2-3 Agriculture, Irrigation and Drainage

2-3-1 Agricultural productiond

(1) General

Irrigated arable land area in Chancay-Huaral valley extends approximately 22,000 Ha. which is managed by about 5,700 household of small and medium scaled farmers.

Main products in the area are cotton, maize, citrus, apple, vegetables etc., besides the production of egg and broiler is high level in national wise.

In particular, the project area is conveniently situated close to Lima, therefore, it seems that farmers in the project area will proceed to the farm management to respond to multifarious demands and elevates the position of food supply base for Lima metropolitan area with concentrated urban population.

(2) Farm scale

Farm management scale in the project area is rather different from other rural area according to the Padron (Register Book of Irrigation) of Ministry of Agriculture, but farmers of less than 6.0 Ha. is accounted at 85%.

Further there remain four cooperatives which have the common land holding system by the land reform in the project area, Huando, Huerta Margaret, Esquivel and Pasamayo. Their managed areas are accounted at only 8% (1,578 Ha.) in the project area.

(3) Farm formation

Farm formation in the project area can be seen with a distinctive features as follows.

Location	Left bank	Right bank
Upper reaches:	Cotton, Maize, Fruits	Fruits
Middle reaches:	Cotton, Maize	Cotton, Maize
	Tuber crops,	Tuber crops,
	Vegetables,	Vegetables,
	Fruits	Beans
Lower reaches:	Vegetables	Vegetables
	Maize	Maize

Though the farm management condition has differs by farming area, and there are many fruit growers of large and medium scale at the coarse soil zone of the upper area, so they are growing citrus in the well watered area, but apple, grape and mango in the poorly watered area. In the coastal area, there are many small scaled farmers who cultivated vegetables and maize.
The salt accumulated area with poor drainage produces mainly cotton.

Planted area, planting period and yield of the main products are shown in Table 2-3-1 - 2 and Fig.2-3-1.

(4) Demand and supply of the agricultural products

Actual situation of demand and supply of the principal agricultural products is as follows;

Citrus: Planted area of mandalin orange has been increased on account of temporary sluggish market price of Washington orange, but it shows no marked fluctuation in the present time. Some fruit growers export mandalin oranges to Canada. Exporting price is US$0.47 - 0.49/kg, its price is higher than domestic price.

Maize: Monthly demand of maize for feed in Peru is a quantity of 40,000 metric ton, and imported 60% among the demand in 1983. The price of imported maize is s/. 830 - 840, for Lima in August, 1984, and it is higher than domestic

produce. As for the feed for broiler, domestic produce is better than imported maize, therefore, is in great demand.

Cotton: The commercialization of cotton has been liberalized from January, 1984. Cotton varieties of Tanguis which is cultivated in the project area has steady demand. Principal exporting area is Asia and Western Europe, and the amount of exporting accounts for 7% among the total amount of the national exportation.

The farm land suited for cotton cultivation is also suited for maize, therefore, farmers intend to transfer to cotton cultivation in recent years though planted area fluctuates with the international market price.

Vegetables: Vegetables which is produced in the project area sharing over 50% in Lima market, are such as Caihua, Cabbage, Peas, kidney beans, peppers, tomate, cauliflower, sweet potato, etc. Further market price of tomate, strawberry, onion, cabbage and cauliflower was merely fluctuated in the past.

The tendency of main agricultural products price is shown in Fig.2-3-2.

There are burling mill, feeding mill and tomato processing plant in the project area, and the numbers and capacities are as follow.

	Number	Capacity
Burling mill	5	250,000 - 400,000 Quintal/year
Feeding mill	2	6,000 - 6,500 MT/month (Receipt amount of maize)
Tomato processing plant	1	600 MT/day, but working rate is 10% in the present time.

Table 2-3-1 Present Planted Area

Crops	Planted Area (ha)	(%)	(%)
Cotton	5,300	(23)	
Maize	3,850	(16)	
Potato	900	(4)	
Beans	900	(4)	
Tomato	500		(10)
Cabbage	600		(13)
Choclo	500		(10)
Kidney bean	700		(15)
Califlower	400		(8)
Others	2,100		(44)
Vegetable Total	4,800	(20)	(100)
Apple	1,680		(26)
Orange	1,550		(24)
Mandarin	570		(9)
Pasion Fruit	550		(9)
Grape, Other	2,180		(33)
Fruit total	6,530	(28)	(100)
Maize Choclo	1,200	(5)	
Total Cropped Area	23,480	(100)	
Grass land	150		
Fallow land	470		
Grand Total	24,100		
Cultivatable Area	20,200		
Cropping Intensity	116%		

1/ Potato, Sweet potato, etc.
2/ Radish, Onion, Carrot, etc.
3/ Peach, Pear, Avocado, etc.
4/ Maize chala

Table 2-3-2 Crop Productivity

Crops	Productivity per ha. A ton	B ton	C ton
Cotton	2.4 - 2.9	1.8 - 2.7	1. - 5.
Maize	2.5 - 4.4	4.5 - 4.6	4.5 - 10.
Choclo	7.3 - 9.6	8.3 -15.	10.5 - 20.
Beans	0.9 - 1.1	0.9 - 1.	1. - 1.3
Kidney beans	3.8 - 4.4		5. - 8.
Potato	11.8 -17.6	13. -18.	12. - 25.
Tomato	15.8 -17.6	8. -17.3	22. - 45.
Cabbage		15. -20.	15. - 30.
Sweet Potato	10.5 -21.2	7. -18.1	20. - 30.
Citrus	9.2 -12.2	13. -22.	20. - 33.
Apple	6.1 -10.2	8. -12.	5. - 17.
Maracuya			7.5 - 20.
Grape	4.9 - 6.8	4. -12.	

Source, A: Productivity in the Huaral district based on the data of Reginal Agraria Lima IV (1978 - 1983)

B: Productivity based on the data of Oficina Agraria en Huaral (1965 - 1982)

C: Productivity based on a hearing in farmers (1983 - 1984)

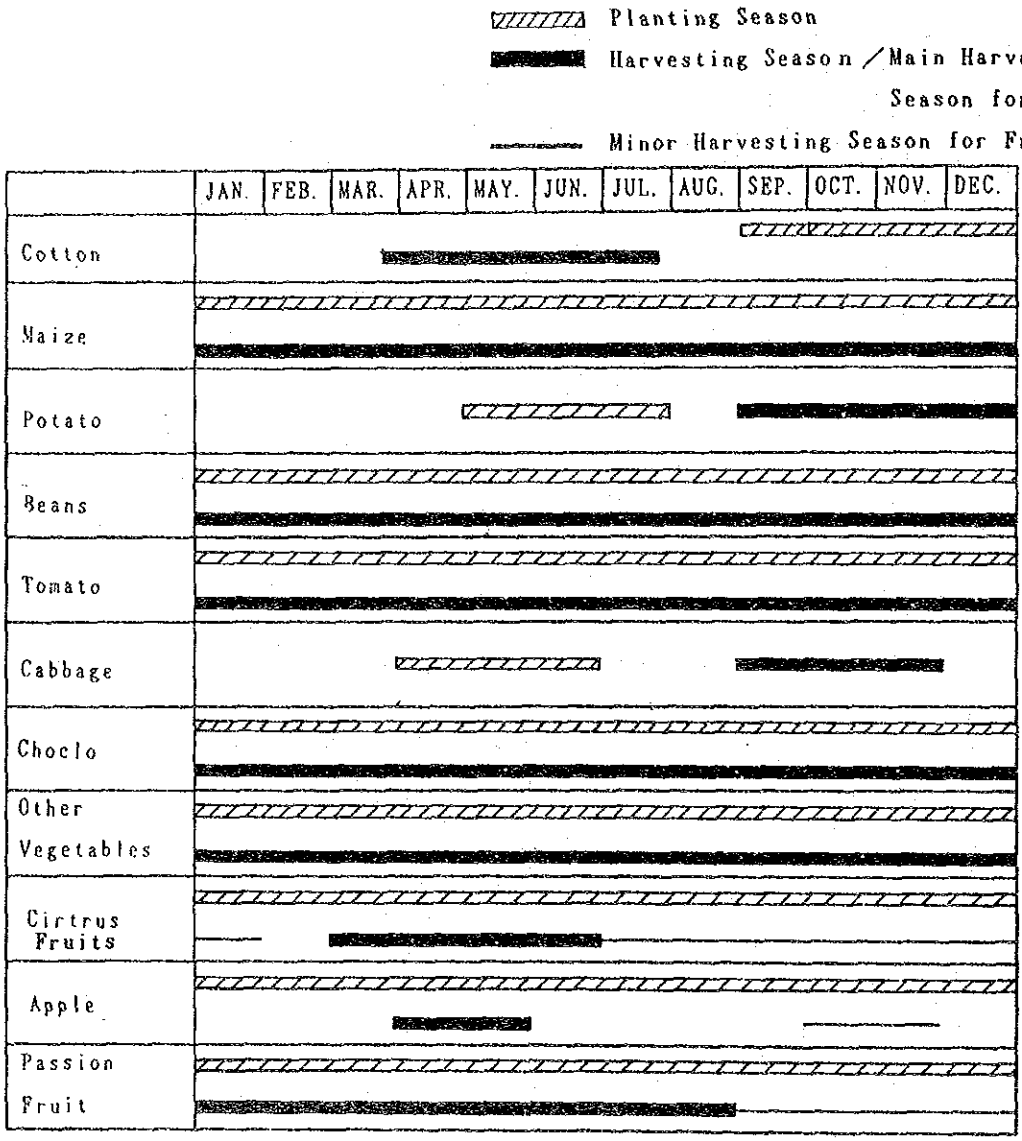


Fig. 2-3-1 Cropping Period (Present)

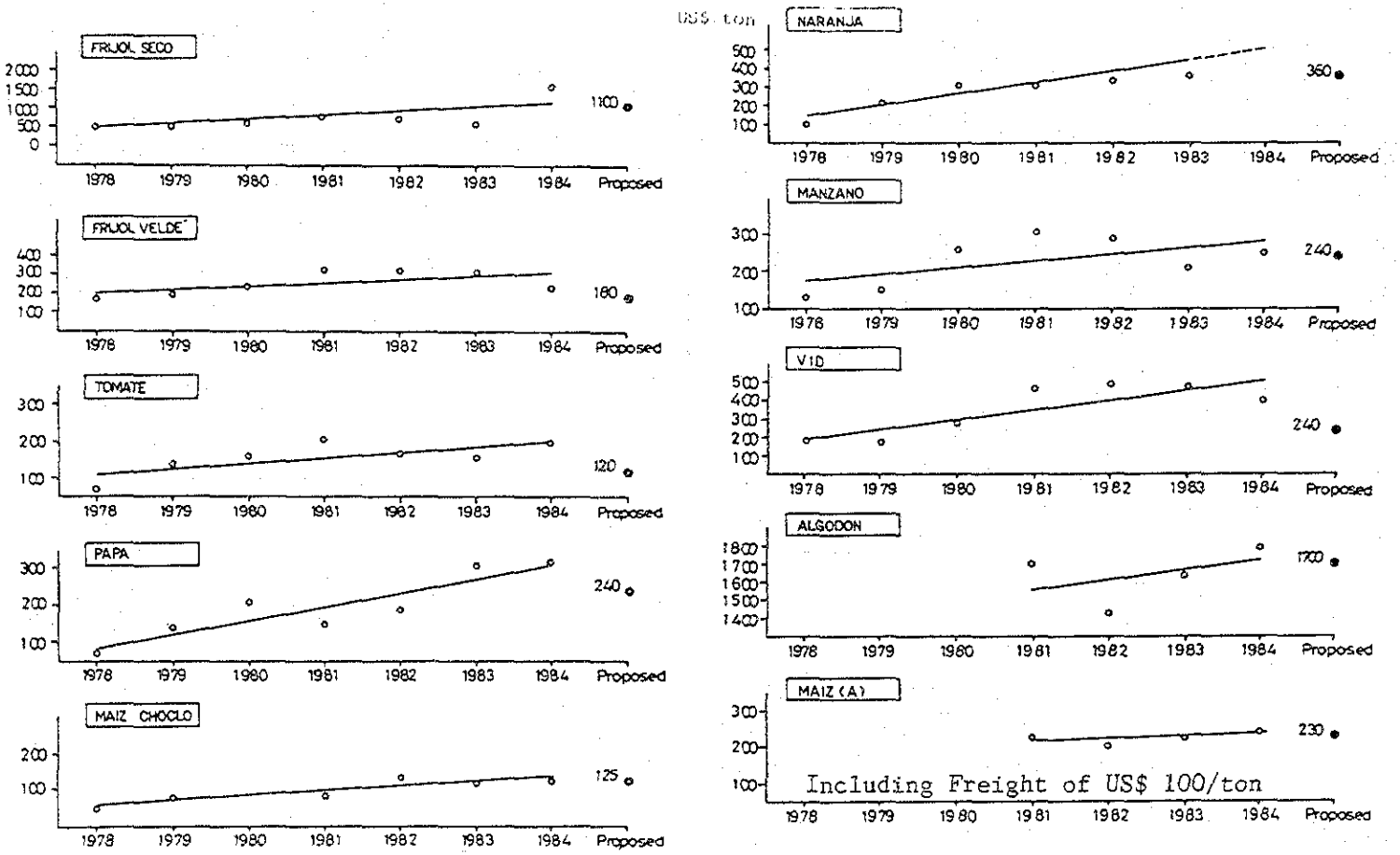


Fig. 2-3-2 Price Tendency of Agricultural Products

2-3-2 Livestock

The stock breeding is put into practice as an business enterprise with cooperatives and limited farmers. Generally the stock breeding of farmer is a small number. Their principal reasons are as follows:

- No well-ordered technical assistance, its extension and the facilities for animal hygiene.
- Deficiency of capital and limitation of land for livestock.

2-3-3 Farm household economy

The ratio by the strata of farm household in the project area is described in the article 2-3-1 (2). A fact finding inquiry of farm management have been carried out by the DEPEREHATIC. Farm household economy for the model farms was analysed on the bases of the above data, based on a characteristic of farming patterns in the rural zone. The result of its analysis is shown in Table 2-3-3, the criterion of the model selected is also on account of the following reason.

Model	Area	Farming pattern	Farming scale	Note
A	Upper	Fruit	15.0 Ha.	Fruit growers medium scale of over 10.0 Ha.
B	Middle	Cotton, Maize	6.0 Ha.	Traditional farm formation, medium scale, similar with the both bank
C	Middle	Cotton, Maize	4.5 Ha.	Salt accumulated area
D	Middle	Maize, Vegetables	6.0 Ha.	Small scale
E	Lower	Vegetables	4.5 Ha.	Small scale, only vegetable culture
F	Lower	Vegetables	1.0 Ha.	Minifundio
G	Upper	Cotton, Beans	2.0 Ha.	Minifundio
H	Middle	Fruit, Vegetable	6.0 Ha.	Small scale

Table 2-3-3 FARM HOUSE-HOLD ECONOMY OF MODEL FARMER (ACTUAL SITUATION)

us $1.00 = s/. 2,324

ITEM	A	B	C	D	E	F	G	H
AREA	ESPERANZA	ESQUIVEL	JECUAN	ESQUIVEL	CHANCAY BAJO	LOS LAURELES	PALPA	SAN JOSE
FARMING PATTERN	FRUIT	COTTON, MAIZE	COTTON, MAIZE	VEGITABLES MAIZE	VEGITABLES	VEGITABLES	COTTON BEANS	FRUITS VEGITABLES
FARMING SCALE	15.0ha	6.0ha	4.5ha	6.0ha	4.5ha	1.0ha	1.96ha	6.0ha
FARMING SYSTEM	NARANJA 13.5ha MANDARIN 1.5ha	COTTON 3.5ha MAIZE 2.5ha	COTTON 3.5ha MAIZE 1.0ha	VEGITABLES 2.5ha MAIZE 3.5ha	CHOCLO 4.5ha PUMPKIN 4.5ha	CHOCLO 1.0ha TOMATO 1.0ha COULIFLOWER 1.0ha	VAINITA 1.0ha CHOCLO 1.0ha COTTON 1.0ha	APPLE 2.5ha MARACUYA 2.0ha WATER MELON 1.5ha
FARMER'S FAMILY	FAMILY 6 FAMILY-WORKER 2	FAMILY 3 FAMILY-WORKER 1	FAMILY 4 FAMILY-WORKER 1	FAMILY 6 FAMILY-WORKER 1	FAMILY 5 FAMILY-WORKER 1	FAMILY 2 FAMILY-WORKER 1	FAMILY 2 FAMILY-WORKER 1	FAMILY 4 FAMILY-WORKER 2
FARMER'S INCOME	$13,049	$5,097	$4,424	$5,795	$5,631	$1,314	$1,293	$4,537
AGRICULTURAL INCOME	$13,049	$5,097	$4,424	$3,902	$5,631	$1,237	$1,271	$4,537
GROSS INCOME	$100,430	$9,742	$7,138	$9,345	$8,810	$3,390	$3,107	$6,398
PRODUCTION COST	$87,381	$4,645	$2,714	$5,443	$3,179	$2,154	$1,930	$1,861
NON-AGRICULTURAL INCOME	—	—	—	$2,151	—	$ 77	$ 116	—
NON-AGRICULTURAL EXPENDITURE	—	—	—	$ 258	—	—	—	—
HOUSEHOLD EXPENSE	$ 7,986	$2,143	$2,668	$2,828	$2,978	$1,532	$1,532	$2,829
SURPLUS AMOUNT OF AGRICULTURAL ECONOMICS	$ 5,063	$2,954	$1,756	$2,967	$2,653	(-)$ 218	(-) $ 239	$1,708
Remarks	Holding Tractors Trucks and other Farm machinary	Similar area with caqui		Holding a Tractor		Typical mini Farmer	Typical mini Farmer	Holding a Pickup

The above mentioned models are located; A - F in the right bank, G - H in the left bank of the Chancay River.

Model A belong to medium in farming scale is realized a substancial earnings with fruit growing. Model B and C under the small scale farming are cultivated cotton and maize as traditional farming pattern, and made earnings of about $ 1,750 -- 2,950 in an year. Model D and E are also small scale farmers, but their earnings are made higher profit in the truck farming. In case of mini farmer (model F and G), it shows difficult situation to derive earnings from his farming. Model H is performed the combined farming with fruit and vegitables but makes lower earnings on deal with a broker due to difficult condition on his finance.

Besides, Huando cooperative as a common land holding organization took over the farm planted citrus orchard from the plantation (Hacienda), its farming situation is as follows;

Proprietary land areas:	1,125 Ha.
Planted area:	Naranja (Washington orange) and Mandarin orange; 900 Ha.
	Apple; 36 Ha.
	Maize; 100 Ha.
	Green maize for feed; 150 Ha.
	(Maize and green maize are planted as interval cultivation in orchard.)
Non cultivated area:	Artificial forest; 55 Ha.
	Site of office and houses; 189 Ha.
Members of cooperative:	530 members
Annual earnings (1983):	s/. 9,000,000,000.-
Annual expenditure (1983):	s/. 7,000,000,000.-
Annual income (1983):	s/. 2,000,000,000.-

Note: An amount of money is based on 1983.

The sum of s/.52,813,921.- of the annual budget in order to operate and maintain irrigation facilities and roads in the orchard and its surroundings has been appropriated and maintained. Also the water tariff is paids at amount of s/.6,500,000.- in 1983.

2-3-4 Irrigation

(1) Irrigation network

Twenty-three intakes are installed from Santo Domingo where a water gauging station managing by Administracion Tecnica del Distrio Riego de Chancay-Huaral,Ministerio de Agricultura is placed.

In humid period, these intakes are directly diverted irrigation water from the river. In droughtly period, the lower reaches from San Jose intakes can not directly use the river water and infiltrated water from the upper area and return flow are utilized. Besides, there are some areas which use water in different manners; collective infiltrated (drain) water from the upper area through the year, utilizing ground-water due to insufficient diverted water from the river, utilizing sewage water from Huaral etc. The diagram of existing irrigation system the lower reaches from La Esperanza and Palpa is shown on Fig.2-3-3, and the irrigated area by diversion and canal are shown in Table 2-3-4 and 2-3-5. Further these area has respectively characteristic on the farming patterns therefore, it can be divided to five blocks as shown in Table 2-3-6.

(2) Water source

1) Utilization of lagoon water

For irrigation water supply in the droughty period, dams constructed at seven langoons among the Andian highland in the upper basin is used. The total storage capacity of the mentioned lagoon is 45 million m^3, but effectively utilized lagoon are only five in the present time so that the limitation of available capacity is atmost 30×10^6 m^3 in the year(Refer to 2-1-2).

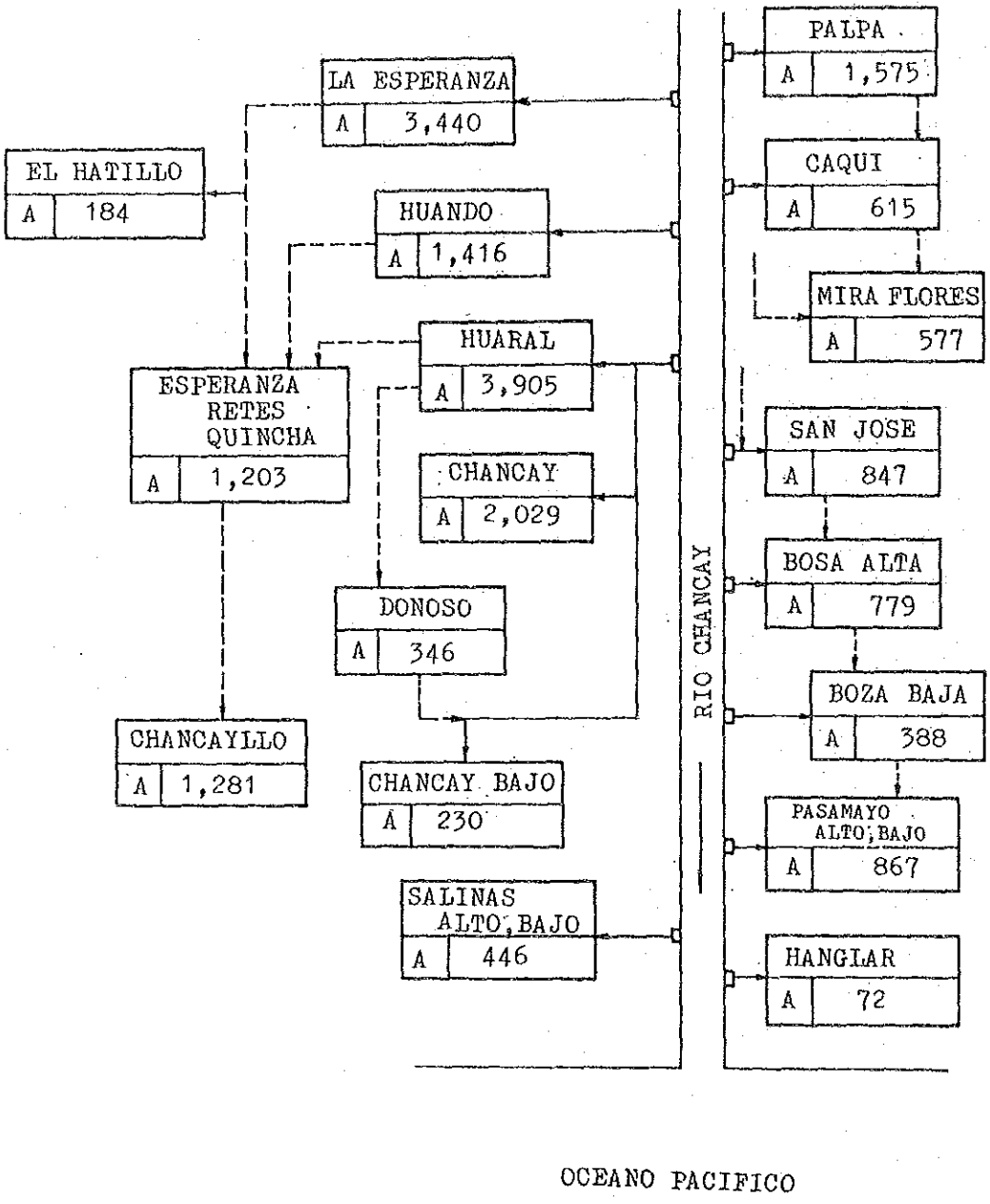


Fig. 2-3-3 Diagram of Existing Irrigation System

Table 2-3-4 Commanding Area by Water Source-wise

Source of Irrigation Water	Existing System				Total
	Left Bank		Right Bank		
	System	Area	System	Area	
		ha		ha	ha
Chancay River	ESPERANZA	3,231	PALPA	1,575	
	MALACA	9	CAQUI	615	
	HUANDO	1,416			
	CHANCAY-HUARAL	5,934			
					12,780
Chancay River + Return Flow	SALINAS ALTA	183	SANJOSE	847	
			BOZA ALTA	779	
	" M_1	79	BOZA BAJA	388	
	" M_2	19	PASAMAYO ALTO	271	
	" BAJO	165			
			MONTE CHICO	17	
			PASAMAYO BAJO	579	
			HANGLAR	72	3,399
Infiltrated Water	RETES	869	MIRA FLORES	577	
	CHANCAYLLO*	1,799			
	DONOSO	576			3,821
Total		14,280		5,720	20,000

Table 2-3-5 Commanding Area in Canal wise

		Gross Area	Net Area
(LEFT BANK)		ha	ha
PALPA-CAQUI	PALPA	1,656	1,575
	CAQUI	647	615
MIRA FLORES	MIRA FLORES	466	443
	Dren PUQUIO	141	134
SAN JOSE	SAN JOSE	891	847
BOZA	BOZA ALTO	820	779
	BOZA BAJO	408	388
PASAMAYO	PASAMAYO ALTO	303	288
	PASAMAYO BAJO	609	579
HANGLAR	HANGLAR	75	72
Sub-Total		6,016	5,720
(RIGHT BANK)			
ESPERANZA	LA ESPERANZA	3,558	3,440
HUANDO	HUANDO	1,491	1,416
CHANCAY-HUARAL	HUARAL	4,110	3,905
	CHANCAY	2,136	2,029
SALINAS	SALINAS(A.M.M.B.)	469	446
Filt PETES-QUINCHA	Dren ESPERANZA	130	124
	Dren RETES	486	462
	Dren QUINCHA	195	185
	Filt QUINCHA	234	222
	CALERA	177	168
	EL PROGRESO	44	42
Filt DONOSO	Filt DONOSO	364	346
	Dren DONOSO	242	230
CHANCAYLLO	SAN SAYETANO	200	190
	SAN JUAN	224	213
	CANDERLARIA	370	352
	CHANCAYLLO Der	152	144
	CHANCAYLLO Izg	402	382
EL HATILLO	HATILLO	200	184
Sub-Total		15,184	14,480
Total		21,200	20,200

Table 2-3-6 Project Area in Blockwise

Bank	Block	Area (ha)	Percentage	District
Left Bank	Upstream	2,320	11%	PALPA-CAQUI
	Midstream	3,400	17	MIRAFLORES-SANJOSE, PASAMAYO BOZA-AUCALLAMA
	Sub-Total	5,720	28	
Right Bank	Upstream	4,860	24	LA ESPERANZA HUANDO
	Midstream	5,790	29	RETES-NATURALS, CHANCAY ALTO JESUS DEL VALLE-ESQUIVEL
	Downstream	3,830	19	CHANCAYLLO, CHANCAY-BAJO SALINAS
	Sub-Total	14,480	72	
Total		20,200	100	

These dams of lagoons are managed under Chancay-Huaral Irrigation District Technical Administration Office. The stored water will be released when the discharge in the Santo Domingo station indicated 3.8 m^3/s. or less.

2) Utilization of groundwater

As described in the article 2-1-3, the pumping stations are operated in response to the conditions of demand for irrigation water by the irrigation committee which managed well and its groundwater, and recently using condition of groundwater is shown in Table 2-3-7, its maximum use showed 20,510,000 m^3 in 1979.

Table 2-3-7 ANNUALLY GROUNDWATER USE

Year	Using quantity x 1,000 m^3
1977	8,523
1978	12,375
1979	20,510
1980	7,220
1981	5,618
1982	-

3) Infiltrated water and return flow

The lower reaches from Chancay Huaral intake in the project area utilize infiltrated water from the upper area and return flow to the river in droughty period. The using quantity of infiltrated water is approximately 51 x 10^6 m^3 - 122 x 10^6 m^3 through the year according to the record of Chancay-Huaral Irrigation District Technical Administration Office.

In 1979/1980 (Droughty year), the infiltrated water capacity used for irrigation was 199,000,000 m^3.

In 1979/1980 (Droughty year), the infiltrated water used for irrigation was an amount of 108,000,000 m^3 * as against an amount of 199,000,000 m^3 of the diversion requirement from the river.

This is indebted to the irrigation and drainage system which had been devised many years' experience, and it may be said that is a specific feature in the project area.

* Excluded the return flow to the river.
(Irrigation water for Pasamayo and Salinas.)

(3) Supply and demand in balance of irrigation water

The most of project area is affected by water shortage at the droughty period every year. In the above case, it is devised a countermeasure against the farm management according to the condition of irrigation area. The extremely water shortage area is situated in the lower reaches La Experanza, Boza and Chancay Bajo, its area is about 4,900 Ha.

A result of the calculation of water balance study with dry year (probability of 10 years) is shown in Fig.2-3-4-2, and it's approximately 17,600,000 m^3 short. (Refer to Annex G)

(4) Infrastructures

1) Diversion work

A total of 17 existing intakes are located in the Project area along both banks of the Chancay River; 9 in the left bank, and 8 in the right bank. Among these, 4 are concrete structures while the others are natural open cut intakes without weir, with gabion and wood set in both sides of the bell mouth as a training levee. Maintenance cost is excessive due to the rapid stream of the Chancay River and the large volume of stones and soil carried by floods. Intakes are filled with soil and stones and the river bed is changed, so a natural result, reconstruction of conduction canal is necessary. The natural open cut intakes of small scale are particularly prone to washouts when river discharge exceeds 100 m^3/sec. Concrete intakes and related facilities are antiquated and incapable of controlling water during floods which occur ocasionally and it results in damage to main canals. Early rehabilitation of the above is thus urgently required. Existing condition of the intakes and location are shown in Table 2-3-8.

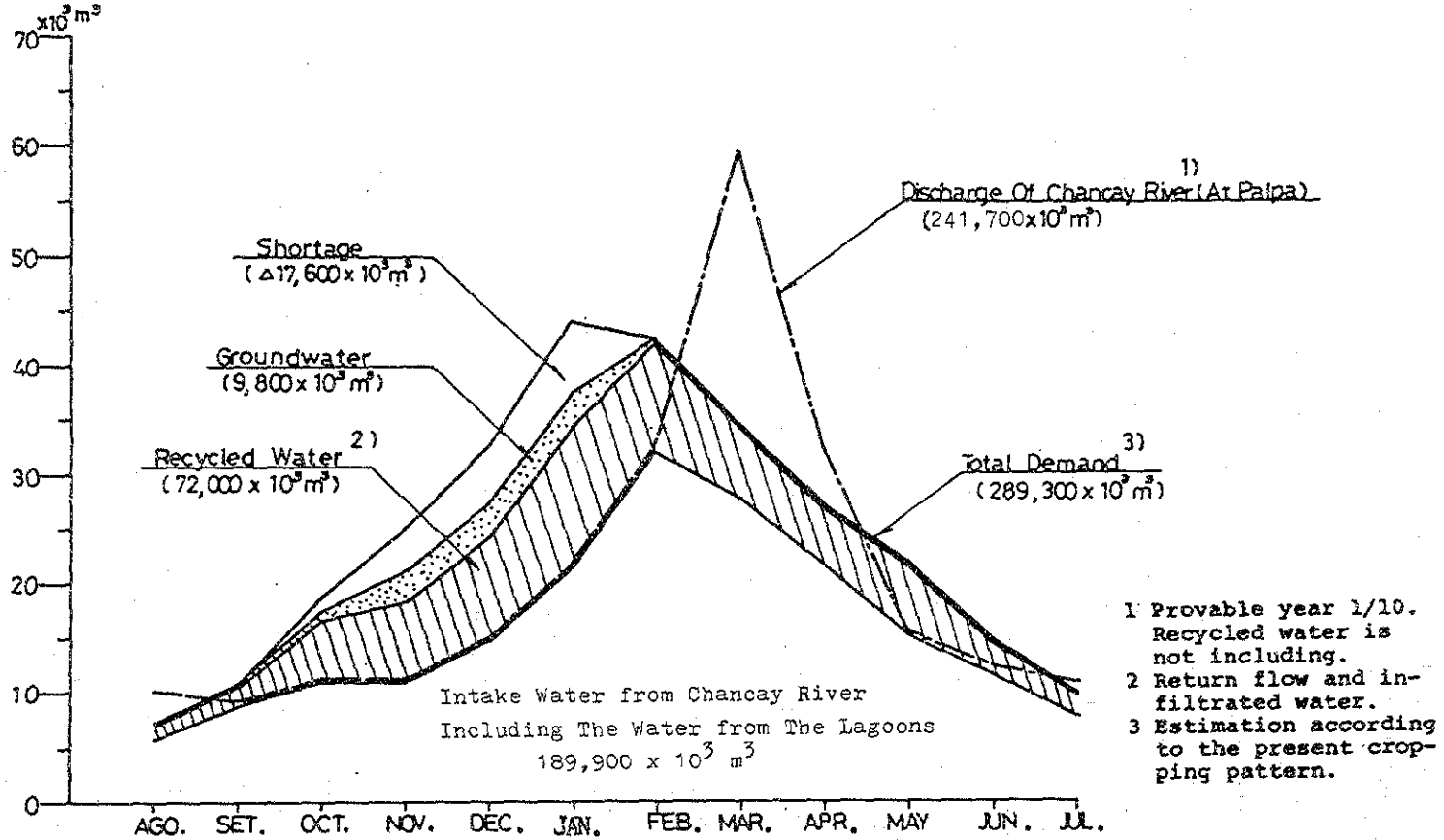
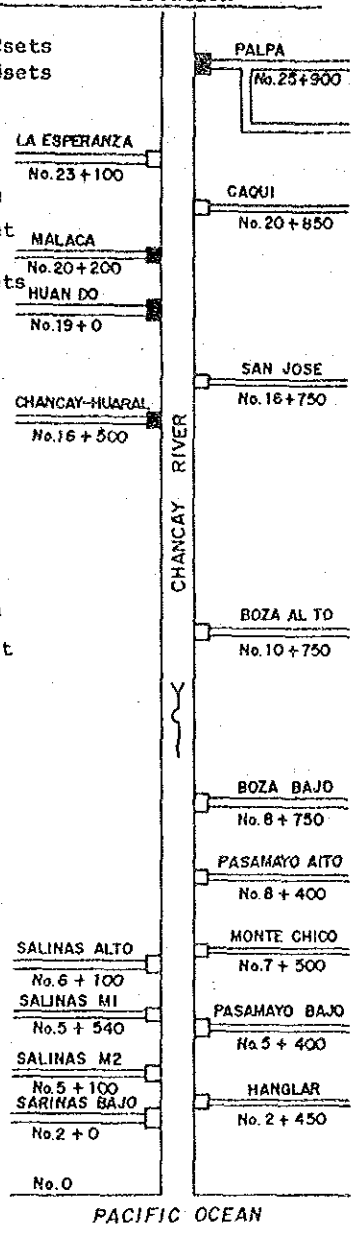


Fig. 2-3-4 Present Water Balance Diagram

Table 2-3-8 Existing Intake Condition

	Intake	Bank	Discharge (m^3/sec)	Structure
1	Esperanza	Right Bank	4.0	Sluce way gate 2sets Intake gate 4sets
2	Malaca	"	0.1	Intake without Diversion Dam
3	Huando	"	3.5	Fixed Weir ℓ=76m Intake gate 1 set
4	Chancay Huaral	"	7.0	Intake gate 4 sets
5	Salinas Alto	"	0.3	Intake without Diversion Dam
6	Salinas M_1	"	0.6	"
7	Salinas M_2	"	0.008	"
8	Salinas Bajo	"	0.4	Intake with Concrete Canal
9	Palpa	Left Bank	2.5	Fixed Weir ℓ=29m Intake gate 1 set
10	Caqui	"	0.5	Intake without Diversion Dam
11	San Jose	"	0.8	Intake with Concrete Canal
12	Boza Alto	"	0.6	Intake without Diversion Dam
13	Boza Bajo	"	0.5	"
14	Pasamayo Alto	"	0.4	"
15	Monte Chico	"	0.1	"
16	Pasamayo Bajo	"	0.6	"
17	Hanglar	"	0.1	"

* Discharge is based on the water right.



2) Irrigation canal

Total length of main irrigation canals in the Project area is about 340km. Some parts have been rehabilitated; however, some cracks occur in the concrete lined canals. Fallen stones in the wet masonry canal, erosion in unlined canal and broken or damaged divisions are also observed. Consequently, water management in these area is insufficient. Most of the canals, except in the lower portion of the Project area, are aligned in coarse textured soil with good percolation, causing leakages in some parts.

Table 2-3-9 shows the existing irrigation canal condition and rehabilitation required rank according to the degree of damage. The total canal length of Group I is about 160km, and the sectional rehabilitation is insufficient to repair damages to lined concrete and wet masonry or to restore their farmer function. Function of unlined canals were damaged by excessive erosion. Related structures like divisions which are broken or damaged have also been impaired requiring urgent rehabilitation or improvement work. Total canal length of group II is about 100km. Compared to group I, these canals are in good condition and can fulfil their function if there is a adequate maintenance. Total canal length of group III is about 70km, and the same consists of recently reconstructed or newly constructed canals. The same are well maintained and functioning adequately.

The conducting canals from intakes along the Chancay River, on the other hand, all suffer from excessive deposits during flood. Although the some are dredged by the farmer's association, two or three times a year, more reliable canal maintenance is required to maintain canal function. This is the same for canals which collect filtration water.

Table 2-3-9 EXISTING CONDITION OF CANAL

Area	Canal length		Soil	Rehabilitation rank		
	Lined Canal	Unlined canal	texture	I	II	III
	(km)	(km)		(km)	(km)	(km)
Eaperanza	59.91	7.05	Coarse	33.25	11.43	21.78
				(0.50)		
Huando	3.20	23.00	Medium	13.00	12.85	0.35
Chancay-Huaral	3.45	80.27	Medium	54.45	21.92	7.10
				(0.25)		
Chancayllo	12.50	27.90	Fine	0.00	27.90	12.50
Salinas	-	18.10	Medium	2.00	12.60	3.50
Palpa	6.22	68.91	Medium	43.91	13.15	18.07
			& Fine			
Boza	-	13.45	Medium	11.00	0.00	2.45
Pasamayo	-	13.60	Medium	4.80	2.00	6.80
Total	85.28	252.28		162.41	101.85	72.55
				(0.75)		

Note: Number in a parenthesis is the unnecessary to rehabilitation the length of canal.

3) Reservoir

There are 13 reservoirs in the Project area as shown in the Table 2-3-10. The reservoirs are filled with water at night which is used for irrigation in the day time. Total capacity of the reservoirs is 221,400 m^3; however, their function is reduced by excessive deposit (according to the survey in 1984, total volume of deposit is 71,000 m^3). Moreover most inlet and outlet facilities for these reservoirs function inadequately.

Reconstruction of the reservoirs to increase capacity is therefore necessary. Construction of additional reservoirs is also required in the said area for more effctive water managment.

Table 2-3-10 Existing Reservoirs Condition

Reservoir	Location	Existing Storage Capacity (m^3)	Volume of Sediment (m^3)	Storage Capacity (m^3)
Esperanza	Esperanza	30,000	12,000	42,000
Huando	Huando	11,300	2,300	13,600
Jesvs Del. Vable	Huaral	19,000	5,600	24,600
Cerrito	Huaral	9,000	3,000	12,000
Quepe Pampa	Quepe Pampa	8,700	2,100	10,800
Buena Vista	Torre Blanca	6,100	4,000	11,300
Galeano	Torre Blanca	8,000	4,500	12,000
Lavreles	Laureles	13,600	2,700	16,300
Chancay Bajo	Chancay Bajo	2,900	4,400	7,300
Chancayllo-I	Chancayllo	8,700	3,300	12,000
San Juan	Chancayllo	2,500	2,500	5,000
Palpa	Palpa	16,900	16,900	33,800
Miraflores	Miraflores	13,000	7,700	20,700
Total		149,700	71,000	221,400

4) Field irrigation

The furrow method is normally used for field irrigation. The amount of irrigation water for each furrow at one time, furrow length, field slope, irrigation time, etc. are determined by the farmer's association or farmers in each area, and accordingly there is no standard criteria for the same.

Local irrigation practise are generally based on experience and custom; however, study of the same is necessary for improvement of water resources utilization.

In some areas, ponding is practised during the post harvest period until sowing of the next crop and is an effective means to wash salinity from the soil. In addition, some farmers regulate the amount of irrigation water and the number of days of intercepted irrigation thus obtaining higher yields. Such techniques should be extended to every farm at the same time maintaining a stable irrigation water supply.

2-3-5 Drainage

1) Poor drainage area

Drainage in the middle of lower portion of the foothills and the lower terrace of the Chancay River is poor and the groundwater table is within 1.5m from the ground surface. The poorly drainage area of about 2,180 ha. is tabulated in Table 2-3-11 according to irrigation block and groundwater table classification. Pipe drains have been installed in part of the area but the same is insufficient for land improvement. In addition this area also suffers from salinity problems. (Refer to 2-1-5)

Table 2-3-11 POOR DRAINAGE AREA

	Grouond Water Table		Total
	-1.0m	-10.0 -- 1.5m	
	(ha.)	(ha.)	(ha.)
Quincha	420	390	810
Donoso	360	510	870
Boza	60	90	150
San Luise	120	130	250
Lunavilca	30	20	50
Palpa	-	50	50
Total	990	1,190	2,180

2) Drainage canal

Existing drainage canals in the Project area are unlined and their total length is about 52km. The some runs along the steep natural land slope and consequently, many portions have been scoured and eroded. The Esperanza-Jecuan drainage canal (L=4.65km), and other canals required urgent rehabilitation to prevent damaging of conserved upland field along the canal by continued erosion.

Canals designated class I in Table 2-3-12 is (L=6.5km) evidence excessive erosion of the canal bed or side slope and accordingly do not function satisfactorily. Total length of class II canals is 39.3km. The side slopes of the same are slightly damaged but presently no structural problem if the canal is sufficiently maintained. Class III canals, which have a total length of 6.2km, are used only during flood.

Table 2-3-12 EXISTING CONDITION OF DRAINAGE CANAL

Location	Canal length	Soil texture	Rehabilitation Rank		
			I	II	III
	(km)		(km)	(km)	(km)
Right bank	27.9	medium	4.2	23.7	-
Left bank	24.1	- do -	2.3	15.6	6.2
Total	52.0		6.5	39.3	6.2

3) Flood damage

Although there are partial flood protection embankments on both banks of the Chancay River, the river is generally unconfined.

The Esperanza intake as well as 3 other intakes were damaged by flood in 1984, and about 400 ha. of land was washed away. The Palpa area along the river was damaged by each flood occurring from early 1970. Total damaged area, depending flood scale, is about 290 ha.

2-3-6 Road network and bridge

The road network in the Project area consists of the main road mentioned in 2-2-5 and farm roads between villages and the farm fields. Most of these roads, however, are narrow and irregular. The Palpa and San Jose bridge was used to be a railway bridge and condition of the same is poor and too dangerous for use unless repaired.

2-3-7 Organization and operation and maintenance

Under existing institutions in Peru, operation and maintenance of the irrigation facilities, roads and rivers under the control of the water authority of irrigation district Ministry of Agriculture, The operation of these facilities is carried out by the water users' organization (Junta de Usuarios) on the instruction from the water authority.

An important matters on the management (include water distribution) of the water users' organization (Junta de Usuarios) is determined by representatives of the irrigation commission.

There is a water user's authority (Administracion Tecnica del Distrit Riego de Chancay-Huaral) in the project area and the water user's organizatin (Junta de Usuarios del Distrito de Valle Chancay-Huaral) is organized by fifteen representatives of fifteen irrigation commision (Comision de Regantes) in the same area.

These organizations are shown in Annex J.

The water users' organization (Junta de Usuarios) collected an amount of s/.5,100.- per hectare as water charge, then an amount of its 10% paid to the government and the rest is appropriated for maintenance cost (Refer to Annex J).

In view of actual water management and maintenance of existing facilities, it seems that it needs to strengthen the organization and establishing the operation rule in order to step up to more reasonable operation.

2-4 The Problem and Necessity of Rehabilitation Project

2-4-1 The problem

As mentioned foregoings, the project area is furnished with one of the most favorable farming condition in Peru. Neverthless the agricultural production is not out of the stage of hover around, farm house-hold economy is unstable state except some farmers.

The hindrance factor is considered as follows;

(1) Water shortage caused by a mal-function for superannuated the intake facilities, irrigation cannals, regulating reservoirs etc. of irrigation facilities.

(2) Inefficient diversion structure with many simplefied inlet works installed at primitive river and increase of the maintenance cost due to silting inlet.

(3) Sufferings of headworks from flood and water shortage is accompanied with interruption of diverted water.

(4) Poor drainage in the lower part as a result of a mal-function is of superannuated or poor drainage facilities.

(5) Salt is cumulated on ground surface at poor drainage area.

(6) A mal-function of catch canal for infiltrated water, reservoir, drainage canal and well basis on the imperfection of maintenance. (Concerning the wells, over pumping up from well is one of the reason).

(7) Inundation caused by the flood of the Chancay River in lower terrace at Palpa.

(8) Shortage of storage capacity and number of reservoirsin the project area for irrigation water.

(9) A mal-function and inperfection of local and rural roads.

(10) A gap of water management level in the arable land and agricultural technology of farmers and non-planned cultivation.

(11) Delay of mechanization due to shortage of farming capital and unfavorable dealing on farming commercialization.

2-4-2 Necessity of rehabilitation plan

In view of the foregoings, it is urgentry necessary to rehabilitate the existing irrigation and drainage facilities and to construct additional facilities in the project area in order to eliminate the constraints for agricultural development and utilize effectively valuable national resources such as water and land.

A decline of productivity is not merely confined to the economical lose, but is quite capable to cause disincentive to production by farmers. Accordingly immediately action will be needed for the resolution of these problems.

There are many problems to be solved in the project area such as dissolution of water shortage, improvement of salt damaged land and a part of poor drainage area and rehabilitation and preparation of agricultural infrastructure.

For that reason, first of all, rehabilitation and or improvement of superannuated facilities in existing service inlets and canals should be done in full swing, and in addition, it is necessary to establish the comprehensive improvement plan including land use, agricultural production, farm management, irrigation water usage, and maintenance of irrigation facilities.

CHAPTER 3. REHABILITATION PLAN

CHAPTER 3. REHABILITATION PLAN

3-1 Basic Scheme

3-1-1 Determination of project area

The limit of Project area is proposed to be in 20,200 has., including the existing cultivated land from La Esparanza to coast of the lower reaches in the right bank, from Palpa to coast of the lower reaches in the left bank of the Chancay River. The area is as follows:

	Area	Irrigation area	%	Remarks
Right bank	15,184 ha	14,480 ha	72 %	
Left bank	6,016 ha	5,720 ha	28 %	
Total	21,200 ha	20,200 ha	100 %	

20 ha of irrigable land will be increased by moving the location of the La Esperanza intake to the Palpa upstream.

The reason why the above mentioned area is determined for the project area is as follows;

(1) Farm land under the irrigation system in the upper reaches from Palpa and La Esperanza is excluded from the proposed project area because of small area in terms of it scale and it can be taken irrigation water from the Chancay River into these area independently, while it seems that surplus water will return to the Chancay River in view of geographical feature.

(2) Though existing farm land in the lower reaches from Palpa and La Esperanze is separated by the irrigation system, these areas utilize the waters of the Chancay River and/or infiltrated water from the upstream area for irrigation. Regarding water use, farmer's associations (Comision and Comite de Regantes) are organized by each irrigation system and they are doing in collaboration with each other. Therefore, these areas are included in the proposed project area.

(3) Orcon River basin (one of the branches of the Chancay River) has approximately 400 has. of farm land from upper part of Palpa Alto Cannal, which is irrigated by flood (February, March) of the Orcon River and groundwater. However, pumping facility will be necessary to irrigate regularly this area because elevation of this area is higher than that of the Chancay River and operation cost of the pumping facility is also high. Therefore, this area has to be excluded from the project area.

(4) Fallow land in surrounding of the project area, called "Tierras Eriazas" is extended. Parts of this land are occasionally cultivated as farm land by utilizing surplus water of irrigation canal in the humid period of wet year.
The owners of this land have no water right and it would involve great expenses to ensure the stable irrigation water for this land, therefore, the mentioned land is excluded.
(Refer to Annex G)

3-1-2 The major components of the project

Agricultural infrastructure development, improvement and conservation of farmland should be given a priority as a measure for solution of the problems on the farming and consideration should be given to the following 3 items ;

(1) A countermeasure for water shortage

(2) Improvement of poor drainage land

(3) Improvementof damaged land by salinity or flood

The followings are also proposed to be included in the Project ;

(4) Provision of roads

(5) Enforcement of operation and maintenance organization for the adequate usage of the facilities.

(6) Reasonable water usage on the farm land.

(7) Improvement and extension of agricultural production and farm management techniques.

(8) Enforcement of cooperative organization (measurement of credit and commercialization)

As to countermeasures to solve water shortage;

- Unification and improvement of intake structures
- Linning of canals
- Installation of collecting conduit and rehabilitation of filtration canals
- Improvement and installation of additional reservoirs in the project area
- Reasonable distribution of irrigation water (regulate for water right)
- Enforcement of water management (organization and usage)
- Reasonable water usage in the farm

As to the improvement of poor drainage land;

- Installation of pipe drain for the area of 2,180 ha of which groundwater table is higher than 1.5m depth from ground surface
- Installation and improvement of drainage canal
- Enforcement of maintenance for the facilities

For the salt damaged land;

- Leaching and improvement of drain
- Use of neutralizing materials

For preventing the land (Palpa) from disaster of flood

- Establish the protection levee and improvement of drainage canal

On the occasion of carrying out these measures mentioned above, orderly implementation based on the consistently plan shall be proposed.

3-2 Irrigation

3-2-1 Water requirements

(1) Evapotranspiration

There are many methods to predict evapotranspiration for water requirements of the proposed cropping pattern. Among them, modified Penman method would offer the best results with minimum possible error. All necessary meteorological data are available in the project area to estimate crop evapotranspiration by the modified Penman method. Therefore, it is considered that the modified Penman method is the most reliable for the project.

Monthly crop evapotranspiration estimated by the modified Penman method are shown in Table 3-2-1, which are ranging between 1.57 and 3.46 mm/day.

Table 3-2-1
EVAPOTRANSPIRATION (ET^{o}) ESTIMATED BY THE MODIFIED PENMAN METHOD

Unit: mm

Month	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	AUG.	SEP.	OCT.	NOV.	DEC.	Total
Eto	3.44	3.53	2.47	2.34	2.17	1.63	1.57	1.67	2.02	2.34	2.51	3.10	873.4

(2) Irrigation duration and crop coefficiency

Irrigation duration and crop coefficiency of the crops are shown in Table 3-2-2 -- 3. 5 types of cropping pattern correspond to the farming will be proposed as explained in Chapter 4-3-3 of this report and Annex G.

Table 3-2-2 IRRIGATION DURATION OF THE PROPOSED CROPPING PATTERN

Crop	Area	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
	ha												
Fruits	6,530	----	----	----	----	----	----	----	----	----	----	----	----
Cotton	5,660	----	----	----	----	----	----	----					
Maiz	5,660						----	----	----	----	----	----	----
Beans (Dry)	2,830	----	----	----	----	----							----
Green Manure	2,830	----	----	----	----	----							----
Potato/others	900	----	----	----	----	----	----					----	----
Choclo/others	900						----	----	----	----	----	----	----
Vegetables	1,450	----	----	----	----	----	----	----	----	----	----	----	----

(3) Irrigation efficiency

Based on kind of canal lining and soil texture of the concerned area, irrigation efficiencies are decided as follows:

	Unlined canal			Lined canal		
Soil texture	Coarse	Medium	Fine	Coarse	Medium	Fine
Conveyance eff.Ec.	75%	80%	85%	95%	95%	95%
Field canal eff. Eb.	80	85	90	90	90	90
Field appli. eff.Ea.	55	60	65	55	60	65
Irrigation eff. Ep.	33	41	50	47	51	56

Having combined the above-mentioned efficiency of area classified by soil texture and total length of lined or unlined canal, over-all irrigation efficiency (Ep) is estimated at 46 percent.

(4) Total irrigation water amount

Total irrigation water amount of the project calculated by using the abovementioned in (1), (2) and (3) is annually 201.274 million cubic meters (9,964 m^3/ha), detail of which in monthly basis are shown in Table 3-2-4. Maximum water demand is 1,514 m^3/ha in January and minimum is 232 m^3/ha in July.

In addition to irrigation water, water for livestock, domestic and industrial purposes are required. Except part of domestic water, others are obtained from groundwater and annual water demand is estimated at 10.573 million cubic meters as indicated in Table 3-2-4.

3-2-2 Irrigation canal system

The existing irrigation systems will principally be left as they are.

Retes area (869 ha) where irrigation water is taken from drained water of upstream area is incorporated into Huaral irrigation system and is irrigated by the water from the Chancay River.

In left side bank area, San Jose area (847 ha) is incorporated into Palpa irrigation system in order to reduce area where recycle of irrigated water is prevailing presently.

Furthermore, drainage system on Quincha and Donoso areas are improved to solve water shortage in Los Laureles area.

The total project area classified by water resources is showing in Table 3-2-5 in comparison with present irrigation system and proposed system. (Refer to Fig.3-2-1)

3-2-3 Available water resources

Water resources of the project is mainly natural discharge of the Chancay River. Water resources for irrigation in upstream area are taken directly from the River. In middle reach and downstream area, return flow and infiltrated water from upstream area and ground water are utilized.

(1) River discharge

Natural discharge of the Chancay River is generally increased from December every year and reaches its peak in March. After having reached its peak, the river discharge is gradually decreased and becomes minimum discharge in the period from September to November. Annual total discharge is observed at around 450 million cubic meters in average of last seven years and around 230 million cubic meters in dry year. Average discharge in duration from September to November of dry year is recorded at 2.2 -- 3.0 cubic meter per second in daily average. Monthly discharge of the river of dry year with probability of 1/5 and 1/10 are showing in Figure 3-2-2.

(2) Lagoons located in upstream area

25 natural lagoons are existed in upstream area of the Chancay River. Among them, 5 lagoons, namely, Quisha, Aguashuman, Yuncan, Chungar and Chancan are used as water resources for the project because storage water of these lagoon can be controlled by dikes and regulating gates.

According to the record during the past ten years, maximum water amount released from the lagoons is estimated at approximately 30 million cubic meters per year. Taking into consideration loss of the released water due to long distance between lagoons and the project area, available water amount of the river at Santo Domingo is estimated at 24 million cubic meters which is equivalent to 80 percent of above mentioned 30 million cubic meters.

(3) Recycled water resources

Total area where recycled water which includes infiltrated water and return flow from upstream area as mentioned before, are 3,820 ha for year round use and 3,400 ha for only dry season utilization. Accordingly, total area using return flow is 7,220 ha. Return flow ratio between return flow and intake water amount from the river is calculated using record observed by ATDR Chancay - Huaral office as follows:

Correlation formular: $Re = 12.804 \times Q^{-0.5447}$

Correlation coefficiency: $r = 0.91$

Return flow ratios of irrigation blocks in dry year are showing in Table 3-2-6 and are calculated at 49 to 65 percent.

(4) Groundwater

Groundwater amount utilized actually for irrigation is shown in Table 2-3-7.

Among these years, year of 1979 is equivalent to hard droughty year (see Table 2-1-1) and water amount of 20.51 million cubic meter is quite big amount compared with normal years and seems to be over pumping up.

Groundwater amount available constantly every year will be 11.6 million cubic meters per year, as described in 2-1-3. The maximum groundwater amount per month will be available at 2.7 million cubic meters judging from capacity of the existing pumping facilities.

Table 3-2-3 Crop Coefficiency (Kc)

Cultivos	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.
Fruits	0.15	0.25	0.45	0.70	0.85	0.90	0.65	0.40	0.20	0.10	0.08	0.08
Cotton	0.15	0.35	0.65	0.85	1.01	1.02	0.92	0.57	0.25			
Maize						0.12	0.32	0.66	0.89	0.94	0.60	0.25
Beans	0.47	0.82	0.91	0.61	0.25							0.17
Potato	0.58	0.83	0.92	0.73	0.47	0.21					0.13	0.31
Choclo (Maiz)						0.10	0.33	0.59	0.84	0.74	0.52	0.25
Green Manure (including vegetable)	0.42	0.73	0.83	0.58	0.27							0.17
Vegetable (2) (double cropping)	0.45	0.40	0.70	0.55		0.40	0.70	0.55	0.30	0.60	0.70	0.70

Table 3-2-4 Total Water Demand of the Project

Unit: thousand cubic meter

Month		AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.	Total
Irrigation	N.W.R.	2,860	5,655	9,710	10,694	12,650	14,068	12,422	8,341	6,285	5,049	2,696	2,156	92,586
	G.W.G.	6,217	12,293	21,109	23,248	27,500	30,583	27,004	18,133	13,663	10,976	5,861	4,687	201,274
Water Demand for Other Purpose	Live-stock	87	87	87	87	87	87	87	87	87	87	87	87	1,044
	Domes-tic	792	776	792	776	792	792	746	792	776	792	776	792	9,394
	In-dustrial	11	11	11	12	11	11	11	12	11	11	11	12	135
	Sub-total	890	874	890	875	890	890	844	891	874	890	874	891	10,573
Total		7,107	13,167	21,999	24,123	28,390	31,473	27,848	19,024	14,537	11,866	6,735	5,578	211,847

° Water amount for livestock is derived from present water consumption.

° Water amount for domestic purpose is estimated at double amount of present consumption based on the long term development program prepared by SENAPA (Water Supply Bureau)

° Water amount of Industrial purpose is estimated by the present capacity of the facilities.

° N.W.R.: Net Water Requirement

° G.W.R.: Gross Water Requirement

Table 3-2-5 Commanding Area in Systemwise

Source of Irrigation Water	Existing System					Proposed System				
	Left Bank		Right Bank		Total	Left Bank		Right Bank		Total
	System	Area	System	Area		System	Area	System	Area	
		ha		ha	ha		ha		ha	ha
Chancay River	ESPERANZA	3,231	PALPA	1,575		ESPERANZA	3,440	PALPA	3,037	
	MALACA	9	CAQUI	615		HUANDO, CHANCAY-HUARAL	8,219	(Incl'd CAQUI, SAN JOSE)		
	HUANDO	1,416								
	CHANCAY-HUARAL	5,934								
					12,780	(Incl'd RETES)				14,696
Chancay River + Return Flow	SALINAS ALTA	183	SANJOSE	847		SALINAS ALTA	281	BOZA ALTA	779	
	" M_1	79	BOZA ALTA	779		" BAJO	165	BOZA BAJA	676	
	" M_2	19	BOZA BAJA	388				PASAMAYO BAJO	651	
	" BAJO	165	PASAMAYO ALTO	271						
			MONTE CHICO	17						
			PASAMAYO BAJO	579						
			HANGLAR	72	3,399					2,552
Infiltrated Water	RETES	869	MIRA FLORES	577		CHANCAYLLO	1,799	MIRA FLOW	577	
	CHANCAYLLO*	1,799				DONOSO	576			
	DONOSO	576			3,821					2,952
Total		14,280		5,720	20,000		14,480		5,720	20,200

* *ELHTCCO (184 ha) is included in CHANCYLLO.*

Table 3-2-6 Return Flow Ratios of Irrigation Blocks in dry year, 1979

unit: x 10^3 m^3

Irrigation Block		Sep.		Oct.		Nov.		Dec.		Decided Re
		Q	Re	Q	Re	Q	Re	Q	Re	
Right Side Bank [ESPERANZA + HVANDO + HUARAL] ↓ [CHANCAYLLO]	Up stream	5,339	%	4,819	%	5,089	%	6,166	%	
	Down stream	3,388	63	3,578	74	3,315	65	3,983	65	65
Left Side Bank [PALPA + CAQUI] ↓ [MIRA FLORES]	Up stream	1,540		1,484		1,542		1,888		
	Down stream	899	62	927	62	871	57	924	49	49
[MIRAFLORES, SANJOSE] ↓ [BOZA ALTO, BOZA BAJO, PASAMAYO ALTO]	Up stream	1,519		1,556		1,392		1,352		
	Down stream	1,078	71	1,159	75	972	70	934	69	69
[MIRA FLORES - PASAMAYO ALTO, SANTA ROSA] ↓ [SALINAS + PASAMAYO BAJO]	Up stream	3,015		3,117		2,752		2,806		
	Down stream	1,881	62	1,917	62	1,575	57	1,835	65	57

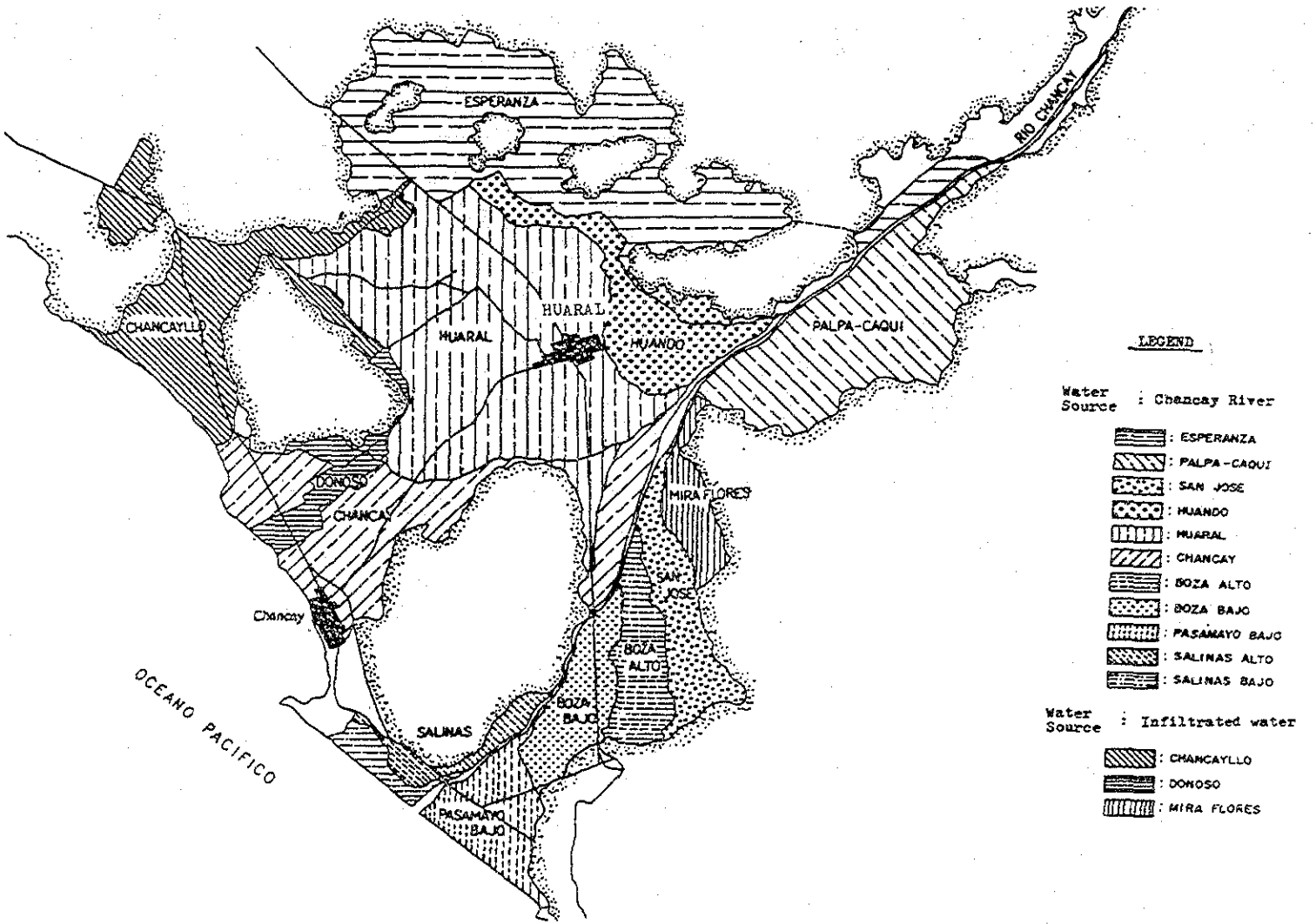


Fig. 3-2-1 Proposed Irrigation System

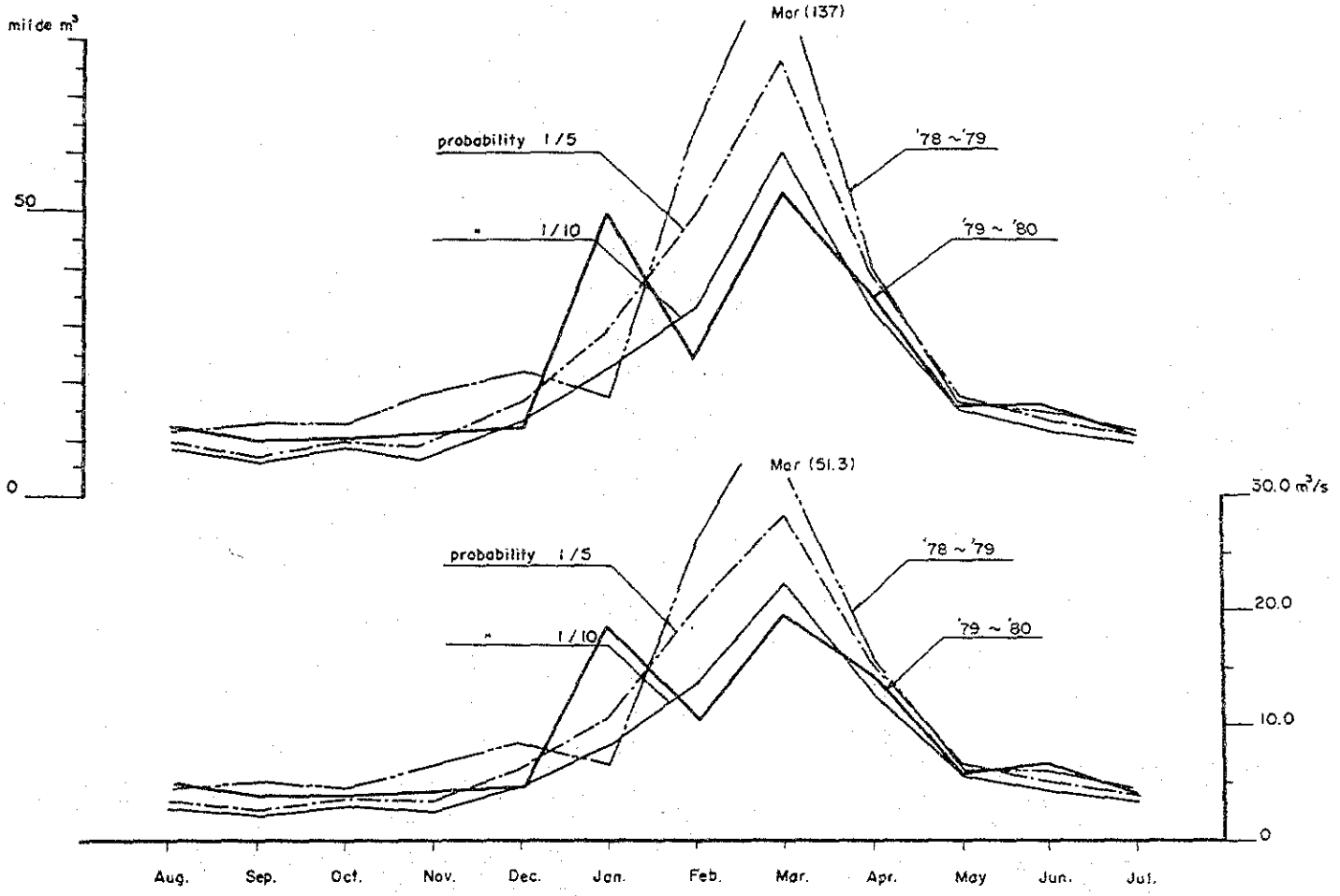


Fig. 3-2-2 Probable Discharge of Chancay River
(At Santo Domingo)

3-2-4 Water balance study and water utilization program

(1) Water balance study

In order to carry out water balance study, water management rules are determined as follows;

1) Priority should be given to irrigation water in management of logoons water. Accordingly, hydro-power should be generated using water released for irrigation from the lagoons.

2) During wet season or rainy season (February to March), river discharge should be stored in the lagoons and stored water of the lagoons should be released during dry season (September to December).

3) Intake structure site should be a control point to check river discharge and the released water amount from the lagoons will be decided taking into account the discharge of the river at the control point and irrigation water demand of the project area downstream.

4) When the stored water amount reaches full level of the lagoons reservoirs of total storage 30,000,000m^3 or more by end of rainy season, the stored water should be released in line with the rules as presented below.

Month	Sept.	Oct.	Nov.	Dec.
Accumulated available quantity	m^3 <4,500,000	m^3 <11,500,000	m^3 <32,500,000	m^3 <30,000,000

When the stored water does not reach full level, the stored water should be released in line with the following formula.

The stored water amount ÷ 30 million m^3 x 100%

5) The order to be released should be as follows:

(1) Aguashuman, Yuncan and Chungar
(2) Chancan
(3) Quisha

The ratios of return flow for each irrigation block are selected as showing in the Table 3-2-7 and Fig.3-2-3.

6) When the irrigation water by discharge from lagoons is insufficient, the groundwater will be used.

The order of released water from the lagoons is determined for the following reasons :

- In related area to Aguashuman, Yunkan, and Chungar lagoons, the hydro-power stations are installed in the comparatively upper reaches. Therefore, there is not enough river water at droughty period in order to generate hydro-power. It is necessary to release water from these lagoons when natural water is not enough for this purpose.

- In related area to Chuncan lagoon, the hydro-power station are located the downstream. Accordingly, natural water of the downstream area from the lagoon is enough more than the first case.

- There is not hydro-power station in the Quisha area, therefore, storage water of the Quisha lagoon must be remained as much as possible for emergency use.

Water balance on the project area were examined for the folloing cases ;

a. Dry year of 1/10 in probability of the Chancay River,
b. Dry year of 1/5 in probability of the Chancay River and
c. Six years starting from 1978 and ending at 1983.

The results of the study are as follows:

In case of 1/10 of dry year, water shortage of 0.64 million cubic meters is estimated in Boza area. (However, this defect can be covered by water amount collected through collecting conduit. See 3-2-4, 2)

In case of 1/5 dry year, surface water resources are enough to supply irrigation water. Therefore, pumping up the groundwater is not necessary.

In case of five years from 1978 to 1983 without 1979/1980, the river discharge is enough every year to distribute irrigation water to the entire project area. (However, the defect in 1979/1980 can be also covered by collecting conduit.)

Even in case of comparative study that field application efficiency is anticipated to be less than the designed efficiency, no shortage of irrigation water is observed in 1/5 dry year.

(2) Water utilization program

Priority of available water resources is given to the natural discharge of the Chancay River. Irrigation water will be taken successively from upstream of the Chancay River. When the Chancay River discharge exceeds the required irrigation water, surplus water will be distributed as leaching water to remove salinity problem and will be supplied to groundwater.

The water amount of 30.0 million can be available from a series of lagoons located in upstream of the river as mentioned before.

The area using the return flow from upstream can be supplied enough irrigation water from return flow if the existing irrigation system remains as it is and sufficient irrigation water is given to the upstream area. However, water resources of Retes area (869 ha) in right side bank and San Jose area (847 ha) in left side bank can be shifted to

the river discharge instead of return flow which will be converted to other area with water shortage. Drained water from Dren Quincha is brought to Chancay Bajo area remaining enough water to the Chancayllo area in order to utilize infiltrated water reasonably.

Available water amount of groundwater will be 11.6 million cubic meters, of which 10 percent will be used in other purposes excluding agriculture. Twenty six places of registered pumping station for irrigation can be seen in the project area (pumping capacity is counted at 1.257 cubic meters per second). However, maximum practical pumping capacities considered to be 1.0 cubic meters per second. (Monthly average of water lifted by the pumping facilities is limited to 2.7 million cubic meters.) It is used for supplemental irrigation water during dry period from June to January.

The results of water balance study shown that Boza Alto and Pasamayo Alto area located in middle reach of left side bank of the river can not be supply enough irrigation water during dry season. Therefore, a new cellecting conduit must be provided to secure sufficient irrigation water. Downstream from the proposed collecting conduit, there are three existing intake structures, which can take enough irrigation water from the river discharge because sufficient return flow can be anticipated in downstream of the Chancay River. (Refer to Annex G).

Available water amount classified by water resources is shown in Table 3-2-9. During dry season, if discharge amount of the Chancay River decreased less than the water requirements of Esperanza, Palpa and Huando area, discharge amount of the Chancay River should be allocated depending upon the ratio of water requirements in the three areas.

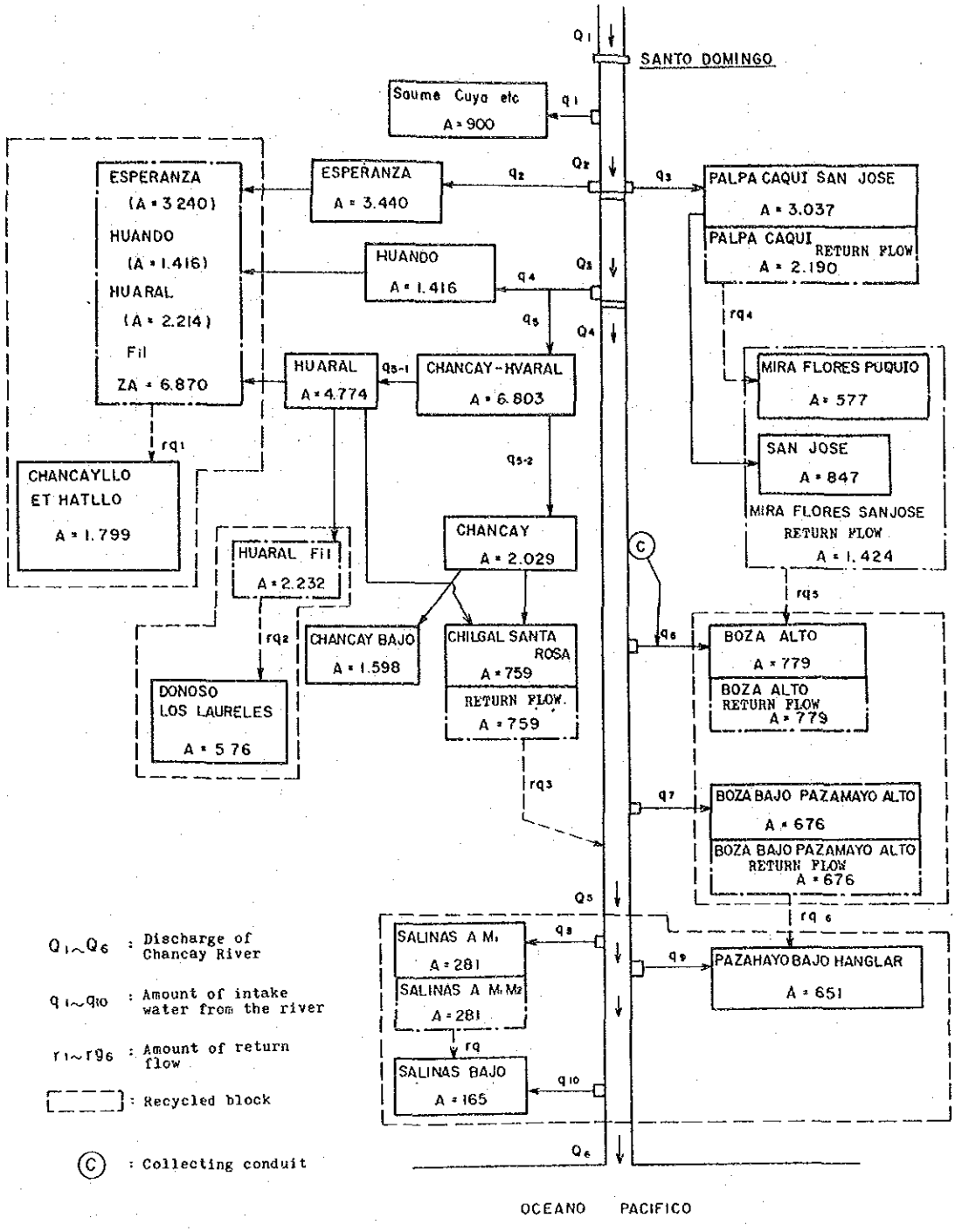


Fig. 3-2-3 Diagram of Proposed Irrigation System

Table 3-2-7 Return Flow Ratio

	Upstream Irrigation Block	Return Flow Ratio	Downstream Infiltrated Water Block	Area Ratio
Annual Utilization	ESPERANZA HUANDO HUARAL [6.870 ha]	65 % ⟶	CHANCAYLLO EL HATILLO [1.799 ha]	26 %
	HUARAL [2.232 ha]	65 % ⟶	DONOSO LOS LAURELES [576 ha]	26 %
	PALPA CAQUI [2,190 ha]	49 % ⟶	MIRA FLORES [577 ha]	26 %
Utilization of Dry Season	MIRA FLORES SAN JOSE [1,424 ha]	69 % ⟶	BOZA ALTO, BOZA BAJO PASAMAYO ALTO [1,455 ha]	102 %
	MIRA FLORES, SANJOSE, BOZA (A, B) PASAMAYO A. SANTA ROSA [3,638 ha]	57 % ⟶	SALINAS A, M_1 M_2 B PASAMAYO BAJO, HANGLAR [1,097 ha]	30 %

Dry Season; September - January (5 months)

Table 3-2-8 Results of Water Balance Study

Unit: $10^3 m^3$

Year	River Discharge at PALPA	Total Demand	Water usage in water sourcewise: River Discharge	Return flow	Release from Lakes	Groundwater: For Agriculture	Groundwater: Others	Collecting conduit	Utilizing ratio of River Discharge (including of lake water) %	Remarks
Probable year 1/5	282,028	211,847	145,397	43,157	22,114	-	1,179	-	59	
Probable year 1/10	222,189	211,847	131,643	46,058	24,000	8,326	1,179	641	70	
'78 - '79	357,749	211,847	149,592	46,087	14,989	-	1,179	-	46	
'79 - '80	247,164	211,847	135,156	43,135	24,000	7,948	1,179	429	64	
'80 - '84	594,372	211,847	168,913	38,826	2,929	-	1,179	-	29	
'81 - '82	401,760	211,847	171,424	37,423	1,821	-	1,179	-	43	
'82 - '83	594,751	211,847	171,026	35,330	4,312	-	1,179	-	29	
'83 - '84	528,431	211,847	160,428	39,657	10,583	-	1,179	-	32	
Comparative study										
Incase that water management is insufficient (provable year 1/5)	282,028	231,016	154,508	47,097	24,000	4,232	1,179	-	63	

* Details are shown in Annex.

Table 3-2-9 Water Utilization Program

unit: $10^3 m^3$

Water Source	Intake	Month	AUG.	SEP.	OCT.	NOV.	DEC.	JAN.	FEB.	MAR.	APR.	MAY	JUN.	JUL.
Maximum Intake water amount from the River	Palpa	Palpa	1,278	1,903	3,206	3,399	3,860	4,252	3,902	2,721	2,129	1,746	934	741
		Esperanza	630	1,256	2,556	3,870	5,824	6,763	4,675	2,360	1,221	678	365	334
	Huando		3,390	6,006	9,588	10,133	11,598	12,532	11,484	8,307	6,676	5,552	3,260	2,734
	Boza Alto		263	512	864	890	962	1,077	1,041	738	578	494	269	214
	Boza Bajo		228	444	750	773	835	934	903	640	502	429	233	186
	Salinas Alto		115	216	358	350	347	392	405	400	244	217	122	99
	Pasamayo Bajo		220	428	722	744	804	900	870	616	483	413	225	179
	Salinas Bajo		67	127	210	205	204	320	238	176	143	127	71	58
	Total		6,191	10,892	18,254	20,364	24,434	27,080	23,518	15,858	11,976	9,656	5,479	4,545
Released water from lake	Water reached full level up to end of May			upto 9,500	upto 11,500	upto 22,500	upto 30,000	-	-	-	-	-	-	
	Other cases as above		Release at the rate of strage water amount ÷ 30,000 x 100% of the above figure.											
Groundwater	Utilizing Water Amount of Groundwater				2,650	2,600	2,650	2,650	Total [10,550]					
	Utilizing Program		During dry season from Sept. to Jan., less than $1.0m^3$ can be irrigated supplimentally. Annual available water amount will be 10,550 m^3.											
	Utilizing Water Amount		During dry season from September 50 January, 0.1 m^3 will be distributed to the area from Boza alto to Pasamayo Alto.											

3-2-5 Distribution scheme

(1) Distribution system

Irrigation water taken from each intake structure will be distributed to the farm area through main and lateral canals and farm ditches. Regulating reservoir will be provided in vicinity of turn-out and lower area of the canal as shown in Fig.3-2-4.

The purpose of these reservoirs is for saving water resources and reducing farmer's labor for irrigation during night time.

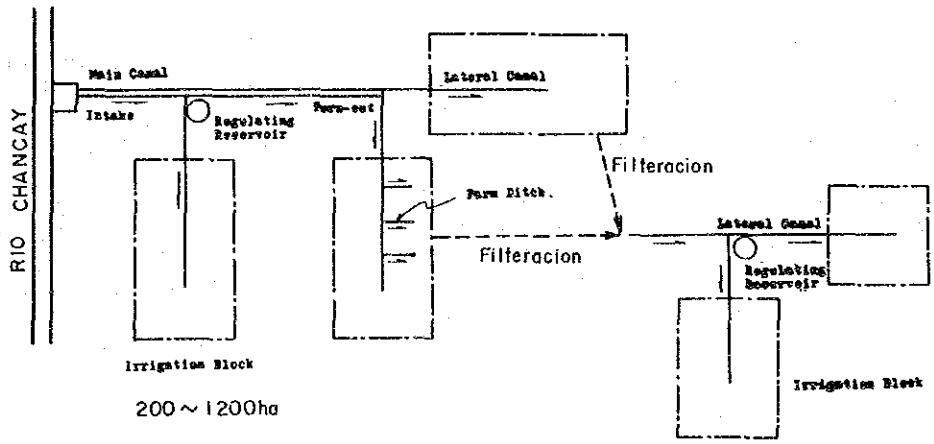


Fig. 3-2-4 DIAGRAM OF DISTRIBUTION SYSTEM

(2) Capacity of distribution system

1) Main irrigation canal

Required irrigation water shall be delivered within 24 hours through the main irrigation canals.

Design discharge will be estimated by means of irrigation area multiplied by diversion water requirement at the peak time. (Refer to Table 3-2-10)

2) Lateral irrigation canal

Lateral irrigation canals are diverted from the main irrigation canals and delivered the water which regulated by diversion structure and regulating reservoir to the irrigation block.

Lateral irrigation canals are designed having a capacity which could be irrigated the irrigation block in the daytime at the peak.

Farm ditch shall be designed as same as lateral irrigation canals.

3) Regulating reservoir

13 reservoirs are utilized as the regulating reservoir in the project area. Capacity of existing reservoirs are ranged 7,000m^2 - 27,800m^3 (13,000m^3 in average) and it is insufficient under the existing conditions.

For the proper distribution of the irrigation water, enlargement and improvement of the existing reservoirs will be required and other 5 regulating reservoirs will newly be constructed.

Capacity of each reservoirs are shown in Table 3-2-11 -- 12.

4) Collecting conduit

As the new water resorce, collecting conduit which can take 0.1m^3/sec will newly be constructed to the upstream along the river side of Boza Alto, and delivered the water to Baza Alto canal.

(3) Modification of the existing irrigation network

Currently, 17 intake structures exist along the Chancay River downstream from Palpa. In order to take river discharge effectively, 17 intake structures are integrated into 7 places and connecting canals are furnished for area of Esperanza, Chancay Huaral, Palpa, Caqui, Pasamayo Alto and Salinas.

Together with integration of the intake structures, presently recycled area, namely San Jose (847 ha) in left side bank and Retes (869 ha) in right side bank are converted to area irrigated directly from river discharge. In addition, return flow of Quincha Drain is re-used to Chancay Bajo area so as to utilize return flow efficiently as described in 3-2-2. However, in this case attention should be paid not to affected adversely to Chancayllo area.

These modification are showing in Fig.3-2-5.

3-2-6 On-farm irrigation

(1) Irrigation manner

Project area is mainly occupied by farm land which is divided into two parts, one is orchard area in upstream and another is mono crop cultivation area (cotton, maize and vegetables) in middle reach and downstream. Project area is gently sloped at 1 to 2 degree and furrow irrigation is prevailing. The basic intake rate of the area is observed at 20 to 60mm per hour normally. More than 100mm per hour of intake rate is observed in some part of coarse sand area.

Taking into consideration farm management and economic condition, prevailing furrow irrigation manner is selected for the Project.

(2) Amount of each irrigation and irrigation interval

Net amount of each irrigation (T.R.A.M.) is 30 to 70mm depending upon the kinds of crops and soil textures (Refer Table 3-2-13). Accordingly, irrigation interval will be 12 to 20 days. For this Project, 10 days interval at peak of water requirements is selected following the present furrow irrigation manner. Interval of normal irrigation period will vary by irrigation hours per day.

(3) Daily irrigation hour

Irrigation hour can be calculated by using crop water requirements and available irrigation water amount to the farm area. Taking 15 liter per second as being used currently for available irrigation water amount, irrigation hour can be estimated at 8 to 12 hours at peak as indicated in Table 3-2-14.

(4) Rotation block

Commanding area of a lateral canal in this project is ranging from 100 to 200 ha which can be irrigated every day as one block. If this area should be irrigated within 10 days, area of one rotation block is 10 to 20 ha. In other word, commanding area of a lateral canal can be irrigated within 10 days in case that 10 to 20 ha of one rotation block would be irrigated one by one every day. Accordingly, 0.15 to 0.30 cubic meter of irrigation water should be supplied to one rotation block at peak period.

Table 3-2-10 Canal Capacity

Irrigation Block	Canal	Irrigation Area	Unit water Requirement	Net Water Requirement	Irrigation Efficienty	Diversion Requirement	Canal Capacity
ESPERANZA	ESPERANZA	3,440 ha	0.358 l/s/ha	1.23 m^3/sec	35 %	3.51 m^3/sec	3.51 m^3/sec
	CABUYAL ALTO	1,192	"	0.43	48	0.90	1.80
	GRANADOS	1,818	"	0.65	"	1.35	2.70
HUANDO CHANCAY-HUARAL	HUANDO	1,416	"	0.51	35	1.46	1.46
	CHANCAY-HUARAL	6,803	0.347	2.36	41	5.76	5.76
	HUARAL	4,774	"	1.66	51	3.25	3.25
	CHANCAY	2,029	"	0.70	42	1.67	1.67
SALINAS	SALINAS ALTO	281	0.341	0.10	38	0.26	0.26
PALPA-CAQUI	PALPA	3,037	0.347	1.05	41	2.56	2.56
	PALPA BAJO	2,270	"	0.79	51	1.55	1.55
	CAQUI	1,462	"	0.51	"	1.00	2.00
SAN JOSE	SAN JOSE	847	"	0.29	"	0.58	1.16
BOZA PASAMAYO	BOZA ALTO	779	"	0.27	"	0.54	0.54
	BOZA BAJO	676	"	0.23	"	0.46	0.46

Table 3-2-11 Proposed Storage Capacity of Existing Reservoir

Name of Reservoir	Location	Existing Condition: Storage Capacity (m^3)	Existing Condition: Beneficial Area (ha)	Required Beneficial Area (ha_1)	Proposed Storage Capacity (m^3)	Assumption: Crop	Assumption: ETc (mm/day)	Assumption: Irrigation Efficiency (%)
Esperanza	La Esperanza	42,000*	1,270	-	-	Fruits	3.1	47
Huando	Huando	13,600*	400	-	-	Fruits	3.1	47
Jesus Del Valle	Huaral	24,600	570	800	34,100*	Cotton Maize	3.5	41
Cerrito	Huaral	12,000	270	410	17,700*	Cotton Maize	3.5	41
Quepepampa	Chancay (Quepepampa)	10,800	300	420	13,800*	Cotton Maize	3.5	50
Buena Vista	Chancay (Torre Blanca)	11,300*	430	-	-	Maize Vegetable	2.6	50
Galeano	Chancay (Torre Blanca)	12,000*	460	-	-	Maize Vegetable	2.6	50
Laureles	Chancay (Laureles)	16,300*	620	-	-	Maize Vegetable	2.6	50
Chancay Bajo	Chancay	7,300	210	270	9,300*	Maize Vegetable	2.6	38
Chancayllo	Chancayllo (San Cayetano)	12,000*	350	-	-	Maize Vetable	2.6	38
San Juan	Chancayllo (San Juan)	5,000	140	210	7,300*	Maize Vegetable	2.6	38
Palpa	Palpa	33,800	920	1,100	40,200*	Cotton Maize	3.5	48
Niraflores	Niraflores	20,700*	500	-	-	Cotton Maize	3.5	39
Total		221,400						

Note: - The storage capacity has been estimated assuming that the volume correspond to the diversion water requirement for 12 hours.

- Proposed storage capacity (marked *) is 250,300 m^3 in total.

Table 3-2-12 Capacity of Proposed Reservoir

Name of Reservoir	Location	Beneficial Area ha	Required Strage Volume m^3	Asamption: Crop	ETc mm/day	Irrigation Efficiency %	Diversion Requirement m^3/S
Res. GRANADOS 1	Divergent point between CABYAL BAJO and CAYO MURILLO	420 (Villa Garcia 112Ha Cayo murillo 308Ha)	13,850	Fruits	3.1	47	0.321
Res. GRANADOS 2	Divergent point between VIRGEN GRANADOS and LAT-3 GRANADOS	570 (Granados)	18,800	Fruits	3.1	47	0.435
Res. AUCALLAMA	Midstream in SAN JOSE	450	16,420	Cotton, Maize	3.5	48	0.380
Res. LOS LAURELES (BAJO)	Midstream in LOS LAURELES	400	12,700	Maize, Vegetable	2.6	41	0.294
Res. BOZA BAJO	Divergent point between BOZA BAJO and PASAMAYO ALTO	680	14,510	Cotton, Maize	3.5	41	0.346
Total			76,280				

Note: - The storage capacitis of the reservoirs except Res. Boza Bajo are of diversion water requirement for 12 hours.

- The storage capacity of Res. Boza Bajo is equivalent to the valume of diversion water requirement for 6 hours.

Table 3-2-13 Irrigation Water Amount of the Crops and Irrigation Interval

Crops	Soil Texture	Trem mm	Field Application (E) %	Water Requirement mm	Water Demand per ha m^3/ha	Max etc mm/day	Irrigation Interval day
Fruits	Coarse	42.00	55	76	760	3.1	13
Cotton	Medium	76.13	60	127	1,270	3.8	20
	Coarse	60.30	55	110	1,100	3.8	18
Maiz (Frijol Papa)	Medium	57.00	60	95	950	3.3	17
	Coarse	45.23	55	82	820	3.3	13
Vegetable	Medium	38.08	60	63	630	2.5	15
	Coarse	30.15	55	55	550	2.5	12

Table 3-2-14 Irrigation Hour

Crops	Water Requirement at Peak mm/day	Irrigation Interval (day)	Total Water Demand per ha mm/ha	Total Water Demand per ha m^3/ha	Inflor Water Amount l/sec	Irrigation Hour (hr)
Fruits	3.1	10	56	560	15	10.4
Cotton	3.8	"	63	630	"	11.7
Maiz	3.3	"	55	550	"	10.2
Vegetable	2.5	"	42	420	"	7.8

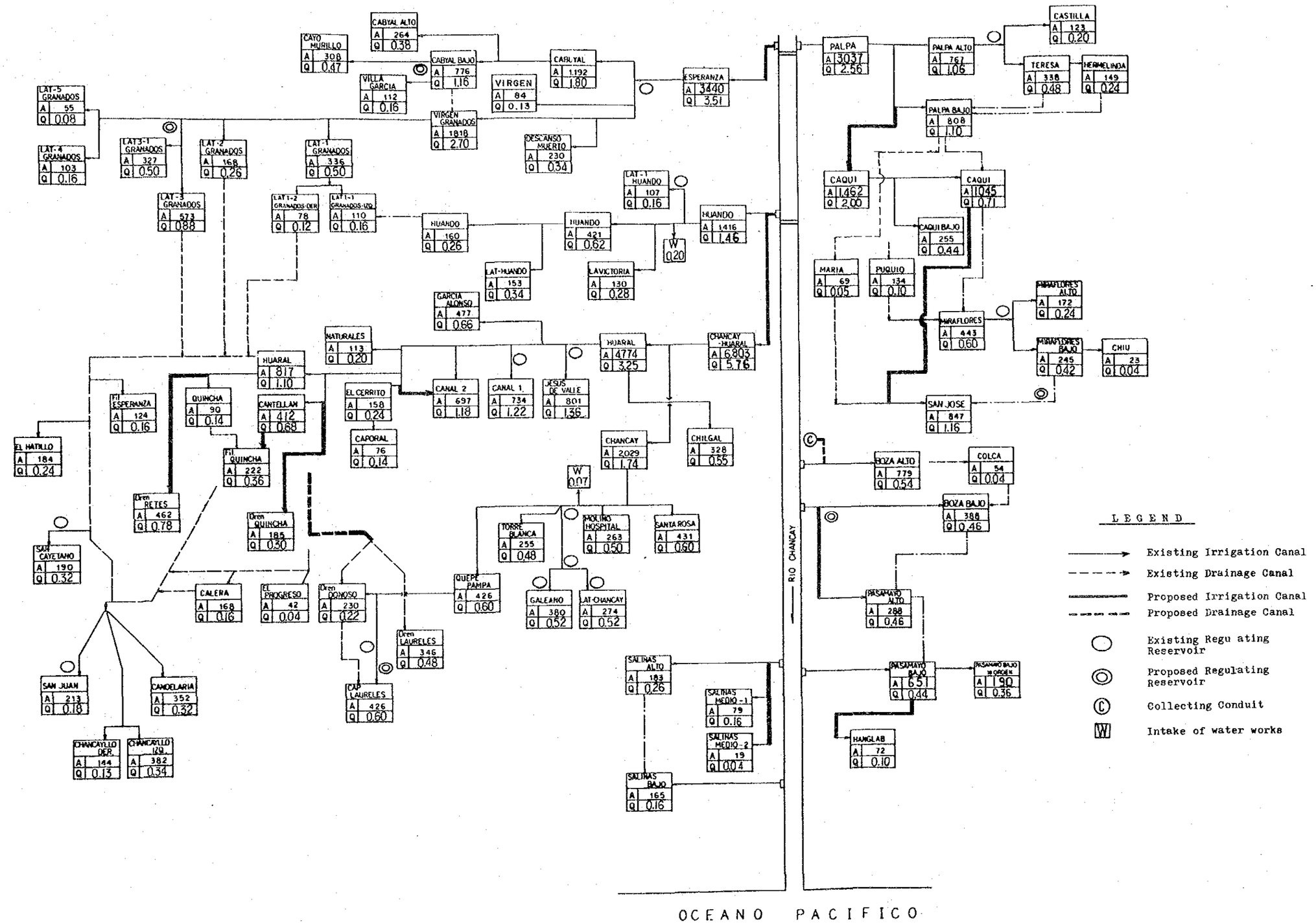


Fig. 3-2-5 Modified Irrigation Network

3-3 Drainage

3-3-1 Drainage condition of the project area

Soil of the project area is composed of alluvium materials conveyed by the Chancay River. To say generally, alluvium materials includs mainly coarse sand and have considerably good permeability. On the contrary, soil of downstream area extended along the coast is consisted of medium and fine soil. The downstream area is poor drainage condition due to underground formation. Coefficient of water conductivity in this area is 1.5 to 5.0 x 10^{-3} centimeter per second.

Depth of root zone of the proposed crops is 0.60 to 1.50m. Therefore, area of 2,180 ha is taken up to the project as drainage improvement component because depth of groundwater level is less than 1.50 meter.

Arera classified by depth of ground water level is shown as below.

	Depth of groundwater		
Area	0 to 1.0m	1.0 to 1.5m	Total
Quincha	420 ha	390 ha	810 ha
Donoso	360	510	870
Boza	60	90	150*
San Luis	120	130	250
Lunavilca	30	20	50
Palpa	-	50	50
Total	990	1,190	2,180

* Except surrounding area of Boza Bano

Location of these area are indicated in Fig.3-3-1.

Groundwater of the project is originated from infiltrated water of irrigation in upstream area and utilized as water resources of

downstream area. Groundwater is affected by topographical condition. Underground flow route can be classified into three directions, namely Quincha to Chancayllo, Donoso to Lavreles and Rio Chancay to Pasamayo, Salinas. Poor drainage areas are located on these underground flow lines.

3-3-2 Drainage improvement

(1) Principal concept

Poor drainage condition is caused by topography of underground geological formation, not by soil texture. Groundwater level of some area is located in shallow depth from ground surface which results in salinity problem. Reasonable drainage improvement measures will be necessary for these area.

In order to carry out effective leaching by lowering groundwater level, appropriate patten of drainage canal system should be provided and pipe drains should also be furnished in farm land through which excess water contained in soil must be removed as fast as possible.

(2) Drainage canals

Drainage canals are classified into intercepting canal main and lateral drainage canals depending on topographical characteristics of the area.

Interval of the drainage canals will be between 300 and 500 meters taking into account present pattern of farm lots and topography of the area.

(3) Pipe drains

Pipe drains will be installed at depth of 1.50 to 2.00m (average 1.80m) from ground surface and connected to drainage canal. Interval of pipe drain lines is calculated at 60m by Hooghoudt's Formular. The

interval of 40 m will be adopted in the same area considering size of a farm lot and soil texture.

3-3-3 Design of drainage canals

(1) Designed drainage water amount

Drainage canals are classified into two categories, one is intercepting canal which receives drainage water from outside of the area, and another is drainage canal located in the area. The following figures are taken to design each of them.

In case of drainage canals in the project area:

q_1 = water amount from pipe drain (4mm/day) + infiltrated water from irrigated upstream area (2mm/day)

(Surplus irrigation water is not counted in above equation because of canal sections has sufficient capacity.)

In case of intercepting canal:

q_2 = infiltrated water from upstream and outside of the area

(2) Typical cross section of drainage canals

Depth of intercepting canal and main drainage canal will be 2.50m and that of lateral drainage canal will be 2.20m.

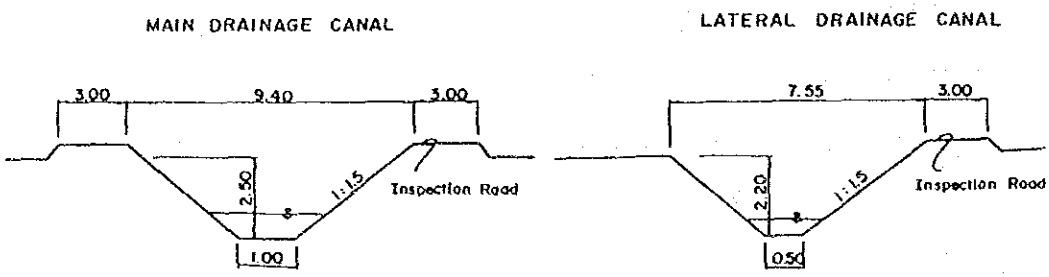
Slope of embankment is 1 : 1.5,variable by soil condition.

Maximum flow velocity is 0.80m/second and drop structure will be constructed, if necessary.

Operation and maintenance roads will be attached to both side of catch drain and main canal, and one side of lateral drainage canal.

As an alternative plan, canal lined with concrete panel is studied to save area occupied by canal. However, trapezoidal cross section without lining is more economical because cost of land aquisition is cheaper compared with cost of lining material.

Typical Cross Section of Drainage Canal



3-3-4 Design of pipe drain

(1) Designed drainage water amount

Designed drainage water amount is 4.0 mm/day which is calculated as follows:

Maximum irrigation water amount (7.0 mm/day)
- Evapotranspiration of the crops (3.0 mm/day)

(2) Pattern and material of pipe drain

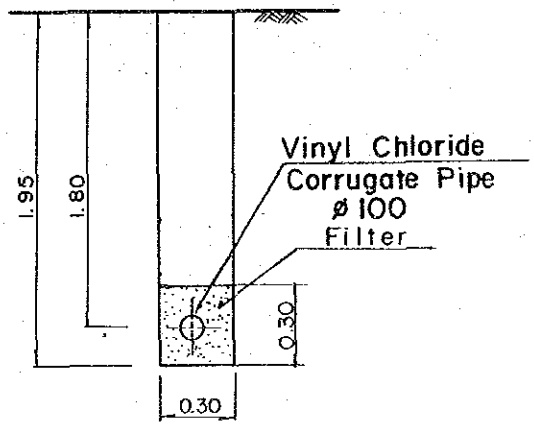
Layout of pipe drain system will be parallel pattern or herring bone pattern in line with topography and slope of the area. Every pipe drain system is connected with one of lateral drainage canals.

Depth of pipe drain is 1.80m in average (1.50m to 2.00m) and ditch for pipe drain is excavated by large size of trencher.

100mm is diameter of pipe drain which is corrugated poly chloride vinyl pipe. Pipe drain is packed by filter material such as small size of gravel.

The standard section of filter material for drain is designed with 30cm x 30cm. However, 30cm x 80cm section of filter material is considered to be desirable at area of clayey soil.

Typical Cross Section



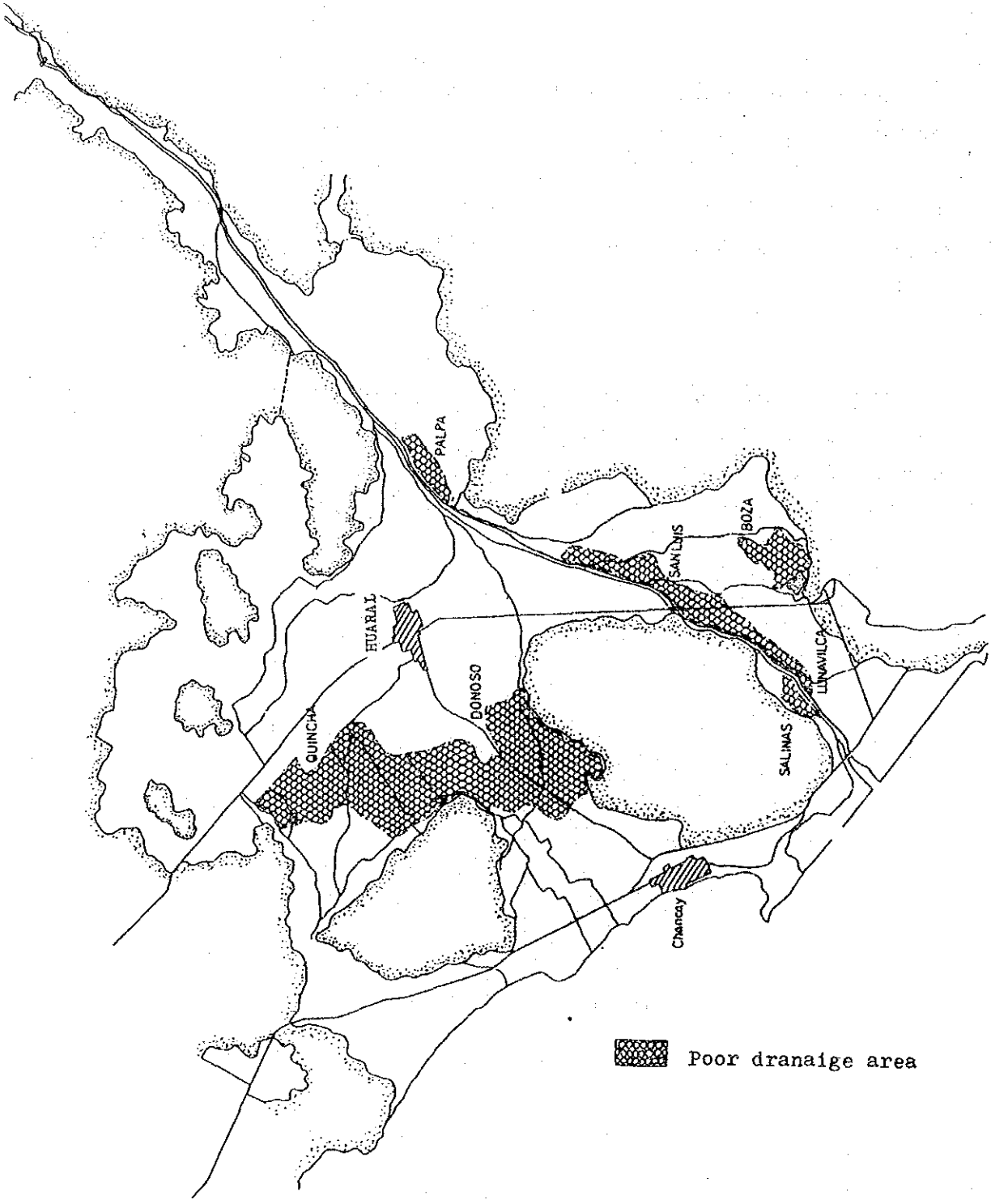


Fig. 3-3-1 Poor Drainage Area