Concerning the problems with agricultural credit, the interest rate is high and the credit amount granted is not enough. Also, the default rate is quite high among the small farmers (70%). According to the results of the farmers' household survey, only 16% use BANADESA services.

(5) Supply of Agricultural Inputs

Following major agricultural inputs are supplied in Comayagua or Tegucigalpa.

a. Rice seed : SRN
b. Nursery plants : SRN
c. Fertilizer, agro-chemicals, agricultural machineries and tools : BANADESA, agricultural cooperatives and merchants

3.3.6 Farmer's Organizations

(1) Small Farmers' Groups

Small farmers' group is the organization of small scale farmers settled by the Agrarian Reform. INA guides and give technical advice to them. About 131 farmers established 11 small farmers' groups in the Flores Irrigation District occupying 385ha. Average farmland area allotted to a group is around 35ha. Each member has been allotted around 2.9 ha as an average. Obtaining settlement lot, hardness in joint management, rise up of farmer's cultivation techniques are major problems.

(2) Agricultural Cooperatives

Following two regional agricultural cooperatives are functioning in the Comayagua Valley.
- Cooperative Carcomal
- Cooperative Fruta del Sol

Cooperative Carcomal is organized by 25 small farmers groups located in Comayagua Valley (11 groups are located in Flores Irrigation District). The major activities of the cooperative are:

a. Providing agricultural credit through negotiations with banks;
b. Arranging rental farm-machine for the members;
c. Marketing of some products of the groups (rice, tomatoes);
d. Securing inputs at a cheaper price (fertilizers).

The cooperative belongs to a nation-wide organization, ANACH, and receives assistance from it.

Cooperative Fruta del Sol consists of about 170 members (30 members of the Flores area) and performs the following activities:

a. Providing agricultural credit
b. Technical assistance to members
c. Mechanization of agriculture
d. Agricultural inputs supply such as fertilizers, agro-chemical and seeds
e. Trading of associates' products, i.e., cucumber and pumpkins
f. Marketing of agricultural products such as rice, tomatoes and soybeans

This cooperative together with other 7 cooperatives belong to a cooperatives' federation. At the same time, this UNICOOP belongs to CHC (Confederación Hondureña de Cooperativas Limitada). This CHC receives assistance from similar organizations in developed countries.

Fruta del Sol has financial and organizational problems at present.

(3) Water Users' Union

In accordance with the Water Act, water users union must be established in each government-operated irrigation district. The water users' union in the Flores Irrigation District was established in 1957. The water users union supposedly is responsible for operation and maintenance of irrigation facilities in cooperation with the Flores local office of SRN. However, lack of funds and members' commitments make difficult to carry out adequate O/M activities.

3.4 Present Condition of Coyolar Dam

3.4.1 Brief Description of Coyolar Dam

The Coyolar Dam is situated in the southeast of the Comayagua Department, in the northern end of the Honduran Southern Mountains Ranges. The Dam is located about 40 km and 7 km away from the capital Tegucigalpa and Flores District, respectively. The Coyolar Dam was constructed for the purpose of supplying stable irrigation water to Flores Irrigation District, however recently San Antonio Village is also being benefited with this water supply. Therefore, the present Dam may be an indispensable facility for the irrigation agriculture and satisfaction of human needs of local habitats.

The Coyolar Dam is a concrete masonry dam located at the upper reach of the San José River. It has a Dam height of about 60 m and live capacity of reservoir of 12.6 million m^3. The construction of the Dam was carried out during two phases, which begun in 1956 and completed in 1965 . However, the spillway was constructed by way of three phases and finished in 1971.

The Dam, however continues to suffer deterioration such as strength decline of the Dam body, cracks and leakage, etc. In this connection, the Government of Honduras puts high priority on the safety of the Dam and the stable supply of irrigation water to the benefit area.

In this chapter, the Dam body and foundation will be studied from a geological and engineering point of view in order to prepare a basic background for the rehabilitation of the Dam.

A brief description, plan, and cross section of Coyolar Dam are shown Table 3.4-1, Fig. 3.4-1, and Fig. 3.4-2, respectively.

Table 3.4-1 Brief Description of Coyolar Dam

Reservoir		
Catchment Area	:	192 km²
High Water Level	:	807 m
Low Water Level	:	775 m
Effective Storage Volume	:	12.6 million m³
Dead Storage Volume	:	0.78 million m³
Reservoir Area	:	75.6 ha.
Dam		
Type	:	Concrete Gravity Dam with Masonry
Height	:	60 m
Crest Length	:	125.4 m
Crest Elevation	:	EL. 809 m (excluding 1 m height of parapet)
Crest Width	:	6 m
Slope	:	Upper Stream 1:0.05 Downstream 1:0.72 (upper 9m:Vertical)
Outlet		
Draw off pipe	:	ϕ 750 mm
Valve	:	ϕ 600 mm (Howell Bunger Valve)
Max. Discharge	:	Approx. 4.7 m³/sec *
Spillway		
Elevation of Inlet Type	:	EL. 807.0 m
Upper part	:	Flat Chute Width 39 m Gradient 1/10
Lower part	:	Heavy gradient bucket-style chute (two step-wise form)
Construction Period		
First Period	:	Crest EL. 749m-782m (1956-1957)
Second Period	:	Crest EL. 782m-809m (1964-1965)

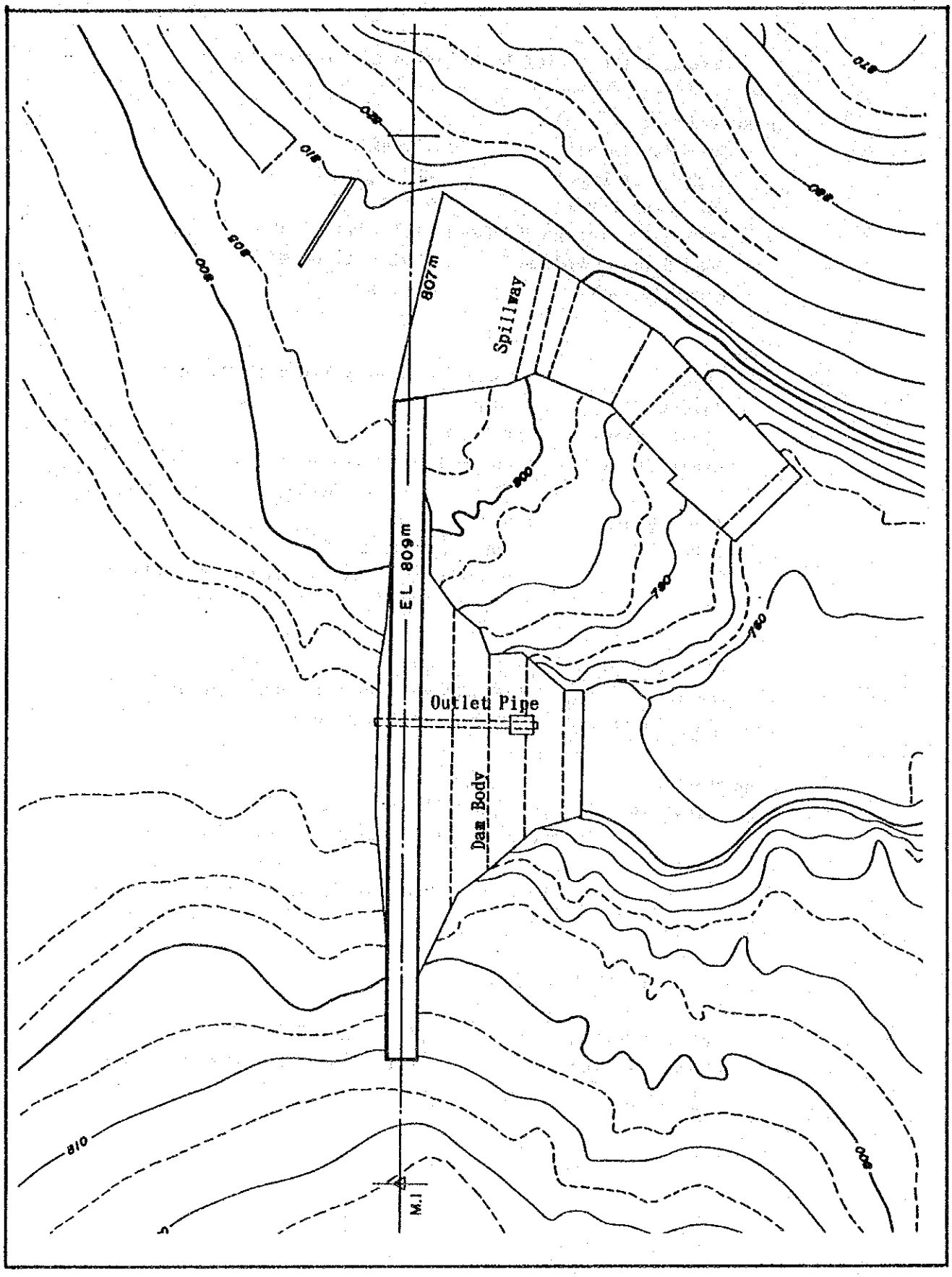


Fig. 3.4-1 General Plan of Coyolar Dam

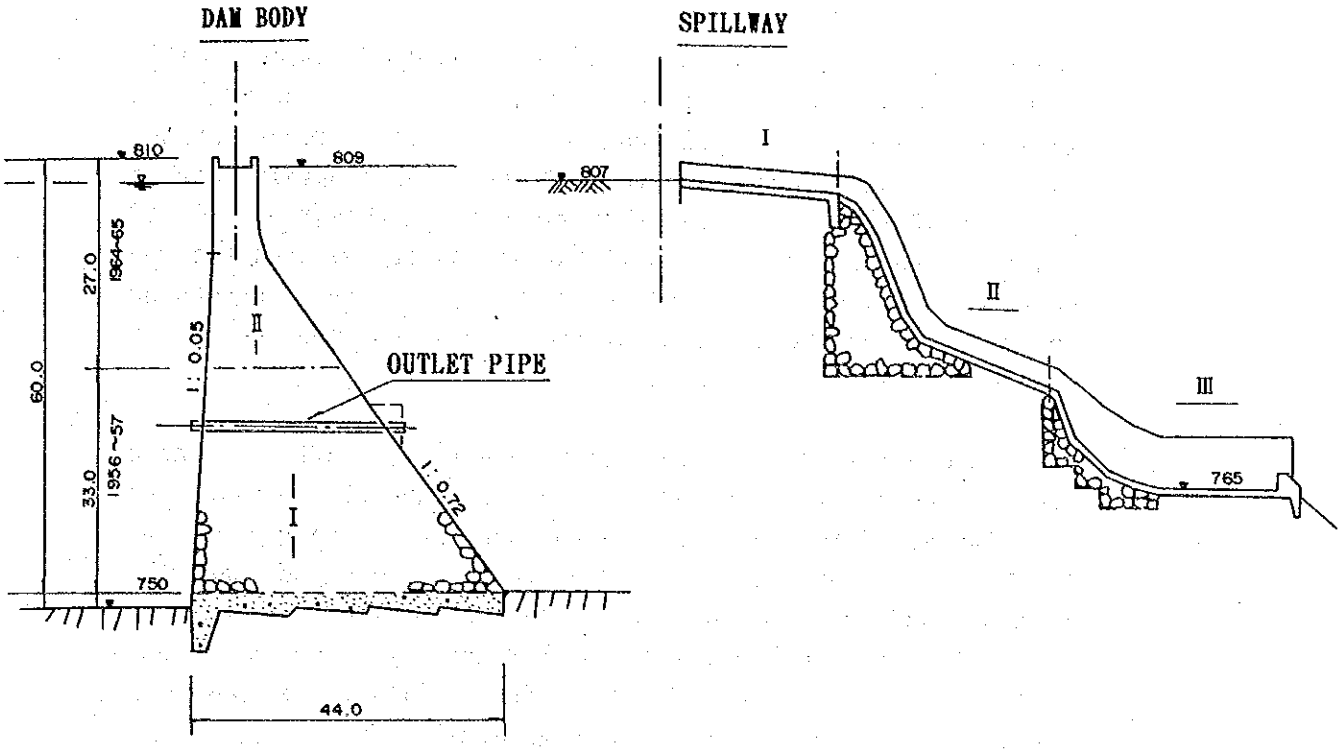


Fig. 3.4-2 Cross Section of Coyolar Dam

3.4.2 Dam Geology

(1) Geological Study

A geological study and laboratory test were conducted to assess the actual conditions of the Dam body and its foundation. They were as follows:

- Geological survey of the Dam and their surroundings;
- Boring study and in-situ tests.
- Laboratory test of Dam body material and foundation rock

The geological survey was carried out by means of detailed mapping based on topographical maps on the scale of 1/200 and 1/500 made in 1985.

Boring was made at 8 wells with a total depth of 600 m. Also, results reported by LAVALIN-GATESA on boring made at 10 wells of 702.15m total deep were reviewed.

(2) Geological and Topographical Aspects

The topography of the Dam is an eroded V-shaped valley 50 m deep and 75 m wide at an altitude of 800 m. The Dam is located downstream from the confluence of the rivers Zenon, Los Chivos and Bermejo. The face of the right margin has a gradient of 70° and the right margin has a gradient of 30° of mountain slope. There is a dividing promontory between the Dam and the spillway. The direction of the valley may correspond to the principal tectonic events and weakened zone such as fractures, alterations, etc..

The lithological composition is: welded tuff, tuff, volcanic breccia and riolite. Welded tuff can be found all around the Dam. The geological unit of the surrounding of the Dam belong to the group Padre Miguel of the Tertiary Age between the Miocene and Pleistocene Ages. In accordance with the temperature of sedimentation, the hardness of welded tuff and tuff varies significantly, forming the cooling units; however, the limit of each unit is reached gradually.

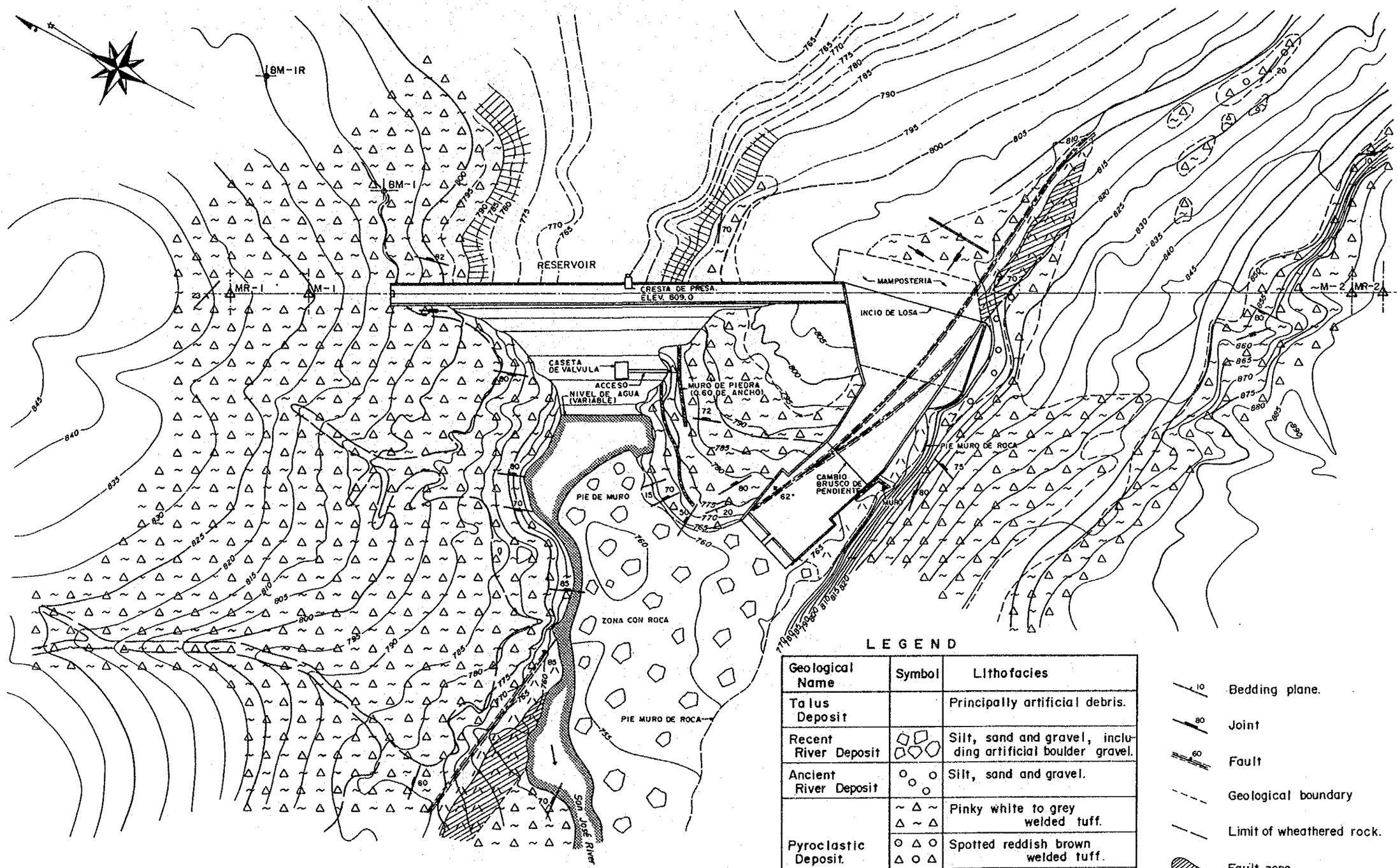
For the geo-engineering rock classification of the Dam the 'Electric Power Central Institute Method' was used. This is a method widely accepted in Japan.

(3) Geological Component

The Geological Map of the surrounding area of the Dam, Geological Units and Geological Profile of the zone along the Dam are shown in Fig. 3.4-3, Table 3.4-2 and Fig. 3.4-4, respectively.

(4) Geological Structure

The foliation structure is composed by flat pumice and tuff. The foliation of the pyroclastic rocks show a slight slope of around 20° from the right margin (northeast) to the left margin (southeast) except in certain steep part according to the paleotopography. A monoclinal structure is commonly noticed without folding.



LEGEND

Geological Name	Symbol	Lithofacies
Talus Deposit		Principally artificial debris.
Recent River Deposit		Silt, sand and gravel, including artificial boulder gravel.
Ancient River Deposit		Silt, sand and gravel.
Pyroclastic Deposit.		Pinky white to grey welded tuff.
		Spotted reddish brown welded tuff.
		White to red fine compact tuff.

- Bedding plane.
- Joint
- Fault
- Geological boundary
- Limit of wheathered rock.
- Fault zone.

Fig.3.4-3 Geological Map of Coyolar Dam

Table 3.4-2 Geological Units of Coyolar Dam

Unit	Thickness	Distribution	Characteristics
Detritic Deposit	1~2m	Promontory, Left margin, and River Bed	Deposit covered by non-homogeneous materials of sand, gravel, and rubble produced during the construction.
Recent Fluvial Deposit	aprox.10m	River Bed of San José River	Non-classified sand of medium and coarse grain. Round angled gravel of welded tuff, andesite and cher with a 1 to 20 cm size. Talud formed by the detritic from the construction of a size up to 2 m.
Old Fluvial Deposit	aprox.10m	Left margin and down-stream	Silt stuffing between gravel and talud. Round gravel, semi-round welded stuff, and andesite of 5-15 cm size. Talud of the same lithography of a size 1.5m maximum. Bad classification as it is a deposit along the concadefalla. ve section of the zone of the fault.
Pyroclastic Dep. Fine Welded Tuff	≥100m	Dam body foundation, surroundings of the Dam	Fine grained and compact rock of a pink, clear, red, beige, gray and whitish color mainly of class CM, except at the walls just downstream from the Dam where they belong to Class CH with many fractures, with a whitish tuffaceous layer and inclusions of andesite and fractures with a normal to high frequency of appearance. Weathered layer on the upper level is 2 m thick.
Spotted Welded Tuff	max.30m	Left margin and foundation of the Dam	Fine compact rock of a brown and/or reddish brown color with oval tuffaceous spots of 5-10 mm sometimes empty along the foliation with fractures filled with oxide and/or clayish materials.
Coarse Welded Tuff	max.30m	Spillway foundation and Dam body	Compact rock altered with a reddish brown with a reddish brown and orange color of class CL with a lower frecuency of fractures.
Fine	max.20m	Left margin and foundation of Dam body	Fine compact rock of class between CM and CL, and pink reddish brown and whitish color.
River Bed Deposit	2m	Left margin and foundation of Dam body	Fine to coarse grained sand of a grayish color of class CM-CL without fractures. Possible lacustral sedimentation.
Altered Zone		Foundation of the Spillway	Fault clay and breccia, and tuff and welded tuff by hydrothermal action of class CL-D with numerous fractures.

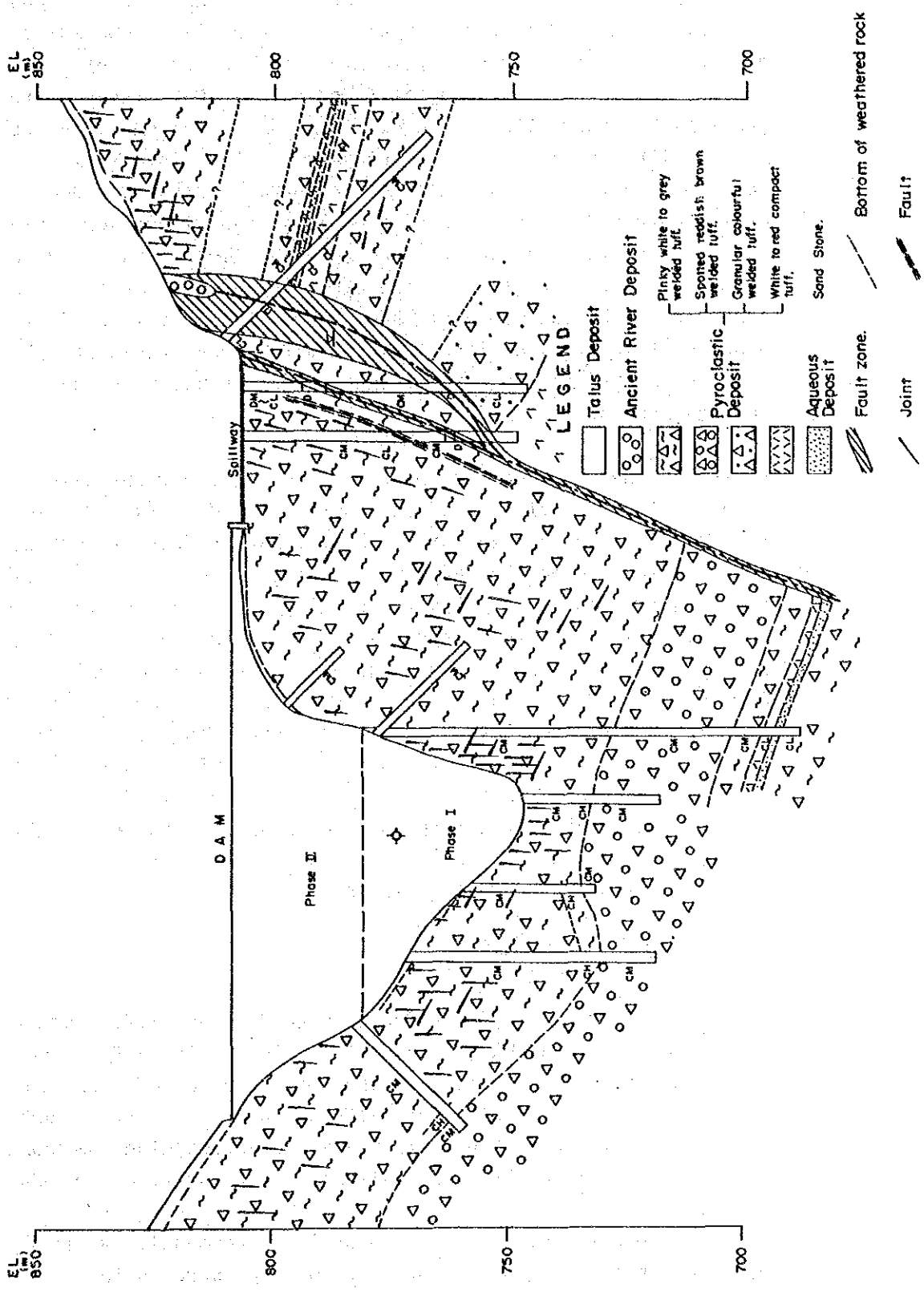


Fig.3.4-4 Geological Profile along Dam Axis

Fractures are found abundantly, consisting in two types: fractures formed as a by-product of a cooling process and tectonic joints. The first type is generally composed of welded tuff, specially columnar joint in the walls of both margins composed of welded tuff of class CH. They have varying characteristics: some of them show 10 cm openings filled with clayish tuff or secondary minerals. They run east-west,northeast-southeast, north-south, northwest-southeast according to the order of apparition and with a vertical-semivertical inclination. The second type corresponds to a fracture running parallel to the direction of the fault with a scaled distribution. Some of them show a lineal cove 1-2 mm wide sometimes filled with clayish stuff. These cracks may be closely related to the water leakage at the foundation and can be the cause of landslides.

At the northern end of dissipator of the spillway, one slikenside fault with strike east-west and 60-65° dip is exposed. This fault has been also noticed by the borings carried out at the spillway and on the left margin. In other words, this fault runs to the east below the spillway and close to the landslide site and also transversely crossing the San Jose River. Two fault zones were detected below the spillway consisting in fault clay 10 m wide at the most, fault breccia, and altered soft strata. The topographical analysis revels that this fault is of a normal type with a vertical dislocation of some decades m. The old river bed deposit located along the left margin does not show cracks or small faults; by this fact, we can infer a scarcity of tectonic movement during the recent geological age.

(5) Hydrogeology

The groundwater level of the Dam is high at the left margin and low at the right margin and the spillway. This fact may show relatively high up-lift at the left margin of the Dam body. This level gradually increases as it gets further away from the river bed in the section just downstream the Dam that may indicate little lateral filtration of water from the reservoir.

To evaluate permeability of foundation, permeability tests have been performed utilizing the boring bore holes. The Lugeon map is graphically shown in Fig.3.4-5.

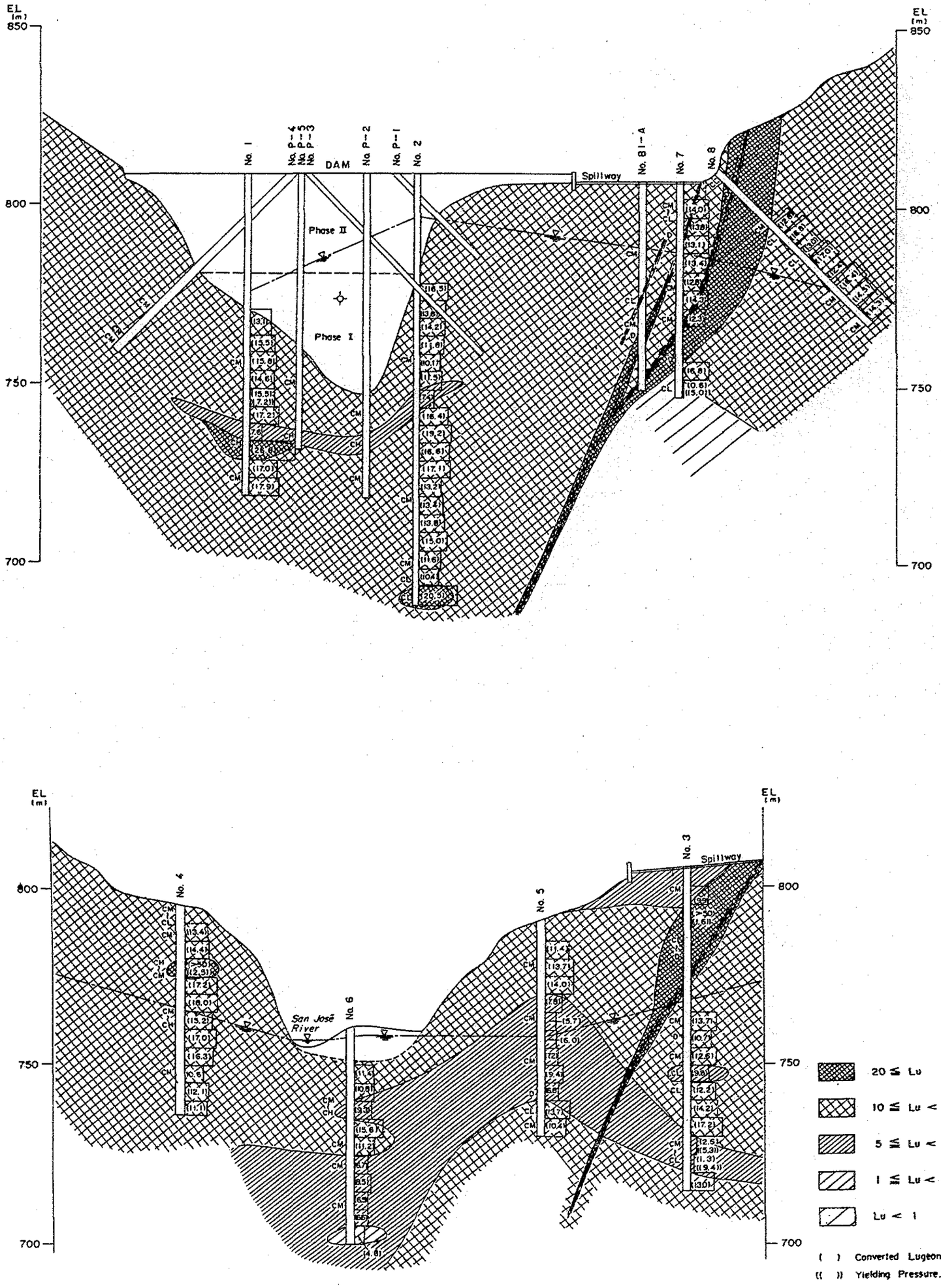


Fig.3.4-5 Lugeon Map

The Lugeon values for the foundation vary between 10 and 20 which make it classifiable as a semi-permeable foundation. These values come from diaclase or fractures presented at the foundation. There is not variation by depth.

(6) Physical Characteristics of the Foundation

According to the rock classification of the foundation, most of the welded tuff belongs to the class CM except to the one distributed immediately downstream the Dam body which belong to CH. On the other hand, the classes CL and D are prevalent at the foundation of the spillway and the fault zone.

The Lugeon test reveals that almost the rock have high yield pressure of more than 8 kgf/cm^2 and not destroyed. There is a different characteristic only at some part of the spillway foundation (boring site No. 3).

To contribute to the final design for the rehabilitation of the Dam, the physical constant values of the foundation have been independently obtained from the qualitative and experimental evaluation. With this purpose, lateral loading tests were carried out at the boring sites. This test helped to assess the degree of deformation. Moreover, physical test was carried out at the laboratory(Table 3.4-3).

The results indicate that the deformation and elasticity tangent coefficients are higher as the quality of the rocks improve. On the other hand, almost all the results show a deformation due to elastic behaviour due to latent diaclase.

These physical values must be examined together with the results of other deformation tests such as horizontal loading plate test and shearing test, etc.

The mortar shows very variable physical values. The mortar of Phase I presents relatively favourable values compared to those of the Phase II. The welded tuff shows better values according to the increase of rock class.

Table 3.4-3 Results of the Physical Test

Class	Apparent Gravity			Absorption Rate (%)			Non-restrained Compression (kgf/cm²)		
	Average	Max.	Min.	Average	Max.	Min.	Average	Max.	Min.
Dam									
Rock	2.2	2.3	2.2	5.0	6.2	3.7	392	642	180
Mortar	1.9	2.3	1.7	12.0	23.0	3.7	163	574	71
Foundation									
CH	2.3	2.4	2.2	5.4	7.9	2.0	486	724	334
CM	2.1	2.3	1.6	8.3	14.4	4.9	254	508	93
CL	1.9	2.0	1.7	14.8	17.9	12.4	65	85	36
D	1.8	1.9	1.5	16.8	25.0	12.7	46	64	34

(7) Geology of the Surroundings of the Dam

The original topography of mountain slope is shown in the surroundings of the reservoir; slope gradient about 10 grades at southern side and 5 grades at northern side. Some ancient river terraces are distributed on the northern side showing some plain top. Vegetation is shown sporadic and/or normal due to thin soil strata. There are not landslide and notorious erosion along the reservoir. Cone delta is not shown at river mouth of three affluents River sediments of these rivers are mainly silt and clay.

Rocky outcrops are distributed discontinuously along the shore and their components are slightly weathered CM, CL class white welded tuff except some precipices of class CH hard brown welded tuff with columnar joints.

(8) Landslide Zone

Landslide zone is located about 150m left upward from the Dam showing approximately a width of 150m. This phenomenon caused the cut of access road to the Dam site, making it necessary to access the Dam by means of a frail stair. A steep rocky wall of 50 m height was used as a quarry to obtain rocks for the mortar of the Dam body on the southern side. The detritics form an unstable deposit with a 20° declination towards the catchment at the base of the curtain. Landslides can be found

from almost at the beginning, a few meters upwards from the access road to the edge of the catchment zone. This adopts a bowed form.

This landslide took place between December 22, 1982 and January 28, 1983. Some cracks running parallel to the border of the precipice were found. Later these were devastate by sliding masses of detritic mass.

The causes of this phenomenon can be interpreted as follows:

- Deficient drainage along the way

  Drainage is installed at the base of the southern part of the curtain before reaching the place of the landslide, but there are not any drainage facilities at the quarry due to the difficulties of performing jobs there. On the other hand, there is a drainage pipe of 80cm of diameter crossing the road without having a water conduction mean to the catchment area. The flow of the drainage caused the movement and the devastation of the land stuffing and welded stuff at the time of a strong rainfall.

- Instability of the strata between the sub-basement and the detritic material

  Only lime, sand and gravel for the sub-base material of the road without compacting, being this enough reason to explain how easy it was to flow downward due to any abnormal phenomenon. Also, the detritics of a heavier weight depositted above the first deposit start sliding in a natural way.

It is also important to mention other factors linked to this phenomenon: this zone corresponds to to the continuation of the fault zone which cross it under the spillway where there are parallel fractures to the faults and a sharp reduction of the water level, around 29 m which may have caused a hydraulic disequilibrium

At present, trees of 7-8 years old can be seen over the landslide zone and there is not any indication of a further landslide.

3.4.3 Present Condition of Coyolar Dam

(1) Introduction

In this study of the Dam, attention is paid on the comprehensive understanding of the existing Dam conditions and grasping of issues. In the light of this, necessary reconnaissances and investigation, collection of data and information, review of previous reports, etc. are carried out. Moreover interview to engineers concerned the dam construction is also carried out.

(2) The construction steps and method

1) Construction Phases

Coyolar Dam was constructed in two phases: first phase was between 1956 and 1957 and constructed up-to EL. 782 m, second phase was between 1964 and 1965 and constructed up-to EL. 809m.

While the spillway was constructed in three phases as follow :

First Phase : Flat chute along the left edge of the dam and its guide wall

Second Phase : Upper chute and guide wall after the first step construction

Third Phase : Down chute, stilling basin, guide wall and reconstruction of guide wall

2) Construction method

The construction method of the dam body are as follows:

a. 1 m height of certain size of mortar box was prepared
b. stuff rubble in the box
c. plug mortar(1:4) in the box

The spillway was planned to construct only the flat chute, however the flood after the completion of the first phase of the spillway scooped out the downstream of the flat chute.

Therefore, heavy gradient chute was connected in the second phase after rubble was stuffed in the cavity. After the second phase construction, the same thing occurred and the third phase spillway was added.

(3) Present Condition of the Dam

1) Reservoir

a. Water level

There are three rivers flowing into the Dam: Zenón, Los Chivos, and Bermejo. The reservoir water is discharged by the drain pipe and/or the spillway. The reservoir capacity curve is shown in Fig. 3.4-6. Recent fluctuation of the water level is shown in Fig 3.4-7.

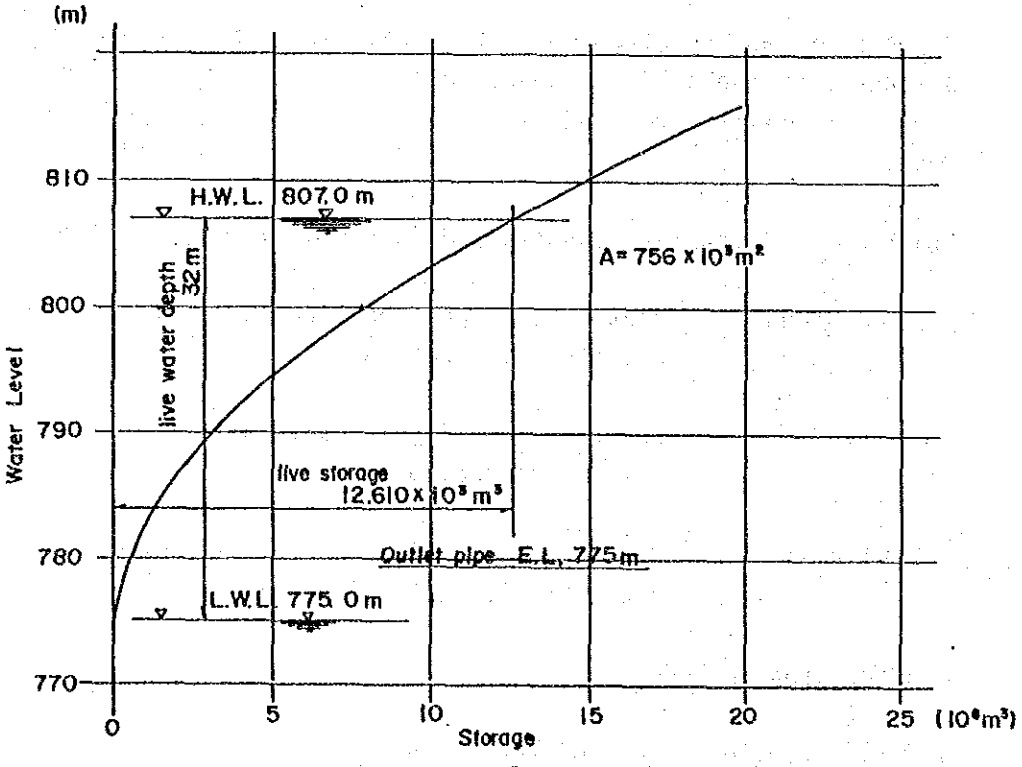


Fig.3.4-6 Water Level and Reservoir Volume Curve

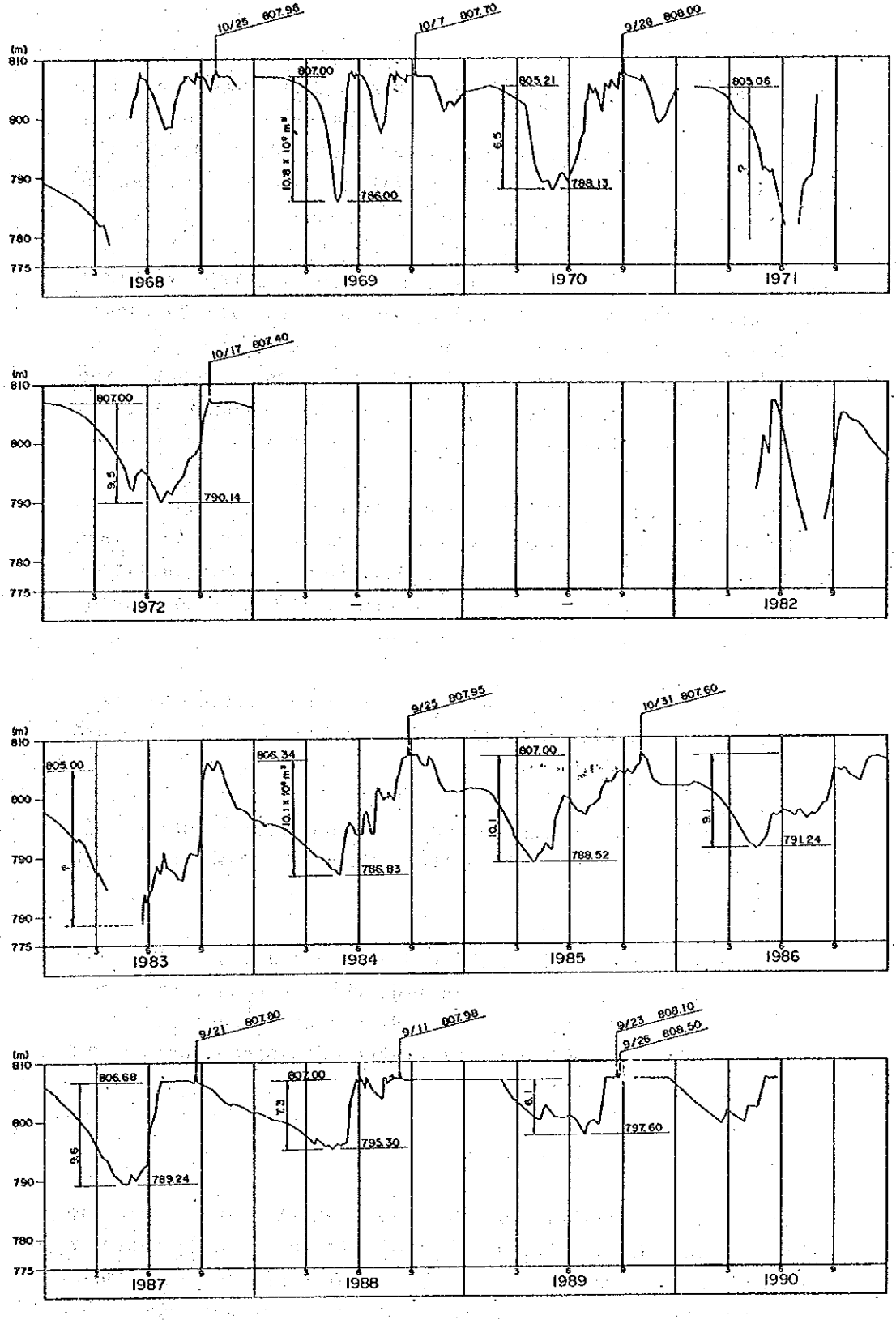


Fig.3.4-7 Recent Fluctuation of the Water Level at the Reservoir

b. Sedimentation

A three-line bathometric measure was taken place at the upstream of the Dam body. the results do not show significant variations of the bottom level compared with the the date obtained by LAVALIN-GATESA (1985). Remarkable increaseof sedimentation has not been found.

On the other hand, in spite of that there is a topographical map before the Dam construction, the map is 1:1000 scale with 10m at the level curve. This is the reason why it was not possible to calculate without any doubt the sedimentation volume. However, it can be deduced that a lower sedimentation volume exists for the following reasons:

- There is abundant vegetation during the rainy season which helps to retain the material dragged from the land surface. In dry season, even though there is only a little vegetation, due to the scare rainfall, there is no sliding of free material towards the reservoir;

- Geologically speaking, the basin is constituted by hard volcanic rock with a little soil stratum of volcanic ash origin.

- The basin does not show a rough topographic profile. It shows a gently sloped profile. There is not too much sliding.

The sediments coming from the hydrographic basin of the Dam is fine-grained and light weighted. this is the reason why most of the sediments float and discharge downstream with the exception of some sediment at the discharge points of the contributing rivers.

c. Water Quality and Temperature

Results of the analysis of the water quality are shown in Fig. 3.4-8. The quality of the water is good, and shows a neutral acidity with only few Ionic material. In any case, the quality of the reservoir water does not cause an unfavourable effect to the Dam body. The bacteriological analysis reveals that this may be available as potable

water.

According to the depth, the water temperature of the reservoir shows an inverse section of the temperature at the part which is lower than the drainage pipe level. At the lower and upper sections there is water flows circulation.

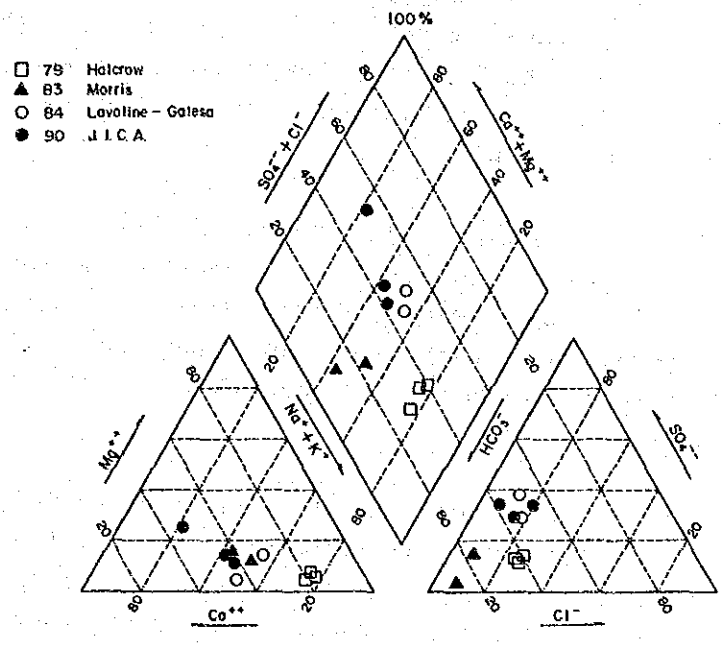


Fig.3.4-8 Compositional Diagram of Water Quality

2) Dam Body

There is a parapet of 1 m high on the both sides of the body, valve room at the middle of the downstream face. And gauging station is at the upstream side.

The body surface is mortar covered; however, there is mortar peeling in the upward section of the body and a total peeling below the pipe with exposed rocks and internal mortar. There are two sub-verticals cracks on the left side of the body located around 33m and 39m from the left side. The posterior crack has a slit between 1 and 2cm crossing the crest towards the downstream face. The anterior crack shows a significant disjoint at the contact point with the foundation at an elevation of EL.798m and a bad contact with the foundation rocks.

The construction corresponding to Phase I is composed of the mix of angular dark red welded tuff of CH class, CM class nearly CH class about 50-300mm of length and mortar. Moreover, the mortar is divided into two types according to the grain type: coarse and fine. The coarse part shows many little coves 2-3mm of diameter and low degree of alteration. In general, few cracks with silt deposits and iron oxidation can be found. The contact between rock and mortar seems to be tight. The fine part shows many coves with silt sedimentation, which indicate leakage from the Dam body. The number of cracks is normal. Some of the cracks located closely above the foundation show wide openings.

The part of Phase II has almost the same composition as the one of Phase I above. However, fine grained mortar is predominant. It contains many coves 1-2mm of diameter containing beige and brown silt. Some mortar has been altered to white talc possibly produced by a chemical reaction. Cracks appear less frequently.

The dam body shows the permeability coefficient of an order of 10^{-5}-10^{-4} cm/s. A relatively high permeability coefficient has been found in the part of Phase II construction in comparing with the lower part of Phase I. Generally speaking, there is not a noticeable variation in the values for the contact point with the foundation.

3) Spillway

The spillway is a lateral canal structure located at the left bank of the Dam. This spillway has a particular form, like a scalinated shape.

A salient feature of the spillway is its abnormal shape. Also, there is a pipe leakage at the middle level of this structure leaking some liter per second.

To resume the geological condition of the Dam, there are some rubble made of welded stuff class CM with spaces between them over the spillway foundation. At the southern part of geological faults laying across the spillway, it can be found some fault clay with breccias at a band 2m wide. There are many diaclase running parallel to the faults which

permeability is quite high. Along these faults there is a weak field composed by soft altered rock class D of a whitish and/or rosy color. This weak band is around 26m wide at the dispersion point and a resistance to free compression of 50 Kgf/cm^2, which means that this section is too much weak. Therefore, the foundation of the spillway is built upon a weak stratum , free rubble without enough mortar filling.

The spillway structure is not hydraulically stable. It is supposed that an opposite negative force at the concave part is what causes vibration and noise at the moment of a raising of the water level of the reservoir. When the level is above 0.5m, the flow is 50m^3/sec; is in this moment when vibration and noise can be felt. There is a spill over the guidance wall due to a "rebound" of the flow against it. The previous flood discharge is shown in Table 3.4-4.

Table 3.4-4 Maximum Annual Discharge in Spillway

Year	Date	Water Level (m.A.S.L)	Discharge (m^3/sec)
1968	10/25	897.96	88
1969	10/7	807.70	55
1970	9/28	808.00	94
1972	10/17	807.40	24
1984	9/25	807.95	87
1985	10/31	807.60	44
1987	9/21	807.80	67
1988	9/21	807.98	91
1989	9/26	808.50	173

4) Water leakage

- Dam body

The leakage from the crack of foundation rock and joins is one of the serious problems which the Coyolar Dam involves.Four leakage points are located near the contact part with Dam and rock between 30 m and 40 m from the left edge of the Dam. One of them is through a continuous crack about 1 cm wide, however leakage is weak. The largest

leakage is located about 37 m from left edge of the dam (El.794.0 m: below 15 m of the crest). This leakage might be from rock mass deeper than the contact line. These leakage water flow into the canal which was constructed as bypass canal during the construction and measured by notch (it is around 80 ℓ/sec). Fig. 3.4-9 shows the measurement of leakage for 8 months in 1982 and in 1990. The figure shows good correlation between leakage and water level of the reservoir. Comparing the measurement in 1982 and this year, no change of leakage behavior is noticed.

The other type of leakage is found at the border limit of the Phases I and II. As in the former case, the leakage flow lowers when the water level of the reservoir is also reduced.

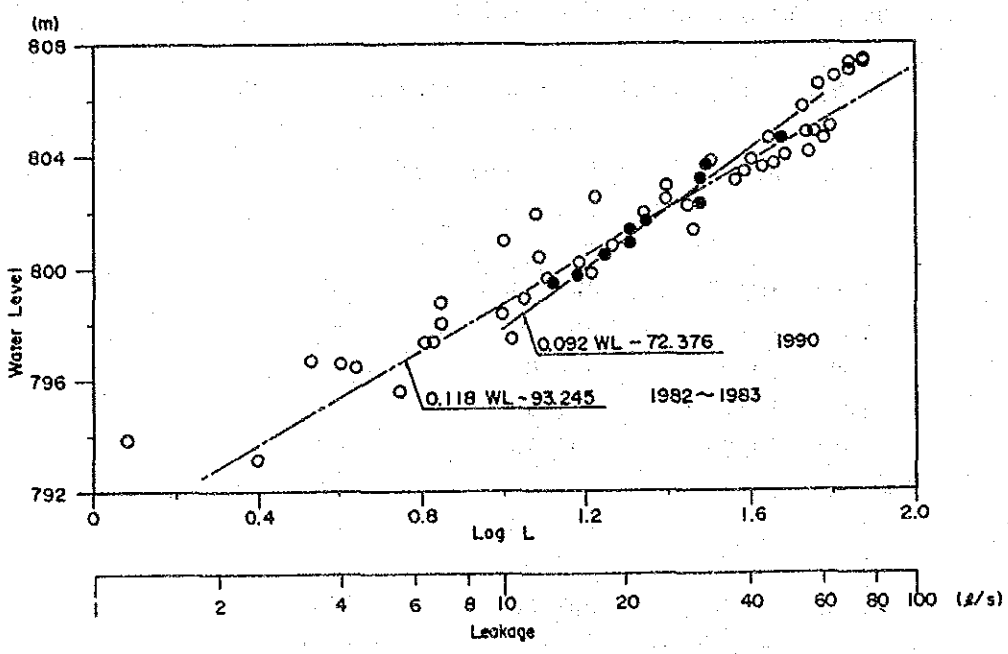


Fig.3.4-9 Relationship between the Water Leakage and Water Level of the Reservoir

- Spillway

There exists a leakage of some liters per second by a small pipe chute. This pipe recollects all the infiltrated water at the scouring site. The grouting work was carried out at the month of spillway, but this leakage could not be stopped.

- Surroundings of the Dam

There is a leakage through a fracture of the foundation immediately downstream of the Dam body by the left bank. There is also a possible filtration through the foundation of the Dam body. however, these leakages do not become of matter of worry concerning the Dam security.

5) Outlet Pipe (drainage pipe) and Valve

At the middle of the Dam body, at EL.775m there is a outlet pipe with a "Howell Bunger" valve installed. Dimensions of this pipe is 750mm of diameter and around 25m long. The valve has 600mm of diameter and is manually operated.

The valve operation is made according to the water requirementsfor the Irrigation District of Flores and the level of the water of he reservoir; however, generally speaking, the calculation of the released flow depends on the operator's judgement based on his experience. The available information about the operation of the Dam shows released water volume: 1.5 - 2 m^3/sec when the water level is high, 1 - 1.2 m^3/sec at irrigation season, and 0 - 0.3 m^3/sec at the dry season.

6) Dam Body and Spillway Stability

Present Dam stability

The concrete Dam must have enough stability to hold the charge force in relation to the shearing, stress and resistance.

The charge force consists in the weight of the Dam, water, hydraulic pressure, sedimentation pressure, uplifting force, and seismic energy, etc.

At the initial moment of the design, the following was considered:

Seismic factor : Not considered
Uplifting force : 25%
Unitary weight of the Dam body : 2.1 ton/m^3

It is important to take into account the seismic factor for the construction of a dam. The uplifting coefficient can be a value above to the one shown above. Based on the condition of the foundation and the available results of the grouting tests. The unitary weight of the Dam body is of 2 ton/m^3 according to the results of the Dam body mechanics test.

Assuming a physical characteristics of the Dam body mentioned below, an study of the Dam body stability has been carried out (Table 3.4-5 and Fig.3.4-10).

Design seismic factor : K = 0.15
Uplifting force coefficient : ω = 2.0 ton/m^3
Foundation coefficient = f = 0.8 ζ_o = 150 ton/m^3

The body Dam has a slender shape(base width=44m, maximum dam height=60m). Therefore,there is a lack of shearing resistance with respect to force including seismic movement. The force vector sum lays outside the middle third. In this case, there is a tension force. Based in the result of the preliminary results above mentioned, and taking into account the seismic factor, the Dam stability cannot be guaranteed to establish a complete safety of the Dam, the reservoir water level must be kept at a lower level than the 797m.

Flow capacity of the present spillway

The present spillway has a design flow capacity of 288m^3/sec and specific discharge of 1.5m^3/sec/km^2. According to the tentative calculation of the cross section of spillway, it is possible to flow this discharge(Fig.3.4-11). However, there are a noise as a product of the negative force due to a small flood and possibility of overflow beyond the guide wall. Judging from these facts and foundation condition, the structure can not be guaranteed even the case of flood of design flood discharge.

Table 3.4-5 Calculation of the Present Dam Stability

	Section present conditions m=1 : 0.72 K=0.15 U=0.50					
HWL (m)	807	807	807	807	797	809 No sism
Check Point	EL=749 B=44.12	EL=765 B=31.80	EL=780 B=20.25	EL=795 B=8.86	EL=749 B=44.12	EL=749 B=44.12
V (t)	2054.2	1906.5	495.6	156.8	2140.5	2036.9
H (t)	2422.2	1314.3	578.0	139.5	1799.4	1853.9
M (t·m)	78312	31101	8973	1221	62866	66703
F.S	3.41	4.30	5.94	10.43	4.63	4.45
l (m)	33.41	38.06	23.63	10.01	29.37	32.75
e (m)	16.06	12.46	7.98	3.36	7.31	10.69
p (t/m²)	46.6	34.5	24.5	17.7	48.5	46.2
p_1 (t/m²)	148	116	82	58	97	113
p_2 (t/m²)	-55	-47	-33	-23	0	-21

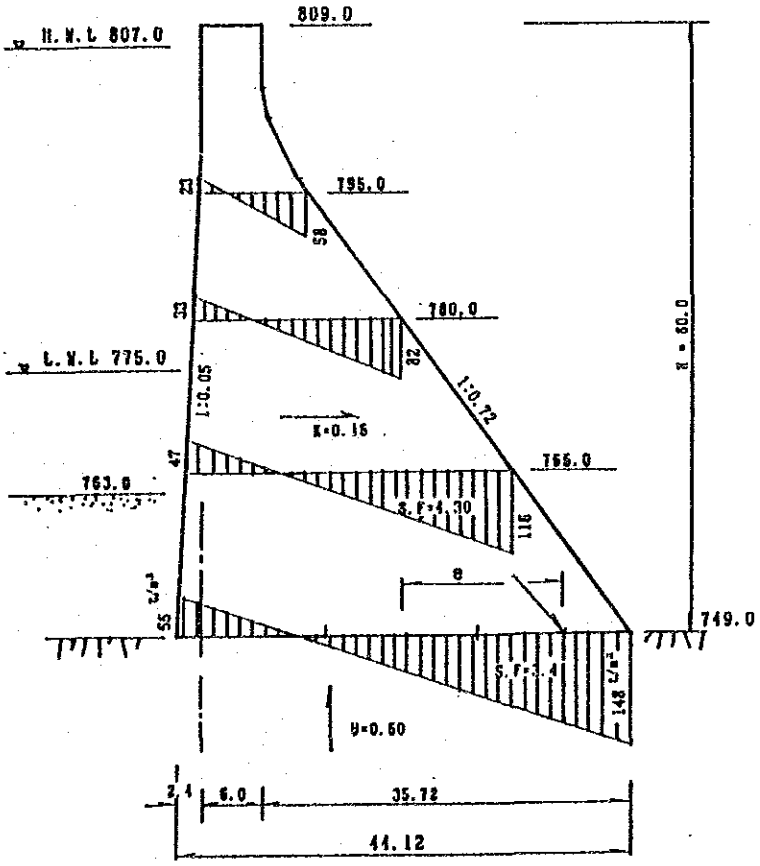


Fig.3.4-10 Calculation of the Present Dam Stability

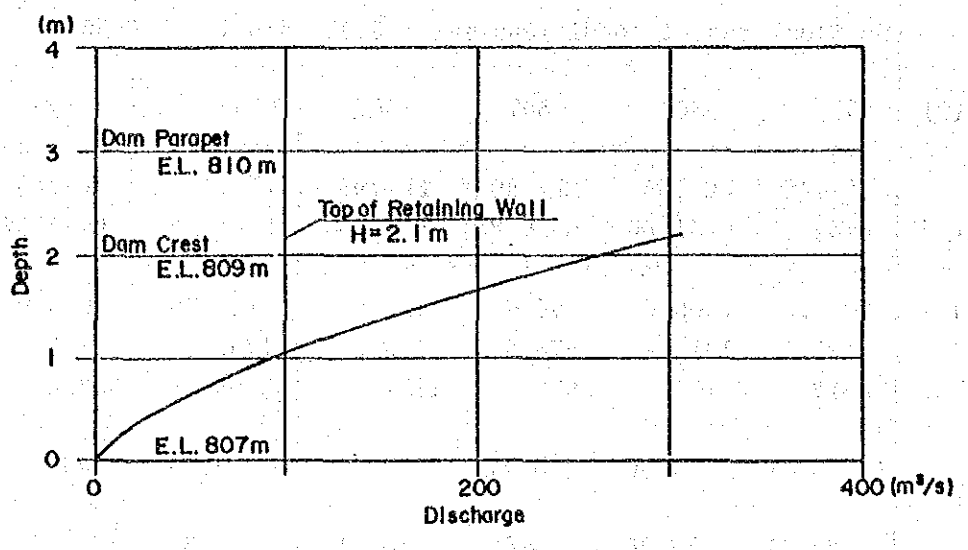


Fig.3.4-11 Discharge Capacity of the Spillway

3.5 Present Condition of Flores Irrigation District

3.5.1 Irrigation and Drainage on Farm

(1) Irrigation Area

The Flores Irrigation District consists of two irrigation systems, namely Sector I on the left bank and Sector II on the right bank of the San José River (Fig. 3.5-1).

The construction of the Sector I system started in 1954 as the first national irrigation project in Honduras, covering a gross area of 1,300 ha.in which irrigable area is 950 ha. Irrigation water is supplied from the diversion works at the left bank of the San José River through the principal canal whose capacity is rated at 1.5 m^3/sec.

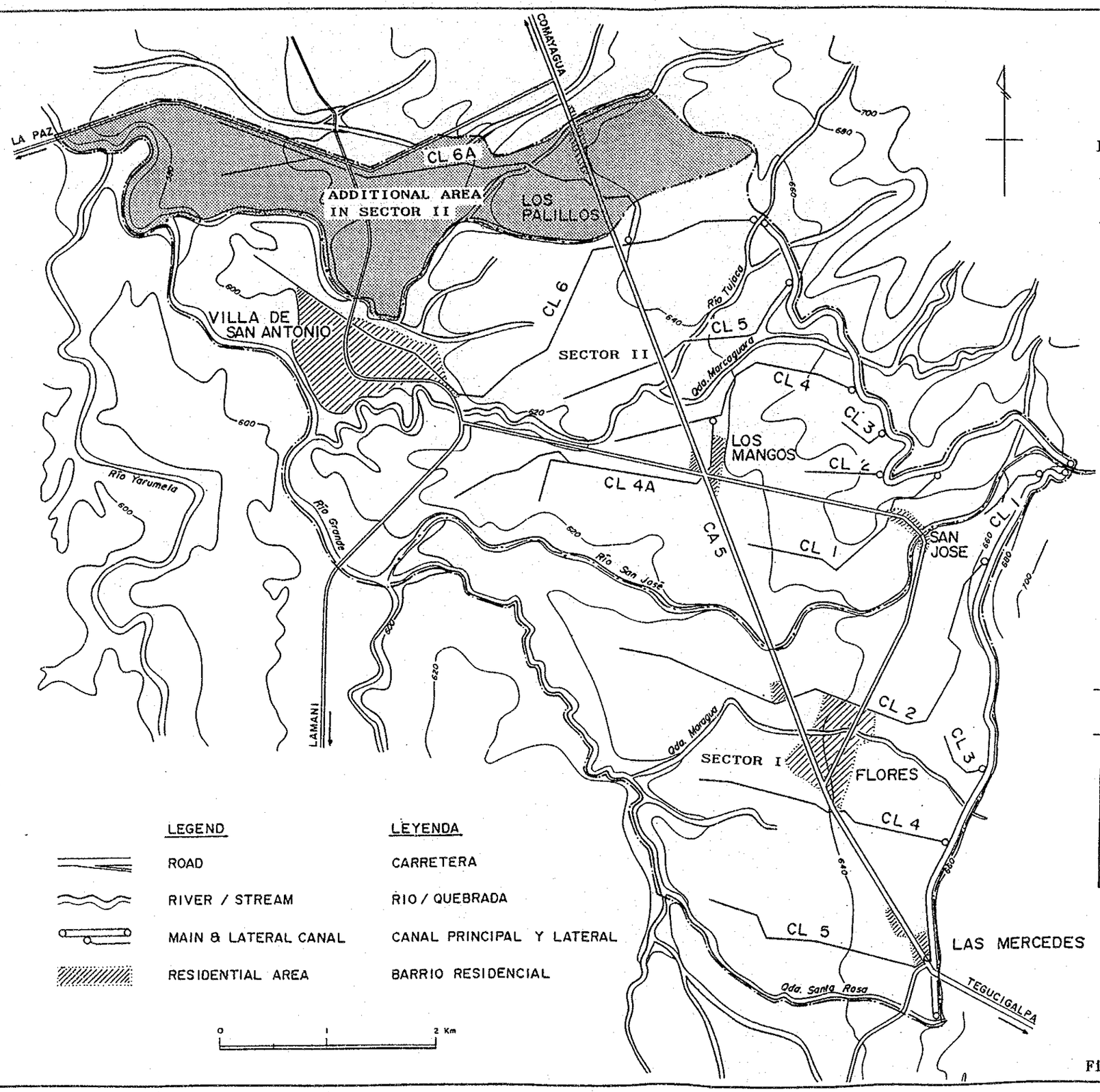
In 1965, the Coyolar Dam was completed. At about same time the construction of Sector II started on the right bank of the San José River. Irrigation water is supplied from the diversion works which is installed on the right bank of the same river, and upstream of the Sector I diversion works.

Sector II covers a gross area of about 1,600 ha, however the 700 ha area was extended by the construction of lateral canal 6A. Then, the total gross area of Sector II become 2,300 ha and irrigable area is estimated to be about 1,500 ha.

(2) Irrigation Practice

Irrigation period in the Study Area starts normally on November and terminates on May. Besides, in certain period in the wet season, which is about a month from middle of July to middle of August, so called CANICURA, irrigation is usually practiced.

In order to estimate the irrigation area, the Flores Irrigation Office sets out a questionnaire before the dry season. In accordance with the results of the questionnaire, the irrigation area for the year is determined. When the imbalance occurs between required and available water, the irrigation area may be regulated.



Irrigation area by canals in the dry season

Canal	Sector I	Sector II
C.L. 1	13 ha.	10 ha.
C.L. 2	152 ha.	22 ha.
C.L. 3	8 ha.	2 ha.
C.L. 4	73 ha.	38 ha.
C.L. 4A	-	28 ha.
C.L. 5	64 ha.	49 ha.
C.L. 6	-	117 ha.
C.L. 6A	-	39 ha.
T.G. 1	-	1 ha.
T.G. 2	28 ha.	6 ha.
T.G. 3	2 ha.	5 ha.
T.G. 4	5 ha.	-
T.G. 5	6 ha.	-
T.G. 6	2 ha.	4 ha.
T.G. 7	4 ha.	2 ha.
T.G. 8	4 ha.	-
T.G. 9	16 ha.	-
T.G.10	13 ha.	-
T.G.11	2 ha.	2 ha.
T.G.12	-	2 ha.
Total	393 ha.	327 ha.

IRRIGATION SERVICE AREA IN GROSS	
SECTOR I	:1300 ha
SECTOR II	:1600 ha
ADDITIONAL AREA IN SECTOR II	: 700 ha
TOTAL AREA	:3600 ha

Fig. 3.5-1 Flores Irrigation District

(3) Water Distribution System

According to the results of the questionnaire conducted by Flores Irrigation Office in 1990. The required irrigation area reached to 950 ha. However, the actual irrigation area was 393 ha in Sector I, 327 ha in Sector II and 720 ha in total in February 1990 (Fig.3.5-2).

(4) Farm Drainage

Farm drainage system was not found in the area. In the Flores area, ground slope is relatively steep and erosion by natural drainage channel are seen. Inundation or floods are not recorded. However, because of impermeable subsoil and depressions, water tends to pond. Ponding caused by leakage of canals are seen along irrigation canals and interrupts vehicle travels. It is easily expected that ponding during the wet season is much more difficult for the vehicle travels.

(5) Water Charge

There are two ranks of basic water charge, i.e.,Lps.3.00 / Mz. for the farmer holding more than 20 Mz. and 2.00 Lps. for the farmers holding less than 20 Mz.

Besides the basic water charge, Lps.0.0025 /m^3(Lps.1.00/400m^3) is charged additionally

In order to obtain water, the users have to apply and pay by directly to the Flores Irrigation Office. Normally after three days of their payments, the users can obtain necessary water by showing the receipt to the ditch rider. In case of water shortage at site, the ditch rider diverts additional water by his judgement and the additional water cost will be collected. The amount of demand is adjusted roughly by the farmer's or ditch rider's experience.

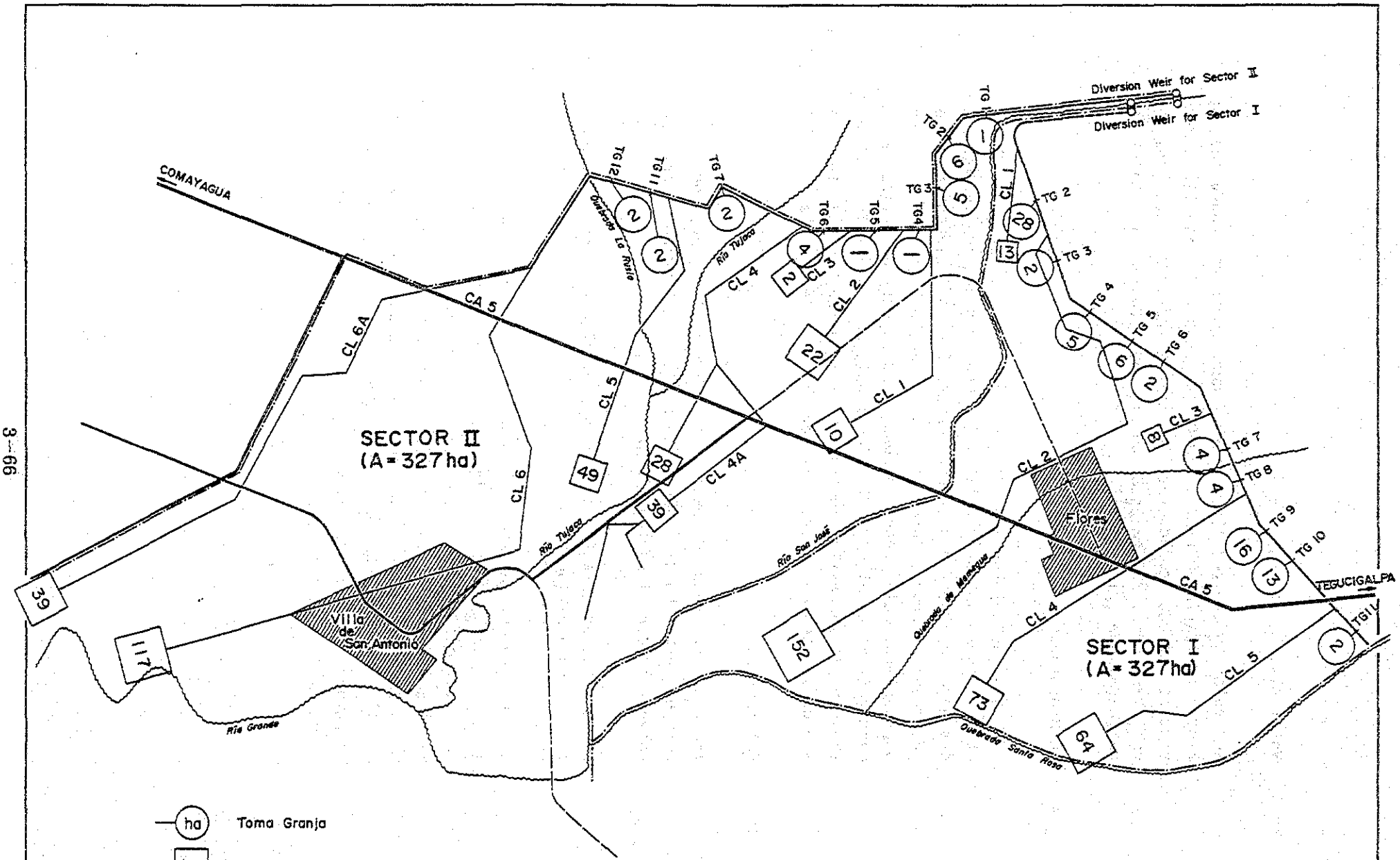


Fig. 3.5-2 Schematic Irrigation Canal System

The farmer requires sufficient water since they paid for the water. Normally ample water is diverted and the farmer is unable to control distribution effectively. Consequently, ponding, erosion,scouring of ditches and remarkable waste of water occurred.

3.5.2 Irrigation Facilities

(1) Diversion Works

The Flores District is successively irrigated since the canal system was established in 1975.

The system consisted of the two diversion works, two main canals and twelve lateral canals and planned to irrigate 1,100ha of Sector I in left bank and 1,140 ha of Sector II in the right bank.

Two diversion works are installed for the intake in the San José River. The distance of both diversion works is about 200m. The weir is composed of fragile structure consisting of gravels and sand bags, therefore annual maintenance is required and intake efficiency is poor. The design discharge is 1.5m^3/s, but measured value is less than 1.5m^3/sec. Original characteristics of diversion works is shown in Table 3.5-1.

Table 3.5-1 Characteristics of Diversion Works

Description	Sector I	Sector II
-Location	200 down st. from Sect. II	3.5km down st. from Coyolar Dam
-Dam up	0.5m	1.0m
-Weir Length	35.0m	37.0m
-Gate	0.9mx2units	0.9mx2units
-River width	35.0m	37.0m
-Discharge	1.5m^3/s	1.5m^3/s
-Feeder canal sect.	2.0mx1.0m	1.5mx1.4m

(2) Main and Lateral Canals

Feeder canal is concrete box culvert type and conduit in the Sector I. Main canal has trapezoidal open type with earth lining except some parts of around of ancillary works. Main canals run along the mountain skirt about elevation 670m to 650m for Sector I and II. Leakage from the banking base of main canal and destruction of slope are observed frequently. Irrigation water is distributed to lateral canals through diversion works. Lateral canals are located along the topographical slope from the east to west direction. The water distribution on farm has been conducted by a turnout gate installed along the lateral canal. The outline of main and lateral canals, and their irrigation areas are shown in the Table 3.5-2.

Table 3.5-2 Main and Lateral Canals

	Sector I			Sector II		
Canal	Leng. (km)	Cap. (m^3/s)	Area (ha)	Leng. (km)	Cap. (m^3/s)	Area (ha)
Main Canal	6.11	1.50	1100.0	6.44	1.50	1140.0
Lat. Canal	10.10	-	883.2	17.60	-	1015.2
CL-1	0.84	0.15	25.9	2.48	0.50	167.0
CL-2	4.87	0.50	465.9	1.12	0.50	13.9
CL-3	0.30	0.16	14.7	0.38	0.50	19.6
CL-4	2.80	6.16	167.7	2.66	0.50	135.4
CL-4A	-	-	-	2.48	0.50	168.1
CL-5	2.29	0.16	209.0	2.48	0.50	83.3
CL-6	-	-	-	6.05	0.50	427.9
Dir. Distri. from Main C.	11 units	44-100ℓ/s	212.5	12 units	30-70ℓ/s	126.2

Source: Inventario de la Situacion Actual de Los Recursos Flores Disponibles en el Distrito de Riego de Flores, issued by SRN.

3.6 Related Irrigation Projects

Irrigation area in Comayagua Valley is estimated to be about 10,000 ha, However 5,400 ha are insufficiently irrigated. The existence of national irrigation districts such as Flores, Selguapa, San Sebastían is characteristic in the Valley. The DGRH under the SRN has the responsibility for the O/M of these irrigation districts.

The total gross area of these districts is about 6,200 ha and the irrigated area is estimated to be 2,675 ha. Water is taken by a diversion works in Selguapa and by pump station in San Sebastían .

Deterioration and/or damage are remarkable in all these systems. In this connection, a rehabilitation of facilities is now on-going since 1987 by the assistance of the Government of Japan(KR II).

A new strategy of irrigation development project, PRORIEGO, has being recently implemented. The targets of the project are as follows:

- to propel irrigation agriculture to middle and small scale farmers
- to attempt diversification of cultivation
- to transfer irrigation techniques

A short term goal is established in order to obtain results as soon as possible. Extension of the water saving irrigation technique such as drip irrigation is on-going in Choluteca, Comayagua, and San Pedro Sula under the technical and economical assistance of USAID.

Profitable crops are selected for this project. Tomato cultivation of about 25 ha by drip irrigation is an on-going in Los Palillos in the Study Area.

3.7 Issues in the Study Area

Following are summary of issues in the Study Area.

Coyolar Dam

- Remarkable leakage of water is recognized at the part of base rock.
- Strength decline of the dam body material can be observed.
- To maintain the stability of the dam, the water level is obligated lower down.
- Foundation of the spillway is weak fault zone.
- Design discharge of the spillway is quite small.
- Alignment of the spillway does not meet hydraulic aspect.
- Access road is sliding and discontinued at the entrance of the dam.

Flores Irrigation Facilities

Diversion Weir

- Due to the traditional type with cobble-stone, whenever flood comes easily flushed away and reconstruction will be required.
- Leakage and overflow due to lack of height is observed. No effective intake of water is expected.

Canal and other Facilities

- Seepage loss and leakage is remarkable due to unlining canal.
- Remarkable leakage is observed at gates of diversion works.
- No system to stop the excess water to other unnecessary area are found.
- Scouring at drops are remarkable.
- Leakage from siphon and aqueducts are recognized.
- Reducing the conveyance capacity due to the sedimentation and grasses in the canals.
- Canal embankment is partly destroyed by cattle steps for their drinking water from canals.
- Water stealing is observed.
- No measurement of water distribution is carried out.
- Required water is distributed based on the experience of

canal operator.
- No sufficient function of water use organization is recognized.
- Expenses for the facilities maintenance is quite small.
- No control of water distribution from lateral canal to farm due to no control gate.

Agriculture

- Farm size is smaller than that of national average and proportion of small scale farm's share is rather big.
- Due to the shortage of irrigation water, cropping of rice is limited during the dry season.
- With the same reason, crops other than rice are also limited.
- Proportion of pasture land which has low profitability is rather high.
- Unit yield is relatively low comparing with other irrigation area.
- Utilization ratio of fertilizer and chemical is low.
- Number of extension worker and transportation for them are insufficient.
- Products are bought with low price by broker due to the immature market system.- Low operation rate of agro-processing factories due to the lack of row material.
- Lack of agricultural machinery.
- Participation to the agricultural cooperative by individual farmer is not sufficient.

CHAPTER 4 THE PROJECT

4.1 Objectives and Project Components

4.1.1 Objectives

Flores Irrigation District is one of the irrigation districts in the Comayagua Valley. It is an area suitable for crop cultivation due to its natural conditions like topography, climate and soils. Socio-economic conditions of the area are also appropriate for propeling agricultural development compared with other areas in Honduras. The area is located between two major domestic markets, Tegucigalpa and San Pedro Sula, and has high potential of productivity and profitability because of experience in irrigation agriculture. However, Coyolar Dam , the water resource of the area, has a stability problem which imposes a limit to the distribution of irrigation water. Moreover, irrigation facilities in the area are also damaged in many places and no smooth distribution of water is practiced. Consequently cropping is restricted by shortage of required water.

Under the light of these problems, the Project aims to attain the following objectives by rehabilitating the Coyolar Dam and improving the irrigation system.

- effective use of water resources all year around
- increasing irrigation area
- rising up of productivity and profitability,
- increasing farmers' income,
- increasing employment opportunities, and so on.

Attainment of those objectives will contributes to revitalize the regional economy, rise living standards and stabilize the civil administration.

4.1.2 Project Components

The Project involves two major works: one for the existing Coyolar Dam rehabilitation and another one for the irrigation canal system improvement in the Flores Irrigation District.

Facilities Plan

- Coyolar Dam Rehabilitation :
  Stopping of leakage from Dam body, reinforcement, improvement of the spillway.

- Flores Irrigation System Improvement :
  Installation of new diversion weir, repair of existing canals, arrangement of maintenance of roads, arrangement of rural water supply. However, arrangement of tertiary canal is excluded in this Project.

Agricultural Improvement Plan

- Flores Irrigation System Improvement Plan :
  With an adequate water management, it is expected to introduce agricultural techniques so to cultivate a self-supporting, exportable and cash crops.

- Agricultural Technical Extension Plan :
  Establishment of a model farm to train farmers and to provide technical extension for irrigation agriculture.

4.2 Alternative Plans and Project Formulation

The Project aims to attain the agricultural development of the area by supplying stable irrigation water. In order to realize the above aim, to obtain the stability of the Dam is indispensable and given the first priority and urgency to other related works.

Therefore, the Project is phased in Rehabilitation of the Coyolar Dam (Phase I) and Improvement of the Flores Irrigation System (Phase II).

In order to determine an optimum development plan following three alternative plans considering the full water level, dam stability, effective capacity, benefited area are proposed.

Case A :Keeping the full water level at EL.797 m.
To secure the Dam stability without any further treatment.

Case B :Keeping the full water level at EL.807m which was

originally planned.
To recover the originally designed effective capacity of 12.6 million m^3 of the reservoir.

Case C: Elevate the full water level at EL.812m to increase effective capacity.
To raise the Dam body in order to increase the effective capacity of the reservoir in order to increase the irrigation area.

To formulate the optimum development plan, each case study is discussed from the point of view of technical and economical study related to the Coyolar Dam rehabilitation and improvement of the irrigation system in the Flores District.

(1) Water Balance Study

In order to examine maximum acreage of the Flores Irrigation Area under the condition of above three alternative plans, a water balance study was undertaken.

For calculation of the water balance, data of water inflow to the Dam, water demand (for irrigation, and water supply), inflow at the upstream diversion weir, and looses (evaporation and leakage), etc., have been taken into account. Data for the period 1964-1988 (25 years) has been used. Result are shown in Table 4.2-1.

Table 4.2-1 Summary of Water Balance Study for 25 years (1964 - 1988)

Item	Case A	Case B	Case C
Height of Spillway (EL.m)	797	807	812
Capacity of the Coyolar Dam (million m^3)	6.2	12.6	16.7
Maximum Irrigable Area (ha) *	1,150	2,140	2,700

*Irrigable area for each Case is the area (ha) of maximum acreage which has shortage of water not more than 5 years during 25 years simulation.

(2) Coyolar Dam Rehabilitation Plan

Technical merits and demerits of the three alternative planes are shown.

	Merits	Demerits
Case A	not expensive No improvement needed of the Dam body. Obvious leaks disappear	Effective water capacity is half of the designed one. Need reparation of the spillway or new design of the spillway New access road must be needed on the right bank.
Case B	Restoration of initial designed capacity. No leaks shown.	Needs reinforcement of Dam body. Needs removal of outlet pipe at the construction time. Need reparation of the spillway or new design of the spillway
Case C	Increase of reservoir capacity No leaks shown.	Body crest needs to be raised. Needs reinforcement of Dam body. Needs removal of outlet pipe at construction time. Need reparation of the spillway or new design of the spillway Present spillway foundation needs treatment

4.3 Optimum Plan

To achieve the objectives of the optimum plan stated in Chapter 4.1.1, the alternatives must be studied from a technical point of view considering the financial and economic factors. Therefore, in analysing the three alternative planes, the following basic criteria are considered.

- Chosen rehabilitation method must not be difficult to implement;
- Construction cost must be the lowest and multiplier investment effects must be the highest;

- The maximum potential irrigable area must be expected;
- The most efficient use of present facilities must be made.

In Table 4.3-1 it shows effective capacity, maximum irrigated area, specific benefited area, construction cost, financial internal rate of return (FIRR), economic internal rate of return (EIRR) for each case.

Table 4.3-1 Comparison of each Alternative Plan

Case	Effective capacity	Irrigation area	Benefited area	Cost	FIRR (B/C)	EIRR (B/C)
A	6,220 $x10^3m^3$	1,150ha	Upland except artificial pasture	Lps. 49.8 $x10^6$	8.7 (3.9)	12.4 (5.7)
B	12,600 $x10^3m^3$	2,140ha	Upland & converted land from natural pasture	Lps. 72.6 $x10^6$	10.5 (4.5)	14.4 (6.6)
C	1,677 $x10^3m^3$	2,700ha	Including surrounding of Flores District	Lps. 119.5 $x10^6$	8.3 (3.7)	11.7 (5.4)

As a result of the evaluation of the alternatives, case B is the most adequate. The main reasons are described below.

- Potential irrigable area, including the natural pastures of the diversion area, is 2,140ha which can be benefited.
- The rehabilitation plan is feasible from a technical point of view and can secure the initial designed effective water capacity of 12.6 million m^3.
- Both the FIRR, EIRR for the three cases are high.
- Actual irrigation facilities cover the original 2,400ha initially designed, making it possible to try to make a better and efficient use of the irrigation system.

4.4 Proposed Agricultural Improvement Plan

In order to improve the agricultural conditions, the strategy of agricultural improvement plan is as follows:

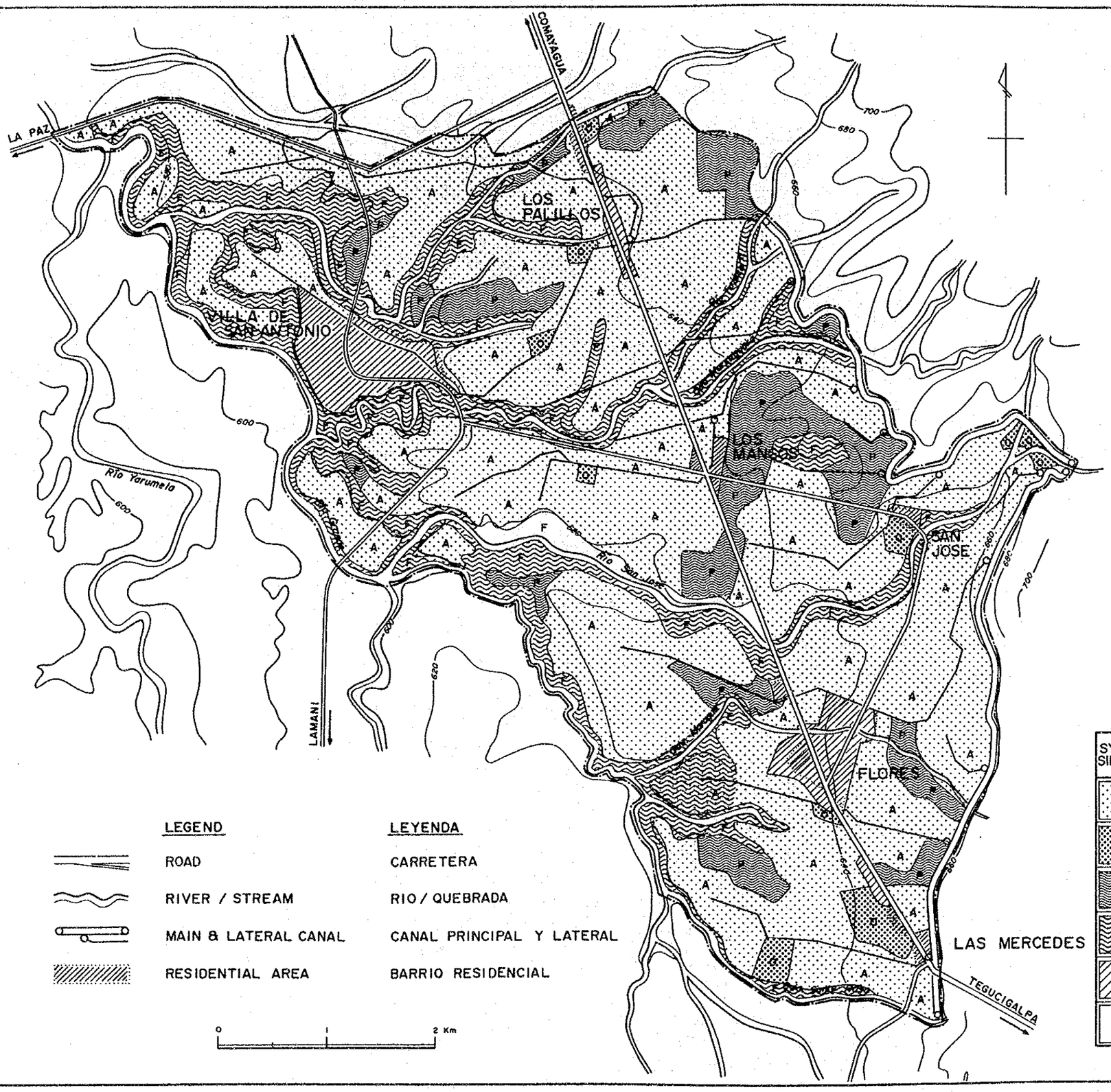
- To use the irrigation water effectively for cash crops,
- To increase production of basic grains of rice and maize in order to assure self-sufficiency,
- To produce horticulture crops bound for exportation and required agricultural products. Intensive cultivation of these crops will create employment opportunity,
- To plan development program mainly for small scale farmers,
- To establish a demonstration farm with training facilities for technical guidance of farmers,- To take into account of the environmental aspects such as protection of forests, soil erosion,etc.
- To effectively utilize the land resources.

4.4.1 Land Use Plan

The result of land classification indicates that suitable lands for irrigation farming are 2,110 ha comprising the lands of classes 1, 2 and 3 in the Study Area. Additionally, the lands of class 4, which are suitable for pasture or orchard, occupy 390 ha. From such results, net cultivated area including improved pasture has been delineated as 2,500 ha. And net irrigation area under the condition of gravity irrigation system is 2,140 ha in the Project. Table 4.4-1 and Fig.4.4-1 show the proposed land use plan.

In the proposed plan, 270 ha of present natural pasture lands which are suitable for cultivation, will be developed into cultivation lands. The forests which are located on sloped eroded lands, have to be remained in order to environmental conservation.

Fig. 4.4 – 1
LAND USE PLAN MAP
MAPA DEL USO PROPUESTO DE LA TIERRA.



LEGEND
LEYENDA

ROAD	CARRETERA
RIVER / STREAM	RIO / QUEBRADA
MAIN & LATERAL CANAL	CANAL PRINCIPAL Y LATERAL
RESIDENTIAL AREA	BARRIO RESIDENCIAL

LEGEND
LEYENDA

SYMBOL SIMBOLO	LAND USE USO DE TIERRA	AREA AREA
A	ANNUAL CROPS LAND TIERRA DE CULTIVOS ANUALES	1910 ha
C	PERMANENT CROPS LAND TIERRA DE CULTIVOS PERENNES	140
F	IMPROVED PASTURE LAND PASTO MEJORADO	450
G	NATURAL PASTURE AND FOREST LAND TIERRA DE PASTO NATURAL Y BOSQUE	750
	RESIDENTIAL AREA AREA RESIDENCIAL	170
	OTHERS OTRAS	180

Table 4.4-1 Proposed Land Use

(unit : ha)

	Present	Proposed	Balance
Cultivated land	2,230	2,500	270
Annual crops land	(1,120)	(1,910)	(790)
Perennial crops land	(140)	(140)	(0)
Improved pasture land	(970)	(450)	(-520)
Natural pasture land	460	190	-270
Forest land	560	560	0
Urban & settlement area	170	170	0
Roads,canals,rivers,etc.	180	180	0
Total	3,600	3,600	0

Note: Refer to ANNEX D.

4.4.2 Agricultural Production Plan

(1) Crop Selection

Crops to be produced in the Project Area have been screened from suitable crops for climatic conditions as shown in Annex D. The crops have been evaluated by the following terms of examination:

- Soil suitability ,
- Requirement for self-supply in the country ,
- Marketability (domestic and overseas markets),
- Technical familiarity, and
- Profitability.

As a result of total assessment, the following 17 crops, including pasture grass, have been selected:

- Basic food grain crops ; maize, rice and soy beans

There is a big increase in the domestic demand of basic grains and, in order to stabilize it through self-supply of them, specially maize and rice, their production must be increased. The country is importing soy beans as a basic grain and concentrated animal feed. Soy beans, leguminous crop is effective to soil fertilization.

- Vegetables and fruits ; Tomatoes, cucumber, onion, cabbage, chili, melon and water melon.

  Domestic demand of above products has been increasing and they can be used for processing and to increase the rate of capacity utilization of processing companies specially for tomato processing companies. These crops have high potential for export, and are familiar to farmers in cultivation techniques.

- Commercial crops ; tobacco and coffee

  Tobacco are planted under contract with tobacco company. Both crops are major export products in Honduras.

- Tree fruits ; avocado, mango, papaya and orange

  Both crops are produced in the Project Area for local market.

- Pasture ;

  Regarding livestock, a remarkable effect of irrigation can not be expected. The benefit of pasture irrigation is very low. However, the pasture lands in the Project Area occupy presently over 43 % of cultivated lands, and livestock products supply protein as meat, milk, lactose products, to habitants in and around the Project Area. It is necessary to produce nearly amount of livestock products at present by improvement of pasture productivity and animal management.

(2) Proposed Cropping Pattern

To formulate the cropping pattern, cropping calendar and cropping area, the following matters have been taken into consideration.

- Effective use of irrigation water and rainfall ;

  Crops of high consumption of water like rice are planted mainly in the rainy season. And fully planted period is set up in the rainy season.

- Crops characteristics ;

  Photosensitivity, response to rainfall and temperature are examined.

- Labor force balance and available machineries ;

  Labor and agricultural machinery requirement for farming are examined by the availability in and around the Project Area.

- Maintenance of soil fertility ;

  In order to maintain soil fertility and to prevent damage from continuous cropping, crop rotation system is introduced.

- Tendency and forecast of the demand for agricultural products ;

  The proposed cropping area has been decided taking into consideration the demand tendency from the processing companies, the domestic market, and the export potentiality of the agricultural products.

Maize : The production will contribute to self-sufficiency of basic grains through supplying to other regions 80-85% of the product.

Rice : Actually, due to the insufficient of irrigation water, the cultivation restricted. However, it is well suitable for the physical conditions and the domestic demand is increasing. Considering it an important crop in the Study Area, an extension of its cropping area is proposed.

Soy-bean : Together with other vegetables and using the rotating cropping system, self-supporting domestic production must be increased.

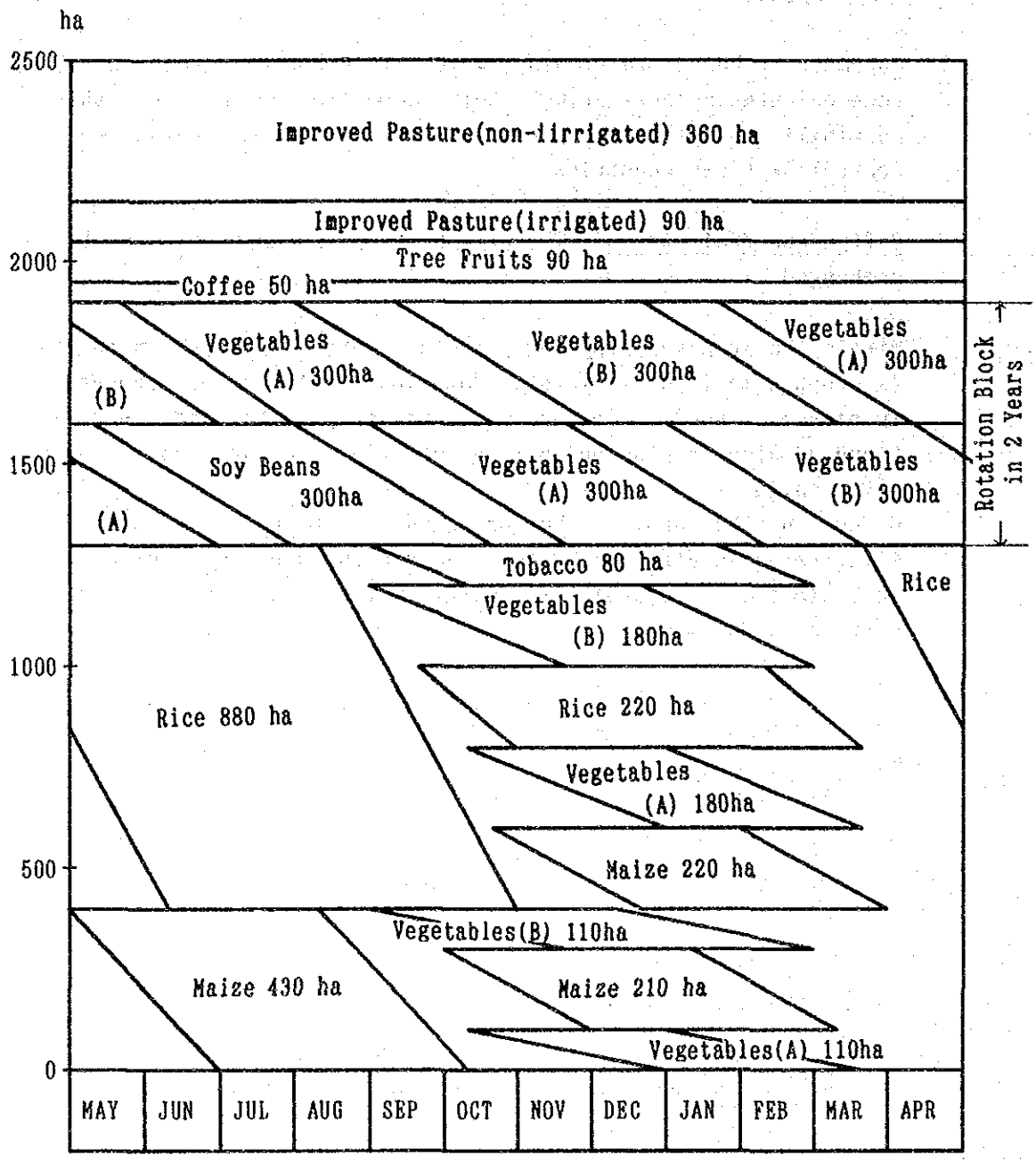
Tomato, onion, chili : Considering the increasing tendency of the domestic demand for fresh consumption products and the fact that the processing companies in the Comayagua area are working only at 30% of their capacity due to insufficient raw

material, it is decided to increase the cropping area for these products.

Cucumber, cabbage, watermelon, melon : Cropping areas have been calculated considering their domestic demand and the possibility of their exporting to the United States and Central American countries.

Coffee and fruit trees : The present cropping areas are to be unchanged.

Within the proposed cropping pattern, improved pasture, mainly is cropped in land of class 4. Rotation vegetables are cropped in classes 1 and 2. Rice and maize are cropped in land classes 2 and 3. Rice is planted in lands of fine texture soil for water saving.
Based on the above, the proposed cropping pattern is illustrated in Fig. 4.4-2, and the cropping area is indicated in Table 4.4-2. Cropping intensity in the proposed cropping pattern is 200 %.



Tree Fruits : Papaya, Avocado, Mango and Orange

Vegetables (A): Tomato and Cucumber

Vegetables (B): Cabbage, Onion, Chili, Water Melon and Melon

Fig. 4.4-2 Proposed Cropping Pattern

Table 4.4-2 Proposed Cropping Area (unit : ha)

Crops	Rainy season	Dry season	Total
Basic Grains	1,610	650	2,260
Maize	430	430	860
Rice	880	220	1,100
Soy beans	300	-	300
Vegetables	300	1,780	2,080
Tomatoes	230	670	900
Cucumber	70	220	290
Cabbage	-	130	130
Onions	-	300	300
Chili	-	60	60
Watermelons	-	200	200
Melons	-	200	200
Tobacco	-	80	80
Tree Fruits	90	(90)	90
Papaya	30	(30)	30
Avocado	30	(30)	30
Mango	20	(20)	20
Orange	10	(10)	10
Coffee	50	(50)	50
Improved Pasture	450	(450)	450
Irrigated	90	(90)	90
Non-irrigated	360	(360)	360
Total	2,500	3,100	5,010
Cultivated Area	2,500	2,500	2,500
Cropping Intensity (%)	100	124	200
Irrigated Area	2,140	2,140	2,140

Whole area is irrigated except 360 ha of improved pasture.
Figures in () represent perennial cropping areas.

(3) Proposed Improved Farming Practices

1) Improvement of Farming Practices

Improvement of farming practices is the most essential factor to realize full exploitation of agricultural potential in the Project Area. Proposed farming practices consist of the following components (Table 4.4-3):

- Introduction of high yield varieties and improved seeds,
- Application of fertilizers with proper amount and at proper period,
- Application of agro-chemicals; insecticides, fungicides and herbicides, in proper period and by proper manners,
- Proper management of irrigation water on farm,
- Proper soil and farm management such as deep plowing, harrowing, weeding, intertillage, erosion control, etc.,
- Mechanization of farming for speedy operation, deep plowing, etc.,
- Proper crop management such as nursery management, transplant, inoculation of leguminous bacteria, seeding, replanting, pruning, pollination, flower picking,harvesting, etc., and
- Post harvest practices such as threshing, drying, grade selection, packing, transportation, storage, etc.

Table 4.4-3 Proposed Farming Practices

Crops	Yield ton/ha	Variety	Growth period day	Fertilization (N-P-K) kg/ha	Agro-chemical (application)	Mechanization *	Others
Maize	4.0	B-102 H-12	100	110-40 30	3	Pl,Hr,Sw, Wd,Sp	
Rice	5.0	CICA-8 ICA-LIBERTADO	140	100-60-30	5	Pl,Hr,Sw, Sp,Hv	
Soy bean	2.0	5020G,1804 DARCO-1	80	20-60-30	3	Pl,Hr,Sw, Wd,Sp	Inoculation
Tomato	28.0	FLORA DATE PETO-98	80	140-170-40	10	Pl,Hr,Wd, Sp	
Cucumber	24.0	DASHER II TROPIC CULE	80	100-70-40	9	Pl,Hr,Wd, Sp	
Cabbage	17.0	IZALCO, GREEN BOY	100	120-90-40	10	Pl,Hr,Wd, Sp	
Onion	14.0	BONANZA TEXZAS YELLOW	100	160-120-80	10	Pl,Hr,Wd, Sp	
Chili	7.0	JALAPENO CALFOLNIA WONDER	100	100-80-40	10	Pl,Hr,Wd, Sp	
Water melon	18.0	MICLE LEC CHARRYSTON GREY	100	80-80-80	8	Pl,Hr,Wd, Sp	
Melon	16.0	MAGNUM-45, MISSION,SJ-45	100	120-80-40	8	Pl,Hr,Wd, Sp	
Tobacco	2.3		140	120-100-80	7	Pl,Hr,Wd, Sp	
Coffee	1.5		Perenial	55-50-75	5	Sp	1100p/ha
Papaya	19.0		do	150-240-130	17	Sp	1600p/ha replant/4y.
Avocado	6.0		do	115-95-85	10	Sp	110p/ha
Mango	12.0		do	115-95-85	9	Sp	110p/ha
Orange	6.0		do	115-95-85	9	Sp	176p/ha
Pasture irrigat.	milk 4.5 meat 0.215		do	40-30-30	-	Sp	reseed/ 10year
Pasture no-irr.	milk 2.7 meat 0.129		do	30-25-25	-	Sp	reseed/ 10year

* Mechanization
Pl : Plowing Hr : Harrowing Sw : Sowing
Wd : Weeding Sp : Spraying Hv : Harvesting

2) Improvement of Animal Husbandry

Main problem of livestock sector is shortage of animal feed in the dry season. This problem limits carrying capacity of cattle per unit of pasture. By the following countermeasures, supply of animal feed in the dry season and increase of livestock products can be achieved.

- Irrigable 90 ha of improved pasture is irrigated in the dry season.
- Improved pasture is reseeded every 10 years by grass seeds such as Guinea grass, Jaragua, Pangola, Star grass. It is possible to practice stripes plowing and reseeding in order to carry out with cheaper cost.
- In order to avoid over-grazing, rotation grazing is introduced into the whole pasture.
- By-products of rice, maize, soy bean and some vegetables: straws, stalks and leaves can be supplied to be used as feed in the dry season. By-products of rice mill, maize mill and soy beans are effective as concentrated feed for livestock.
- For improvement of animal health and hygiene, vaccination and getting ride of parasites have to be done completely.
- Nutritious improvement of cattle will be achieved by supply of concentrated feed.

(4) Farm Inputs Requirement

In order to improve farming practices, it is necessary to supply to farmers required seeds, fertilizers, insecticides, fungicides and herbicides. Taking into consideration the cropping area and recommended dosages per hectare, annual requirement has been calculated and shown in Table 4.4-4.

Table 4.4-4 Annual Requirement of Main Inputs

Input		Total requirement
Seeds		
Basic grain	ton	103
Vegetable, others	ton	2.4
Saplings	tree	26,000
Fertilizers		
Nitrogen	ton	505
Phosphated	ton	411
Potassium	ton	194
Agro-chemicals		
Insecticides	kg or ℓ	2,800
Fungicides	kg or ℓ	2,300
Herbicides	kg or ℓ	1,100
Cattle rising materials		
Vaccines, bug killers	head	1,530
Minerals	ton	3.1
Concentrated feed	ton	46

(See Annex D)

(5) Anticipated Unit Yield and Production

With complete irrigation and improvement of farming practices in the project area, as well as with the proper supporting services, an average unit yield of each crops is expected increase substantially. For estimation of the anticipated unit yield, data and information have been collected from experimental farm, extension staff of the government and advanced agricultural company farms around the Project Area. Unit yield in without Project condition is projected from the trend of it in the past 16 years. An increase of 12% in unit yield compared with present has been found in without Project condition. Production of present, without and with Project conditions are shown in Table 4.4-5.

Table 4.4-5 Agricultural Production Plan

Crop	Present			Without Project			With Project		
	Area ha	Yield ton/ha	Prod. ton	Area ha	Yield ton/ha	Prod. ton	Area ha	Yield ton/ha	Prod. ton
Maize	690	1.6	1,104	690	1.8	1,242	860	4.0	3,440
Rice	480	2.6	1,248	480	2.9	1,392	1,100	5.0	5,500
Kidney Beans	70	0.6	42	70	0.7	49	-	-	-
Soy Beans	-	-	-	-	-	-	300	2.0	600
Sorghum	20	1.2	24	20	1.3	26	-	-	-
Tomato	220	15.5	3,410	220	17.4	3,828	900	28.0	25,200
Cucumber	10	10.5	105	10	11.8	118	290	24.0	6,960
Cabbage	-	-	-	-	-	-	130	17.0	2,210
Onion	15	8.0	120	15	9.0	135	300	14.0	4,200
Chili	25	4.3	108	25	4.8	120	60	7.0	420
Water Melon	15	10.0	150	15	11.2	168	200	18.0	3,600
Melon	-	-	-	-	-	-	200	16.0	3,200
Tobacco	40	1.6	64	40	1.8	72	80	2.3	184
Coffee	50	1.0	50	50	1.1	55	50	1.5	75
Papaya	30	12.0	360	30	13.4	402	30	19.0	570
Avocado	30	4.0	120	30	4.5	135	30	6.0	180
Mango	20	5.0	100	20	5.6	112	20	12.0	240
Orange	10	3.5	35	10	3.9	39	10	6.0	60
Pasture with Irrigation									
(Milk)	-	-	-	-	-	-	90	4.50	405
(Meat)	-	-	-	-	-	-	90	0.215	19
Pasture without Irrigation									
(Milk)	970	1.38	1,339	970	1.54	1,494	360	2.70	972
(Meat)	970	0.069	67	970	0.077	75	360	0.129	46

note: see proposed unit yield in Annex D

(6) Labor and Machinery Requirement

1) Labor Requirement and Labor Balance

Under with-project condition, labor requirement for farming practices will be increased due to increase of cropping intensity and introduction of intensive farming. Based on the proposed recommended farming practices labor requirement by month was estimated.

The available manpower is estimated as below;

① Total population in the Villa de San Antonio Municipality in 1988 (population census) : 11,429

② Total population in the project area in 1988 :
① x 0.75 = 8,570

③ Total population in the project area in 2000 (projected 3.6 % of annual population growth rate, same growth rate during 1961 to '88) : 13,100

④ Economically active population (EAP) in the project area in 2000 (total population X 0.3*) : 3,930

⑤ Agricultural labor population in 2000 (EAP x 0.7*) : 2,750

* These are estimated from the population rate of growth of the census in 1974.

⑥ Available manpower in 2000
(⑤ X 365 days X 0.8) = 803,000 man-day/year
(⑤ X 365 days X 0.8 / 12 m) = 66,920 man-day/month

Total labor required is 570,000 man-day/year against available labor force of 803,000 man-day/year.The peak of labor requirement will occur in December and January. In both months, manpower will be short in the Project Area. However, the man-days deficit is small: 6% (4,000 man-days/month) of requirement in December and 2% (1,400 man-days/month) in January. It will be easy to supply temporary labor from Comayagua in where many unemployment workers are living.

2) Agricultural Machinery Requirement

In order to get anticipated unit yield, mechanization of farming is essential. Available agricultural machineries are presently limited in the Project Area. Requirement of machineries is estimated on the basis of the recommended farming practices. It will be required 58 tractors and 3 combines.

(7) Agricultural Products and Farming Materials Prices

Financial prices of agricultural products were obtained in real terms from market research information and statistics; economic prices were obtained from allying conversion factor to the border prices or domestic prices(see Annex D).

(8) Agricultural Production Value

From unit yield and production cost of production with-project and without-project, gross production , production cost and net profit by ha have been gathered in Annex D. Based on those results, monetary amount of total production in the Project Area has been calculated in Table 4.4-6 below.

Table 4.4-6 Total Production Value and Net Profit

(unit : thousand Lps.)

	Without-project	With-project	Benefit
Financial price			
Total production	6,002	29,996	--
Net profit	4,525	19,824	15,299
Economic price			
Total production	5,205	27,049	--
Net profit	3,529	17,113	13,584

4.4.3 Farm Household Economy

The results of the financial analysis of the benefits that can be obtained by a representative individual farmer and a member of small-farmers group can be seen in Table 4.4-7. By implementing the Project, the farmers income increase around 4.4 to 4.9 times compared with present.

Table 4.4-7 Balance of Farmers' Income

		Small Farmer	Medium Farmer	Small-farmers Group Member
Farming area	(ha)	1.71	11.89	2.77
Total income	(Lps.)	25,640	59,700	34,550
On farm	(Lps.)	(25,100)	(59,700)	(34,130)
Wage	(Lps.)	(540)	(---)	(420)
Living expenses	(Lps.)	7,430	16,100	10,700
Remains	(Lps.)	18,210	43,600	23,430

Note 1 : Living costs have been assumed to be 1.5 times the present costs.
Note 2 : See Annex D

4.4.4 Demand Forecast of Agricultural Products

In Table 4.4-8 is shown the projected production coming from the Project in the year 2000 and the balance between the production and demand of those products in 1989. The demand forecast has been made taking into account the demand trend and the population growth.

Domestic demand for rice, maize and soy-bean has not been satisfied. For this reason, imports have to be made to cover the supply deficits. If the actual tendency is kept. It is possible to estimate that imports will strongly increase in the future. As these basic grains form part of the basic diet of the Honduran people, and considering the increase of the population, marketability of these grains is very high.

Table 4.4-8 Forecasted Demand of Agricultural Products
(unit : thousand ton)

	1989 year			2000yr.
	Prod.Vol.	Demand	Balance	Requirm.
Rice	47.9	54.5	-6.7	91.4
Maize	395.9	618.2	-222.5	739.6
Soy-bean	2.1	36.9	-34.8	218.0
Tomato	33.6	33.0	0.6	40.2
Onion	5.2	5.1	0.1	7.5
Tobacco	8.3	8.6	-0.2	8.9
Coffee	115.0	115.0	0.0	206.0

Source : Agricultural Planning Division, Comité de Emergencia de Granos Básicos, División de Estadísticas

For the year 1989 the demand and supply balance has been taken and from that it can be said that domestic and foreign demand for tomato and onion (raw and processed like tomato juice and paste) has been increasing. Specially for the comayagua Valley, there are two of the biggest processing companies who are working only at 30% of their production capacity due to a lack of enough raw material supply. It is possible to think that if production increases, the demand from these companies will be enough to absorb the increase. There are also an exporting company which has been exporting cucumbers and tomatoes. Due to season and prices differences, there is a good chance for exports to Central America and to the United States.

The demand for tobacco has been increasing in later years. in 1989 tobacco had to be imported to satisfy the demand.

In the above way, it is possible to think that with the proposed agricultural products, the domestic demand will be satisfied.

4.4.5 Agricultural Extension Service

The Agricultural extension service is carried out in Flores Irrigation District and around of the Area for 600 small scale households by extension workers of the office of agricultural development.

Technical guidance about intensive irrigation agriculture for horticulture is one of important factors. To attain benefit planned in the Project, integrated organization for operation & maintenance of irrigation facilities and agricultural extension services is necessary Therefore, agricultural extension service plan is included in the operation & maintenance plan. Major installations for this purpose are shown as follow:

- Model farm
  With demonstration model farm, farmers will be received training.

- Agricultural machineries
  Agricultural machineries will be provided to train farmers in the model farm.

- Administration office
  Administration office with hall will be provided for farmers' training.

Extension workers have to receive more training in CEDA to acquire knowledge of intensive horticultural farming practices.

4.5 Irrigation Plan

(1) Irrigation Water Requirement

Irrigation water requirements are calculated on the basis of Evapotranspiration for Crops (ETcrop), Effective Rainfall, Irrigation Efficiency and leaching water requirement if necessary.

1) Evapotranspiration for Crops (ETcrop)

ETcrop is calculated in accordance with the proposed cropping pattern and cultivation area of representative main crops such as Maize, Rice, Tobacco, Vegetables (Tomato, Melon), Fruits, Coffee and Pasture in 2140 ha ; Sector I is 800 ha and Sector II 1340 ha of benefited area discussed in Chapter 3.3.

In order to obtain crop coefficient of proposed crops, reference is made to FAO Technical Paper No. 24 (Crop Water Requirements). Each 10 days' ETcrop for representative crops above mentioned are shown in Annex F.

Monthly ETo was analysed in Chapter 3. In accordance with the proposed cropping pattern, monthly ETcrop of each proposed crop are obtained based on 10 days' evapotranspiration (ET) and crop coefficient (Kc)(see Annex F).

2) Effective Rainfall

Various computational methods are used in order to determine effective rainfall. Evapotranspiration and precipitation ratio method by USDA stated in the FAO report described previously is employed in this report.

In order to obtain the effective rainfall, the monthly average rainfall data of at Flores meteorological station between 1945 and 1988 is used.

The result of the calculation is shown in Table 4.5-1 below.

Table 4.5-1 Effective Rainfall

(unit:mm)

	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr
Rainfall	129.3	170.3	104.3	125.8	171.8	106.9	25.2	6.2	1.8	6.2	7.2	33.4
Effective Rainfall	80	95	70	80	75	60	15	0	0	5	0	20

500 mm of effective rainfall which is about 56% of annual precipitation is concentrated for 7 months in the rainy season between May and Nobember and end of dry season in April.

3) Irrigation Method

Generally, two major irrigation methods; one is surface irrigation ,the other is sub-irrigation, are employed. Furrow, border, contour-ditch, basin, drip, and spray irrigation such as sprinkler and drip are categorized as surface irrigation.

Many factors are considered to determine the irrigation method in the Study Area such as topographic feature, soil characteristics as natural condition, farm size, irrigation facilities as irrigation system, and kind of crops planted, cultivation methods as farm management.

Considering natural condition, the topographic feature is a gradient of 2-3 % with undulation and basic intake rate ranges from 16 to 67 mm/hr of soil characteristics, furrow irrigation method is optimum and economical for the area.

Presently drip irrigation is employed in the part of area, however major practice of irrigation method is furrow irrigation. As the irrigation system, farm size, irrigation system in the area is suitable for furrow irrigation.

Moreover, crops introduced in this plan will be able to produce proposed yield with furrow irrigation method. Therefore, as mentioned above, it indicates that furrow irrigation is suitable in the area.

4) Irrigation Efficiency

Taking into account the topographical feature, canal structure, distribution system, irrigation method, irrigation system and so on, irrigation efficiency is estimated in accordance with FAO guideline as below.

Ea: Field Application Efficiency ratio	0.60
Eb: Field Canal Efficiency ratio	0.90
Ec: Conveyance Efficiency ratio	0.85
Ep: Project Efficiency ratio (Ea x Eb x Ec)	0.46

5) Irrigation Water Requirement

The seasonal and yearly irrigation water requirements for Sector I and Sector II will be determined for each proposed crop based on the crop requirement, effective rainfall, cropping area for each crop, and irrigation efficiency.

No leaching water requirement is considered in this Project in accordance with results of soil and water quality test.

The result of the 10 days' seasonal and yearly water requirement calculation for Sector I and Sector II are summarized in Table 4.5-2(see detail in Annex F).

Table 4.5-2 Summary of Water Requirements by Sector

Water Requirement	Sector I	Sector II	Total
Yearly (million m^3)	9.9	16.6	26.5
Seasonal			
Rainy Season (million m^3)	3.4	5.8	9.2
Dry Season (million m^3)	6.4	10.8	17.3

The total water requirement is calculated 26.5 million m^3 of which water requirement in the rainy and dry seasons are calculated 9.9 and 16.6 million m^3.

(2) Water Distribution Plan

1) Main Canal

Existing main canal for Sector I and Sector II will be utilized, however after the intake of the required water at the proposed diversion weir on the right bank of San Jose river, main canal will be shifted to the left bank of the river for the Sector I irrigation area. Sector I main canal governs maximum 800 ha and Sector II main canal does 1340 ha. The operation hour of Coyolar dam is proposed 12 hours and operation of main canals will be governed by the dam operation.

The maximum discharge of canals will occur in the last 10 days on January by the calculation of 10 days' water requirement and the discharge of Sector I and II are 1.1 and 1.8 m^3/sec, respectively.

2) Lateral Canal

Required water diverted to each lateral canal is calculated irrigation area governed by each lateral canal and unit water requirement at the time of maximum intake. Unit water requirement at the time of maximum intake is 1.378 ℓ/sec/ha(detailed computation see Annex F).

Fig.4.5-1 shows the schematic diagram of irrigation system.

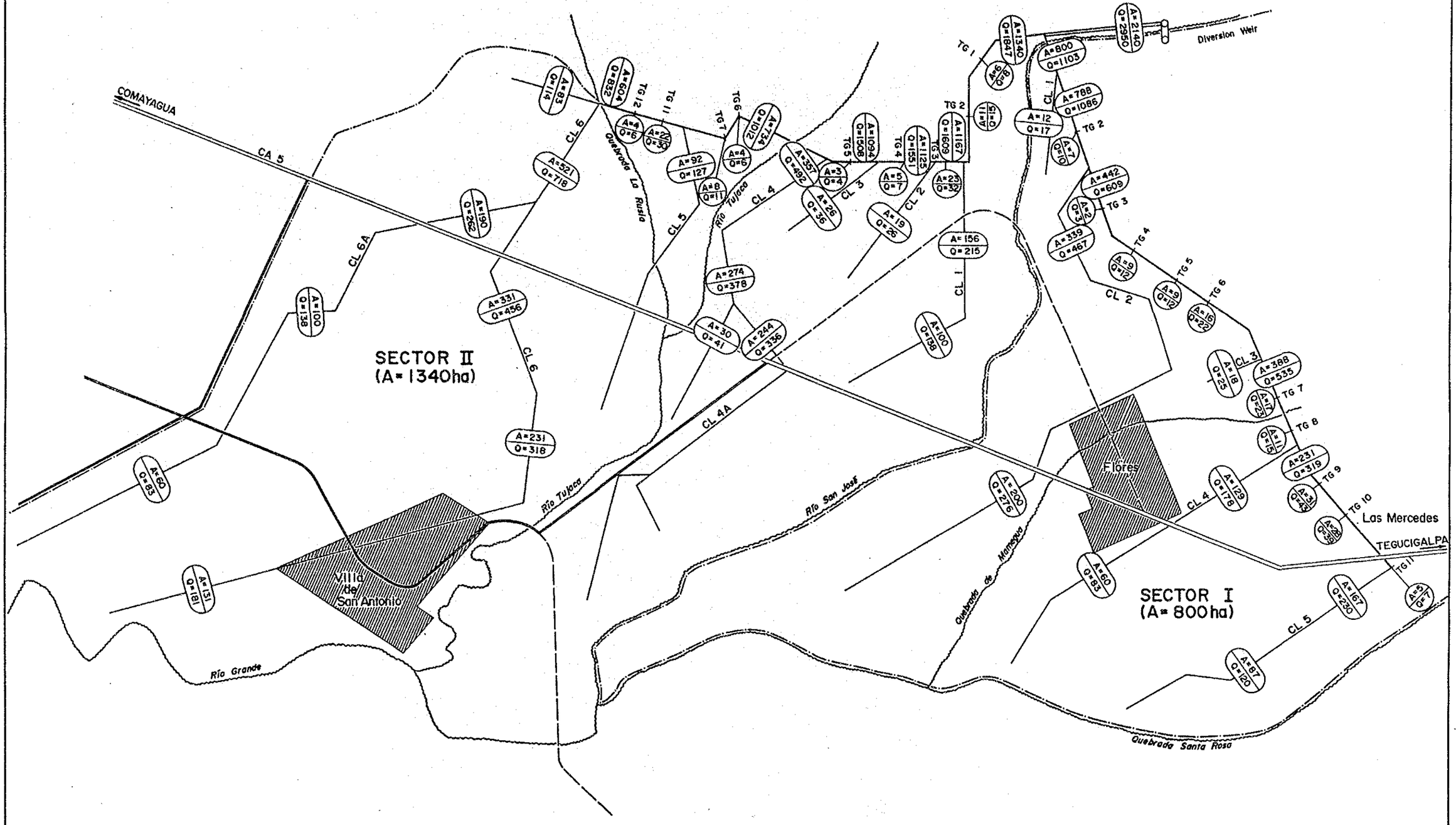


Fig.4.5-1 Schematic Distribution of Irrigation Water

4.6 Improvement Plan of Facilities

4.6.1 Summary of Improvement Facilities

(1) Brief description of Coyolar Dam rehabilitation

Dam body		
	Type	:To reinforce a masonry gravity dam with concrete
	Height	:62.5 m
	Crest length	:125.0 m
	Crest elevation	:EL. 811.5 m
	Crest thickness	:6m
	Slope	:Upstream 1:0.05, Downstream 1:0.90
Spillway		
	Design flood discharge	:700 m^3/sec
	Type	:Overflow type
	Width	:60.0 m
	Elevation of inlet	:EL.807.0 m
Reservoir		
	Catchment area	:192 km^2
	High water level	:807 m
	Low water level	:775 m
	Effective capacity	:12.6 million m^3
	Dead capacity	:0.78 million m^3
	Reservoir area	:75.6 ha
Sub-dam		
	Location	:Enclosing of previous spillway
	Type	:Concrete gravity dike
	Height	:7.5 m
	Crest length	:65 m
	Crest width	:6.0m
	Crest elevation	:EL.811.5 m

(2) Brief Description of Flores Irrigation System Improvement

Diversion works

Location	:50 m downstream of the Sector II diversion works
River width	:63.0 m
Design flood discharge	:190 m^3/*sec*
Width	:63.0 m (Fixed weir 53.5 m, Movable weir9.5 m)
Crest elevation	:EL.667.8 m
Length of apron	:11.0 m
Intake gate	:1.5 m x 1.5 m x 3 gates Bottom elevation EL. 665.25 m
Amount of intake	:3.5 m^3/sec for irrigation 3.0 m^3/sec, for water supply 0.5 m^3/sec
Scouring sluiceway gate	:2.8 m x 2.0 m x 1 gate Bottom elevation EL.665.10 m
Settling basin	:10 m x 49 m Design flood discharge 0.2 m^3/sec
Siphon	:Box type 1.2 m x 1.2 m, L=70.0 m

Canal work

	Sector I	Sector II
Canal		
Main canal(m)	6,110	6,440
Discharge(m^3/sec)	1.1~1.3	1.8~0.8
Lateral canal(m)	5 lines	7 lines
	10,000	17,600
Discharge(m^3/sec)	0.47-0.03	0.72-0.03
Type	Open canal with brick lining	
Ancillary facilities		
Aqueduct	-	1 unit
Siphon	1 unit	1 unit
Division works	91 units	107 units
Drop	91 units	107 units
Maintenance road	16.2 km	24.0 km