore, $Hf + hw + he + 1 = 1{,}039.50 + 1.50 + 0.38 + 1.0$
$= \text{EL } 1{,}042.38 \text{ m}$

- In case of high water level (HWL 1,041.00 m)

$$hw = 1.50 > 1.0$$

Therefore, $Hh + hw + q = 1{,}041.00 + 1.50 + 1.0$
$= \text{EL } 1{,}043.50 \text{ m}$

The non-overflow crest is EL 1,043.50 m as obtained from the above calculations.

2) Elevation of dam crest

The elevation of the dam crest is EL 1,044.00 m, that is, the elevation of non-overflow crest plus the protective layer 50 cm for the impervious zone.

4.4 Agriculture Development Plan

4.4.1 Agriculture Production Plan

(1) Cropping area

Table 4.4.1-1 shows the total cropping area calculated from the cropping area of the wet and dry seasons on the basis of the cropping pattern in Fig. 4.2.3-1. The total cropping area is doubled as compared with the present, and the annual average rate of cropping increases from 129% to 234%. The rate is decreased a little from 110% to 109% in the wet season but significantly increased from 18% to 125% in the dry season. The reason why the dry season differs from the wet season in the proposed cropping rate is that maize is mostly cropped in the wet season because of the longer growth period while vegetables are mostly cropped in the dry season bacause of the shorter growth period.

(2) Production volume

1) Yield

Table 4.4.1-2 shows the estimated yield, which is based on collected data , the survey result of the Hoyo Lake irrigation preject area, and the forecast of increased yield due to technical improvement through full discussion on these data with local personnel involved. In Table 4.4.1-1, the "Present" indicates the present yield based on the survey result, the "Without Project" the yield expected to increase at any rate with technical improvement made by farmers themselves without the project, and the "With Project" the yield estimated with reference made to the level of excellent farmers.

The plan indicates a difference in crop yield between dry and wet seasons on the assumption that the wet season has a little more unstable yield than the dry season because of dependence largely on rain water and partly on irrigation during draught while the dry season depends on stable irrigation water. The plan assumes that the yield of maize is increased by 1.3 - 1.4 times the present yield, kidney beans by 1.4 -1.6 times, tobacco by 1.4 times, tomatoes by 1.4 times, broccoli by 1.3 times, and onions by 1.4 times.

2) Total Production Volume

The proposed total production volume of crops in the Study area Table 4.4.1-3 shows that maize is increased by 1.9 times the present production, kidney beans by 6 times, tobacco by 1.3 times, tomatoes by 4 times, broccoli by 4.5 times, and onions by 8.1 times.

Table 4.4.1-1 Proposed Cropping Area

(unit: ha)

Crop			Without Project	With Project	Balance
Maize	W	1st	2,950	2,400	-450
	W	2nd	160	450	290
	D		24	1,200	1,176
Sub-total			3,134	4,050	916
Kidney beans	W	1st	600	750	150
	D - W			1,200	1,200
	D		57	450	393
Sub-total			657	2,400	1,743
Tobacco	W	1st	480	450	-30
Tomatoes	W	1st	320	1,200	880
	W	2nd	290	-	-290
	D		259	1,200	941
Sub-total			869	2,400	1,531
Broccoli	D		340	1,200	860
Onions	D		130	750	620
Total	(a)		5,610	11,250	5,640
Upland field (b)			4,350	4,800	
Cropping rate a/b x 100			129	234	
Pasture			1,000	550	-450

W : wet season D : dry seaon
1st : 1st cropping 2nd : 2nd cropping

Table 4.4.1-2 Proposed Yield

(unit : t/ha)

Crop		Present	Without Project	With Project
Maize	W	2.7	2.8	3.8
	D	3.2	3.4	4.1
Kidney beans	W	1.1	1.2	1.8
	D	1.4	1.5	2.0
Tobacco	W	1.4	1.4	1.9
Tomatoes	W	17.0	17.9	24.0
	D	18.5	19.4	26.0
Broccoli	D	8.3	8.3	10.5
Onions	D	8.5	8.7	12.0

W : wet season D : dry season

source 1. Costo Estimado de Produccion de los Principales Productos Agricolas, Temporada 1987 - '88, Banco de Guatemala, 1987.
2. Diagnostico de la Sub-Region VI-2, DIGESA, Region VI-2, 1986.
3. Oficina de Unidad de Riego " Laguna de Hoyo", 1987.

Table 4.4.1-3 Proposed Production Volume

(unit : ton)

Crop		Present	Without Project	With Project
Maize	W	8,397	8,708	10,830
	D	77	82	4,920
Sub-total		8,474	8,790	15,750
Kidney	W	660	720	3,510
beans	D	80	86	900
Sub-total		740	806	4,410
Tobacco	W	672	672	855
Tomatoes	W	10,370	10,919	28,800
	D	4,792	5,025	31,200
Sub-total		15,162	15,944	60,000
Broccoli	D	2,822	2,822	12,600
Onions	D	1,105	1,131	9,000

(3) Production material

The production material plan is outlined as below.

Seed : Qualitative improvement such as employment of improved varieties and renewal of seeds, and seed quantity are kept equal to the present.

Fertilizer: Input of fertilizer is increased by about 1.5 times the present input.

Agricultural chemicals :
Agricultural chemicals for tabacco and broccoli are input almost at the present because purchasers furnish them and give technical extension. For kidney beans and tomatoes, they are given in optimum frequency and amount. For other crops, they are given in time in an amount equal to that at present.

Herbicide : Labor-saving is intended by use of herbicide because study on demand in labor by season has proven that weeding requires considerable labor.

(4) Required labor

1) Labor input per unit area

Table 4.4.1-4 shows required labor per ha for each crop at present and with project.

The plan assumes that required labor remains almost unchanged though seeding, fertilizer application, and agricultural chemical spray, which may be greatly improved in cultivation techniques. Weeding labor is decreased by about 10% through use of herbicide. It is assumed that irrigation labor is saved by about 20% as compared with the present labor through improvement of the canal, etc. However, irrigation requires labor of 6 workers per ha because of planned irrigation during drought in the wet season. Labor for harvesting is increased by about 10% due to an increase of yield.

Required labor for each crop and per ha for work is shown in Table A.4.2.2-6.

Table 4.4.1-4 Required Labour by Crops

(unit : man /day/ha)

Crops		Present	With Project
Maize	W	57	63
	D	82	75
Kidney beans	W	40	46
	D	69	65
Tobacco		192	198
Tomato	W	121	133
	D	160	159
Broccoli		129	124
Onion		253	250

W: Wet season, D: Dry season

2) Required labor per month

The plan requires about 1,179,000 man per year, which are more than twice the present. Thus, an employment opportunity is markedly enlarged in agricultural production (Table 4.4.1-5).

In the wet season maize and kidney beans are cropped, both of which require less labor, and required labor per month is kept almost at the present level. On the other hand, intensive vegetable cropping becomes the main stream between the end of the wet season and of the dry season, when labor demand is increased.
In the Study area agriculture workers accout for about 80% (about 4,200) of economical active population. Assuming that they are employed for 25 days per month in average, labor

necessary in the Area is about 105,000 man/day on the monthly average. In the proposed cropping pattern, required labor between September and March exceeds supplied labor in the Area. However, this period is mostly within the dry season, when unemployed labor in the neighbor area is conveniently utilized. As a result, an employment opportunity is increased, not limited to labor in the Area.

Table 4.4.1-5 Monthly Required Labor

(Unit : Man/Day)

	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Total
P (a)	21.114	55.230	55.310	77.255	46.452	41.072	48.270	64.872	28.092	28.170	26.706	8.868	591.411
Y (b)	36.594	58.873	64.071	66.774	111.595	141.754	149.071	130.145	109.147	134.443	109.774	66.459	1.178.700
(b)-(a)	15.480	3.643	8.761	▲10.481	65.143	100.682	100.801	65.273	81.055	106.273	83.068	57.591	677.289

The required labor by month in the whole study area is detailed in Table A.4.2.2-7.

(5) Production Value

1) Farm-gate price

The farm-gate price is set on the basis of results of household survey, deta obtained from DIGESA, Hoyo Lake Irrigation Project office, Bank of Guatemala (Table 4.4.1-6). Farm-gate price widely varies in accordance with seasonal production volume, intentions of broker, and variation of international prices, etc.

Considering intentions of local people concern, seasonal and annual variation and contracted cultivation, annual average farm-gate prices around Monjas area are estimated in order to propose farm-gate prices for the project.

a. Maize : The average price in Monjas area is 460 Q/t from DIGESA, 400 Q/t from data of Bank of Guatemala and 400 - 460 Q/t from household survey. The plan employs 400 Q/t.

b. Kidney beans: The average price in Monjas area is 1,035 Q/t, and 1,650 Q/t from Hoyo Lake Irrigation office, 1,090 Q/t from data of Bank of Guatemala and 925 - 1,010 Q/t from household survey. The plan employs 1,090 Q/t.

c. Tobacco : The average price of contracted cultivation in Monjas area, 4,460 Q/t is employed as a farm-gate price.

d. Tomatoes : The survey of Hoyo Lake Irrigation Project office shows 260 - 530 Q/t, and the household survey shows 190 - 240 Q/t. The plan employs 260 Q/t.

e. Broccoli : The plan employs 500 Q/t, which is the contract price in 1987 and 1988.

f. Onions : The plan employs 590 Q/t according to information issued by Bank of Guatemala.

Table 4.4.1-6 Farm-gate Price

(unit : Q/t)

Crops	Maize	Kidney beans	Tobacco	Tomatoes	Broccoli	Onions
Farm-gate price	400	1,090	4,460	260	500	590

Source : 1. Costos Estimados de Produccion de los Principales Productos Agricolas, Temporada 1987 - '88, Banco de Guatemala, 1987.
2. Diagnostico de la Sub-Region VI-2, DIGESA, Region VI-2, 1986.

2) Gross production value, production cost, net production value

Table 4.4.1-7 shows the gross production value, production cost, and net production value at present, with and without project.

Tobacco and vegetables register higher net production value per unit area than maize and kidney beans, which are traditional basic crops. The proposed cropping pattern is oriented to increase vegetables in the dry season, and evidently contributes to a significant increase in productivity in the Area.

The plan assumes that cattle breeding remains unchanged in productivity. Table 4.4.1.8 shows gross production value, production cost, and net production value in the whole proposed area on the basis of data shown above.

It is expected that gross production value increase by about 3.1 times that at present and net productions by about 5.4 times.

Table 4.4.1-8 Net Production Value and Production Cost

(Unit: 1000 Q)

	Gross production value	Production cost	Net production value
Present	13,672	9,989	3,681
Without Project	14,088	9,661	4,027
With Project	42,391	22,618	19,773

Table 4.4.1-7 Proposed Production Value and Cost

(unit:Q/ha)

		Gross Production Value			Production Cost			Net Production Value		
		Present	Without Project	With Project	Present	Without Project	With Project	Present	Without Project	With Project
Maize	W	1,080	1,120	1,520	1,024	1,024	1,215	56	96	305
	D	1,280	1,360	1,640	1,210	13,03	1,316	70	57	324
Kidney Beans	W	1,199	1,308	1,962	826	826	1,032	373	482	930
	D	1,526	1,635	2,180	1,010	1,103	1,156	516	532	1,024
Tabacco	W	6,244	6,244	8,474	5,328	5,328	5,482	916	916	2,992
Tomato	W	4,420	4,654	6,240	2,134	2,134	2,430	2,286	2,520	3,810
	D	4,810	5,044	6,760	2,410	2,482	2,655	2,400	2,562	4,105
Broccoli	D	4,150	4,150	5,250	2,772	2,844	3,043	1,378	1,306	2,207
Onion	D	5,015	5,133	7,080	3,315	3,388	3,486	1,700	1,745	3,594
Pasture	W-D	474	474	474	378	378	378	96	96	96

W: Wet season, D: Dry season

4.4.2 Agricultural Management Plan

(1) Scale of Agricultural Management

In the Study area, sub-families, families, and multi-families own average land area of 2.2 ha, 14.9 ha, and 53.1 ha, respectively. The plan converts 450 ha of pasture into upland field. As a result, each scale of farmer has upland field increased to 2.3 ha, 15.4 ha, and 66.6 ha, respectively (Table 4.4.2-1).

Table 4.4.2-1 Cropping Area by Farm Scale

(unit: ha)

	Sub-families		Families		Multi-families	
	Present	With P.	Present	With P.	Present	With P.
Upland field	2.2	2.3	14.9	15.4	53.1	66.6
Pasture	0.1	-	1.0	0.5	31.3	17.8
Cropping area						
Maize	1.9	1.8	10.8	13.8	32.0	54.1
Kidney beans	0.4	1.3	2.9	9.2	5.4	24.7
Tobacco	0.3	0.2	1.5	1.2	6.0	7.3
Tomato	0.8	1.6	2.3	8.1	6.3	20.6
Broccoli	0.2	0.6	0.7	2.6	5.1	19.8
Onion	0.2	0.4	0.1	3.5	0.1	4.3
Sub-total	3.8	5.9	18.3	38.4	54.9	130.8
Rate of land use %	173	257	123	249	103	196

(2) Cropping plan

The sub-families mark a rate of cropping of 173%, the families 123%, and the multi-families 103% at present. The larger the scale, the lower the rate. The sub-families register a rate of grain cropping of 105% and tobacco and vegetables of 68%, the families 92% and 31%, and the multi-families 70% and 38%.

The plan determines the cropping area by the scale of agricultural management as shown in Table 4.4.2-1 through study on the present rate of cropping. The rate of proposed cropping is 257% for sub-families, 249% for families, and 196% for multi-families.

(3) Cultivation technique

The plan employs techniques discussed in paragraph Agricultural Production Plan for seeding, manuring, agricultural chemical spray, herbicide utilization, and various work means, etc.

(4) Agricultural labor plan

Average family labor employed by each scale of farmer are: 2.4 laborers for sub-families, 2.8 laborers for families, and 3.8 laborers for multi mamilies and total yearly laborers are 720 man·day, 840 man·day, and 1,140 man·day, respectively.

The surplus labor of self-labor out of family labor are employed by multi-families in vicinity as agricultural employee. On the other hand, the shortage of self-labor are procured from sub-families, families and micro-families having less than 0.7 ha in vicinity. Required labor for each scale of farmer are 372.2 man·day for sub-families, 725.9 man·day for families, and 1,121.2 man·day for multi-families (Table A.4.2.2-11).

Due to increase of cropping area and the change of cropping pattern, required labor for each scale of farm will be increased by 635.9, 4,033.5, and 13,093.4 man·day, respectively. As a result, each scale of farm needs employed labor (Table A.4.2.2-12). For the new agricultural labor demand, surplus labor due to unemployment around Monjas area will be utilized.

(5) Agricultural Income plan

1) Gross agricultural profit

Gross agricultural profit is sum of income originated by crops and livestock by income, i.e: income by selling of products and self-consumption at farm. (Table A.4.2.2-15)

Gross agricultural profit become 2.3 - 3.5 times bigger than that of without project.

2) Agricultural management cost

Agricultural management cost is obtained by subtracting self-labor cost from agricultural production cost. Self-labor cost is Q 5/man/day.

Table 4.4.2-2 Agricultural Management Cost

(Unit: Q)

Farm Size		Self-labor (person)	Self-labor Cost	Production Cost	Agricultural Management Cost
Sub-families	Present	372.2	1,861	6,957	5,096
	Without P.	372.2	1,861	6,996	5,135
	With P.	543.1	2,716	12,001	9,285
Families	Present	725.9	3,630	29,219	25,589
	Without P.	725.9	3,630	29,293	25,663
	With P.	840.0	4,200	74,395	70,195
Multi-families	Present	1,121.2	5,606	109,641	104,035
	Without P.	1,121.2	5,606	109,942	104,336
	With P.	1,140.0	5,700	267,845	262,145

Source: Tables A.4.2.2-11, -12, -16

3) Agricultural net income

Agricultural net income is obtained by subtracting agricultural management cost from gross agricultural income.

Table 4.4.2-3 Agricultural Income

(Unit: Q)

Farm Size		Agricultural Gross Income	Agricultural Management Cost	Agricultural Net Income
Sub-families	Present	9,991	5,096	4,895
	Without P.	10,325	5,135	5,190
	With P.	23,489	9,285	14,204
Families	Present	38,867	25,589	13,278
	Without P.	40,169	25,663	14,506
	With P.	141,435	70,195	71,240
Multi-families	Present	143,818	104,035	39,783
	Without P.	147,179	104,336	42,843
	With P.	472,328	262,145	210,183

Source: Tables A.4.2.2-15, 4.4.2-2

Agricultural net income with project increase 2.7 - 4.9 times of without project.

(6) Farm Household Income plan

1) Non-agricultural income

Surplus self-labor obtain non-agricultural income by outside employment. The job opportunity in Monjas area is 0.4 (Table 3.3.4-10) and labor fee is Q 5/man/day. Multi-families have no outside work.

Table 4.4.2-4 Non-Agricultural Income

Farm Size		Surplus Family Labor (persons)	Family Labor Out of Farm (persons)	Non-Agricultural Income (Q)
Sub-families	Present	347.8	139.1	696
	Without P.	347.8	139.1	696
	With P.	176.9	159.2	796
Families	Present	114.1	45.6	228
	Without P.	114.1	45.6	228
	With P.	0	0	0
Multi-families	Present	18.8	(7.5)	0
	Without P.	18.8	(7.5)	0
	With P.	0	0	0

Source: Tables A.4.2.2-11, -12

Families have not outside employment with project. Outside employment of sub-families will be reduced, however job opportunities increase up to 0.9 (Table A.4.2.2-7). As a result, non-agricultural income increase.

2) Farm Household income

Farm house hold income is the sum of agricultural income and non-agricultural income.

Table 4.4.2-5 Household Income

(Unit: Q)

Farm Size		Agricultural Income	Non-Agricultural Income	Farm Income
Sub-families	Present	4,895	696	5,591
	Without P.	5,190	696	5,886
	With P.	14,204	796	15,000
Families	Present	13,278	228	13,506
	Without P.	14,506	228	14,734
	With P.	71,240	0	71,240
Multi-families	Present	39,783	0	39,783
	Without P.	42,843	0	42,843
	With P.	210,183	0	210,183

Farm household income with project became 2.6 - 4.9 times greater than that of without project.

Comparing with minimum labor wage (1,620 Q/year), farm household income by farm scale are 9.3 laborers for sub-families, 44.0 for families, and 129.7 for multi-families.

(7) Farmer's economic surplus

Farmer's economic surplus is obtained by substracting living costs from farm household incomes.

Present living cost per person is Q 856/man.

Proposed living costs estimate 1.5 times as greater as than that of without project.

Table 4.4.2-6 Farmer's Economic Surplus

(Unit: Q)

Farm Size		Family Number	Living Cost	Farmer's Income	Farmer's Economic Surplus
Sub-families	Present	6.5	5,564	5,591	27
	Without P.	6.5	5,564	5,886	322
	With P.	6.5	8,345	15,000	6,655
Families	Present	7.1	6,078	13,506	7,428
	Without P.	7.1	6,078	14,734	8,656
	With P.	7.1	9,117	71,240	62,123
Multi-families	Present	8.4	7,190	39,783	32,593
	Without P.	8.4	7,190	42,843	35,653
	With P.	8.4	10,785	210,183	199,398

Farmer's economic surplus with project become 5.6 - 7.2 times of that of without project.

4.4.3 Marketing and Processing of Agricultural Product

(1) Forecast of marketing of agricultural product

In the Republic vegetable export tends to increase year by year, and tomatoes and bloccoli show a significant increase tendency.

Most broccolies are exported to the USA. Considering recent increase trend of export, broccoli is expected to increase in the future. Almost all tomatoes are exported to El Salvador; exports in 1986 were increased 1.7 times in comparison with the previous year. Information of FAO in 1985 shows that El Salvador depends for 37.6% of consumption on import, therefore El Salvador should be emphasized as a export country in the future. Onions are exported mainly to El Salvador, which depends for 66.7% of consumption on imports. Onions tend to be exported to other countries when less export to El Salvador. Countries besides El Salvador are expected as export of onion.

As in the export market overviewed above, steadily growing of domestic market is also expected, supported by an increasing tendency of population and domestic consumption (Table A.4.2.3-2).

Maize and kidney beans are for self-supply food and domestic market. Steadily growing of demand with an increase in population as national food is expected.

(2) Marketing of agricultural products

Should the project be implemented, Monjas area become prominant vegetable producing center in the Republic. For the raising of a effectiveness of the project, whole marketing system including utilization of idle processing facilities from the production to the comsumption is recommend to be improved. For example, marketing system like wholesale market where farmer can participate to marketing directly at Monjas area should be considered.

4.4.4 Agricultural Support System

Extension and guidance of agricultural techniques and fulfillment of the agricultural finance system are indispensable to obtain the stable agricultural production. Therefore, agricultural support system should be established. In this project DIRYA must promote such organizations, tie up with relevant agriculture authorities such as ICTA, DIGESA, and BANDESA, etc. More particularly, ICTA transfers through agriculture popularization advisers, techniques established by improvement of varieties and cultivation test for the purpose of improving productivity of vegetables. DIGESA takes charge of guidance of agricultural management and extension of agricultural techniques in close cooperation with DIRYA. BANDESA has to fulfil agricultural finance under proper administrative guidance.

The project promotion organization should include a technical guidance system in order to establish integrated support system.

4.4.5 Farmer Organization

Bringing up the farmer's organization is very important to carry out effective rationalization of marketing of agricultural products, popularization, and improvement of techniques. Organization is strongly desired by farmers and must be promoted under guidance of INACOP and other relevant authorities. In the light of the present status, farmers should be progressively organized. For this purpose, the following steps are proposed.

Step 1 : Education period
Farmers are periodically given guidance on organization. The point at issue for managing and operating the farmer's organization is taken as reference of other cases in the Republic.

Step 2 : Period of building up the organization
A preparatory organization is required to determine the scale, management policy, rule, etc. of the farmer's organization.

Step 3 : Activity period
Activities are oriented to collection of information necessary for management of cooperatives and planning of management.

- Information on finance, material suppliers, marketing, processing of agricultural products, export crops, etc. are collected.

- Distribution of cultivated crops, material supply, technical guidance, delivery, etc. are planned.

- A cooperative is managed and operated under the guidance of competent authorities.

4.5 Facilities Plan

4.5.1 Outline of Facilities

Proposed facilities for the Project are summarized below.

Catchment Area: Direct 26.0 km2 Indirect 177.0 km^2

DAM	Dam Body	Main Dam	Type		Zone Type Fill Dam
			Dam Height		49 m
			Crest Length		1,072 m
			Width of Dam Crest		8.0 m
			Dam Slope	upstream	1:2.8
				downstream	1:2.3
			Dam Volume		2.63 MCM
		Saddle Dam	Dam Height		31 m
			Crest Length		397 m
			Width of Dam Crest		6.0 m
			Dam Slope	upstream	1:2.8
				downstream	1:2.3
			Dam Volume		0.40 MCM
	Dam Capacity		Gross Capacity of Reservoir		40.9 MCM
			Live Capacity of Reservoir		39.6 MCM
			Designed Sediment		1.3 MCM
			Reservoir Area in FWL		2.05 km^2
			Full Water Level F.W.L		1,039.50 m
			High Water Level H.W.L		1,041.00 m
			Dead Water Level D.W.L		1,008.00 m
			Usable Water Depth		39.50 m
	Spillway		Type		
			Design Flood Discharge		461 m^3/s
			Crest Length of Overflow		120 m
	Diversion Canal		Design Flood Discharge		135 m^3/s
			Tunnel Diameter		4.0 m
	Intake Works		Type	Drop inlet	
			Maximum Intake Discharge		3.28 m^3/s

DIVERSION WEIR	Diversion Weir	Type	Fixed Weir		
		Length	Fixed Part		90.5 m
			Sand Sluiceway Part		9.5 m
		Weir Height			4.7 m
			Elevation of Weir Crown		1,059.2 m
	Intake	Width			2.0 m 4 units
		Water Level of Intake			1,059.2 m
	Settling Basin	Method	Blow off by Supercritical Flow		
		Length of Basin			25.0 m
	Riprap	Riprap Revetment	Concrete Block, Gabion Wet Masonry		
	Foot Protection		Gabion		
CANAL	Driving Canal	Canal Type	Trapezoidal Section Concrete Lining		
		Maximum Discharge			4.0 m^3/s
		Length			9.5 km
		Ancillary Facilities	Siphon		5 units
			Total Length		1,650 m
			Drop		2 units
			Division Works		2 units
	Diversion Canal	South Diversion Canal	Canal Type	Trapezoidal Section Concrete Lining	
			Maximum Discharge		3.28 m^3/s
			Length		8.0 km
			Ancillary Facilities	Siphon	1 unit
				Length	357 m
				Division Works	7 units
		North Diversion Canal	Canal Type	Trapezoidal Section Concrete Lining	
			Maximum Discharge		2.227 m^3/s
			Length		15.2 km
			Ancillary Facilities	Siphon	9 units
				Total Length	1,170 m
				Drop	1 unit
				Division Works	16 units

CANAL	Main Canal	Canal Type	Trapezoidal Concrete Lining	
		Maximum Discharge		1.526 m^3/s
		Length		18.0 km
		Ancillary Facilities	Siphon	10 units
			Total Length	1,440 m
			Divisions Works	27 units
			Drop	10 units
	Lateral	Canal Type	Trapezoidal Section Concrete Lining	
		Maximum Discharge		0.338 m^3/s
		Length		39.0 km
		Ancillary Facilities	Siphon	20 units
			Total Length	1,350 m
			Division Works	69 units
			Drop	34 units
			Pump Station	1 place
	Regulating Reservoir	through North Diversion Canal		2 units
		through South Diversion Canal		1 unit
	Pump Station	through South Diversion Canal		1 unit
	Other	One Administration Office		

4.5.2 Reservoir and Regulating Reservoir Plan

(1) Basic conditions

1) Basic data

Basic data of topography, geology, embankment material, etc. concerning reservoir and regulating reservoir are prepared and studied about the following matters.

Topography

Topographic map scale 1 : 50,000
Topographic map scale 1 : 12,500
Longitudinal section along dam axis
scale 1 : 2,000

Aerial photograph

Study area scale 1 : 25,000

Geological map

Guatemala national map
scale 1 : 500,000

Geological survey

Core boring	number of drilling 2 places	
	total length	85 m
Permeability test	21 times	

Imperious material test

- Physical test
  Specific gravity
  ASTM D854 one sample
  Moisture content
  Grading test — ASTM D2216 one sample
- Mechanical test
  Compaction test — ASTM D422 one smaple
  Triaxial compression strength test (U-U)
  ASTM D2435 one sample

Rock test

This test was carried out by using of boring core.

Unconfined compressive strength	4 samples
Bulk specific gravity	4 samples

2) Seismic intensity

Design seismic intensity is 0.12 as obtained in chapter 3.3.4 Analysis of Seismology.

3) Designed flood discharge

Designed flood discharge of the spillway is 461 m^3/s, and it of the diversion tunnel is 135 m^3/s of 10-year return period.

4) Designed intake capacity

Designed intake capacity is maximum 3.28 m^3/s as obtained from water balance calculation.

(2) Guirila dam site

1) Topography and Geology

a. Topography

The dam site is situated in the area where the Guirila River transfers from mountain land to plain land. Rough Speaking, the surroundig mountain land exhibits a relatively steep stage of maturity, while a wide eroded vally is found that has a width of 400 to 800 m and a gradient of about 1/120. The river markedly meanders on the upstream of the dam site. River terraces are found on both banks, with talus slopes partly distributed. However, the river flows almost straight in the downstream of the dam site, with no terraces significantly developed.

Tuff is exposed on both abutments in the dam axis point. Two roofs protrude to the river almost at a right angle: one is a dome-like slope with a gradient of 30 to 35° on the right bank and the other is the roof with a gradient of 15 to 20°.

Left roof has a width of about 200 m. The river gently meanders between extended roofs in the direction parallel to the slope on the right bank. The base of left bank river terraces with a width of about 300 m and a height of 1 to 10 m from the river bed are found.

b. Distribution of exposed rock

Geologically, the bedrock around the dam site is composed of tuff. In some sections fine tuff and welded tuff are transitionaly interbedded, but the main section consists of tuff.

The tuff is widely exposed on the river bed and overall slope on the right bank, and on the roof of the left bank. The tuff is massive rock with fewer cracks and fractures, with the surface somewhat weathered. Solid tuff with relatively high welding compactness is distributed on the abutment of the right bank. The tuff beds up an almost horizontal, with no fold.

c. Bearing capacity

The bedrock is a soft rock, which is classified into rock class CIa according to the standard of Civil Engineering Laboratory in Japan. Boring survey proves that solid rock is distributed as depth increases. Unconfined compression strength test shows about 150 kg/cm^2 at the shallow layer and about 350 kg/cm^2 at the deep layer. Therefore, it is considered that the bedrock causes no trouble in serving as the foundation of a fill dam with a height of about 50 m.

d. Permeability

The bedrock is considered having no geological weak points such as fault and shear zone as far as the present topographical and geological survey, and having fewer cracks and fractures. The bedrock shows a Lugeon value (Lu) of 5 or less in Lugeon test carried out using the boring hole, except for the weathered surface. Presumably, the same value is obtained at the dam axis point, where the same rock is anticipated. Thus, the bedrock is considered having fewer problems with permeability.

e. Thickness of unsolidified deposits

The Guirila River has a limited basin (about 26 km^2) as well as less river discharge (12 MCM/month). This suggests that river deposits have small thickness. The boring survey point PM-1 was carried out on the river bed in the upstream about 200 m from the dam axis, and proves the presence of deposits with a thickness of about 18 m. The origin of these deposits is topographically deducted as follows; The boring point is a place where a deep depression is originally formed (This is because a solid bedrock is exposed at the downstream about

60 m from the boring point, and caused the erosion action of a spiral water flow). The deep depression was supplied with sand flowing from the tributary in the left bank, and the sand locally formed thick unsolidified deposits. However, it is assumed that the unsolidified deposits have a thickness of about 10 m at the dam axis point, judging from the extension of the roof, exposed rock on the right bank, flowing condition of the river, and the result of the electric prospecting test.

f. Precautions for design and work

The Guirila dam plan requires the following considerations because the dam is constructed on the bedrock consisting of a soft rock.

- Distribution of bedrock (bearing bedrock depth in the filter core zone in particular)
- Deformation of foundation
- Permeability of foundation
- Distribution of groundwater
- Foundation treatment method

These points will be stated in Chapter 7 Recommendation.
In summary, various geological surveys and tests must be conducted prior to detailed design, and the results reflected to design and work.

2) Dam type

In general, the dam is mainly classified into two types: fill dam and concrete dam.

A concrete dam is not suitable at this dam site for the following reasons:

- The profile along the center of the dam is an inverted trapezoid and the span-length ratio is 22. It is too wide to construct a concrete dam,

- According to the geology of dam site, the bedrock is formed of low welded tuff. This bedrock is not hard, and the bearing capacity and the shear resistance force of this foundation is too small for a concrete dam, and

- Embankment materials are available around the dam site.

A type of fill dam is mainly classified into 3 types: the homogeneous type, zone type and dams with impervious membranes of reinforced concrete and asphaltic concrete, etc.

The zone type of earth fill dam at the dam site will be adopted by the following reasons:

- Dams with artificial impervious membranes have difficulty in construction and are expensive. And also, a gallery is required for maintenance of dam.

- A homogeneous dam is not a suitable type from the viewpoint of dam stability for a large dam more than 30 m height.

The zoning of dam is taken into account on the basis of topography, geology, and distribution and volume of embankment materials around the dam site as shown below:

- The impervious zone should be arranged on the center of dam depend on the topography. And, the size of the impervious zone should be decided by the water pressure, quantity of borrow material, width of the foundation treatment at the core trench.

- The filter material obtained from the Ostua River should be put on both sides of the impervious zone in order to prevail a piping through the impervious zone.

- The previous and semi-previous zones should be arranged on the both outsides considering dam stability.

The saddle dam is designed to a height of 31.0 m and to the same zoning as the main dam. Appendix 4.3.1 (8) shows the typical cross section of main and saddle dams.

3) Width of dam crest and slope

Width of dam crest adopts 8.0 m in main dam and 6.0 m in saddle dam upon consideration of workability, economy, settlement and deformation of dam body. Slopes apply 1 to 2.8 for the upstream slope and 1 to 2.3 for the downstream slope from the results of stability analysis. Stability analysis of dam body are shown in Appendix 4.3.1 (2).

4) Spillway

a. Designed flood discharge

Flood discharge of 200 year return period obtained from hydrological analysis is 384 m^3/s, and the designed flood discharge adopts discharge of 1.2 times as much as the said 384 m^3/s taking consideration of safety of dam because Guirila dam is fill dam. Therefore, designed flood discharge is 461 m^3/s.

b. Route and type of spillway

The spillway as the most appropriate location placed on the right side judging from the topographical conditions. The reasons are as follows:

- The Guirila River is located on the right bank of dam site and changes its direction of flow from west to south at the downstream course of the dam site. Therefore, it is possible to discharge easily from stilling basin to the river.

- It is difficult to place spillway on the left bank because there exist ravine at the upstream course of dam site. And there is no river at the downstream slope of dam site, and

- The right bank is steep in comparison with the left bank, but quality of welded tuff is better than left bank.

The type of spillway to the proposed dam was determined as an uncontrolled spillway (spillway without gate) for the following reasons:

- Spillway with gate is required artificial operation and daily maintenance. And also, spillway with gate is not suitable for important facilities such as dam which there needs strict operation and maintenance.

- Spillway gate has possible dangerousness caused by delay and mishandling to gate operation.

The shape of over-flow section adopts side channel type because the contour cross at right angles with dam axis.

c. Length of weir

Length of weir is calculated by the following equation.

$$L = \frac{Q}{C \cdot H^{3/2}}$$

where, Q ... Designed flood discharge 461 m3/sec
C ... Coefficient of overflow 2.1
L ... Length of weir
H ... Overflow depth 1.5 m

$$L = \frac{461}{2.1 \times 1.5^{3/2}} \doteqdot 120 \text{ (m)}$$

5) Diversion Tunnel

During dam construction, the flow of the Guirila River is changed through the diversion tunnel with 4.0 m diameter, and after completion of dam construction, this diversion tunnel is used as intake facility.

Coffer dam having approximate 10 m height is placed on the upstream course of dam site during dam construction.

The designed flood discharge for the diversion tunnel and coffer dam is 135 m^3/s of 10 year return period.

6) Intake facilities

Intake is done through steel pipe installed on the inside of diversion tunnel after completion of dam construction, and this steel pipe joined by drop-inlet constructed in the reservoir.

The intake discharge is controlled by a jet flow gate installed at the end of diversion tunnel. And a slide gate should be installed in front of jet flow gate in consideration of emergency case. A stilling basin is designed after the jet flow gate.

(3) Regulation reservoir plan

Regulating reservoir should be constructed for discharge control of main canal during a few days.

The main aims of construction of regulating reservoir are summarized below.

- It absorb the fluctuations in demand of irrigation water, and makes easy to supply irrigation water smoothly and flexibly.

- It prevents spoilt discharge. And it is possessed of function to be supplied irrigation water during maintenance and inspection of canal.

The location of regulating reservoir should be constructed at the following three places in consideration of the distribution system of irrigation water.

No. 1 Regulating reservoir: Along North Diversion Canal
No. 2 Regulating reservoir: Along North Diversion Canal
No. 3 Regulating reservoir: Along South Diversion Canal

No. 3 regulating reservoir is used as water tank of pump, too.

1) Capacity of regulating reservoir

A capacity of regulating reservoir is estimated by the following formula.

$$V = \frac{D}{E} \cdot \frac{10}{24} (24 - T).A$$

where, V: Capacity of regulating reservoir (m^3)
E: Irrigation efficiency
D: Consumptive use (mm/day) max. 5.73 mm/day
T: Net irrigation hour per day 18 hours
A: Irrigable area belonged under regulating reservoir (ha)

Irrigation efficiency is calculated as follows:

The proposed irrigable area is irrigated by furrow irrigation of 80% and sprinkler irrigation of 20%.

Therefore, irrigation efficiency is obtained by means of a weighted average of each irrigable area correspondence to furrow and sprinkler irrigation.

$$\text{Irrigation efficiency (E)} = \frac{0.60 \times 0.8 + 0.7 \times 0.2}{1}$$

$$= 0.62$$

The capacity of regulating reservoir obtained by the formula is capacity of 6 hours per day.

The design capacity adopts three times of the above capacity due to consideration of the said chief aims.

① Capacity of No. 1 regulating reservoir

$$V = \frac{5.73}{0.62} \times \frac{10}{24} \times (24 - 18) \times 739.2 \times \frac{24}{6} \times 3$$

$= 205,000\ m^3$ Round 210,000 m3

② Capacity of No. 2 regulating reservoir

$$V = \frac{5.73}{0.62} \times \frac{10}{24} \times (24 - 18) \times 560 \times \frac{24}{6} \times 3$$

$= 155,300\ m^3$ Round 160,000 m3

③ Capacity of No. 3 regulating reservoir

$$V = \frac{5.73}{0.62} \times \frac{10}{24} \times (24 - 18) \times 1,044.6 \times \frac{24}{6} \times 3$$

$= 289,600\ m^3$ Round 300,000 m3

2) Type of regulating reservoir

A homogeneous dam type is suitable for regulating reservoir judging from topography and geology. The reasons are as follows:

- The height of each dam is less than 10 m,
- It is possible to obtain easily embankment materials at the site, and
- Construction of dam is easy.

3) Dimension of regulating reservoir

Dimension of regulating reservoir will be decided as follows judging from topography.

Item		No. 1 regulating reservoir		No. 2 regulating reservoir		No. 3 regulating reservoir
Full water level	FWL	990.00 m	FWL	989.00 m	FWL	1,000.50 m
High water level	HWL	990.50 m	HWL	989.50 m	HWL	1,001.00 m
Low water level	LWL	988.00 m	LWL	987.00 m	LWL	994.50 m
Live capacity of of reservoir		210,000 m^3		160,000 m^3		300,000 m^3
Usable water depth		2.0 m		2.0 m		6.0 m
Dam height		5.0 m		5.0 m		9.0 m
EL of dam crest	EL	991.50 m	EL	990.50 m	EL	1,002.00 m
EL of Min. trench	EL	986.50 m	EL	985.50 m	EL	993.00 m
Width of dam crest		3.0 m		3.0 m		3.0 m
Slope						
upstream		1 : 2.5		1 : 2.5		1 : 2.5
downstream		1 : 2.0		1 : 2.0		1 : 2.0

Note: Freeboard of dam is 1.0 m.

4.5.3 Irrigation Facilities Plan

(1) Ostua Diversion Weir

1) Selection of location

The location of the Ostua diversion weir is determined considering the following:

- Elevation of the driving canal end (outlet to the dam) higher than the crest height of the dam (EL 1,044.0 m),

- Nearest vicinity to the Guirila dam for saving construction cost of the driving canal,

- Narrow river width to minimize the weir body volume,

- Stable water route near the river bank less subject to a change, and

- Easy operation and maintenance.

The diversion weir point is determined through an integrated study of the above factors.

2) Topography and geology

The diversion weir is located about 1 km down from Ingenio Ayarza at the upstream cource of the Ostua River. At this location, the Ostua River flows down along the base of the mountain slope on the left bank, a river bed gradient of about 1/60 forming a rapid current. The left bank is a mountain slope with a gradient of about 40 degree while the right bank is a flat plain.

Geologically, the upper layer of the left bank is composed of welded tuff, which is the bedrock of the Ostua River, and basalt is found in the base. Basalt covers the valley over a wide range, and is presumed to have a thickness of about 5 m at this location. The basalt is solid and relatively massive. The welded tuff has low welding compactness and is a quasi-soft-rock, but neither cracks nor fractures are progressed significantly.

On the right bank, the same basalt is covered by river deposits of about 1 m in thickness which consist of sand and gravel.

As a result, the geological survey has lead to the assmuption that the basalt has no problem as for bedrock strength and permeability in serving as the foundation of the diversion weir.

3) Type of intake weir

The intake weir is classified into the fixed type and floating type accordance with compatibility with the bedrock. The fixed type is adopted for this intake weir because the location is composed of the bedrock in shallow level described in the geology discussed above.

The fixed weir type is employed by following reasons:

- ease in operation and maintenance,
- economic aspect,
- topographic feature of weir site, and
- environment of the upstream.

4) Intake level

The intake level is determined considering the outlet level of the driving canal to the Guirila dam.

The intake level is to be 1,059.10 m in elevation, taking into account the dam crest 1,044.00 m in elevation as stated above and a head loss caused by structures such as siphons in the driving canal 9.5 km in total length.

5) Weir crest elevation

The weir crest is to be 1,059.10 m in elevation; a head loss caused by waves or clogged screens of the intake inlet are added to the design level 1,059.20 m in elevation.

6) Inlet

The inlet structure is determined according to the following design consideration:

- Inlet height is made as low as possible to reduce intake water depth because the diversion weir is at a position in sufficiently high elevation.

- Inlet flow velocity is designed to 1.0 m/s or less to prevent the inflow of sand.

The inlet has the following size according to calculation in the equation shown below.

$$B = \frac{Q}{V \times H}$$

where, Q = maximum intake discharge (4.0 m^3/s)
V = inlet velocity (0.85 m/s)
H = inlet water depth (0.60 m)

The inlet has a width of 8.0 m and consists of 4 gates 2.0 m in span.

7) Ancillary facilities

Generally, necessary ancillary facilities include the boat way, fish way, settling basin, etc.

The boat way is omitted because of absence of boat service on the Ostua River and the fish way because of absence of fishes for fishery.

The settling basin is provided on the assumption that the dam facilities are subject to reverse sand and silt because ① the Ostua River has the upstream basin considerably eroded, and ② the Ostua River has relatively high turbidity in the wet season.

(2) Canal facilities

The basic design concept of canal facilities is as shown below:

- to select a canal route as straight as possible,
- to avoid banking as far as possible, and
- to keep water level as high as possible.

1) Design conditions

Maximum allowable velocity (irrigation canal): 1.5 m/s
(siphon) : 2.25 m/s

Minimum allowable velocity (irrigation canal): 0.60 m/s

Discharge calculation: Manning's formula

Freeboard : 60 cm if > 2.0 m^3/s of design discharge
30 cm if < 2.0 m^3/s of design discharge

Canal type: trapezoid cross section, slope 1 : 1.5
concrete lining on 3 surfaces

Coefficient of roughness: 0.015

a. Driving canal

This plan takes surface water from the Ostua River through the diversion weir in the wet season, and temporarily stores the intake water in the Guirila dam as irrigation water in the dry season. This involves a driving canal from the diversion weir to the Guirila dam.

This plan determines a driving canal capacity of 4.0 m^3/s depending on a relationship between a driving capacity and water storage requirement using discharge data of the Ostua River in the past 15 years. This is because the storage capacity of a dam varies with the capacity of the driving canal.

The driving canal is routed along a contour line of 1,060 to 1,050 m in elevation from the intake point to the Guirila dam, and is provided with 5 siphons on the driving canal route.

The driving canal has a gradient of about 1/3,000.

b. Irrigation canal

The diversion, main, lateral, and tertiary canals are planned as the irrigation canal.

The following table shows the specifications of each type of canal.

Table 4.5.3-1 Specification of Irrigation Canals

	Longitud (m)	Discharge (m^3/s)	Division Works	Drop Works	Cross Works	Siphon
Diversion Canal						
South Diversion Canal	8,000	3.28-0.909	8	-	-	1
North Diversion Canal	15,200	2.227-0.615	16	1	-	9
Main Canal						
Ovejero	2,700	0.418	5	-	-	2
San Pedro	3,000	0.722-0.418	5	2	-	2
Monjas	2,800	0.691	6	7	-	2
Salamo	5,000	0.826-0.506	10	4	-	2
San Juancito	4,500	0.627-0.412	31	13	-	2
Lateral Canal						
Ovejero	4,000	0.087-0.137	8	3	4	2
San Pedro	6,125	0.074-0.200	8	4	3	2
Hoyo	7,750	0.168-0.053	14	2	1	3
Monjas	2,875	0.161-0.257	6	-	-	1
Salamo	4,375	0.073-0.171	6	-	2	3
San Juancito	2,500	0.144	3	4	2	1
Others	11,350	0.054-0.207	22	18	3	10

4.5.4 Construction Plan

(1) Basic condition for construction

1) Workable day

The workable day per month are determined considering daily rainfall data in the latest 5 years obtained from La Ceibita meteorological station as shown below.

Work item	Wet season	Dry season
Embankment of impervious zone	16 days	25 days
Embankment except impervious zone	21 days	25 days
Normal works	21 days	25 days
Diversion tunnel	25 days	25 days
Grout works	25 days	25 days

2) Main construction equipment

a. Excavation

Item	Dam		Canal	
Excavation	Bulldozer	32 t	Bulldozer	21 t
	Ripper dozer	32 t	Bulldozer	15 t, 8t
			Back hoe	0.6 m^3
			Back hoe	0.8 m^3
Loading	Wheel loader	1.8 m3,	Back hoe	0.6 m^3
		2.2 m^3, 3.2 m^3	Back hoe	0.8 m^3
Hauling	Dump truck	15 t, 20 t	Dump truck	8 t
Spoil bank & stock yard	Bulldozer	15 t	Bulldozer	15 t

b. Embankment works

Work item	Dam		Canal	
Excavation of borrow area	Bulldozer	21 t	-	
	Ripper dozer	32 t	-	
Excavation of filter material	Drag line	1.2 m^3	-	
Excavation of randam material	Bulldozer	21 t	-	
Loading	Wheel loader	1.8 m^3	Back hoe	0.6 m^3
Spoiling	Wheel loader	3.2 m^3	Back hoe	0.8 m^3
Leveling	Back hoe	0.8 m^3	-	
Hauling	Dump truck	15 t, 20 t	Dump truck	8 t
Spreading	Bulldozer	21 t	Bulldozer	8 t, 15 t
Compaction:				
Impervious material	Tamping roller with vibration	10 t	-	
Randam material	Flat roller with vibration	10 t	-	
Pervious material	Flat roller with vibration	10 t	-	
Filter material	Flat roller with vibration	10 t	-	
Canal banking	-		Bulldozer Tamper	8 t, 15 t

c. Thickness of spreading and passing number

Item	Thickness of spreading	Passing number
Impervious material	20 cm	8
Randam material	40 cm	6
Pervious material	60 cm	4
Filter	40 cm	3
Canal banking	30 cm	3

(2) Construction method

1) Reservoir

a) Diversion tunnel

During the period of construction of dam and its ancillary facilities, diversion tunnel should be constructed in order to divert the flow and flood of the Guirila River for purpose of the performance of construction works at the dam site. This construction of diversion tunnel should be carried out first and foremost. The excavation of tunnel is commenced from the outlet in order to carry construction materials into tunnel and obtain safety to flood. The excavation method takes full face excavation because the tunnel section is small as about 35.0 m^2. After completion of tunnel excavation, the concrete lining is performed first placing of concrete to arch side from the inlet, and after that, placing of concrete to bottom is done. Mortar grout should be carried out after finishing of concrete works.

After the completion of diversion tunnel works, the coffer dam should be constructed.

b) Excavation works

Excavation works are carried out at main and saddle dam foundation, the foundation of structures and borrow area etc.

Materials to be excavated are classified as follows:

- Excavation of stripping is to excavate and remove by bulldozer earth materials which include vegetable or organic matter.

- Common excavation is to excavate and remove by mainly bulldozer at the foundation of dam, structures and borrow area, etc. after stripping.

- Rock excavation is to excavate and remove by mainly bulldozer with ripper at the foundation of dam, structures. The excavated materials should be spoiled because of low welded tuff.

c) Foundation treatment

After the completion of a part of core trench excavation of dam, grout works is commenced at the core trench. Drilling of grout holes and injection should be performed from the upper part of remained 1.0 m on the designed core trench elevation. Before the dam embankment, the remained part used as grout cap should be removed.

d) Embankment works

After the completion of foundation works and excavation of spillway, dam embankment should be commenced. The range which the impervious zone contact with the foundation should be contacted enoughly by using fine material including sufficient clay in order to prevent seepage. Embankment surface of each zone should be as same elevation as possible.

e) Concrete works

The concrete volume used in concrete works becomes approximate 42,000 m^3 including diversion tunnel spillway and intake facilities etc. Concrete batching plant is installed on the site because no ready mixed concrete factory is in the vicinity of the Study area.

Aggregate for concrete is produced by plant using sand-gravel obtained from the Ostua River bed. This plant is used for concrete for canal lining, too.

Placing of concrete is scheduled to be done by trunk with concrete pump from the viewpoint of simplification of preparation.

2) Irrigation facilities

Main irrigation facilities include the diversion weir, driving canal, irrigation canal, etc.

The diversion weir is constructed by the half-cofferdam system. A concrete cofferdam is planned by use of pebbles, which are available at the site composed of sandy gravel layers including pebbles.

The irrigation canal is constructed mainly by earth work and concrete work.

For earth work, cutting is balanced to banking for each route, and cutting is reused for filling. Excavation depends mainly on bulldozers. The back hoe is used where the bulldozer is not serviceable.

Where cutting is not balanced to filling for the topographical reason as in the branch canal, the bulldozer callects required soil along the canal.

Embanking is compacted by the bulldozer. If impossible, filling is manually compacted with a tamper. Concrete work depends on a concrete plant (constructed for this dam), which supplies concrete by concrete mixer car. Small structures are constructed by a truck mixer which supplies concrete through the chute. The pump truck is used for such as the diversion weir and siphon, which need much concrete with the chute.

4.6 Estimate of Project Cost

The project cost consists of civil works cost, land acquisition and compensations cost, project facilities cost, project administration, pre-engineering, consulting service, physical contingency and price escalation (escalation by inflation).

4.6.1 Estimation Method

The project cost is estimated based on the following conditions.

- Civil works will be carried out by the contract basis. The contractor is responsible for heavy equipment necessary for civil works. Therefore, the construction equipment cost is estimated as depreciation cost.

- The basic cost such as labor wage, material cost, and equipment cost are estimated on the basis of market price in October, 1987.

- The price of import construction material and the construction equipment are on the basis of CIF Santo Tomas or Quetzal plus inland freight, excluding taxes such as import duty and commodity excise, etc.

- The price of domestic construction material is quoted on delivery at site basis, including the value added tax (7%).

- The unit price is expressed in foreign currency and in local currency for each work item. The reference foreign currency value is CIF price in 1987, and reference local currency value is actual price in the same period.

- The physical contingency is 10% of civil work and Land Aquisition and Compensation costs. The price escalation is subject to annual interest rate of 3.3% for foreign currency and 13.1% for local currency (Table A.2.2.1-13). The calculation is carried out by method of compound interest.

- The applicable foreign exchange rate is US $ 1.00 = Q 2.5 = ¥ 130, the official rate in October, 1987.

4.6.2 Project Cost

(1) Project cost

The project cost is summarized as shown below. The project cost including physical contingency is the sum of Q 28.398 million (US $ 11.359 million) in local currency and Q 58.981 million (US $ 23.592 million) in foreign currency, that is, Q 87.379 million (US $ 34.952 million) in total. The share of local currency is 32.5% while that of foreign currency is 67.5% (Table 4.6.2-1).

Table 4.6.2-1 Total Project Cost

	Q (X 1000)			US $ (X 1000)		
	Foreign currency	Local currency	Total	Foreign currency	Local currency	Total
Project cost	54853	25947	80800	21941	10379	32320
Physical contingency	4128	2451	6579	1651	980	2632
Sub-total	58981	28398	87379	23592	11359	34592
Price escalation	11982	17763	29745	4793	7105	11898
Total	70963	46161	117124	28385	18464	46850

The investment plan of this project is as enumerated below, including the price escalation.

Table 4.6.2-2 Project Investment Plan

Year	Foreign Currency Q (X 1000)		Domestic Currency Q (X 1000)	Total Q (X 1000)
1988/89	2271	(908)	111	2382
1989/90	3509	(1404)	1305	4814
1990/91	6408	(2563)	3127	9535
1991/92	15281	(6112)	11952	27233
1992/93	21983	(8793)	16643	38626
1993/94	14490	(5796)	9619	24109
1994/95	7021	(2808)	3404	10425
Total	70963	(28385)	46161	117124

* Figures in parentheses indicate values in U.S. dollar (unit : US $ 1,000)

(2) Components of project cost

The project cost consists of the following component.

1) Civil works

a. Preparatory works

The preparatory works is generally called indirect construction cost divided into two categories, the one is common temporary works and the another is technical control work.

The cost of common temporary works includes (1) preparation cost (topographical, geological, and soil mechanical survey and temporary access road for construction), (2) mobilization cost of equipment, (3) building and repairs expenses such as, labour camp, laboratory, mortor pool, work shop, etc., cost for material yars, (4) safty control facilities, etc.
Technical Control work cost includes quality, progress and work schedule control. The preparatory work cost is estimated as a proportion to the civil works cost.

b. Dam

Foundation treatment, dam body, spillway, intake equipment, etc.

c. Regulating reservoir

Embankment, intake facility, etc.

d. Diversion and driving facilities

Diversion facilities such as weir, sand sluice way, settling basin, and driving facilities

e. Canal

Excavation, embanking, concrete lining, siphon, division work, pump station, cross works, etc.

f. Land Reclamation

Leveling of pasture land which will be comented to upland field.

2) Land acquisition and compensation

Acquisition and compensation of private land and house in the dam site.

3) Project facilities cost

Installation cost of construction office, camp, etc.

4) Administrative expenses

Allowance for construction personnel, miscellaneous office expenses, expenses for fuel, light, and water, etc. during the construction term.

5) Pre-engineering and consulting services expenses

Expenses for consultants for pre-engineering, detailed design, and supervision during the construction term.

6) Physical contingency

Construction cost unforeseenable at the point of the study or subject to an increase; 10% of total construction cost is allowed.

7) Price escalation

Expenses due to escalation by inflation from the point of design to completion of construction. For the foreign currency, the average of consumer price index (last three years) of five advanced countries is adopted. For the local currency, consumer price index prospeeded by SEGEPLAN (Table A.2.2.1-12) is employed. The escalation rate for each year of the project is shown as below.

	1988	1989	1990	1991	1992	1993	1993	1995
Foreign currency (%)	3.3	6.7	10.2	13.9	17.6	21.5	25.5	29.7
Local currency (%)	11.2	22.3	33.2	43.7	53.8	64.6	76.1	88.4

(3) Construction unit price

The unit price of construction work is obtained by the sum-up system. The unit price of labor and material has been researched in Guatemala city and the Study area, and collected data used for computation of project cost (Appendix 4.4.1).

(4) Content of project cost

Table 4.6.2-3, 4.6.2-4 shows the content of the project cost for each component and disbursement schedule, respectively.

Table 4.6.2-3 Content of Project Cost

(Unit: 1000Q)

Item	Foreign C.	Local C.	Total
1. Civil Engineering Work			
1-1 Preparatory Work	2,300	900	3,200
1-2 Dam			
(a) Diversion Tunnel	2,037	1,146	3,183
(b) Foundation Treatment	2,477	2,327	4,804
(c) Dam Body	13,367	5,488	18,855
(d) Spillway	3,853	1,915	5,768
(e) Intake Facilities	1,023	68	1,091
(f) Maintenance Road	543	233	776
Sub-total [1-1 & 1-2]	23,300	11,177	34,477
1-3 Regulating Reservoir	903	225	1,128
1-4 Diversion and Driving Facilities			
(a) Diversion Weir	3,295	1,137	4,432
(b) Driving Canal	2,462	2,574	5,036
Sub-total [1-1 to 1-4]	5,757	3,711	9,468
1-5 Canal System			
(a) Diversion Canal	3,174	2,656	5,830
(b) Main Canal	2,192	1,971	4,163
(c) Lateral Canal	2,925	1,670	4,595
(d) Tertiary Canal	364	1,347	1,711
Sub-total [1-1 to 1-5]	8,655	7,644	16,299
1-6 Land Reclamation	372	162	534
Sub-total [1.]	41,287	23,919	65,106
2. Land Acquisition & Compensation	-	678	678
3. Project Facilities	100	300	400
4. Project Administration	-	650	650
5. Pre-engineering	1,544	-	1,544
6. Consulting Services	11,922	500	12,422
Sub-total [1. to 6.]	54,853	25,974	80,800
7. Physical Contingency (15%)	4,128	2,451	6,579
Sub-total [1. to 7.]	58,981	28,398	87,379
8. Price Escalation	11,982	17,763	29,745
Grand Total	70,963	46,161	117,124

Table 4.6.2-4 Summary of Annual Disbursement Schedule

Base Year 1987 Cost Unit 1000 Q'

Item	1989 F.C	1989 L.C	1989 Total	1990 F.C	1990 L.C	1990 Total	1991 F.C	1991 L.C	1991 Total	1992 F.C	1992 L.C	1992 Total
1. Civil Works												
1-1. Preparatory Works	---	---	---	---	---	---	2300	900	3200	---	---	---
1-2. Dam												
(a) Diversion Tunnel	---	---	---	---	---	---	581	327	908	1456	819	2275
(b) Foundation Treatment	---	---	---	---	---	---	---	---	---	1338	1257	2595
(c) Dam Body	---	---	---	---	---	---	---	---	---	401	165	566
(d) Spillway	---	---	---	---	---	---	---	---	---	1271	632	1903
(e) Intake Facility	---	---	---	---	---	---	---	---	---	---	---	---
(f) Maintenance Road	---	---	---	---	---	---	---	---	---	---	---	---
Sub-Total [1-2.]	---	---	---	---	---	---	581	327	908	4466	2873	7339
1-3. Regulating Reservoir	---	---	---	---	---	---	90	23	113	542	135	677
1-4. Diversion System												
(a) Diversion dam	---	---	---	---	---	---	264	91	355	1648	569	2217
(b) Driving Canal	---	---	---	---	---	---	197	206	403	1231	1287	2518
Sub-Total [1-4.]	---	---	---	---	---	---	461	297	758	2879	1856	4735
1-5. Canal Network System												
(a) Diversion Canal	---	---	---	---	---	---	---	---	---	1047	876	1923
(b) Main Canal	---	---	---	---	---	---	---	---	---	592	532	1124
(c) Lateral Canal	---	---	---	---	---	---	---	---	---	614	351	965
(d) Tertiary Canal	---	---	---	---	---	---	---	---	---	76	283	359
Sub-Total [1-5.]	---	---	---	---	---	---	---	---	---	2329	2042	4371
1-6. Land Reclamation	---	---	---	---	---	---	---	---	---	---	---	---
Sub-Total [1.]	---	---	---	---	---	---	3432	1547	4979	10216	6906	17122
2. Land Acquisition & Compensation	---	---	---	---	678	678	---	---	---	---	---	---
3. Project Facilities	---	---	---	---	---	---	100	300	400	---	---	---
4. Project Administration	---	66	66	---	100	100	---	100	100	---	100	100
5. Pre-engineering	1544	---	1544	---	---	---	---	---	---	---	---	---
6. Consulting Services	584	25	609	3183	134	3317	1753	74	1827	1753	74	1827
Sub-Total [1. to 6.]	2128	91	2219	3183	912	4095	5285	2021	7306	11969	7080	19049
7. Physical Contingency (10% of 1+2)	---	---	---	---	68	68	343	155	498	1022	691	1713
Sub-Total [1. to 7.]	2128	91	2219	3183	980	4163	5628	2176	7804	12991	7771	20762
8. Price Escalation	143	20	163	326	325	651	780	951	1731	2290	4181	6471
Grand Total	2271	111	2382	3509	1305	4814	6408	3127	9535	15281	11952	27233

Table 4.6.2-4 Summary of Annual Disbursement Schedule (Continued)

Base Year 1987 Cost Unit 1000 Q'

Item	1993 F.C	1993 L.C	1993 Total	1994 F.C	1994 L.C	1994 Total	1995 F.C	1995 L.C	1995 Total	Grand Total F.C	Grand Total L.C	Grand Total Total
1. Civil Works												
1-1. Preparatory Works	---	---	---	---	---	---	---	---	---	2300	900	3200
1-2. Dam												
(a) Diversion Tunnel	---	---	---	---	---	---	---	---	---	2037	1146	3183
(b) Foundation Treatment	1139	1070	2209	---	---	---	---	---	---	2477	2327	4804
(c) Dam Body	5347	2195	7542	5347	2195	7542	2272	933	3205	13367	5488	18855
(d) Spillway	2196	1092	3288	386	191	577	---	---	---	3853	1915	5768
(e) Intake Facility	---	---	---	---	---	---	1023	68	1091	1023	68	1091
(f) Maintenance Road	---	---	---	543	233	776	---	---	---	543	233	776
Sub-Total [1-2.]	8682	4357	13039	6276	2619	8895	3295	1001	4296	23300	11177	34477
1-3. Regulating Reservoir	271	67	338	---	---	---	---	---	---	903	225	1128
1-4. Diversion System												
(a) Diversion dam	1383	477	1860	---	---	---	---	---	---	3295	1137	4432
(b) Driving Canal	1034	1081	2115	---	---	---	---	---	---	2462	2574	5036
Sub-Total [1-4.]	2417	1558	3975	---	---	---	---	---	---	5757	3711	9468
1-5. Canal Network System												
(a) Diversion Canal	1587	1328	2915	540	452	992	---	---	---	3174	2656	5830
(b) Main Canal	877	788	1665	723	651	1374	---	---	---	2192	1971	4163
(c) Lateral Canal	907	518	1425	907	518	1425	497	283	780	2925	1670	4595
(d) Tertiary Canal	113	418	531	113	418	531	62	228	290	364	1347	1711
Sub-Total [1-5.]	3484	3052	6536	2283	2039	4322	559	511	1070	8655	7644	16299
1-6. Land Reclamation	---	---	---	342	149	491	30	13	43	372	162	534
Sub-Total [1.]	14854	9034	23888	8901	4807	13708	3884	1525	5409	41287	23819	65106
2. Land Acquisition & Compensation	---	---	---	---	---	---	---	---	---	---	678	678
3. Project Facilities	---	---	---	---	---	---	---	---	---	100	300	400
4. Project Administration	---	100	100	---	100	100	---	84	84	---	650	650
5. Pre-engineering	---	---	---	---	---	---	---	---	---	1544	---	1544
6. Consulting Services	1753	74	1827	1753	74	1827	1143	45	1188	11922	500	12422
Sub-Total [1. to 6.]	16607	9208	25815	10654	4981	15635	5027	1654	6681	54853	25947	80800
7. Physical Contingency (10% of 1+2)	1485	903	2388	890	481	1371	388	153	541	4128	2451	6579
Sub-Total [1. to 7.]	18092	10111	28203	11544	5462	17006	5415	1807	7222	58981	28398	87379
8. Price Escalation	3891	6532	10423	2946	4157	7103	1606	1597	3203	11982	17763	29745
Grand Total	21983	16643	38626	14490	9619	24109	7021	3404	10425	70963	46161	117124