REPUBLICA DEL PERU

MINISTERIO DE AGRICULTURA
INSTITUTO NACIONAL
DE
AMPLIACION DE LA FRONTERA AGRICOLA
(INAF — PE-REHATIC)

FEASIBILITY STUDY ON CHANCAY-HUARAL VALLEY REHABILITATION PROJECT

ANNEX (VOLUME II)

MARCH 1985

JAPAN INTERNATIONAL COOPERATION AGENCY

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INTRODUCTION

The feasibility study on the Chancay - Huaral Valley Rehabilitation Project has been carried out by the study team, dispatched from the Japanese government (JICA), started on February 15, 1984. This report was prepared based on the result of field and home studies.

The report is compiled by the following four volumes.

- Main report (English)
- Annex (English)
- Drawings (English)
- Summary (Spanish)

The annex comprising two volumes are attached to the main report.

Volume I

Annex A Meteorology and Hydrology
Annex B Geology and Ground water
Annex C Soil and land classification
Annex D Salinity control
Annex E Agriculture
Annex F Agricultural economy

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IRRIGATION AND DRAINAGE

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G. Irrigation and Drainage

1 Project Area

1-1 Extent of Project Area

Service area of the project extends from La Esperanza to the edge of coast in the right bank of Chancay river, and from Palpa to that in the left.

Service area is the cultivated land, shown as follows:

Bank	Gross Area	Net Area	Ratio
	ha	ha	%
Right	15,184	14,480	72
Left	6,016	5,720	28
Total	21,200	20,200	100

Table G-1-1 and G-1-2 present the block area and commanding area in system wide respectively.

1-2 Study on Scope of Project Area

Cultivated land of 22,000 ha in gross has an extension in the Chancay-Huaral Valley. There are non-cultivated areas called "Tierra Eriasas" around the cultivated land.

Assumed that irrigation water would be supplied to this non-cultivated land, the crops would be grown. Then, the following subjects were considered on scope of the project area.

(1) Problem to be soluted covering non-cultivated land.

- Comprehensive water resource development whole Chancay river basin,

- Contrive of irrigation water by making the canal lining long and improvement of irrigation method (refer to paragraph G-5-6),

- Apportionment of risk caused by water shortage, including vested water right, and

- Construction of new irrigation network.

(2) The understanding matters between JICA and government of Peru concerning the scope of works on technical cooperation (Dec. 7,6 ,1983).

- An objective of the project is to be rehabilitated for irrigation and drainage facilities and salt damaged farm land aimed at cultivated land.

- The new development of farm land is not included in this project.

(3) The ascertained matters from the result of reconnaissance during the field study based on preliminary survey regarding the river basin development of which had been carried out by the government of Peru.

- Some dam sites in the Chancay River basin, which have been studied by ONERN have some problems on technical and economical difficulties.

- The economical measures for improve the agricultural productivity in cultivated land alone is still remained.

- Rehabilitated facilities by the project will prove serviceable to the increase of water demand in future, if it should become possible to economical water resource development in the Chancay River basin by the improvement in engineering.

Acordingly, economic conparison was made as shown in Table G-3-1.

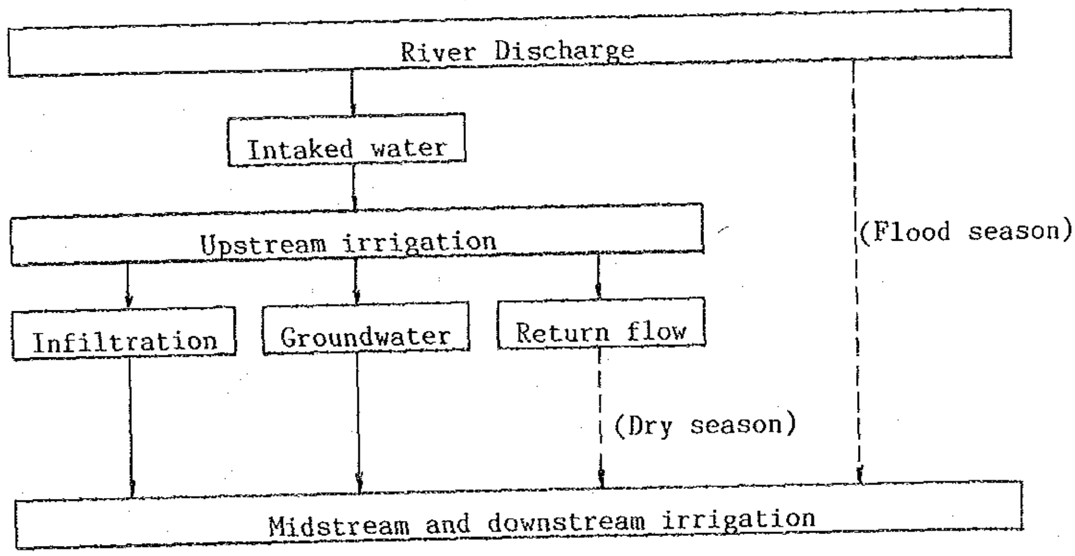
As the result, original of A has an advantage compared with B and C in both Case 1 and Case 2.

2 Existing Irrigation System and Water Utilization

2-1 Existing Irrigation System

Annual rainfall in Chancay-Huaral Valley basin would be recorded 550 mm at Santo Domingo that is located the upstream of Chancay river and elevation from sea level is 3,700 m, while equals to no rain with 10 mm in the project area.

Consequently, water requirements would be dependent on Chancay river. Upstream irrigated area is covered by the river discharge intaked. On the other hand, irrigation system, which irrigated water would be recycled such as infiltration from upstream area, return flow and groundwater, has been provided in the downstream. The following chart presents the flow of irrigation water, commanding area in system wide is shown in Figure G-2-1.



2-2 Water Use Condition

ATDR has the data of river discharge and utilized water for irrigation. According to the data in the past seven years, annual irrigation water is steady with 350 to 400 x 10^6 m^3. On the other hand,river discharge has ranged from 260 to 600 x 10^6 m^3. (refer to Figure G-2-2)

Annual pattern of river discharge shown in Figure G-2-3 would be constant, viz, flood season from January to April and drought season from May to December with its bottom of September to November.

On the contrary, irrigation water has been utilized corresponding to river discharge, as shown in Figure G-2-4. Water requirements are more than river discharge in drought period and it would be guessed that infiltration, groundwater and return flow are recycled in downstream area.

2-3 On-farm Irrigation Condition

Irrigation water is administrated by ATDR. The system for water distribution has been built up in the project area. In some district, discharge of 50 l/sec per Fenegada (2.7 ha)/hr would be assigned in drought season, 250 l/sec in flood season.

Furrow irrigation method is generally carried out, the result of field investigation in Boza area is shown in Table G-2-1. Existing irrigation method in the project area was investigated, as described in Table G-2-2. Considerable different result was obtained, although, approximate intermittent period ranges from 4 days to 15 days.

3 Water Shortage and Cause

Water shortage has been occurred whole the project area except Chancayllo area, and is concentrated in the area of canal end, especially in drought period from September to November. These areas are shown in Table G-3-1 and would be estimated at 4,900 ha in total.

It would be considered the follows for its cause:

- Imperfection of intake facilities installed along Chancay river,
- Superannuated irrigation facilities such as intake, canal and reservoir,
- Capacity decreasement by sedimentation in the canal and reservoir, and
- Unskilled on-farm irrigation method.

4 Irrigation without Project

It would be the important factor whether steady intake is possible or not, for maintaining the water resource, since irrigation water in the service area is dependent on Chancay river.

Intake facilities of 23 are provided along Chancay river in the project area, however, these require much labor forces and charges for operation and maintenance, since intake facilities have been destroyed and/or sedimented by annual floodings.

The project area would be formed of alluvial soil with coarse textured and permeable layer, nevertheless, canal linning would be imperfect. Therefore, it would be seen water shortage area in the canal end.

Assumed that this project would not be executed, operation and maintenance for agricultural facilities will come into more difficult and rational irrigation system whole the project area would not be expected, because the cropping pattern is obliged to meet the river discharge and this fact makes the crop production trouble.

5 Irrigation Scheme

5-1 Water Requirements

(1) Evapotranspiration

There are many methods for calculating the evapotranspiration, however, it would be considered that Penman method is fit to this area, taking into account the meteological condition.

The evapotranspiration in each month by this method ranges from 1.57 to 3.46 mm/day (average; 2.40 mm/day) as shown in Table G-5-1.

(2) Planting area and irrigation period

The project area is cultivated land and is classified broadly into both fruits in upstream area and one year crops such as cotton, maize and vegetables in midstream and downstream region. Planting area of each block is presented in Table G-5-2 and G-5-3.

Irrigation period is shown in Table G-5-4. The area for fruits and vegetables would be applied to the whole year irrigation, although, the period corresponding to the cropping pattern would be adopted for others.

(3) Crop coefficient (Kc)

Crop coefficient (Kc) can be calculated based on "Irrigation and Drainage Paper No.24" by FAO and is shown in Table G-5-5, G-5-6, and Figures G-5-1 (1) to (3).

Kc of fruits is adopted the value used in the resembled project in Peru, since fruits have many varieties such as orange, mandarina, apple, peach and so on.

(4) Net water requirements

Following equation gives the net water requirements.

$$ETcrop = Kc \cdot ETo$$

where, ETcrop : Crop evapotranspiration (mm/day)
Kc : Crop coefficient
ETo : Reference evapotranspiration (mm/day)

Calculated net water requirements are given in Table G-2-7. Total net water requirements whole the project area would be calculated as shown in Table G-2-8 and G-2-9, 80,839 x 10^3 m^3 in present planting area and 92,586 x 10^3 m^3 in proposed.

(5) Irrigation efficiency

Irrigation efficiency would be changed by the conditions such as soil texture, water management, canal condition and distribution management, etc. Irrigation efficiency was determined as shown in Table G-5-10, based on the field investigation, FAO "Irrigation and Drainage Paper No.24", data of Utah Agr. Exp. Sta. Bul. 311, etc.

Both the efficiency and ratio of canal linning would make possible to calculate the comprehensive irrigation efficiency whole the project area. The result is shown in Table G-5-11 and G-5-12, 29% in present and 46% in proposed.

(6) Gross water requirements

Gross water requirements can be calculated, based on the items there fore. Yearly gross water requirements become 278,747 x 10^3 m^3 (13.8 x 10^3 m^3/ha) in present condition, 201,274 x 10^3 m^3 (10.0 x 10^3 m^3/ha) in proposed.

Tables G-5-13 (1) to (5) present the gross water requirements in each block in proposed condition.

Month	Present	Proposed	Notes
Aug.	6,524	6,217	
Sep.	10,076	12,293	
Oct.	17,990	21,109	
Nov.	24,217	23,248	
Dec.	31,679	27,500	
Jan.	43,048	30,583	
Feb.	41,572	27,004	
Mar.	33,600	18,133	
Apr.	26,221	13,663	
May	20,197	10,976	
Jun.	13,848	5,861	
Jul.	9,055	4,687	
Total	278,747	201,274	x 10^3 m^3

5-2 Leaching Requirements

(1) Improvement plans for salinity soils

The furrow flooding method has been adopted as leaching for salinity soils in the poor drainage area considering topographic conditions and water availability. The plans are proposed as follows:

(a) 1st type: Salinity soils in poor drainage areas

(i) Water requirements

The water requirements for furrow flooding was calculated according to the following conditions:

- Initial leaching method : Furrow flooding
- Time of initial leaching : May - July
- Intensity of furrows : Width of ridge : Width of furrow = 1:1 (50 % of ground surface to be flooded)
- Rate of water application: One third of total water requirements for furrow flooding to be applied in each year
- Proposed cropping plan : Cotton-green manure-maize in rotation (first crop: cotton)

Water requirements in depth per ha for furrow flooding is tabulated below.

	Salinity Class	
	S2	S3
1. Average ECe (m^S/cm) of surface layer	10	30 - 40
2. Total water requirements in depth for furrow flooding (cm)	45	90
3. Rate of application in each year	1/3	1/3
4. Water requirements in depth for furrow flooding/year (cm)	(2 x 3) 15	(2 x 3) 30
5. Intensity of furrows (% of ground surface to be flooded) (%)	50	50
6. Water depth in cm to be applied in furrows (cm)	(4/5) 30	(4/5) 60

Water requirements in depth and in volume per ha for furrow flooding is tabulated below.

	Salinity Class	
	S2	S3
Depth/ha.year (cm)	15	30
Volume/ha.year (m3)	1,500	3,000
Depth/ha.3 years (cm)	45	90
Volume/ha.3 years (m3)	4,500	9,000

Water requirements for furrow flooding in the drainage improvement study area is tabulated below.

				Water Requirements in Volume for Furrow Flooding x 1,000 m3			
				Total			
Drainage Improvement Study Area	Salinity Class	Area (ha)	Per ha (year)	1st year	2nd year	3rd year	total
Donoso/Quincha	S2	273	1.5	410	410	409	1,229
	S3N1	524	3	1,572	1,572	1,572	4,716
Sub-total				1,982	1,982	1,982	5,946
Boza	S2	15	1.5	23	23	22	68
	S3	61	3	183	183	183	549
	S3N1	69	3	207	207	207	621
Sub-total				413	413	413	1,239
San Luis	S2	168	1.5	252	252	252	756
	S3	82	3	246	246	246	738
Sub-total				498	498	498	1,494
Lunavilca	S2	50	1.5	75	75	75	225
Palpa	S2	30	1.5	45	45	45	135
Total		1,272		3,013	3,013	3,011	9,037

Water requirements for furrow flooding in the entire drainage improvement study area:

about 3 million m^3/year
about 9 million m^3/3 years

(b) 2nd type B: Salinity soils in Hattillo

For the desalinization of this soil type, the ponding method has been adopted.

i) Water requirements for initial ponding

i. Conditions

Initial leaching method : Ponding
Time of initial leaching: May - July
Proposed cropping plan : Cotton-green manure-maize in rotation (first crop: cotton)

ii. Water requirements for initial ponding

Initial ponding water requirements in depth : 50 cm
Initial ponding water requirements in volume/ha : 5,000 m^3/ha
Area to be leached : 160 ha
Total water requirements for initial ponding : 800,000 m^3

In total, 800,000 m^3 of irrigation water are required for leaching of the area by initial ponding.

(c) 2nd type A: Salinity soils in slightly sloping area

The leaching of sandy to gravelly salinity soils on slightly sloping area (2nd type A) is not included in the present improvement plan for the following reasons:

i) The adverse effects of salt accumulation above the root zone of fruit trees are not considered significant and therefore sufficient benefit can not be expected.

ii) Low salt-tolerant crops of citrus and apple are prevailing in the area. A large quantity of irrigation water will be required in a short period to prevent salt accumulation in the lower root zone of these crops. However, availability of water is limited in the area.

It is recommended to promote leaching gradually from one place to another by wide-bottom furrow irrigation.

(2) Water quality for leaching

Water quality for leaching has little annual variation with 340 to 400 μmho/cm of ECw as presented in Table G-5-14. ECw of 450 to 950 μmho/cm was observed in the area where recycled water has been used for. Salinity of 200 to 480 ppm would be harmless to the growth of crops.

The following equation gives the ratio of leaching requirements against irrigation water.

$$LR = \frac{ECw}{(5\ ECe - ECw)\ Le}$$

where, LR: Ratio of leaching requirements

ECw: Electric conductivity of irrigated water

River ; 0.4 mmhos/cm

Recycled ; 1.0 mmhos/cm

ECe: Electric conductivity of saturated extract in the soil of root zone

Le: Leaching efficiency ; 80 % (coarse to medium textured soil)

Assumed that the forecasted decreasement ratio of 10 % would be occurred by the salinity in the irrigation water, the principal crops require the leaching requirements, as follows:

Ratio of Leaching Requirements

Crop	ECe mmhos/cm	River	Recycled
Cotton	9.6	0.01	0.03
Maize	2.5	0.04	0.11
Fruit	3.5	0.03	0.08
Tomato	2.3	0.05	0.12

The ratio of leaching requirements against irrigation water would be 5 % and 10 % in river and recycled, respectively. The requirements would be supplied in flood season.

(3) Leaching requirements for salinity soil

The soil, with salinity class S2 (ECe 8-15 mmhos/cm) and S3 (ECe > 15 mmhos/cm), requires the water depth for leaching of 30 cm and 60 cm respectively.

The area of 1,432 ha would be necessary to be leached and total leaching requirements amount 12,297 x 10^3 m^3, as shown in Table G-5-15.

5-3 Requirements for Others

There are two cities in the project area, Huaral and Chancay. Municipal water is supplied from river and groundwater, industrial use and water for livestock from groundwater.

These requirements are decided based on the field investigation. Municipal water utilization of Huaral City in 1983 and 1984 is presented in Tables G-5-16 (1) to (2), with tendency to increase.

- Municipal water for the cities of Chancay and Huaral would become two times of present use, corresponding to the long term formation.

- Industrial use equals to the yield of the existing well.

- Water for livestock is the same volume as present.

Monthly requirements are shown as follows:

Month	Municipal	Industrial	Livestock	Total
Aug.	792	11	87	890
Sep.	776	11	87	874
Oct.	792	11	87	890
Nov.	776	12	87	875
Dec.	792	11	87	890
Jan.	792	11	87	890
Feb.	746	11	87	844
Mar.	792	12	87	891
Apr.	776	11	87	874
May	792	11	87	890
Jun.	776	11	87	874
Jul.	792	12	87	891
Total	9,394	135	1,044	10,573

5-4 Water Resource

Water resource in the project area would be all dependent on Chancay river. Upstream area is directly covered by the water from river. Recycled water such as infiltration, return flow and groundwater have been utilized in midstream and downstream. As for water resource, river, upstream lagoons, return flow and groundwater, etc. would be considered.

(1) River

Discharge of Chancay river has been observed by ATDR Chancay-Huaral. Annual pattern of discharge, as shown in Figure G-5-2 and Table G-5-17 (1), would be obtained from the probability calculation by using the data in the past twenty one years (1963-1983).

According to the results, discharge of Chancay river starts to increase between December and January, with the peak in March. After that, discharge decrease little by little and the bottom comes in September to November. Annual discharge of each probable year is presented as follows:

Probable year	Annual discharge
	x 10^3 m^3
2	463,018
5	305,467
10	247,331
20	208,320

Since the observed data include drained discharge from upstream lagoons, Tables G-5-17 (2) to (3) present the value excluding the discharge. The discharge by river itself, therefore, would be 287,616 x 10^3 m^3/year in probable year of 5 years, 227,777 x 10^3 m^3/year in that of 10 years.

(2) Upstream lagoons

There are seven lagoons with reserved capacity of 50,000 x 10^3 m^3, however, utilization record in the past ten years was 28,300 x 10^3 m^3, in maximum, shown in Table G-5-18.

Effective reserved capacity of 30,000 x 10^3 m^3 would be applied to this project, based on the capacity of useful 5 lagoons. Available volume at Santo Domingo would be 24,000 x 10^3 m^3 (30,000 x 10^3 x 0.8 m^3), since the distance between lagoons and the service area is very long, and so on.

(3) Infiltration and return flow

In the area lower than the intake at Chancay-Huaral, infiltration from upstream and return flow to the river has been utilized for irrigation in drought period. Intaked and its recycled discharge in drought period observed by ATDR is presented in Table G-5-19 and G-5-20.

Correlation between river discharge and ratio of recycled would be obtained as shown in Figure G-5-3 and Table G-5-21, using this data. Ratio of recycled water ranges from 50 % to 90 %.

$$\text{Ratio of recycled (Re)} = 12{,}804 \times Q^{-0.5447}$$
$$\text{Correlation Coefficient } (r) = 0.91$$

Where, Q : River discharge ($\times 10^3$ m^3/month)

Ratio of recycled of each commanding area in system wide in drought period, 1979 equivalent to drought year, is presented in Table G-5-22. Ratio of recycled shown in Table G-5-22 would be adopted to infiltration and return flow in proposed condition.

(4) Groundwater

Regarding groundwater development in the project area, though the development should be required carefully handling as described in B-2-6, study of newly use of groundwater is carried out (economical comparison) as follows:

In case of pumping equipment;

- Facility	US$ 735/ha	(US$ 25,000/unit)
	(US$ 588/ha)	(US$ 20,000/unit)
Depreciation	US$ 113	(Period25 years,i=15%)
Maintenance cost	US$ 26	(US$ 900/34 ha)
Running cost	US$ 35	(3,000 hr x 0.4 $ /34ha)

- Connecting cannal	US$ 44	(100 m x 15 $ /34ha)
Depreciation	US$ 7	
Maintenance cost	US$ 2	
Total	US$ 183	
	(161)	

Furthermore, to supply lift water the capacity of 1,807 m3/year (36,500,000 m3/20,200 ha) per ha as use for leaching besides irrigation water alike cannal system is added at least US$7.00 (17 hr x 0.4), therefore, the sum of annual cost amounts to US$190.00 (US$168.00).

Note:

	Location	Maximum	Annual
Gross water requirement			
(Maximum)	Right bank (upper)	0.697 1/sec	8,431 m3
	- ditto - (middle)	0.495	9,427
	- ditto - (lower)	0.565	10,695
(Average)		0.586	9.518

Capacity of pumping equipment per unit 30 1/sec

Operation hour Max. 16 hr/day (1,728 m3/day)

Irrigation area of pumping equipment per unit 34 ha

Operation hour of pumping equipment per unit

Annual average 2,996 hr (88 hr/ha)

In case of cannal system;

- Facility	US$ 778/ha	
Depreciation	US$ 117	(Period 50 years, i=15%)
Maintenance cost	US$ 16	
Administration cost	US$ 13	
Total	146	

Note:

Temporary facility;	US$ 784,000
Intake structure;	5,521,000
Cannal;	9,408,000
Total	15,713,000 / 20,200 ha

From comparison of the abovementioned, the cost for secure new irrigation water by pumping up groundwater is higher than cannal system (use of surface water), therefore, it is desireble to give high priority for use of surface water. Further existing pumping equipment would utilize in dry season by no abolition.

As use of groundwater in this case, the followings can be found. Utilization of groundwater is shown as follows, based on the records in the past seven years:

Year	Utilization Record $\times 10^3$ m^3
1977	8,523
1978	12,375
1979	20,510
1980	7,220
1981	5,618
1982	-
1983	301

It would be considered that the utilization is too much in 1979, which was the minimum in river discharge during the past 20 years.

Since the annual available volume, which can be utilized in steady, would be 10,000 x 10^3 m^3 to 12,000 x 10^3 m^3, the availability would amount 11,600 x 10^3 m^3 every year.

Monthly utilization is decided 2,700 x 10^3 m^3 in maximum corresponding to the present yield (1.257 m^3/sec) as shown in Table G-5-23.

5-5 Water Balance

(1) Course for water balance calculation

Based on the existing irrigation system, water resource would be classified into three types as follows:

- River discharge directly from Chancay river throughouot the year,
- River discharge in flood period and return flows in drought period, and
- Infiltration.

Groundwater would be supplied in some parts, however, the course for water balance calculation would be proposed as follows:

(a) Present

- River discharge at Palpa can be obtained from that at Santo Domingo without water requirements in Saume and Cuyo area.
- Water requirements, in flood season from February to August, would be gotten from intake facilities of 17 along Chancay river.
- In drought season from September to January, water requirements would be obtained from the facilities that extend Palpa to Chancay-Huaral in due order. These five intakes irrigate the area of 12,780 ha, the shortage would be supplied by groundwater. Return flow from upstream area would be used for the area of 3,399 ha where are irrigated by the intakes of 12, located between San Jose and Hanglar.
- Chancayllo, Jecuan, Derisias and Laureles area of 3,244 ha in the right bank, and Mira Flores area of 577 ha would be irrigated by infiltration from upstream irrigated area

through the year.

(b) Proposed course

At the improvement of cannal, unification of the intake facilities would be planned as described in H-3. However, as the system of irrigation cannal would have no altered. Condition of proposed cannal system is as shown in Fig.G-5-4, and studies of water balance will be carried out as follows;

- River discharge at Palpa (Q2) can be estimated from that at Santo Domingo (Q1), minus water requirements in Saume and Cuyo area of 900 ha (q1). [Q2 = Q1 - q1]

- Irrigation Water for La Esperanza,Plpa,Caqui and San Jose will be intaked at Palpa diversion weir for both banks, Esperanza area of 3,440 ha in right (q2), Palpa,Caqui and San Jose area of 3,037 ha in left (q3).
  [Q3 = Q2 - (q2 + q3)]

- Irrigation Water for Huando area of 1,416 ha (q4) and Chancay-Huaral area of 6,803 ha (q5) would be diverged at Huando diversion weir. [Q4 = Q3 - (q4 + q5)]

- In case of $Q1 < q1 + q2 + q3 + q4 + q5$, upstream lagoons with effective capacity of 24,000 x 10^3 m^3 in maximum are operated to drain. Assumed that water requirements are lack even if the treatment mentioned above would be done, the shortage would be supplied by the pumps for groundwater, limited annual utilization of 11,600 x 10^3 m^3 in maximum, in the area irrigated by both Palpa and Huando diversion weir.

- In the wet season from February to August, water can be obtained at the proposed diversion weirs of Boza Alto (A = 779 ha, q6), Boza Bajo (A =676 ha, q7), Salinas Alto (A = 281 ha, q8), Pasamayo Bajo (A = 651 ha, q9) and Salinas Bajo

(A = 281 ha, q10). In case of Q4 > q6 + q7 + q8 + q9 + q10, the remained water flow out to the sea. Recycled utilization using the return flow to downstream block would be calculated in each block corresponding to the diversion weir in drought season.

- Since chancayllo area of 1,799 ha is dependent on infiltration through the year, water balance calculation would be carried out as recycled from Esperanza, Huando and Huaral area (A = 6,870 ha).

- The same method would be applied to the area of Donoso and Laureles (A = 576 ha), and Mira Flores (A = 577 ha).

- Collecting conduit would be provided in midstream area such as Boza Alto for the counterplant of water shortage.

Flow chart of water balance calculation in proposed is shown in Figure G-5-4,the proposed commanding area in system wide in Fig. G-5-5.

(2) Present water balance calculation

The results in probable year of 10 years are presented in Figure G-5-6 and Tables G-5-24 to G-5-30. Annual shortage would amount 17,800 x 10^3 m^3 with its peak in January. The area where irrigation water is short are distributed in the canal end from directly river, Donoso area and downstream parts of Chancay river.

(3) Proposed water balance calculation

Monthly intaked water in each diversion weir is shown in Table G-5-31, Water balance calculation in the probable year of 10 years, based on the requirements and the water resource mentioned before, gives Figure G-5-7 and Tables G-5-32 to G-5-38. Proposed utilization in each resource would be as follows:

Resource	Amount
	x 10^3 m^3
River	131,643
Return flow	46,058
Lagoons	24,000
Groundwater	8,326
Others	1,179
Total	211,206
Total demand	211,847
Shortage	641

Water shortage is occurred in Boza area, therefore, irrigation water would be supplied by the collecting conduit.

The results in the probable year of 5 years and in the past six years (1978/'79 - '83/'84), using the same method, are presented in Tables G-5-39 to G-5-45.

Table G-5-46 shows the case that on-farm water management is not enough. Summary of the calculation is shown in Table G-5-47, the water shortage would be seen in 1979/'80.

(4) Available volume for leaching

The remained water except irrigation water can be used for leaching requirements. Assumed that the utilization is limited to the capacity of irrigation facility, available volume per annum would amount 36,500 x 10^3 m^3 as shown in Table G-5-48. Leaching requirements can be concentrately supplied to defend the salt accumulation between March and May due to the flood period with much non-effective discharge.

Leaching for salinity soil would be effective before seeding of cotton, from June to August, and the requirements of 12,000 x 10^3 m^3 can be utilized in this period.

(5) Water Management considering supply with groundwater

River water should be utilized for the purpose of strengthen groundwater availavility and water for dissalinization of farm land (for leaching) besides irrigation water.

The condition of river water utilization in the probability of 10 years is estimated as follows;

Water balance in consideration of leaching and supply with groundwater; (Probability : 10 years)

- River discharge including the water from lagoons
  246,189 x 10^3m^3 ((222,189 + 24,000) x 10^3m^3)
- Intake water from the Chancay river
  155,643 x 10^3m^3 ((24,000 + 131,643) x 10^3m^3)
- Reserved water in the lagoons in wet season
  30,000 x 10^3m^3
- Available water for leaching
  36,506 x 10^3m^3
- Run-off discharge to the sea (Period; from Feb. to Apr.)
  24,040 x 10^3m^3 1/
- Available intake water for irrigation and leaching
  (2,400 + 131,643 + 36,506) x 10^3m^3 = 192,149 x 10^3m^3
  187,300 x 10^3m^3 2/

1/

(Unit : 10^3m^3)

Month	River Discharge (1)	Max.Intake (2)	(1) - (2)
Feb.	32,420	23,518	8,902
Mar.	59,517	23,518	35,999
Apr.	32,657	23,518	9,139
Total			54,040

Reserved water in the lagoons	30,000
Run-off discharge	24,000
	54,000

Refer to Table G-5-32, 48, Fig G-5-6 and 7.

2/

River discharge in 1979/80 ; $265,000 \times 10^3 m^3$

Intake water from the river ; $199,000 \times 10^3 m^3$ (1)

Intake water from return flow ; $11,700 \times 10^3 m^3$ (2)

(Period : from Aug. to Nov.)

Intake water excluding return flow; (1) - (2)

$= 187,300 \times 10^3 m^3$

Refer to Fig.G-2-2.

5-6 Canal and On-Farm Irrigation

(1) Irrigation facility

Irrigation water intaked from each diversion weir are distributed to on-farm by way of main and lateral canals.

Regulated reservoir is provided at the diverged point of canal. It would be expected the rational distribution, viz, reserved in the night and drained in the daytime. The capacity of intakes and pricipal canals to be connected, therefore, would be proposed at 24 hours capacity of maximum water requirements in the service area. But the capacity of the other canals, lower than the reservoir and or main diversion of principal canals required to be enough to deliver the water for irrigation in the daytime, then the water diverted from the river at night will be reserved in the regulating ponds or reservoirs. Moreover, the examination on the capacities of these canals were considered the scale of rotation blocks.
Maximum capacity of principal intakes and canals are shown in Tables G-5-49 (1) to (4) and Tables G-5-50 (1) to (5).

There are 13 existing reservoirs with the capacity of 7,000 to 42,000 m^3/place (average; 17,000 m^3/place) in the service area, however, the managements are not always good and the capacity is short. Consequently, the effective capacity would be changed, as shown in Table G-5-51. Construction of five reservoirs are proposed from the viewpoint of water distribution, as shown in Table G-5-52.

The considered points in the determination of the storage capacity and the construction of new reservoirs are as follows :

- La Esperanza Irrigation System

  Though this system has a reservoir with the capacity of 42,000 m^3 at the upstream area, the irrigation water from the intake gate since the commanding area is slender in shape. Therefore, the remnant water in canal after finish irrigation works on the farm would be waisted.

  As it is easy to come out the water shortage in the down stream area, the new construction of two reservoirs would be proposed, i.e., one with the capacity of 13,900 m^3 at the divergent point between Cabyal Bajo and Cayo Murillo and the other one withe the capacity of 18,800 m^3 at the divergent point between Virgen Granados and Lat.-3 Granados.

  Three reservoirs above mentioned will store the capacity equivalent to approximately six hours' maximum diversion water requirements for the total areaof this system, and it will be able to intermit the irrigation works, averaging six hours a day.

- Huando Irrigation system

  Huando area is small limited as compared with La Esperanza and Palpa-San Jose, and its farm land is almost owned by the cooperative Huando. Therfore, the area is under facilitated condition for water management.

  Further, if the surplus irrigation water should arise, it flows into Chancay-Huaral Irrigation System. From this reson, the construction of new reservoir has no taken consideration. The reservoir with a capacity of 13,600 m^3 has been constructed at the upstream area in this system, then it can be stored the capacity for 2.6 hours' diverson water requirements in the total area.

- Huaral Irrigation System

  The intake facilirty of this system would be able to take the stabilized water than actual situation by means of the unification with the intake facility of Huando. Accordingly, the new

construction of a reservoir which is provided at diverged point in the upstream area of the canal system would be no considered in this system.
However, as the existing reeservoirs of two places have been examined, so that the capacity equivalent to twelve hours' diversion water requirements in the commanding area may store up, in the same as Chancay Irrigation System.
As a result, the storage capacity of proposed reservoirs is as follows :

	Proposed	Present	Commanding Area
Res. Jesus del valle	34,100 m^3	24,600 m^3	801 Ha
Res. Cerrito	17,100 m^3	12,000 m^3	410 Ha

- Chancay Irrigation System

The existing reservoirs of five places are installed in this system as follows :

	Storage Capacity	Commanding Area
Res. Quepepampa	10,800 m^3	426 Ha
Res. Buena Visca	11,300 m^3	400 Ha
Res. Galeano	12,000 m^3	380 Ha
Res. Los Laureles	16,000 m^3	426 Ha
Res. Chancay Bajo	7,300 m^3	
Total	57,700 m^3	

There are situated in the end of Chancay-Huaral Irrigation System, and is easy to occur the water shortage, the surplus irrigation water also flows down into these areas from the upstream area at irregular intervals. Therfore, a large number of reservoir is needed in these areas.
Consequently, as the capacity equivalent to twelve hours' diversion water requirements in the total area has been examined for the capacity of each reservoir.
As a result, the storage capacity of following reservoirs would be enlarged :

	Proposed	Present
Res. Quepepampa	17,000 m^3	10,800 m^3
Res. Chancay Bajo	9,300 m^3	7,300 m^3

Furthermore, the new construction of the second reservoir with the capacity of 12,000 m^3 in the area of Los Laureles would be proposed.

- Chancayllo Area

  This area is favored with abundant irrigation water. But the irrigation area mentioned below have some slopes. There are two existing reservoirs in these irrigation systems on San Cayetano and San Juan as follows :

	Storage Capacity	Commanding Area
Res. Chancayllo(1)	12,000 m^3	190 Ha
Res. San Juan	5,000 m^3	213 Ha

  Assuming that the capacity is equivalent to six hours' diversion water requirements, the Res.San Juan would be enlarged the capacity by 7,300 m^3.

- Palpa-Caqui-San Jose Irrigation System

  There is an existing reservoir with the capacity of 33,800 m^3 at Palpa Alto in this system. The system would be needed to enlargement and/or new construction of reservoir by reason of the same as stated on La Esperanza Irrigation System.

  In this system, the capacity which is equivalent to six hours' diversion water requirements by the construction of new reservoir with the capacity of 16,400 m^3 at Aucallama and enlargement of Res. Palpa to the storage capacity of 40,200 m^3 (limited to enlarge by means of geographical features) would be proposed.

- Boza Bajo-Pasamayo Alto Irrigation System

  Assumed that the capacity is equivalent to six hours' diversion water requirements, the construction of new reservoir with the

capacity of 14,500 m^3 for its commanding area of 676 Ha would be proposed.
The new reservoir's site is desireable to provide at place in the existing canals of Boza Boja and Pasamayo Alto.

- Boza Alto, Salines and Pasamayo Irrigation System
  Each commanding area of these systems is comparatively small, and utilizes underflow, return flow and/or infiltration water.

  It is possible to intake the irrigation water constantly in all cases, therefore, construction of reservoir has no consideration in particular.

Collecting conduit with capacity of 0.1 m^3/sec would be provided for the area of Boza Alto to Pasamayo Alto.

The skeleton and distribution system are presented in Figure G-5-8 and G-5-9, respectively.

(2) On-farm

The project area is classified broadly into two zones, viz, fruits cultivation in the upstream and one year crops such as cotton, maize and vegetables in the midstream and downstream. Land slope ranges from 1 to 2 degrees with mild and furrow irrigation has been carried out.

On-farm intake rate was mesured at Quincha and Donoso, shown in Tables G-5-53 and 54 and Figures G-5-10 (1) and (2). Basic intake rate becomes 47.2 mm/hr at Quincha, 146.4 mm/hr at Donoso.

Present furrow irrigation method would be adopted, taking into account the conditions of farming, economic and so on, in future however, sprinkler irrigation and drip irrigation, etc. would be considered to introduce in keeping pace with the improvements such as on-farm application efficiency, labor forces for irrigation and irrigation technology, etc.

Total readily available moisture (TRAM) would be different from the crops and soils, although, TRAM for the principal crops ranges from 30 to 70 mm/time, shown in Tables G-5-55 (1) to (4). Water requirements per ha and intermittent period, presented in Table G-5-56, can be calculated by using TRAM.

Irrigation hours per time would be obtained from on-farm water requirements of each crop and discharge flowed into. Assumed that the discharge of 15 l/sec flowed into, justised from existing on-farm canal condition, and proposed intermittent period would be ten days. Irrigation hours of 8 to 12 hr/ha would be gotten as shown in Table G-5-57.

(3) Irrigation method in future

Rotation irrigation has been carried out in each irrigation block, however, there is no unified rule whole the project area, with difference in each block. (refer to paragraph G-2 (3))

Assumed that, in future, unification of intake facilities, canal linning, improvement and construction of reservoirs, etc. make water distribution rational, it would be necessary to build up the rules of rotation irrigation in each commanding area in system wide. The service area in each lateral canal would be between 100 and 200 ha.

Assumed of ten days intermittent period, one rotation block would be 10 to 20 ha and all blocks can be irrigated for ten days in due order.

As for on-farm irrigation method, furrow irrigation would be adopted, taking into consideration the farming conditions. However in future, it would be desired to introduce more effective irrigation method from the aspects of soil condition and effective water utilization, when water management and economic condition will be advanced, viz, sprinkler irrigation for vegetables and drip irrigation for fruits, it would be considered.

Excess water of 20 % compared with surface irrigation can be contrived, assumed that these methods would be carried out. This excess water equals to the volume that makes called "Tierra Eriasas" of 5,000 ha around the cultivated land possible to plant the crops.

Example of facility constitution for sprinkler irrigation is shown in Figure G-5-11.

6 Existing Drainage System and Poor Drainage Condition

It has been seen the poor drainage area with high groundwater level where infiltration from upper irrigation area is concentrated, caused by topographical and geological conditions.

Drainage network, which mainly aims at the collecting of infiltration, has been provided for downstream irrigation water. Although, these drainage canals can not make the groundwater level low due to comparative shallow depth of 1.0 to 1.5 m from field surface.

Poor drainage can be seen the area where is intercepted the stream of infiltration and/or groundwater in the midstream to downstream parts having hilly land in the downstream at the viewpoint of topography. Quincha, Donoso and Boza area are applied to this pattern.

On the other hand, river terrace is developed along Chancay river and it is also seen the poor drainage in the lower part of this terrace caused by underflow water from the river, and infiltration. The areas applied to this pattern are San Luis, Lunavilca, Salinas and Palpa. (refer to Table G-6-1)

It would be necessary to build the drainage system both to make groundwater level low and to carry out effective leaching, since the salinity soil is distributed in this area.

Conditions of these poor drainage areas are presented in Table G-6-2.

7 Drainage without Project

Seasonal variation of groundwater level is occurred in the poor drainage area, although, it would be considered that natural fall of groundwater level can not be expected assumed absolute volume of infiltration from upstream irrigation water is not changed. Existing drainage canal would not be able to function to fall down the groundwater level because of sparse density with shallow depth.

Salinity soil is distributed in the area of shallow groundwater level and makes the cultivation trouble. The area where is impossible to plant and keep the weed land or waste land can be seen especially in some part of high salinity soil. Removal of salinity would come into possible by falling down the groundwater level, since there has close relationship between salinity and groundwater level.

It is assumed that this project will not be executed, there would be much possibility to make production will of farmers fall back and to make waste land wider.

8 Drainage Improvement

8-1 Course for Drainage Improvement

Drainage improvement would be proposed the poor drainage area of 2,180 ha where groundwater level is less than 1.5 m from the grouond surface. These areas are occupied by medium to fine textured soil including salinity in some parts and coefficient of water conductivity varies 1.5 to 5.0 x 10^{-3} cm/sec.

The poor drainage area is spreaded in 2,180 ha, a part of the project area of 20,200 ha, out of which 350 ha in San Luis, Luavilca and Palpa being along the Chancay River and 1,850 ha in donoso (810 ha), Quincha (870 ha) and Boza (150 ha) which are located apart from the River.

As shown in Fig. B-2-6, Annex B (Section I-I, J-J), sandy soil layer is dominated in Donoso and Quincha where the influence of the groundwater appeares.

In order to improve drainage condition in the area, the following two measures are commonly considered.

- Sucking up the groundwater by pump equipment
- Pipe drainage

(1) Plan of pumping up

Plan of pumping up is surely one of the way to use the groundwater for irrigation in the surrounding field and the plan seems to be reasonable as a general concept to utilize water resources by vertical circulation in some case. One of the particular merits of the drainage by pumping up is to suck up relatively deep groundwater and to draw down sub-surface groundwater level. Taking into consideration such condition of the pumping plan, the following problems might happen when pumping plan is incorporated into this project.

- Relation with the existing irrigation and drainage systems
  The current irrigation and drainage systems in the project area is formulated to reutilize infiltrated water and return flow for irrigation water based on a long history and experience. Accordingly, if pumping plan would be adopted in this project, the existing systems must be reorganized. Particularly, the existing irrigation systems in Jecuan and Chancayllo area will be severly affected by additional pumping systems.

- Systematic operation of pumping systems
  Under the plan of pumping up, it is not so effective that the individual farmers operate each pumping facility separately bacause pumping drainage must be carried out in normally large area and systematic operation of pumping systems is indispensable. However, it is considerably to operate pumping systems systematically and reasonably when pumping plan is taken into this project.

- Influence to outside of the area
  The plan of pumping up will affect adversely to the existing wells in the vicinity due to pumping up the groundwater from deep zone of underground. There are so many wells for drinking and domestic purpose besides wells of irrigation purpose.

- Uneasiness in predicting the change of groundwater flow
  The movement of groundwater and structure of underground can not be clarified definitely unlike surface water. Therefore, when pumping plan would be adopted, the uneasiness is remained in foreseeing the change of groundwater flow.

- Reliability
  The plan of pumping up has a problem in the mechanical reliability such as stop supplying electric power, etc.

- Relation between irrigation and drainage
  As mentioned in Annex B, underground water flows actually along the channel of groundwater and location of poor drainage area is not always coincided with that of the groundwater channel. Therefor, it seems almost impossible to take irrigation water without fluctuation from wells of which purpose is drainage.

(2) Plan of pipe drainage

Initial construction cost of pipe drainage might be slightly higher than that of pumping equipment and related structures in some case. However, running cost of pipe drainage is no longer necessary unlike pumping drainage. As results, total cost of pipe drainage including construction and running cost is clearly more economical than that of pumping drainage. Furthermore, pipe drainage has merits as below.

- Influence to the existing irrigation and drainage systems
  The existing irrigation and drainage systems remain uchanged and influence to them is not anticipated.

- Influence to the change of groundwater flow in the neighboring area
  The plan of pipe drainage is more reliable than the plan of pumping up because the water of near ground surfface can be controled without any sophistcated machinery and equipment.
- Management by individual farmers
  The farmers are able to manage the system individually which is simple structure without any running cost and skilled technique and not related with neighboring area.

- Re-utilization of drainage water
  Drainage water can be used for irrigation again in the downstream area depending upon the topographical and geological conditions.

In view of the foregoings, the pipe drainage is adopted for the project.

8-2 Designed Discharge

Designed unit discharge of pipe drain is described as follows:

Maximum irrigated water per day (7.0 mm/day) - consumptive use (ETc; 3.0 mm/day) = 4.0 mm/day

On the contrary, open drain system consists of catch drain and ordinary drainage canal (Collector or Sub-collector) and designed unit discharge is adopted the following value.

- Catch drain and intercepting canal

  Infiltration from upstream area (catchment area x ratio of recycled)

- Ordinary drainage canal

  Discharge from pipe drain (4.0 mm/day) + excess water by wide-area surface irrigation (2.0 mm/day) = 6.0 mm/day

8-3 Open Drain Formulation

Open drain is required 2.2 to 2.5 m depth corresponding to designed groundwater level and depth of pipe drain, etc. In this case, both type of unlined and linning would be considered. As a result of cost comparison, unlined type is adopted for the reason of cheaper hereinafter.

Open drains are classified into intercepting canal, main and lateral drainage canals subject to its objection. Interval of drainage canals will be between 300 and 500 m, taking into consideration present condition of existing drainage canals and farm lots, and topography.

Slope would be 1:1.5 caused by geological condition. Assumed that maximum velocity is 0.8 m/sec, longitudinal slope would be 1/100 to 1/400, and drops should be provided in keeping with slope.

Inspection road would be proposed, both sides for catch drain and main drainage canal, one side for lateral drainage canal.

Typical section is shown in Figure G-8-1, length and discharge in Table, G-8-2, location in Figure G-8-2.

8-4 Pipe Drain Formulation

Proposed groundwater level of lower than 1.5 m should be required in accordance with root zone of cultivated crops in the project area. Consequently, depth of pipe as shown below would be installed 1.5 to 2.0 m (average depth; 1.8 m). Pipe connected to open drain is of a parallel or fish skeleton type corresponding to topographical condition. Corrugated PVC pipe with diameter of 100 mm would be utilized.

Interval of pipe will be classified into two types, viz, 40 m and 60 m caused by soil texture. Pipe drain would be constructed by Trencher and filter material to increase the collecting capacity is proposed in the circuit of the pipe.

		Pipe Drain			
Type	Soil Texture	Interval	Density	Area	Length
		m	km/ha	ha	km
1	Coarse or Medium	60	170	1,720	292.4
2	Fine	40	250	460	115.0
Total				2,180	407.4

(1) Interval of pipe drain

Interval of pipe drain can be determined from designed discharge, seepage coefficient of the related soil and depth of impermeable layer. The equation of Hooghoudt is generally used for design of pipe drain and showing as below :

$$q^2 = \frac{4K_1}{S^2} \times H^2 + \frac{8K_2}{S^2} \times a \times H \;\ldots\ldots\ldots\ldots\ldots(1)$$

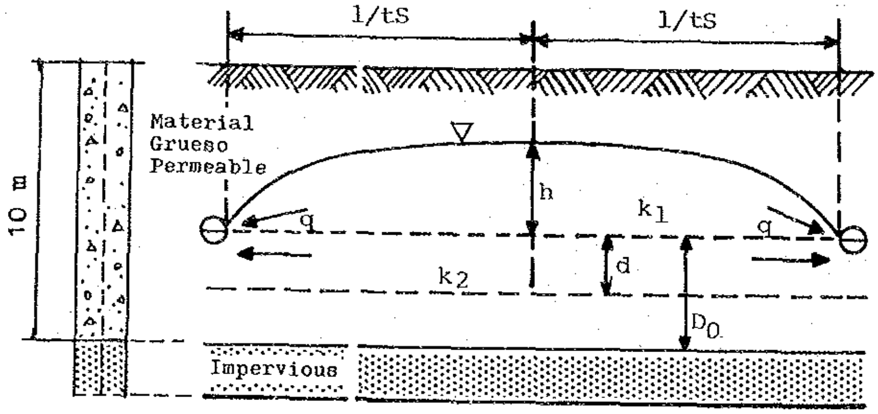
where, S : Interval of pipe drain (m)

H : Hydrostatic head between drain pipe and under-ground water level (m) q : Design discharge of pipe drain (0.004m/day)

K_1 : Seepage coefficient of layer aabove the drain pipe (4 x 10^{-3} cm/sec = 3.5 m/day)

K_2 : Seepage coefficient of layer below the drain pipe (2.3 x 10^{-3} cm/sec = 2.0 m/day)

a : Thickness of Hooghoudt's equivalent layer can be determined by distance between drain pipe and impermeable layer (Do), interval of drain pipe (L) and wet condition surrounding the drain pipe.



In order to facilitate calculation of interval of pipe drain, equation (1) can be converted as follows :

$$S^2 = \frac{4K_1}{q} \times H^2 + \frac{8K_2}{q} \times a \times H \quad ....(2)$$

Before estimating "a" (Thickness of Hooghout's equivalent layer), "Do" should be determined by geological profile. According to the geological profile, impermeable layer with thickness of about 3 meters is located in depth of around 10 meters from ground surface in vicinity of Quincha and Donoso where are poor drainage area. Therefore, "a" is estimated when Do = 10 meters.

When take 10 cm for diameter of pipe and 60 cm meters for interval of pipe derived from similar project such as Mala, Canete and etc., "a" can be estimated by "nomograph for Hooghoudt's d value" as below :

Do = 10. - 1.8 = 8.2 m (1.8 m shows depth of drain pipe)
u = π x r = 3.14 x 0.05 = 0.16
Do/u = 8.20/0.16 = 51

when, q = 0.004 m/day
H = 0.3 m

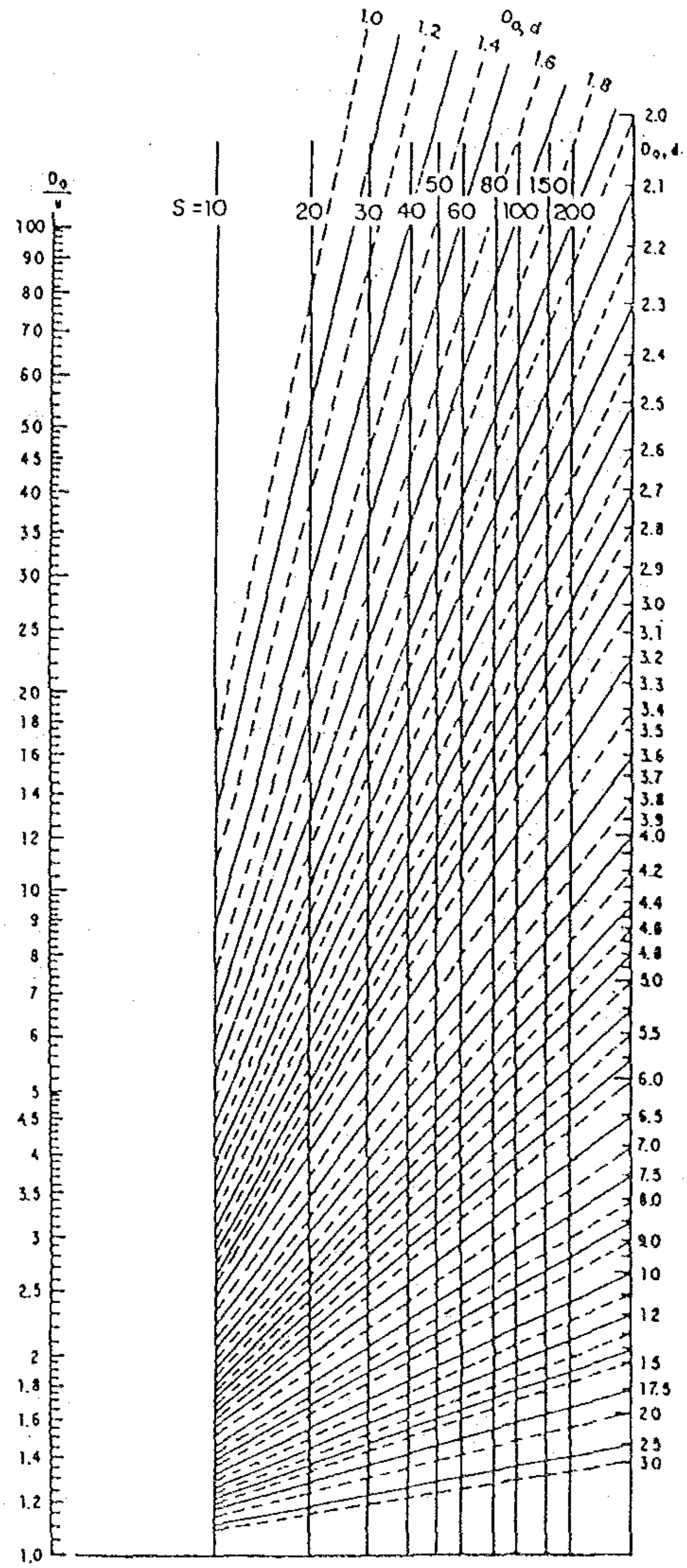
Interevals of pipe drain correspond to K_1 and K_2 in the location are calculated by the above formula of (2). The result is shown below :

k_1 & K_2	Interval of pipe drain
2.0 m/day	70 m
1.5 m/day	57 m
1.0 m/day	40 m

The value by Slater C.S. in United States, present below, ranges from 55 to 75 m thereto.

Interval of Pipe Drain (United State)

Coefficient of water conductivity (cm/sec)	Depth of Pipe Drain 0.9 m	1.2 m	1.5 m
0 - 3.5×10^{-5}	0 - 4.5	0 - 6	0 - 7.5
3.5×10^{-5} - 1.4×10^{-4}	4.5 - 9	6 - 12	7.5 - 15
1.4×10^{-4} - 5.6×10^{-4}	9 - 18	12 - 24	15 - 30
5.6×10^{-4} - 1.7×10^{-3}	18 - 33	24 - 43	30 - 54
1.7×10^{-3} - 3.5×10^{-3}	33 - 46	43 - 61	54 - 76
3.5×10^{-3} - 7.0×10^{-3}	46 - 66	61 - 87	76 - 108



Nomograph for Hooghoudt's D Value

Neverthless, acutual topographical and geological condition has little uniformity and it has been seen the some parts including fine texture soil. The interval of 40 to 60 m, consequently, would be proposed in this project, taking into account these conditions mentioned above.

(2) Diameter of pipe

When corrugated PVC pipe (PVC corrugado) is involved, the following formular is used for caluculation of water discharge flowing in the pipe.

$$q = 38d^{2.667}\ I^{0.5} \quad \text{.....................(3)}$$

where, q : discharge inside the pipe (m^3/sec)
250 m x 0.004 m/86400sec = 0.00069 m^3/sec
take 0.6 for correction factor
0.00069/0.6 = 0.00115 m^3/sec
d : inner diameter of pipe (m), assumed as 0.10 m
I : average hydrodynamic gradient, assumed as 1/600

In order to caluculate diameter of pipe, the above formular is modified as follows :

$$d^{2.667} = \frac{Q}{38 \cdot I^{0.5}} \quad \text{..........................(4)}$$

Then, d = 0.067 m

However,inner diameter of 100 mm of drain pipe is adopted taking account of consideration sedimentation inside pipe, practically.

Table G-1-1 Project Area in Blockwise

Bank	Block	Area	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	

Table G-1-2 Commanding Area in Canal wise

		Gross Area	Net Area
		ha	ha
(LEFT BANK)			
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 Retes-Qüincha	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 G-1-3 Economic Comparison

Case-1. Annual Cost

Alter-native	Probability	Length of Lining	Groundwater Utilization	Irrigated Area	Construction Cost	Annual Cost			Notes
						Amoltization	O/M	Total	
	year	km		ha	x 10^3 \$	\$/ha	\$/ha	\$/ha	
A	10	170	Max	20,200	41,500	308	48	356	Original
B	10	270	Max	20,900	47,800	343	49	392	
C	10	120	Max	18,930	39,500	313	49	362	

Case-2. Annual Benefit

Alter-native	Probability	Length of Lining	Groundwater Utilization	Irrigated Area	Value of Product	Annual Cost	Benefit		Notes
							Total	per ha	
	year	km		ha	x 10^3 \$	x 10^3 \$	x 10^3 \$	\$	
A	10	170	Max	20,200	73,130	26,579	46,551	2,305	Original
B	5	170	Max	20,750	73,749	26,846	46,903	2,260	
C	2	170	Max	21,600	74,705	27,260	47,445	2,197	

Note : Amoltization ;

Period : 50 years

Discount Rate : 15 % per annum

Table G-2-1 Existing Irrigation Method

1. Item

- Date : 18 th, July, 1984
- Place : Boza Alto
- Crop : Initial growth stage of Maize
- Field : Presented below (A= 1.0 ha)

2. Condition

- Furrow slope : 1/100
- Irrigated time : 18 minutes per 5 lines

  $18^{min} \times 50^{lines}/5^{lines} = 180^{min} = 3$ hr/ha
- Velocity between furrow : $160^{m}/18^{min} = 15$ cm/sec
- Water requirements : $(0.010 - 0.015^{m3/sec}) \times 3^{hr} \times 3{,}600^{sec}$

  = 108 - 162 m3/ha = 10.8 - 16.2 mm
- Intermittent day : 15 days

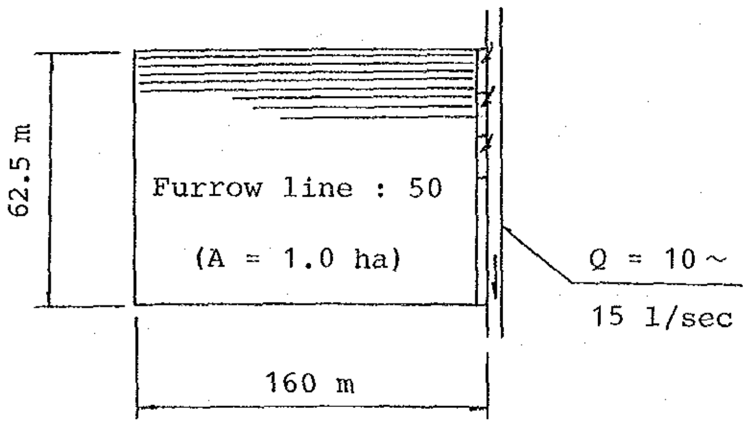


Table G-2-2 (1) <u>Present Irrigation Condition (1 of 2)</u>

Block	Soil Texture	Groundwater Level (m)	Intermittent Day	Basic Intake Rate (mm/hr)	Water Resource	Water Shortage
Palpa and Caqui	SL - L	> 2.0	Fruit: 6-15 days Cotton: 10-15 days (Oct.-Mar.) Maize: 4-5 days	-	River, Infiltration in downsttream, Groundwater	From Jun. to Aug. Use together with pump
Mira Flores and San Jose	S - LS SL - L	> 2.0 (along river) 0.5 - 1.5	Cotton, Maize: 7-14 days	-	Flood season: River Drought season: Infiltration	Caused by sedimentation in canals and reservoir
Boza - Aucallama	S - LS SL - L	(upper) > 2.0 (lower) 0.5 - 1.5	Maize: 15 days	372.0	Flood season: River Drought season: Infiltration	occurs in one third of the irrigation block in wet season
Pasamayo	SL - L	> 2.0	Maize, Vegetable: 7 days	-	Flood season: River Drought season: Return flow	-
Cuyo-Huayan	-	> 2.0	-	-	River	-
Esperanza Alta, Bajo	S - LS	> 2.0	Fruit: 5 days in summer 10 days in winter	-	River	occurs in end of irrigation block

Table G-2-2 (2) Present Irrigation Condition (2 of 2)

Block	Soil Texture	Groundwater Level	Intermittent Day	Basic Intake Rate	Water Resource	Water Shortage
		m		mm/hr		
Huando	SL - L	> 2.0	-	-	River	occurs in partly at the end of irrigation block supply with pump when the river discharge is draught
Jesus del Valle - Esquivel	(upper) SL - L (lower) CL - C	> 2.0 0.5 - 2.0	-	58.0	Upstream: River Downstream: Infiltration, Groundwater	
Retes and Naturales	SL - L (some parts) CL - C	(upper) > 2.0 (lower) 0 - 1.5	4 days	27.6	Upstream: Tiver Downstream: Infiltration, Droundwater	-do-
Chancay Alto	SL - CL	> 2.0	8 - 10 days	-	River, Groundwater in some parts	occurs from Aug. to Dec.
Chancay Bajo	SL - L	> 2.0 (some parts) 0 - 1.5	11 days	-	Infiltration	Area of 20 - 30 % in block can't caltivate
Salinas	S - CL	> 2.0 (some parts) 0 - 1.5	-	-	Infiltration	-
Chancayllo	S - CL	> 2.0	7 days	-	Infiltration	-

Table G-3-1 Water Shortage Area

District	Area (ha)	Cause
Esperanza midstream	550	Imperfection of intake facilities, irrational water management
Esperanza downstream	1,100	Unlined canal, irrational water management
Huando downstream	330	- do -
Esquivel	500	Capacity decreasement by sedimentation in the canal and reservoir
Chancay Bajo	950	- do -
La Huaca	120	Irrational water management
Boza-Aucallama	900	Imperfection of intake facilities, irrational water management
Pasamayo Bajo	450	Unlined canal
Total	4,900	

Table G-5-1 Evapotranspiration by Pemman Method

Month	Tmean	RHmean	U	n	Ra	U	Uday/Unight	Rs	ET	C	ETo
	C	%	km/day			m/sec			mm/day		mm/day
Jan.	21.9	93	74	6.5	16.5	0.86	4	6.22	3.13	1.10	3.44
Feb.	22.8	92	70	6.4	16.3	0.81	4	6.24	3.21	1.10	3.53
Mar.	22.6	93	95	7.8	15.4	1.10	3	4.74	2.57	0.96	2.47
Apr.	20.8	94	77	7.5	14.1	0.89	4	4.56	2.29	1.02	2.34
May	18.7	94	65	6.8	12.6	0.75	4	4.55	2.07	1.05	2.17
Jun.	17.0	95	66	7.7	11.8	0.76	3	3.69	1.66	0.98	1.63
Jul.	16.4	94	61	8.0	12.2	0.71	2	3.62	1.67	0.94	1.57
Aug.	15.8	95	68	8.0	13.3	0.79	2	3.95	1.78	0.94	1.67
Sep.	16.0	94	85	8.0	14.7	0.98	3	4.37	2.04	0.99	2.02
Oct.	17.0	94	108	8.0	15.8	1.25	4	4.69	2.27	1.03	2.34
Nov.	18.4	94	85	7.5	16.3	0.98	3	5.28	2.54	0.99	2.51
Dec.	20.2	93	80	7.1	16.4	0.93	4	5.66	2.82	1.10	3.10

where; $ET^{*} = (WxR_{n}+(1-W)xF_{(u)}x(ea-ed))$

$ET_{o} = Cx\ ET^{*}$

Table G-5-2 Present Planting Area

(unit: ha)

Bank	Block	Fruit	Cotton	Maize	Vegetable	Double Cropping			Pasture	Follow	Total
						Potato	Vegetable	Bean/Forage		Land	
Right	Upper	4,360	215	215	–	–	–	–	–	70	4,860
	Centrral	630	2,595	1,545	420	310	(310)	200	40	50	5,790
	Lower	310	820	820	700	370	(370)	550	–	260	3,830
Sub - total		5,300	3,630	2,580	1,120	680	(680)	750	40	380	14,480
Left	Upper	640	875	475	150	150	(150)	–	–	30	2,320
	Lower	590	795	795	530	70	(70)	450	110	60	3,400
Sub - total		1,230	1,670	1,270	680	220	(220)	450	110	90	5,720
Total		6,530	5,300	3,850	1,800	900	(900)	1,200	150	470	20,200
Ratio (%)		32	26	19	9	5		6	1	2	100

Table G-5-3 Proposed Planting Area

(unit: ha)

Bank	Block	Fruit	Cotton	Double Cropping				Vegetable	Total
				Maize	Green/ Manure	Potato, Others	Choclo, Others		
Right	Upper	4,360	250	250	(125) (125)	-	-	-	4,860
	Centrral	630	2,280	2,280	(1,140) (1,140)	300	(300)	300	5,790
	Lower	310	1,310	1,310	(655) (655)	300	(300)	600	3,830
Sub - total		5,300	3,840	3,840	(1,920) (1,920)	600	(600)	900	14,480
Left	Upper	640	690	690	(460) (230)	150	(150)	150	2,320
	Lower	590	1,130	1,130	(450) (680)	150	(150)	400	3,400
Sub - total		1,230	1,820	1,820	(910) (910)	300	(300)	550	5,720
Total		6,530	5,660	5,660	(2,830) (2,830)	900	(900)	1,450	20,200
Ratio (%)		32	28	28		5		7	100

Table G-5-4 <u>IRRIGATION DURATION OF THE PROPOSED CROPPING PATTERN</u>

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	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Table G-5-5 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 G-5-6 (1) Calculated Kc Value

Cotton

Month	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Aug.	0.45	0.60	0.90	1.05	1.07	0.95	0.75		
Sep.		0.45	0.60	0.90	1.05	1.07	0.95	0.75	
Oct.			0.45	0.60	0.90	1.05	1.07	0.95	0.75
(Kc)	0.15	0.35	0.65	0.85	1.01	1.02	0.92	0.57	0.25

Maize

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Jan.	0.35	0.60	1.02	1.05	0.75		
Feb.		0.35	0.60	1.02	1.05	0.75	
Mar.			0.35	0.60	1.02	1.05	0.25
(Kc)	0.12	0.32	0.66	0.89	0.94	0.60	0.25

Bean

Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Jul.	0.50	0.90	1.07	0.75		
Aug.		0.50	0.90	1.07	0.75	
Sep.			0.50	0.90	1.07	0.75
(Kc)	0.17	0.47	0.82	0.91	0.61	0.25

Table G-5-6 (2) Calculated Kc Value

Potato

Month	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
Jun.	0.50	0.75	1.05	1.03	0.85			
Jul.		0.50	0.75	1.05	1.03	0.85		
Aug.			0.50	0.75	1.05	1.03	0.85	
Sep.				0.50	0.75	1.05	1.03	0.85
(Kc)	0.13	0.31	0.58	0.83	0.92	0.73	0.47	0.21

Choclo

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.
Jan.	0.40	0.90	1.07	1.00			
Feb.		0.40	0.90	1.07	1.00		
Mar.			0.40	0.90	1.07	1.00	
Apr.				0.40	0.90	1.07	1.00
(Kc)	0.10	0.33	0.59	0.84	0.74	0.52	0.25

Green Manure

Month	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Jul.	0.50	0.75	0.95	0.80		
Aug.		0.50	0.75	0.95	0.80	
Sep.			0.50	0.75	0.95	0.80
(Kc)	0.17	0.42	0.73	0.83	0.58	0.27

Table G-5-7 Net Water Requirements

Crop	Irrigated Day		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total (mm/year)
			ETo (mm/day)												
			1.67	2.02	2.34	2.51	3.10	3.44	3.53	2.47	2.34	2.17	1.63	1.57	
Fruit	365	ETc	0.25	0.51	1.05	1.76	2.64	3.10	2.29	0.99	0.47	0.22	0.13	0.13	
		ETm	7.8	15.3	32.6	52.8	81.8	96.1	64.1	30.7	14.1	6.8	3.9	4.0	410.0
Cotton	210	ETc		0.91	1.40	2.26	3.26	3.68	3.35	1.85					
		ETm		27.3	43.4	67.8	101.1	114.1	93.8	57.4					504.9
Maize	150	ETc							1.24	1.48	2.39	2.28	1.22		
		ETm							34.7	45.9	71.7	70.7	36.6		259.6
Bean	110	ETc	0.84	1.82	2.50	1.88									
		ETm	26.0	54.6	77.5	37.6									195.7
Potato	145	ETc	0.84	1.52	2.46	2.59	2.64								
		ETm	26.0	45.6	76.3	77.7	66.0								291.6
Choclo	110	ETc							1.41	2.22	2.50	2.17			
		ETm							39.5	68.8	75.0	43.4			226.7
Green Manure	95	ETc	0.84	1.52	2.22	2.01									
		ETm	26.0	45.6	68.8	10.0									150.4
Vegetable (Double Cropping)	365	ETc	0.75	0.81	1.64	1.38		1.38	2.47	1.36	0.70	1.30	1.14	1.10	
		ETm	23.3	24.3	50.8	41.4		42.8	69.2	42.2	21.0	40.3	34.2	34.1	423.6

Note : ETc ; (mm/day), ETm ; (mm/month)

Table G-5-8 Total Net Water Requirements (Present)

Crop	Planting Area		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
Fruit	6,530	Em	7.8	15.3	32.6	52.8	81.8	96.1	64.1	30.7	14.1	6.8	3.9	4.0	
		Vm	509	999	2,129	3,448	5,342	6,275	4,186	2,005	921	444	255	261	
Cotton	5,300	Em		5.5	14.1	27.7	47.9	70.7	84.0	86.8	73.3	53.1	30.2	11.5	
		Vm		292	747	1,468	2,539	3,747	4,452	4,600	3,885	2,814	1,601	610	
Maize	3,850	Em	5.2		5.0	11.5	21.8	31.9	37.1	37.1	37.1	32.1	25.6	15.3	
		Vm	200		193	443	839	1,228	1,428	1,428	1,428	1,236	986	589	
Vegetable	1,950	Em	23.3	24.3	50.8	41.4		42.8	69.2	42.2	21.0	40.3	34.2	34.1	
		Vm	454	474	991	807		835	1,349	823	410	786	667	665	
Potato	900	Em	45.1	58.3	53.1	44.0	28.7	13.2				5.2	14.3	29.6	
		Vm	406	525	478	396	258	119				47	129	266	
Green Manure	(900)	Em					6.5	17.9	35.1	37.6	31.1	19.7	2.5		
		Vm					59	161	316	338	280	177	23		
Bean	1,200	Em	26.9	52.7	56.6	38.4	12.5							8.7	
		Vm	323	632	679	461	150							104	
Choclo	(1,200)	Em						9.9	27.1	45.8	56.7	46.8	29.6	10.9	
		Vm						119	325	550	680	562	355	131	
Total	19,730		1,892	2,922	5,217	7,023	9,187	12,484	12,056	9,744	7,604	6,066	4,016	2,626	80,839

Note : Em (mm/month)
Vm (x 10^3 m^3/month)

Table G-5-9 Total Net Water Requirements (Proposed)

Crop	Planting Area		ETo (mm/day) Aug. 1.67	Sep. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	6,530	Em	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		Vm	509	993	2,129	3,441	5,337	6,269	4,192	1,998	914	438	255	255	
Cotton	5,660	Em	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		Vm	441	1,200	2,672	3,622	5,496	6,158	5,145	2,468	996				
Maize	5,660	Em						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		Vm						724	1,789	2,858	3,538	3,577	1,658	691	
Bean	(2,830)	Em	24.3	49.7	66.0	45.9	24.0							8.3	
		Vm	688	1,407	1,868	1,299	679							234	
Potato	900	Em	30.0	50.3	66.7	55.0	45.2	22.4					6.4	15.1	
		Vm	270	453	60	495	407	202					58	136	
Choclo	(900)	Em						10.7	32.6	45.2	59.0	49.8	25.4	12.2	
		Vm						96	293	407	531	448	229	110	
Green Manure	(2,830)	Em	21.7	44.2	60.2	43.7	25.9							8.3	
		Vm	614	1,251	1,704	1,237	733							235	
Vegetable	1,450	Em	23.3	24.2	50.8	41.4		42.7	69.2	42.1	21.1	40.4	34.2	34.1	
		Vm	338	351	735	600		619	1,003	610	306	586	496	495	
Total	20,200		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

Note : Em (mm/month)
Vm (x 10^3 m^3/month)

Table G-5-10 Irrigation Efficiency (E)

Present

Efficiency		Unlined Canal			Lining Canal		
		Coarse	Medium	Fine	Coarse	Medium	Fine
(1) Conveyance	Ec	70	75	80	80	83	85
(2) Field Canal	Eb	75	80	85	80	85	90
(3) Field Application	Ea	45	50	55	45	50	55
(1) x (2) x (3) Irrigation	E	24	30	37	29	35	42

Proposed

Efficiency		Unlined Canal			Lining Canal		
		Coarse	Medium	Fine	Coarse	Medium	Fine
(1) Conveyance	Ec	75	80	85	95	95	95
(2) Field Canal	Eb	80	85	90	90	90	90
(3) Field Application	Ea	55	60	65	55	60	65
(1) x (2) x (3) Irrigation	E	33	41	50	47	51	56

Table G-5-11 Comprehensive Irrigation Efficiency (Present)

Bank	Block	Area	Coarse		Medium		Fine		E	Ratio of Canal Lining
			Area	E	Area	E	Area	E		
		ha	ha	%	ha	%	ha	%	%	%
Right	Upper	4,860	3,810	28	1,050	34	-	-	29	72
	Central	5,790	400	24	4,790	30	600	37	30	0
	Lower	3,830	1,400	25	2,430	31	-	-	29	21
Left	Upper	2,320	30	24	2,290	30	-	-	30	0
	Lower	3,400	920	25	2,480	31	-	-	29	12
Total		20,200	6,560	25	13,040	31	600	38	29	(27)

Table G-5-12 Comprehensive Irrigation Efficiency (Proposed)

Bank	Block	Area	Coarse		Medium		Fine		E	Ratio of Canal Lining
			Area	E	Area	E	Area	E		
		ha	ha	%	ha	%	ha	%	%	%
Right	Upper	4,860	3,810	46	1,050	50	-	-	47	90
	Central	5,790	400	43	4,790	48	600	54	48	69
	Lower	3,830	1,400	38	2,430	45	-	-	42	36
Left	Upper	2,320	30	43	2,290	48	-	-	48	68
	Lower	3,400	920	42	2,480	47	-	-	46	61
Total		20,200	6,560	42	13,040	48	600	54	46	(66)

Table G-5-13 (1) Gross Water Requirements (Right Bank, Upper)

Crop	Area(ha)	Month ETo (mm/day)	Aug. 1.67	Sept. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	4,360	mm/month	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		x 10^3 m^3	340	663	1,421	2,298	3,562	4,186	2,799	1,334	610	292	170	170	
Cotton	250	mm/month	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		x 10^3 m^3	20	53	118	160	243	272	227	109	44				
Maize	250	mm/month						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		x 10^3 m^3						32	79	126	156	158	73	31	
Bean	(125)	mm/month	24.3	49.7	66.0	45.9	24.0							8.3	
		x 10^3 m^3	30	62	83	57	30							10	
Green Manure	(125)	mm/month	21.7	44.2	60.2	43.7	25.9							8.3	
		x 10^3 m^3	27	55	75	55	32							10	
Total	4,860	Net Water Requirements	417	833	1,697	2,570	3,867	4,490	3,105	1,569	810	450	243	221	20,272
Gross Water Requirements		(E = 47 %)	887	1,772	3,611	5,468	8,228	9,553	6,606	3,338	1,723	957	517	470	43,130
Unit Gross Water Requirements		10^3 m3/ha	0.183	0.365	0.743	1.125	1.693	1.966	1.359	0.686	0.355	0.197	0.106	0.097	8.875

Table G-5-13 (2) Gross Water Requirements (Right Bank, Central)

Crop	Area(ha)	Month ETo (mm/day)	Aug. 1.67	Sept. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	630	mm/month	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		$\times 10^3 m^3$	49	96	205	332	515	605	404	193	88	42	25	25	
Cotton	2,280	mm/month	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		$\times 10^3 m^3$	178	483	1,076	1,459	2,214	2,481	2,073	994	401				
Maize	2,280	mm/month						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		$\times 10^3 m^3$						292	720	1,151	1,425	1,441	668	278	
Bean	(1,140)	mm/month	24.3	49.7	66.0	45.9	24.0							8.3	
		$\times 10^3 m^3$	277	567	752	523	274							95	
Green Manure	(1,140)	mm/month	21.7	44.2	60.2	43.7	25.9							8.3	
		$\times 10^3 m^3$	247	504	686	498	295							95	
Potato	300	mm/month	30.0	50.3	66.7	55.0	45.2	22.4					6.4	15.1	
		$\times 10^3 m^3$	90	151	200	165	136	67					19	45	
Choclo	(300)	mm/month						10.7	32.6	45.2	59.0	49.8	25.4	12.2	
		$\times 10^3 m^3$						32	98	136	177	149	76	37	
Vegetable (Double cropping)	300	mm/month	23.3	24.2	50.8	41.4		42.7	69.2	42.1	21.1	40.4	34.2	34.1	
		$\times 10^3 m^3$	70	73	152	124		128	208	126	63	121	103	102	
Total	5,790	Net Water Requirements	911	1,874	3,071	3,101	3,434	3,605	3,503	2,600	2,154	1,753	891	677	27,574
Gross Water Requirements		(E = 48 %)	1,898	3,904	6,398	6,460	7,154	7,510	7,298	5,417	4,488	3,652	1,856	1,410	57,445
Unit Gross Water Requirements		10^3 m3/ha	0.328	0.674	1.105	1.116	1.236	1.297	1.260	0.936	0.775	0.631	0.321	0.244	9.923

Table G-5-13 (3) Gross Water Requirements (Right Bank, Lower)

Crop	Area(ha)	Month ETo (mm/day)	Aug. 1.67	Sept. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	310	mm/month	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		x 10^3 m^3	24	47	101	163	253	298	199	95	43	21	12	12	
Cotton	1,310	mm/month	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		x 10^3 m^3	102	278	618	838	1,272	1,425	1,191	571	231				
Maize	1,310	mm/month						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		x 10^3 m^3						168	414	662	819	828	384	160	
Bean	(655)	mm/month	24.3	49.7	66.0	45.9	24.0							8.3	
		x 10^3 m^3	159	326	432	301	157							54	
Green Manure	(655)	mm/month	21.7	44.2	60.2	43.7	25.9							8.3	
		x 10^3 m^3	142	290	394	286	170							54	
Potato	300	mm/month	30.0	50.3	66.7	55.0	45.2	22.4					6.4	15.1	
		x 10^3 m^3	90	151	200	165	136	67					19	45	
Choclo	(300)	mm/month						10.7	32.6	45.2	59.0	49.8	25.4	12.2	
		x 10^3 m^3						32	98	136	177	149	76	37	
Vegetable	600	mm/month	23.3	24.2	50.8	41.4		42.7	69.2	42.1	21.1	40.4	34.2	34.1	
		x 10^3 m^3	140	145	305	248		256	415	253	127	242	205	205	
Total	3,830	Net Water Requirements	657	1,237	2,050	2,001	1,988	2,246	2,317	1,717	1,397	1,240	696	567	18,113
Gross Water Requirements		(E=42 %)	1,564	2,945	4,881	4,764	4,733	5,348	5,517	4,088	3,326	2,952	1,657	1,350	43,125
Unit Gross Water Requirements		10^3 m3/ha	0.408	0.769	1.274	1.244	1.236	1.396	1.440	1.067	0.868	0.771	0.433	0.352	11.258

Table G-5-13 (4) Gross Water Requirements (Left Bank, Upper)

Crop	Area(ha)	Month ETo (mm/day)	Aug. 1.67	Sept. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	640	mm/month	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		$\times 10^3$ m^3	50	97	209	337	523	614	411	196	90	43	25	25	
Cotton	690	mm/month	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		$\times 10^3$ m^3	54	146	326	442	670	751	627	301	121				
Maize	690	mm/month						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		$\times 10^3$ m^3						88	218	348	431	436	202	84	
Bean	(460)	mm/month	24.3	49.7	66.0	45.9	24.0							8.3	
		$\times 10^3$ m^3	112	229	304	211	110							38	
Green Manure	(230)	mm/month	21.7	44.2	60.2	43.7	25.9							8.3	
		$\times 10^3$ m^3	50	102	138	101	60							19	
Potato	150	mm/month	30.0	50.3	66.7	55.0	45.2	22.4					6.4	15.1	
		$\times 10^3$ m^3	45	75	100	83	68	34					10	23	
Choclo	(150)	mm/month						10.7	32.6	45.2	59.0	49.8	25.4	12.2	
		$\times 10^3$ m^3						16	49	68	89	75	38	18	
Vegetable	150	mm/month	23.3	24.2	50.8	41.4		42.7	69.2	42.1	21.1	40.4	34.2	34.1	
		$\times 10^3$ m^3	35	36	76	62		64	104	63	32	61	51	51	
Total	2,320	Net Water Requirements	346	685	1,153	1,236	1,431	1,567	1,409	976	763	615	326	258	10,765
Gross Water Requirements		(E=48 %)	721	1,427	2,402	2,575	2,981	3,265	2,935	2,033	1,590	1,281	679	538	22,427
Unit Gross Water Requirements		10^3 m3/ha	0.311	0.615	1.035	1.110	1.285	1.407	1.265	0.876	0.685	0.552	0.293	0.232	9.666

Table G-5-13 (5) Gross Water Requirements (Left Bank, Lower)

Crop	Area(ha)	Month ETo (mm/day)	Aug. 1.67	Sept. 2.02	Oct. 2.34	Nov. 2.51	Dec. 3.10	Jan. 3.44	Feb. 3.53	Mar. 2.47	Apr. 2.34	May 2.17	Jun. 1.63	Jul. 1.57	Total
Fruit	590	mm/month	7.8	15.2	32.6	52.7	81.7	96.0	64.2	30.6	14.0	6.7	3.9	3.9	
		x 10^3 m^3	46	90	192	311	482	566	379	181	83	40	23	23	
Cotton	1,130	mm/month	7.8	21.2	47.2	64.0	97.1	108.8	90.9	43.6	17.6				
		x 10^3 m^3	88	240	533	723	1,097	1,229	1,027	493	199				
Maize	1,130	mm/month						12.8	31.6	50.5	62.5	63.2	29.3	12.2	
		x 10^3 m^3						145	357	571	706	714	331	138	
Bean	(450)	mm/month	24.3	49.7	66.0	45.9	24.0							8.3	
		x 10^3 m^3	109	224	297	207	108							37	
Green Manure	(680)	mm/month	21.7	44.2	60.2	43.7	25.9							8.3	
		x 10^3 m^3	148	301	409	297	176							56	
Potato	150	mm/month	30.0	50.3	66.7	55.0	45.2	22.4					6.4	15.1	
		x 10^3 m^3	45	75	100	83	68	34					10	23	
Choclo	(150)	mm/month						10.7	32.6	45.2	59.0	49.8	25.4	12.2	
		x 10^3 m^3						16	49	68	89	75	38	18	
Vegetable	400	mm/month	23.3	24.2	50.8	41.4		42.7	69.2	42.1	21.1	40.4	34.2	34.1	
		x 10^3 m^3	93	97	203	166		171	277	168	84	162	137	136	
Total	3,400	Net Water Requirements	529	1,027	1,734	1,787	1,931	2,161	2,089	1,481	1,161	991	539	431	15,861
Gross Water Requirements		(E=46 %)	1,150	2,233	3,770	3,885	4,198	4,698	4,541	3,220	2,524	2,154	1,172	937	34,482
Unit Gross Water Requirements		10^3 m3/ha	0.338	0.657	1.109	1.143	1.235	1.382	1.336	0.947	0.742	0.634	0.345	0.275	10.143

Table G-5-14 Water Quality

Point	Flood Season (Feb. 28, '84)				Drought Season (Jul. 5, '84)				Notes
	Water Temperature	PH	EC	Salinity	Water Temperature	PH	EC	Salinity	
	°C		us/cm	ppm	°C		us/cm	ppm	
Esperanza	23	7.9	340	175	23	8.5	400	200	river
Donoso	26	7.6	740	360	22	8.0	780	390	recycled
Esquivel	25	7.3	800	400	23	7.3	740	360	-do-
Jecuan	25	7.3	820	410	23	8.3	950	480	-do-
Mira Flores	26	7.4	450	220	20	8.4	530	260	-do-

Table G-5-15 Leaching Water Requirements

Block	Salinity Class	Area (ha)	Net Leaching Water Requirement (cm)	Field Leaching Water Requirements in Depth (cm)	Field Leaching Water Requirements in Volume ($X10^3m^3$)	Conveyance efficiency (%)	Gross Leaching Water Requirements ($X10^3m^3$)	Leaching Method
DONOSO/QUINCHA	S_2	273	30	45	1,229			Furrow
	S_3	524	60	90	4,716			
	Sub-Total	797			5,945	80	7,431	
BOZA	S_2	15	30	45	68			"
	S_3	130	60	90	1,170			
	Sub-Total	145			1,238	80	1,548	
LUNAVILCA	S_2	50	30	45	225			"
	Sub-Total	50			225	80	281	
SANLUIS	S_2	168	30	45	756			"
	S_3	82	60	90	738			
	Sub-Total	250			1,494	80	1,868	
PALPA	S_2	30	30	45	135			"
	Sub-Total	30			135	80	169	
EL HATILLO	S_3	160	50	50	800			Flooding
	Sub-Total	160			800	80	1,000	
TOTAL	S_2	536			2,413			
	S_3	896			7,424			
	Total	1,432			9,837	80	12,297	

Table G-5-16 (1) Municipal Water Use (1983)

(Unit: m^3)

Month	River	Well No.1	Well No.2	Total
Jan.	96,730	73,731	35,609	206,070
Feb.	66,200	65,042	27,472	158,714
Mar.	79,490	71,735	36,377	187,602
Apr.	92,580	70,237	42,808	205,625
May	86,310	71,086	36,245	193,641
Jun.	89,380	71,861	35,161	196,402
Jul.	100,090	70,129	45,781	216,000
Aug.	96,730	68,777	44,442	209,949
Sep.	95,940	58,902	42,703	197,545
Oct.	95,168	61,872	41,856	198,896
Nov.	92,684	69,615	44,115	206,414
Dec.	99,250	66,623	44,230	210,103
Total	1,090,552	819,610	476,799	2,386,961

Table G-5-16 (2) Municipal Water Use (1984)

(Unit: m^3)

Month	River	Well No. 1	Well No. 2	Total
Jan.	125,890	68,730	45,113	239,733
Feb.	104,390	70,564	43,692	218,646
Mar.	109,315	74,062	45,447	228,824
Apr.	119,207	73,654	46,954	239,815
May	133,442	76,143	47,493	257,078
Jun.	129,162	72,631	45,622	247,415
Jul.	131,436	72,534	45,602	249,572
Aug.	128,339	72,672	41,785	242,796
Sep.	125,054	79,098	17,622	221,774
Oct.				
Nov.				
Dec.				
Total	(1,106,235)	(660,088)	(379,330)	(2,145,653)

Table G-5-17 (1) Probable Discharge at Santo Domingo

Probability		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
1/2	m^3/sec/month	157.3	148.2	167.9	210.1	330.6	573.5	1,036.8	1,442.3	637.3	280.0	206.1	168.9	5,359.0
	x 10^3 m^3	13,591	12,804	14,507	18,153	28,564	49,550	89,579	124,615	55,063	24,192	17,807	14,593	463,018
1/5	m^3/sec/month	132.2	122.2	142.7	157.6	218.1	339.1	572.6	877.7	455.9	210.2	164.8	142.4	3,535.5
	x 10^3 m^3	11,422	10,558	12,329	13,617	18,844	29,298	49,473	75,833	39,390	18,161	14,239	12,303	305,467
1/10	m^3/sec/month	120.6	110.1	132.9	135.1	180.0	259.4	383.3	697.6	385.5	182.3	145.4	130.4	2,862.6
	x 10^3 m^3	10,420	9,513	11,483	11,673	15,552	22,412	33,117	60,273	33,307	15,751	12,563	11,267	247,331
1/20	m^3/sec/month	111.7	100.7	126.2	118.7	156.0	208.9	249.3	587.9	337.2	162.7	130.6	121.2	2,411.1
	x 10^3 m^3	9,651	8,700	10,904	10,256	13,478	18,049	21,540	50,795	29,134	14,057	11,284	10,472	208,320
1/50	m^3/sec/month	102.4	91.0	119.9	102.4	135.0	164.8	119.2	495.5	291.6	143.8	115.0	111.7	1,992.3
	x 10^3 m^3	8,847	7,862	10,359	8,847	11,664	14,239	10,299	42,811	25,194	12,424	9,936	9,651	172,133

Note: Including the drained discharge from upstream lagoons.

Table G-5-17 (2) Probable Discharge at Santo Domingo

Probability		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
1/2	m^3/sec/month	136.9	108.7	144.9	164.5	321.9	573.5	1,036.8	1,442.3	637.3	273.8	196.1	152.0	5,188.7
	x 10^3 m^3	11,828	9,392	12,519	14,213	27,812	49,550	89,580	124,615	55,063	23,656	16,943	13,133	448,304
1/5	m^3/sec/month	108.5	80.8	114.0	101.4	196.7	339.1	572.6	877.7	455.9	204.9	153.5	123.8	3,328.9
	x 10^3 m^3	9,374	6,981	9,850	8,761	16,995	29,298	49,473	75,833	39,390	17,703	13,262	10,696	287,616
1/10	m^3/sec/month	94.8	68.3	100.5	73.9	151.8	259.4	383.4	697.6	385.5	177.1	133.7	110.4	2,626.3
	x 10^3 m^3	8,191	5,901	8,683	6,385	13,116	22,412	33,117	60,273	33,307	15,301	11,552	9,539	227,777
1/20	m^3/sec/month	84.1	59.0	90.7	53.6	122.4	208.9	249.3	587.9	337.2	157.5	118.6	100.0	2,169.2
	x 10^3 m^3	7,266	5,098	7,836	4,631	10,575	18,049	21,539	50,795	29,134	13,608	10,247	8,640	187,418
1/50	m^3/sec/month	72.7	49.4	80.7	33.0	95.9	164.8	119.2	495.5	291.6	138.5	102.7	88.8	1,732.8
	x 10^3 m^3	6,281	4,268	6,972	2,851	8,286	14,239	10,299	42,811	25,194	11,966	8,873	7,672	149,712

Note: excluding the drained discharge from upstream lagoons.

Table G-5-17 (3) Monthly River Discharge

(Unit: m^3/sec)

Year	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
1963	148.9	114.0	134.2	256.0	726.4	335.8	1,070.7	2,156.3	1,250.6	399.0	226.8	160.8	6,979.5
64	163.5	123.1	168.3	194.9	198.6	415.5	1,036.1	3,028.2	598.9	262.6	183.9	153.3	6,526.9
65	140.8	103.6	123.4	129.6	220.4	514.6	390.1	761.6	321.7	192.3	139.9	107.0	3,145.0
66	86.9	57.2	240.7	239.3	582.7	1,063.9	3,752.0	3,530.7	622.6	333.2	202.0	164.7	10,875.9
67	150.3	121.0	215.0	155.2	221.5	400.3	320.0	690.7	362.2	132.3	114.7	105.9	2,989.1
68	95.7	74.2	133.3	163.0	211.4	214.6	339.2	1,619.9	848.6	181.9	120.1	101.5	4,103.4
69	94.3	63.1	110.5	85.0	1,039.1	2,659.7	754.8	740.4	526.2	380.3	255.1	160.7	6,869.2
1970	124.9	167.4	145.5	164.3	410.2	811.1	1,023.6	1,555.9	772.5	250.0	198.6	165.9	5,789.9
71	151.7	116.9	128.8	131.0	294.4	967.7	1,170.0	6,798.2	1,098.3	464.4	299.6	210.3	11,831.3
72	193.3	144.9	160.3	148.0	493.2	1,390.2	1,334.0	2,235.4	1,311.8	548.1	294.6	208.6	8,462.4
73	190.4	189.9	258.2	226.3	757.4	1,231.7	1,629.4	1,921.7	747.5	371.7	283.5	210.2	8,017.9
74	196.6	90.7	140.8	136.4	125.5	470.2	454.1	1,844.1	551.9	283.2	208.4	164.2	4,666.1
75	163.2	109.2	153.8	161.8	224.0	712.5	1,367.1	1,325.3	620.9	282.5	212.6	183.7	5,516.6
76	174.4	168.8	98.1	16.3	178.3	342.2	1,445.7	1,416.1	580.7	274.0	188.4	149.0	5,032.0
77	133.3	61.0	131.0	258.8	334.8	334.6	881.6	647.8	398.6	198.2	135.7	129.0	3,644.7
78	83.6	92.9	141.4	146.1	253.5	203.7	738.0	1,590.4	392.8	192.0	165.4	140.8	4,140.6
79	93.6	103.8	73.0	68.3	112.0	568.9	285.7	615.1	442.2	203.7	173.9	120.5	2,860.7
1980	114.2	72.4	184.8	207.8	384.8	557.1	1,823.4	2,137.8	777.8	246.8	205.8	166.6	6,879.3
81	126.8	136.9	156.6	211.4	355.8	474.6	1,330.9	713.7	554.7	270.9	183.5	134.2	4,650.0
82	163.9	148.5	127.7	476.4	485.7	840.2	1,461.5	1,468.1	1,178.4	278.4	151.4	103.5	6,883.7
83	130.6	110.3	137.7	118.8	341.5	428.0	1,825.4	1,474.6	677.7	390.3	278.1	203.1	6,116.1
Mean	139.1	112.8	150.6	175.9	373.9	711.3	1,163.5	1,822.5	697.0	292.2	201.0	154.5	5,994.3

Note: excluding the drained discharge from lagoons.

Table G-5-18 Utilization Record of Upstream Lagoons (unit : X $10^3 m^3$)

Year		Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1974	Dv				(37,400)	2,000	40	3,230	3,230	9,600	1,600	3,300	5,300	28,300
	Ut					1,600	32	2,584	2,584	7,680	1,280	2,640	4,240	22,640
1975	Dv				(31,780)	3,380	1,305	763	652	5,900	2,560	2,480	2,410	19,450
	Ut					2,704	1,044	610	522	4,720	2,048	1,984	1,928	15,560
1976	Dv				(33,000)	1,500	1,200	900	-	1,130	6,018	14,152	2,700	27,600
	Ut					1,200	960	720		904	4,814	11,322	2,160	22,080
1977	Dv						(28,870)	2,220	1,920	7,430	570	5,694	-	17,834
	Ut							1,776	1,536	5,944	456	4,555		14,267
1978	Dv					(27,700)	2,730	770	5,510	5,920	70	5,620	-	20,620
	Ut						2,184	616	4,408	4,736	56	4,496		16,496
1979	Dv					(26,530)	1,450	900	4,425	1,395	4,800	5,660	3,400	22,030
	Ut						1,160	720	3,540	1,116	3,840	4,528	2,720	17,624
1980	Dv					(24,100)	1,450	900	600	4,750	2,200	350	-	10,250
	Ut						1,160	720	480	3,800	1,760	280		8,200
1981	Dv				(34,080)	300	300	1,000	3,300	2,373	3,000	3,527	250	14,050
	Ut					240	240	800	2,640	1,898	2,400	2,822	200	11,240
1982	Dv				(32,330)	150	1,650	4,350	1,400	980	5,350	5,350	-	19,230
	Ut					120	1,320	3,480	1,120	784	4,280	4,280		15,384
1983	Dv				(30,180)	700	650	5,180	1,070	1,720	1,720	3,350	1,540	15,930
	Ut					560	520	4,144	856	1,376	1,376	2,680	1,232	12,744
(Mean)	Dv					803	1,078	2,021	2,211	4,120	2,789	4,948	1,560	19,530
	Ut					642	862	1,617	1,769	3,296	2,231	3,958	1,248	15,623

Note: Parentheses show the effective volume of lagoons
Dv; Drained volume
Ut; Utilization (Drained volume x 0.8)

Table G-5-19 Intake Discharge from River

(Unit: x 10^3 m^3)

Year	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.
1977	11,005	9,641	9,871	18,148	20,310	21,700
1978	10,729	11,591	10,945	15,164	15,185	15,045
1979	11,512	8,719	8,051	8,687	10,851	22,128
1980	8,830	8,152	-	-	-	30,123
1981	11,388	10,710	13,701	17,312	25,137	25,476
1982	14,138	11,823	12,966	20,919	17,793	30,422
1983	8,930	8,640	8,898	9,348	19,332	20,630

Note: The volume is the sum of 5 intakes of Palpa, Caqui, Esperanza, Huando and Chancay-Huaral

Table G-5-20 Utilization of Infiltration and Groundwater

(Unit : x $10^3 m^3$)

Year		Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Probable Year
1977	Inf.	8,790	8,924	7,596	11,422	11,384	11,133	-
	Grw.	723	517	551	843	764	837	
1978	Inf.	8,966	8,866	9,276	9,853	10,816	10,772	5 years
	Grw.	917	990	1,152	1,146	1,056	1,067	
1979	Inf.	9,738	8,013	7,995	7,215	8,451	13,429	20 years
	Grw.	1,824	2,272	2,789	2,763	2,743	1,893	
1980	Inf.	10,085	10,000	-	-	-	16,676	-
	Grw.	1,296	1,375	-	-	-	184	
1981	Inf.	10,027	9,998	11,454	10,156	11,977	13,256	2 years
	Grw.	638	304	324	726	713	771	
1982	Inf.	8,470	7,966	7,928	13,758	19,120	13,782	-
	Grw.	-	-	-	-	-	-	
1983	Inf.	13,257	12,622	12,911	12,821	14,006	12,817	-
	Grw.	-	-	-	-	-	-	

Note: Inf.; Infiltration
Grw.; Groundwater

Table G-5-21 Ratio of Recycled in Drought Period

Year	Month	River x 10^3 m3	Recycled x 10^3 m3	Ratio %
1977	Aug.	11,005	8,790	80
	Sep.	9,641	8,924	93
	Oct.	9,871	7,596	77
	Nov.	18,148	11,422	63
	Dec.	20,310	11,384	56
	Jan.	21,700	11,133	51
1978	Aug.	10,729	6,966	84
	Sep.	11,591	8,866	76
	Oct.	10,945	9,276	85
	Nov.	15,164	9,853	65
	Dec.	15,185	10,816	71
	Jan.	15,045	10,772	72
1979	Aug.	11,512	9,738	85
	Sep.	8,719	8,013	92
	Oct.	8,051	7,995	99
	Nov.	8,687	7,215	83
	Dec.	10,851	8,451	78
	Jan.	22,128	13,429	61
1980	Aug.	8,830	10,085	(114)
	Sep.	8,152	10,000	(123)
	Oct.	-	-	-
	Nov.	-	-	-
	Dec.	-	-	-
	Jan.	30,123	16,676	55
1981	Aug.	11,388	10,027	88
	Sep.	10,710	9,998	93
	Oct.	13,701	11,454	84
	Nov.	17,312	10,156	59
	Dec.	25,137	11,977	48
	Jan.	25,476	13,256	52
1982	Aug.	14,138	8,470	60
	Sep.	11,823	7,966	67
	Oct.	12,966	7,928	61
	Nov.	20,919	13,758	66
	Dec.	17,793	19,120	(107)
	Jan.	30,422	13,782	45
1983	Aug.	8,930	13,257	(148)
	Sep.	8,640	12,622	(146)
	Oct.	8,898	12,911	(145)
	Nov.	9,348	12,821	(137)
	Dec.	19,332	14,006	72
	Jan.	20,630	13,817	67

Table G-5-22 Ratio of Recycled of Each Commanding Area in System Wide

(unit: x 10^3 m^3)

Block		Sep.		Oct.		Nov.		Dec.		Adopted
		Q	Re	Q	Re	Q	Re	Q	Re	Re
			%		%		%		%	%
(Right bank)										
[Esperanza + Huando + Huaral]	Upstream	5,339		4,819		5,089		6,166		
↓	Downstream	3,388		3,578		3,315		3,983		
[Chancayllo]			63		74		65		65	65
(Left bank)										
[Palpa + Caqui]	Upstream	1,540		1,484		1,542		1,888		
↓	Downstream	899		927		871		924		
[Mira Flores]			62		62		57		49	49
[Mira Flores, San Jose]	Upstream	1,519		1,556		1,392		1,352		
↓	Downstream	1,078		1,159		972		934		
[Boza Alto, Boza Bajo, Pasamayo Alto]			71		75		70		69	69
[Mira Flores - Pasamayo Alto,	Upstream	3,015		3,117		2,752		2,806		
Santa Rosa] ↓	Downstream	1,881		1,917		1,575		1,835		
			62		62		57		65	57
[Salinas + Pasamayo Bajo]										

Note: Q; Recorded utilization data by ATDR in 1979

Table G-5-23 Existing Pump

Bank	Block	Yield 1/sec	Nos	Location
Left	Upper	25		CAP: Palpa - Caqui
		100		
		27		
		33		
	Sub-total	185	4	
	Lower	40		Boza, Aucallama, Pasamayo
		41		
		47		
		31		
		40		
	Sub-total	199	5	
Right	Upper	40		CAP: Huando
		60		
		80		
		40		
		40		
	Sub-total	260	5	
	Central	92		CAP: Jesus de Valle
		82		
		44	(3)	
		80		Esquivel
		40		
		30		
		20		
		40		
		40		
		25	(7)	
		60		CAP: Candelaria
		60	(2)	
	Sub-total	613	12	
	Total	1,257	26	

Table G-5-24 Present Water Balance (Probability: 10 years)

(Unit : x $10^3 m^3$)

Month	River Discharge at Palpa	Water Requirements			Water Resource					Short-age	Remarks
		Agriculture	Others	Sub-total	River	Return Flow	Groundwater Agriculture	Groundwater Others	Sub-total		
Aug.	10,105	6,524	890	7,414	5,680	1,636		98	7,414		
Sep.	9,227	10,076	874	10,950	8,551	2,301		98	10,950		
Oct.	11,160	17,990	890	18,880	11,160	5,629	643	98	17,530	1,350	
Nov.	11,280	24,217	875	25,092	11,280	7,210	2,592	99	21,181	3,911	
Dec.	15,061	31,679	890	32,569	15,061	9,258	2,678	98	27,095	5,474	
Jan.	21,828	43,048	890	43,938	21,828	12,481	2,678	98	37,085	6,853	
Feb.	32,420	41,572	844	42,416	32,420	9,898		98	42,416		
Mar.	59,517	33,600	891	34,491	27,612	6,780		99	34,491		
Apr.	32,657	26,221	874	27,095	21,629	5,368		98	27,095		
May	15,349	20,917	890	21,807	15,349	6,360		98	21,807		
Jun.	12,177	13,848	874	14,722	11,606	3,018		98	14,722		
Jul.	10,962	9,055	891	9,946	7,731	2,116		99	9,946		
Total	241,743	278,747	10,573	289,320	189,907	72,055	8,591	1,179	271,732	17,588	

Table G-5-25 River Discharge and Intaked Volume in Present (Probability; 10 years)

(unit ; x 10^3 m^3)

Month	River Discharge at Palpa		Flood Season			Drought Season			Shortage	Ground water	Shortage	River to be Dependent
	V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	m3/sec	m3/sec	m3/sec	
Aug.	10,105	3.77	5,680	2.12	< 3.77							5,680
Sep.	9,227	3.56	8,551	3.30	< 3.56							8,551
Oct.	11,160	4.17	14,968	5.59		11,808	4.41	> 4.17	0.24	0.24 (643)		11,160
Nov.	11,280	4.35	20,005	7.72		15,782	6.09	> 4.35	1.74	1.00 (2,592)	0.74 (1,918)	11,280
Dec.	15,061	5.62	26,056	9.73		20,555	7.67	> 5.62	2.05	1.00 (2,678)	1.05 (2,812)	15,061
Jan.	21,828	8.15	35,265	13.17		27,820	10.39	> 8.15	2.24	1.00 (2,678)	1.25 (3,348)	21,828
Feb.	32,420	13.40	34,051	14.08		26,862	11.10	<13.40				32,420
Mar.	59,517	22.22	27,612	10.31	< 22.22							27,612
Apr.	32,657	12.60	21,629	8.34	< 12.60							21,629
May	15,349	5.73	17,339	6.47		13,678	5.11	< 5.73				15,349
Jun.	12,177	4.70	11,606	4.48	< 4.70							11,606
Jul.	10,962	4.09	7,731	2.89	< 4.09							7,731
Total	241,743									(8,591)	(8,078)	189,907

Note: V1; m3, V2; Intaked volume at all intakes (m3)
V3; Intaked volume at intakes of Palpa, Esperanza, Huando, Caqui and Chancay-Huaral (m3)
Q1,Q2,Q3; m3/sec

Table G-5-26 Present Water Balance in Chancayllo Area (Probability : 10 years)

(unit : x $10^3 m^3$)

Month	Water Requirements in Upstream				Retio of Return Flow	Return Flow	Water Requirements	Remained
	Esperanza	Huando	Huaral	Total				
	A=3,240	A=1,416	A=2,042		%		A=2,668	
Aug.	1,136	497	716	2,349	65	1,527	936	591
Sep.	1,710	747	1,078	3,535	65	2,298	1,408	890
Oct.	2,994	1,308	1,886	6,188	65	4,022	2,465	1,557
Nov.	2,722	1,749	2,522	6,993	65	4,545	3,295	1,250
Dec.	3,327	2,277	3,284	8,888	65	5,777	4,291	1,486
Jan.	4,810	3,082	4,445	12,337	65	8,019	5,808	2,211
Feb.	6,810	2,976	4,292	14,078	65	9,151	5,608	3,543
Mar.	5,522	2,414	3,480	11,416	65	7,420	4,547	2,873
Apr.	4,326	1,891	2,726	8,943	65	5,813	3,562	2,251
May	3,468	1,516	2,186	7,170	65	4,661	2,856	1,805
Jun.	2,321	1,014	1,463	4,798	65	3,119	1,911	1,208
Jul.	1,546	676	974	3,196	65	2,077	1,273	804
Total	40,692	20,147	29,052	89,891		58,429	37,960	20,469

Table G-5-27 Present Water Balance in Donoso and Laureles Area (Probability : 10 years)

(unit : x $10^3 m^3$)

Month	Water Requirements in Huaral Area	Ratio of Return Flow	Return Flow	Water Requirements	Remained
	A=1,168	%		A=576	
Aug.	409	65	266	202	
Sep.	616	65	400	304	
Oct.	1,079	65	701	532	
Nov.	803	65	522	711	189
Dec.	942	65	612	926	314
Jan.	1,427	65	928	1,254	326
Feb.	2,455	65	1,596	1,211	
Mar.	1,991	65	1,294	982	
Apr.	1,559	65	1,013	769	
May	1,250	65	813	616	
Jun.	837	65	544	412	
Jul.	557	65	362	275	
Total	13,925		9,051	8,194	829

Table G-5-28 Present Water Balance in Mira Flores Area (Probability : 10 years)

(unit : x $10^3 m^3$)

Month	Water Requirements in Palpa, Caqui	Ratio of Return Flow	Return Flow	Water Requirements	Remained
	A=2,190	%		A=577	
Aug.	768	49	376	202	174
Sep.	1,156	49	566	305	261
Oct.	2,023	49	991	533	458
Nov.	2,704	49	1,325	713	612
Dec.	3,522	49	1,726	928	798
Jan.	4,767	49	2,336	1,256	1,080
Feb.	4,603	49	2,255	1,213	1,042
Mar.	3,733	49	1,829	983	846
Apr.	2,924	49	1,433	770	663
May	2,344	49	1,149	617	532
Jun.	1,569	49	769	413	356
Jul.	1,045	49	512	275	237
Total	31,158		15,267	8,208	7,059

Table G-5-29 Present Water Balance in San Jose - Pasamayo Alto Area (Oct. - Feb.)

(unit : x $10^3 m^3$)

Month	Available Volume				Water Requirements					Shortage
	River	Remained in Mira Flores	Return Flow from Mira Flores	Total	San Jose	Boza Alto	Boza Bajo	Pasamayo Alto	Total	
			(69%)		A=847	A=779	A=388	A=288		
Aug.	4,425	174	139	4,738						
Sep.	676	261	210	1,147						
Oct.	0	458	368	826	783	720	358	266	2,127	1,301
Nov.	0	612	492	1,104	1,046	962	479	356	2,843	1,739
Dec.	0	798	640	1,438	1,362	1,253	624	463	3,702	2,264
Jan.	0	1,080	867	1,947	1,844	1,696	845	627	5,012	3,065
Feb.	5,558	1,042	837	7,437	1,780	1,637	816	605	4,838	2,599
Mar.	31,905	846	678	33,429						
Apr.	11,028	663	531	12,222						
May	1,671	532	426	2,629						
Jun.	571	356	285	1,212						
Jul.	3,231	237	189	3,657						
Total										8,369

Table G-5-30 Present Water Balance in Pasamayo - Salinas (Oct. - Feb.)

(unit : x $10^3 m^3$)

Month	Available Volume				Water Requirements				Shortage
	River	V1	V2	Total	Pasamayo Bajo	Manglar	Salinas	Total	
			A=759		A=579	A=72	A=446		
Aug.	4,425								
Sep.	676								
Oct.	0	565	400	965	535	67	412	1,014	49
Nov.	0	755	534	1,289	715	89	550	1,354	65
Dec.	0	984	696	1,680	931	116	717	1,764	84
Jan.	0	1,332	942	2,274	1,260	157	971	2,388	114
Feb.	2,599	1,285	909	4,793	1,217	151	937	2,305	2,488
Mar.	31,905								
Apr.	11,028								
May	1,671								
Jun.	571								
Jul.	3,231								
Total									312

Note: V1: (Remained and Water Requirements in Mira Flores Area) x 0.57
V2: Water requirements in Santo Rosa area x 0.57

Table G-5-31 Monthly Water Requirements

(unit : x $10^3 m^3$)

Month	Intaked at Palpa			Huando Chancay-Huaral	Total	Downstream Intakes						Grand-total
	Esperanza	Palpa	Sub-Total			Boza Alto	Boza Bajo	Pasamayo-Bajo	Salinas Alto	Salinas Bajo	Total	
Aug.	A=3,440 630	A=3,037 1,278	1,908	A=8,219 3,390	A=14,696 5,298	A=779 263	A=676 228	A=651 220	A=281 115	A=165 67	A=2,552 893	A=17,248 6,191
Sep.	1,256	1,903	3,159	6,006	9,165	512	444	428	216	127	1,727	10,892
Oct.	2,556	3,206	5,762	9,588	15,350	864	750	722	358	210	2,904	18,254
Nov.	3,870	3,399	7,269	10,133	17,402	890	773	744	350	205	2,962	20,364
Dec.	5,824	3,860	9,684	11,598	21,282	962	835	804	347	204	3,152	24,434
Jan.	6,763	4,252	11,015	12,532	23,547	1,077	934	900	392	230	3,533	27,080
Feb.	4,675	3,902	8,577	11,484	20,061	1,041	903	870	405	238	3,457	23,518
Mar.	2,360	2,721	5,081	8,307	13,388	738	640	616	300	176	2,470	15,858
Apr.	1,221	2,129	3,350	6,676	10,026	578	502	483	244	143	1,950	11,976
May	678	1,746	2,424	5,552	7,976	494	429	413	217	127	1,680	9,656
Jun.	365	934	1,299	3,260	4,559	269	233	225	122	71	920	5,479
Jul.	334	741	1,075	2,734	3,809	214	186	179	99	58	736	4,545
Total	30,532	30,071	60,603	91,260	151,863	7,902	6,857	6,604	3,165	1,856	26,384	178,247

Note: Huando includes the municipal utilization.

Table G-5-32 Proposed Water Balance (Probability; 10 years)

(unit : x 10^3 m^3)

Month	Discharge at Palpa	Water Requirements			Water Resources						Shortage
		Agriculture	Others	Sub-total	River	Return Flow	Lagoons	Groundwater Agriculture	Groundwater Others	Sub-total	
Aug.	7,876	6,217	890	7,107	6,191	818			98	7,107	
Sep.	5,615	12,293	874	13,167	5,615	3,787	3,550		98	13,050	117
Oct.	8,360	21,109	890	21,999	8,360	6,488	5,635	1,353	98	21,934	65
Nov.	5,992	23,248	875	24,123	5,992	6,446	8,815	2,597	99	23,949	174
Dec.	12,625	27,500	890	28,390	12,625	6,886	6,000	2,657	98	28,266	124
Jan.	21,828	30,583	890	31,473	21,828	7,667		1,719	98	31,312	161
Feb.	32,420	27,004	844	27,848	23,518	4,232			98	27,848	
Mar.	59,517	18,133	891	19,024	15,858	3,067			99	19,024	
Apr.	32,657	13,663	874	14,537	11,976	2,463			98	14,537	
May	14,899	10,976	890	11,866	9,656	2,112			98	11,866	
Jun.	11,166	5,861	874	6,735	5,479	1,158			98	6,735	
Jul.	9,234	4,687	891	5,578	4,545	934			99	5,578	
Total	222,189	201,274	10,573	211,847	131,643	46,058	24,000	8,326	1,179	211,206	641

Table G-5-33 River Discharge and Intaked Volume at Palpa (Probability; 10 years)

(unit ; x 10^3 m^3)

Month	River Discharge at Palpa V1	River Discharge at Palpa Q1	Flood Season V2	Flood Season Q2	Flood Season Available m3/sec	Drought Season V3	Drought Season Q3	Drought Season Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	Drained Discharge m3/sec
Aug.	7,876	2.94	6,191	2.31	< 2.94							
Sep.	5,615	2.17	(10,892)	(4.20)		9,165	3.54	> 2.17	1.37	1.37 (3,550)		1.71
Oct.	8,360	3.12	(18,254)	(6.82)		15,350	5.73	> 3.12	2.61	2.10 (5,635)	0.51 (1,353)	2.63
Nov.	5,992	2.31	(20,364)	(7.86)		17,402	6.71	> 2.31	4.40	3.40 (8,813)	1.00 (2,597)	4.25
Dec.	12,625	4.71	(24,434)	(9.12)		21,282	7.95	> 4.71	3.24	2.24 (6,000)	1.00 (2,657)	2.80
Jan.	21,828	8.15	(27,080)	(10.11)		23,547	8.79	> 8.15	0.64		0.64 (1,719)	
Feb.	32,420	13.40	23,518	9.72	< 13.40							
Mar.	59,517	22.22	15,858	5.92	< 22.22							
Apr.	32,657	12.60	11,976	4.62	< 12.60							
May	14,899	5.56	9,656	3.61	< 5.56							
Jun.	11,166	4.31	5,479	2.11	< 4.31							
Jul.	9,234	3.45	4,545	1.70	< 3.45							
Total	222,189									(24,000)	(8,326)	

Note: V1; m3, V2; Water requirements at 7 intakes (m3), V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-34 Proposed Water Balance in Chancayllo Area (Probability; 10 years)

(unit; x 10^3 m^3)

Month	Water Requirements				Return Ratio	Return Flow	Water Requirements	Remained
	Esperanza	Huando	Huaral	Total				
	A=3,240	A=1,416	A=2,214		%		A=1,799	
Aug.	593	259	726	1,578	65	1,026	734	292
Sep.	1,183	517	1,492	3,192	65	2,075	1,383	692
Oct.	2,407	1,052	2,446	5,905	65	3,838	2,292	1,546
Nov.	3,645	1,593	2,471	7,709	65	5,011	2,238	2,773
Dec.	5,485	2,397	2,737	10,619	65	6,902	2,224	4,678
Jan.	6,370	2,784	2,872	12,026	65	7,817	2,511	5,306
Feb.	4,403	1,924	2,790	9,117	65	5,926	2,591	3,335
Mar.	2,223	971	2,072	5,266	65	3,423	1,919	1,504
Apr.	1,150	503	1,716	3,369	65	2,190	1,562	628
May	638	279	1,397	2,314	65	1,504	1,387	117
Jun.	343	150	710	1,203	65	782	779	3
Jul.	314	137	540	991	65	644	633	11
Total	28,754	12,566	21,969	63,289		41,138	20,253	20,885

Table G-5-35 Proposed Water Balance in Donoso, Laureles Area (Probability; 10 years)

(unit; x 10^3 m^3)

Month	Water Requirements Huaral A=2,232	Return Ratio %	Return Flow	Water Requirements A=576	Remained
Aug.	732	65	476	235	241
Sep.	1,504	65	978	443	535
Oct.	2,466	65	1,603	734	869
Nov.	2,491	65	1,619	717	902
Dec.	2,759	65	1,793	712	1,081
Jan.	2,895	65	1,882	804	1,078
Feb.	2,812	65	1,828	829	999
Mar.	2,089	65	1,358	614	744
Apr.	1,730	65	1,125	500	625
May	1,408	65	915	444	471
Jun.	716	65	465	249	216
Jul.	545	65	354	203	151
Total	22,147		14,396	6,484	7,912

Table G-5-36 Proposed Water Balance in Mira Flores Area (Probability; 10 years)

(unit; x 10^3 m^3)

Month	Water Requirements Palpa, Caqui A=2,190	Return Ratio %	Return Flow	Water Requirements A=577	Remained
Aug.	681	49	334	195	139
Sep.	1,347	49	660	379	281
Oct.	2,667	49	1,307	640	667
Nov.	2,431	49	1,191	660	531
Dec.	2,814	49	1,379	713	666
Jan.	3,081	49	1,510	797	713
Feb.	2,770	49	1,357	771	586
Mar.	1,918	49	940	546	394
Apr.	1,500	49	735	428	307
May	1,209	49	592	366	226
Jun.	642	49	315	199	116
Jul.	508	49	249	159	90
Total	21,568		10,569	5,853	4,716

Table G-5-37 Proposed Water Balance in Midstream Area of Chancay River

(unit; x 10^3 m^3)

Month	Water Requirements			Return Ratio	Return Flow	Water Requirements	Shortage	Collecting Conduit
	Mira Flores	San Jose	Total					
	A=577	A=847		%		A=1,455		
Sep.	660	556	1,216	69	839	956	117	117
Oct.	1,307	939	2,246	69	1,549	1,614	65	65
Nov.	1,191	968	2,159	69	1,489	1,663	174	174
Dec.	1,379	1,046	2,425	69	1,673	1,797	124	124
Jan.	1,510	1,171	2,681	69	1,850	2,011	161	161

Table G-5-38 Proposed Water Balance in Downstream Area of Chancay River

(unit; x 10^3 m^3)

Month	Water Requirements						Return Ratio	Return Flow	Water Requirements	Remained
	Mira Flores	San Jose	Boza Alto	Boza Bajo	Santa Rosa	Total				
	A=577	A=847	A=779	A=676	A=759		%		A=1,097	
Sep.	379	556	512	444	512	2,403	57	1,370	771	599
Oct.	640	939	864	750	839	3,832	57	2,184	1,290	894
Nov.	660	968	890	773	847	4,138	57	2,359	1,299	1,060
Dec.	713	1,046	962	835	939	4,495	57	2,562	1,355	1,207
Jan.	797	1,171	1,077	934	984	4,963	57	2,829	1,522	1,307

Table G-5-39 River Discharge and Intaked Volume at Palpa (Probability; 5 years)

(unit ; x 10^3 m^3)

Month	River Discharge at Palpa V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	9,059	3.38	6,191	2.31	< 3.38							6,191
Sep.	6,695	2.58	10,892	4.20		9,165	3.54	> 2.58	0.96	0.96 (2,488)	-	6,695
Oct.	9,527	3.56	18,254	6.82		15,350	5.73	> 3.56	2.17	2.17 (5,812)	-	9,527
Nov.	8,368	3.23	20,364	7.86		17,402	6.71	> 3.23	3.48	3.48 (9,020)	-	8,368
Dec.	16,504	6.16	24,434	9.12		21,282	7.95	> 6.16	1.79	1.79 (4,794)	-	16,504
Jan.	28,714	10.72	27,080	10.11	< 10.72							27,080
Feb.	48,776	20.16	23,518	9.72	< 20.16							23,518
Mar.	75,077	28.03	15,858	5.92	< 28.03							15,858
Apr.	38,740	14.95	11,976	4.62	< 14.95							11,976
May	17,301	6.46	9,656	3.61	< 6.46							9,656
Jun.	12,876	4.97	5,479	2.11	< 4.97							5,479
Jul.	10,391	3.88	4,545	1.70	< 3.88							4,545
Total	282,028									(22,114)	-	145,397

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-40 River Discharge and Intaked Volume at Palpa (1978 - 1979)

(unit : x 10^3 m^3)

Month	River Discharge V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	7,223	2.70	6,191	2.31	< 2.70						-	6,191
Sep.	8,027	3.10	10,892	4.20		9,165	3.54	> 3.10	0.44	0.44 (1,140)	-	8,027
Oct.	12,217	4.56	18,254	6.82		15,350	5.73	> 4.56	1.17	1.17 (3,134)	-	12,217
Nov.	12,623	4.87	20,364	7.86		17,402	6.71	> 4.87	1.84	1.84 (4,769)	-	12,623
Dec.	21,902	8.18	24,434	9.12		21,282	7.95	< 8.18	-	-	-	21,902
Jan.	17,600	6.57	27,080	10.11		23,547	8.79	> 6.57	2.22	2.22 (5,946)	-	17,600
Feb.	63,763	26.36	23,518	9.72	> 26.36							23,518
Mar.	137,411	51.30	15,858	5.92	> 51.30							15,858
Apr.	33,938	13.09	11,976	4.62	> 13.09							11,976
May	16,589	6.19	9,656	3.61	> 6.19							9,656
Jun.	14,291	5.51	5,479	2.11	> 5.51							5,479
Jul.	12,165	4.54	4,545	1.70	> 4.54							4,545
Total	357,749		178,247							(14,989)	-	149,592

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
· Q1,Q2,Q3; m3/sec

Table G-5-41 River Discharge and Intaked Volume at Palpa (1979 - 1980)

(unit : x 10^3 m^3)

Month	River Discharge V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	8,087	3.02	6,191	2.31	< 3.02						-	6,191
Sep.	8,968	3.46	10,892	4.20		9,165	3.54	> 3.46	0.08	0.08 (207)	-	8,968
Oct.	6,307	2.35	18,254	6.82		15,350	5.73	> 2.35	3.38	2.38 (6,375)	1.00 (2,678)	6,307
Nov.	5,901	2.28	20,364	7.86		17,402	6.71	> 2.28	4.43	3.43 (8,891)	1.00 (2,592)	5,901
Dec.	9,677	3.61	24,434	9.12		21,282	7.95	> 3.61	4.34	3.18 (8,527)	1.00 (2,678)	9,677
Jan.	49,153	18.35	27,080	10.11	< 18.35							27,080
Feb.	24,684	10.20	23,518	9.72	< 10.20							23,518
Mar.	53,145	19.84	15,858	5.92	< 19.84							15,858
Apr.	38,206	14.74	11,976	4.62	< 14.74							11,976
May	17,600	6.57	9,656	3.61	< 6.57							9,656
Jun.	15,025	5.80	5,479	2.11	< 5.80							5,479
Jul.	10,411	3.89	4,545	1.70	< 3.89							4,545
Total	247,164		178,247							(24,000)	(7,948)	135,156

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-42 River Discharge and Intaked Volume at Palpa (1980 - 1981)

(unit : x 10^3 m^3)

Month	River Discharge V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	9,867	3.68	6,191	2.31	< 3.68						-	6,191
Sep.	6,255	2.41	10,892	4.20		9,165	3.54	> 2.41	1.13	1.13 (2,929)	-	6,255
Oct.	15,967	5.96	18,254	6.82		15,350	5.73	< 5.96			-	15,967
Nov.	17,954	6.93	20,364	7.86		17,402	6.71	< 6.93			-	17,954
Dec.	33,247	12.41	24,434	9.12	< 12.41						-	24,434
Jan.	48,133	17.97	27,080	10.11	< 17.97							27,080
Feb.	157,542	65.12	23,518	9.72	< 65.12							23,518
Mar.	184,706	68.96	15,858	5.92	< 68.96							15,858
Apr.	67,202	25.93	11,976	4.62	< 25.93							11,976
May	21,324	7.96	9,656	3.61	< 7.96							9,656
Jun.	17,781	6.86	5,479	2.11	< 6.86							5,479
Jul.	14,394	5.37	4,545	1.70	< 5.37							4,545
Total	594,372		178,247							(2,929)	-	168,913

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-43 River Discharge and Intaked Volume at Palpa (1981 - 1982)

(unit : x 10^3 m^3)

Month	River Discharge V1	River Discharge Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	10,956	4.09	6,191	2.31	< 4.09						-	6,191
Sep.	11,828	4.56	10,892	4.20	< 4.56						-	10,892
Oct.	13,530	5.05	18,254	6.82		15,350	5.73	> 5.05	0.68	0.68 (1,821)	-	13,530
Nov.	18,265	7.05	20,364	7.86		17,402	6.71	< 7.05			-	18,265
Dec.	30,741	11.48	24,434	9.12	< 11.48							24,434
Jan.	41,005	15.31	27,080	10.11	< 15.31							27,080
Feb.	114,990	47.53	23,518	9.72	< 47.53							23,518
Mar.	61,664	23.02	15,858	5.92	< 23.02							15,858
Apr.	47,926	18.49	11,976	4.62	< 18.49							11,976
May	23,406	8.74	9,656	3.61	< 8.74							9,656
Jun.	15,854	6.12	5,479	2.11	< 6.12							5,479
Jul.	11,595	4.33	4,545	1.70	< 4.33							4,545
Total	401,760		178,247							(1,821)	-	171,424

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-44 River Discharge and Intaked Volume at Palpa (1982 - 1983)

(unit : x 10^3 m^3)

Month	River Discharge V1	River Discharge Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	14,161	5.29	6,191	2.31	< 5.29						-	6,191
Sep.	12,830	4.95	10,892	4.20	< 4.95						-	10,892
Oct.	11,033	4.12	18,254	6.82		15,350	5.73	> 4.12	1.61	1.61 (4,312)	-	11,033
Nov.	41,161	15.88	20,364	7.86	< 15.88						-	20,364
Dec.	41,964	15.67	24,434	9.12	< 15.67						-	24,434
Jan.	72,593	27.10	27,080	10.11	< 27.10							27,080
Feb.	126,274	52.20	23,518	9.72	< 52.20							23,518
Mar.	126,844	47.36	15,858	5.92	< 47.36							15,858
Apr.	101,814	39.28	11,976	4.62	< 39.28							11,976
May	24,054	8.98	9,656	3.61	< 8.98							9,656
Jun.	13,081	5.05	5,479	2.11	< 5.05							5,479
Jul.	8,942	3.34	4,545	1.70	< 3.34							4,545
Total	594,751		178,247							(4,312)	-	171,026

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-45 River Discharge and Intaked Volume at Palpa (1983 - 1984)

(unit : x 10^3 m^3)

Month	River Discharge V1	Q1	V2	Q2	Available	V3	Q3	Available	Shortage	Lagoons	Groundwater	River
					m3/sec			m3/sec	m3/sec	m3/sec	m3/sec	m3/sec
Aug.	11,284	4.21	6,191	2.31	< 4.21						-	6,191
Sep.	9.530	3.68	10,892	4.20		9,165	3.54	< 3.68			-	9,530
Oct.	11,897	4.44	18,254	6.82		15,350	5.73	> 4.44	1.29	1.29 (3,455)	-	11,897
Nov.	10,264	3.96	20,364	7.86		17,402	6.71	> 3.96	2.75	2.75 (7,128)	-	10,264
Dec.	29,506	11.02	24,434	9.12	< 11.02						-	24,434
Jan.	36,979	13.81	27,080	10.11	< 13.81							27,080
Feb.	157,715	65.19	23,518	9.72	< 65.19							23,518
Mar.	127,405	47.57	15,858	5.92	< 47.57							15,858
Apr.	58,553	22.59	11,976	4.62	< 22.59							11,976
May	33,722	12.59	9,656	3.61	< 12.59							9,656
Jun.	24,028	9.27	5,479	2.11	< 9.27							5,479
Jul.	17,548	6.55	4,545	1.70	< 6.55							4,545
Total	528,431		178,247							(10,583)	-	160,428

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-46 River Discharge and Intaked Volume at Palpa (Probability; 5 years)
(Comparison ; In case of unsufficient on-farm management: E = 42 %)

(unit : x 10^3 m^3)

Month	River Discharge V1	Q1	V2	Q2	Available m3/sec	V3	Q3	Available m3/sec	Shortage m3/sec	Lagoons m3/sec	Groundwater m3/sec	River m3/sec
Aug.	9,059	3.38	6,790	2.54	< 3.38						-	6,790
Sep.	6,695	2.58	11,946	4.61		10,052	3.88	> 2.58	1.30	1.30 (3,370)	-	6,695
Oct.	9,527	3.56	20,021	7.47		16,835	6.29	> 3.56	2.73	2.73 (7,312)	-	9,527
Nov.	8,368	3.23	22,335	8.62		19,086	7.36	> 3.23	4.13	3.13 (8,113)	1.00 (2,592)	8,368
Dec.	16,504	6.16	26,799	10.01		23,342	8.71	> 6.16	2.55	1.94 (5,205)	0.61 (1,640)	16,504
Jan.	28,714	10.72	29,701	11.09		25,826	9.64	<10.72			-	28,714
Feb.	48,776	20.16	25,794	10.66	< 20.16							25,794
Mar.	75,077	28.02	17,393	6.49	< 28.03							17,393
Apr.	38,740	14.95	13,135	5.07	< 14.95							13,135
May	17,301	6.46	10,594	3.96	< 6.46							10,594
Jun.	12,876	4.97	6,009	2.32	< 4.97							6,009
Jul.	10,391	3.88	4,985	1.86	< 3.88							4,985
Total	282,028		195,502							(24,000)	(4,232)	154,508

Note: V1; excluding lagoons (m3), V2; Water requirements at 7 intakes (m3)
V3; Water requirements at 2 upstream intakes (m3)
Q1,Q2,Q3; m3/sec

Table G-5-47 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 G-5-48 Available Water for Leaching

(unit; x 10^3 m^3)

Description	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Total
V1	7,876	5,615	8,360	5,992	12,625	21,828	32,420	59,517	32,657	14,899	11,166	9,234	222,189
V2	6,191	5,615	8,360	5,992	12,625	21,828	23,518	15,858	11,976	9,656	5,479	4,545	131,643
V1 - V2	1,685	0	0	0	0	0	8,902	43,659	20,681	5,243	5,687	4,687	90,546
V3	1,685	0	0	0	0	0	0	7,660	11,542	5,243	5,687	4,687	36,506

Note: V1; River discharge
V2; Water requirements to be dependent on river
V3; Available leaching requirements

Leaching water requirement: 12,297 x 10^3 m^3

Table G-5-49 (1) Intake Capacity

1. Esperanza (A = 3,440 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	3,086	3.10	95,666
Cotton	177	3.68	6,514
Maize	177	2.39	4,230
Total	3,440		106,410 = 1.23 m^3/sec

- Irrigation efficiency (E = 34.7 %)

  Soil texture Coarse 2,697 ha - 33 %
  Medium 743 ha - 41 %

- Gross water requirements

  Q = 1.23/0.347 = 3.51 m^3/sec

  (Vested water right : 4.00 m^3/sec)

2. Huando (A = 1,416 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	1,270	3.10	39,370
Cotton	73	3.68	2,686
Maize	73	2.39	1,745
Total	1,416		43,801 = 0.51 m^3/sec

- Irrigation efficiency (E = 34.7 %)

  Soil texture Coarse 1,110 ha - 33 %
  Medium 306 ha - 41 %

- Gross water requirements

  Q = 0.51/0.347 = 1.46 m^3/sec

  (Vested water right : 3.50 m^3/sec)

Table G-5-49 (2) Intake Capacity

3. Chancay-Huaral (A = 6,803 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	740	3.10	22,940
Cotton	2,679	3.68	98,587
Maize	2,679	2.39	64,028
Vegetable	705	2.64	18,612
Total	6,803		204,167 = 2.36 m^3/sec

- Irrigation efficiency (E = 41.2 %)

Soil texture	Coarse	258 ha - 33 %
	Medium	6,201 ha - 41 %
	Fine	344 ha - 50 %

- Gross water requirements

$Q = 2.36/0.412 = 5.76\ m^3/sec$

(Vested water right : 7.00 m^3/sec)

4. Salinas (Alto, M1, M2) (A = 281 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	23	3.10	713
Cotton	96	3.68	3,533
Maize	96	2.39	2,294
Vegetable	66	2.64	1,742
Total	281		8,282 = 0.10 m^3/sec

- Irrigation efficiency (E = 38.1 %)

Soil texture	Coarse	103 ha - 33 %
	Medium	178 ha - 41 %

- Gross water requirements

$Q = 0.10/0.381 = 0.26\ m^3/sec$

(Vested water right : 0.368 m^3/sec)

Table G-5-49 (3) Intake Capacity

5. Palpa (A = 3,037 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	838	3.10	25,978
Cotton	902	3.68	33,194
Maize	902	2.39	21,558
Vegetable	395	2.64	10,428
Total	3,037		91,158 = 1.05 m^3/sec

- Irrigation efficiency (E = 40.9 %)

Soil texture Coarse 39 ha - 33 %
Medium 2,998 ha - 41 %

- Gross water requirements

$Q = 1.05/0.409 = 2.56\ m^3/sec$

(Vested water right : 2.50 m^3/sec)

6. Boza Alto (A = 779 ha)

Crop	Area	Consumptive Use	Net Water Requirements
	ha	mm/day	m3/day
Fruit	135	3.10	4,185
Cotton	260	3.68	9,568
Maize	260	2.39	6,214
Vegetable	124	2.64	3,274
Total	779		23,241 = 0.27 m^3/sec

- Irrigation efficiency (E = 49.9 %)

Soil texture Coarse 210 ha - 47 %
Medium 569 ha - 51 %

- Gross water requirements

$Q = 0.27/0.499 = 0.54\ m^3/sec$

(Vested water right : 0.60 m^3/sec)

Table G-5-49 (4) Intake Capacity

7. Boza Bajo (A = 676 ha)

Crop	Area ha	Consumptive Use mm/day	Net Water Requirements m3/day
Fruit	117	3.10	3,627
Cotton	225	3.68	8,280
Maize	225	2.39	5,378
Vegetable	109	2.64	2,878
Total	676		20,163 = 0.23 m^3/sec

- Irrigation efficiency (E = 49.9%)

Soil texture Coarse 183 ha - 47 %
Medium 493 ha - 51 %

- Gross water requirements

Q = 0.23/0.499 = 0.46 m^3/sec

(Vested water right : 0.50 m^3/sec)

8. Pasamayo Bajo (A = 651 ha)

Crop	Area ha	Consumptive Use mm/day	Net Water Requirements m3/day
Fruit	113	3.10	3,503
Cotton	217	3.68	7,986
Maize	217	2.39	5,186
Vegetable	104	2.64	2,746
Total	651		19,421 = 0.22 m^3/sec

- Irrigation efficiency (E = 49.9 %)

Soil texture Coarse 176 ha - 47 %
Medium 475 ha - 51 %

- Gross water requirements

Q = 0.22/0.499 = 0.44 m^3/sec

(Vested water right : 0.60 m^3/sec)

Table G-5-50 (1) Canal Capacity

Irrigation Block	Canal	Irrigation Area	Water Requirements	Net Water Requirements	Irrigation Efficiency	Diversion Water Requirements	Proposed Capacity for Canal
		ha	l/sec/ha	m3/sec	%	m3/sec	m3/sec
Esperanza	Esperanza	3,440	0.358	1.23	35	3.51	3.51
	Cabuyal Alto	1,192	0.358	0.43	48	0.90	1.80
	2nd Lat Cabuyal Alto	264	0.358	0.09	48	0.19	*
	Cabuyal Bajo	776	0.358	0.28	48	0.58	1.16
	Villa Garcia	112	0.358	0.04	48	0.08	*
	Cayo Murillo	308	0.358	0.11	48	0.23	*
	Granados	1,818	0.358	0.65	48	1.35	2.70
	La Virgen	84	0.358	0.03	48	0.06	0.13
	Descansa Muerto	230	0.358	0.08	48	0.17	*
	1st Lateral Granados	336	0.358	0.12	48	0.25	0.50
	Lateral 1.1 Granados	110	0.358	0.04	48	0.08	*
	Lateral 1.2 Granados	78	0.358	0.03	48	0.06	*
	2nd Lateral Granados	168	0.358	0.06	48	0.13	*
	3rd Lateral Granados	573	0.358	0.21	48	0.44	0.88
	Lateral 3.1 Granados	327	0.358	0.12	48	0.25	0.50
	4th Lateral Granados	103	0.358	0.04	48	0.08	0.16
	5th Lateral Granados	55	0.358	0.02	48	0.04	0.16

Table G-5-50 (2) Canal Capacity

Irrigation Block	Canal	Irrigation Area	Water Requirements	Net Water Requirements	Irrigation Efficiency	Diversion Water Requirements	Proposed Capacity for Canal
		ha	l/sec/ha	m3/sec	%	m3/sec	m3/sec
Huando	Huando (1)**	8,219				7.22	7.22
	Huando (2)	1,416	0.358	0.51	35	1.46	1.46
	1st Lateral						
	Huando	107	0.358	0.04	48	0.08	*
	La Victoria	130	0.358	0.05	35	0.14	*
	Huando (3)	421	0.358	0.15	48	0.31	0.62
	2nd Lateral						
	Huando	153	0.358	0.06	35	0.17	*
	Huando (4)	160	0.358	0.06	48	0.13	0.26
Chancay-Huaral	Chancay-Huaral	6,803	0.347	2.36	41	5.76	5.76
	Huaral (1)	4,774	0.347	1.66	51	3.25	3.25
	Garcia Alonso	477	0.347	0.17	51	0.33	0.66
	Jesus de Valle	801	0.347	0.28	41	0.68	1.36
	Lat. Canal 1	734	0.347	0.25	41	0.61	*
	Lat. Canal 2	697	0.347	0.24	41	0.59	*
	Los Naturales	113	0.347	0.04	41	0.10	*
	Huaral (2)	817	0.347	0.28	51	0.55	1.10
	El Cerrito	158	0.347	0.05	41	0.12	*
	Caporal	76	0.347	0.03	41	0.07	*
	Cantellan	412	0.347	0.14	41	0.34	*
	Quincha	90	0.347	0.03	41	0.07	*
	Dren Quincha	185	0.347	0.06	41	0.15	0.30
	Dren Retes	462	0.347	0.16	41	0.39	0.78

Table G-5-50 (3) Canal Capacity

Irrigation Block	Canal	Irrigation Area	Water Requirements	Net Water Requirements	Irrigation Efficiency	Diversion Water Requirements	Proposed Capacity for Canal
		ha	l/sec/ha	m3/sec	%	m3/sec	m3/sec
Chancay-Huaral	Chancay	2,029	0.347	0.70	42	1.67	1.67
	Quepepampa	426	0.347	0.15	50	0.30	0.60
	Los Laureles	346	0.347	0.12	50	0.24	0.48
	Galeano(Filt.Donoso)	380	0.347	0.13	50	0.26	0.52
	Sta Rosa	431	0.347	0.15	50	0.30	0.60
	Lat Chancay	274	0.347	0.10	38	0.26	*
	Torre Blanca	255	0.347	0.09	38	0.24	0.48
Jecuan Chancayllo	Calera	168	0.341	0.06	38	0.16	*
	El Progreso	42	0.341	0.02	38	0.05	*
	Hatillo	184	0.341	0.06	50	0.12	*
	San Cayetano	190	0.341	0.06	38	0.16	*
	San Juan	213	0.341	0.07	38	0.18	*
	Chancayllo Derecho	144	0.341	0.05	38	0.13	*
	Chancayllo Izquierda	382	0.341	0.13	38	0.34	*
	Candelaria Baja	352	0.341	0.12	38	0.32	*
Salinas	Salinas Alto	281	0.341	0.10	38	0.26	0.26
	Salinas Medio 1	79	0.341	0.03	38	0.08	*
	Salinas Medio 2	19	0.341	0.006	38	0.02	*
	Salinas Bajo	165	0.341	0.06	38	0.16	*

Table G-5-50 (4) Canal Capacity

Irrigation Block	Canal	Irrigation Area	Water Requirements	Net Water Requirements	Irrigation Efficiency	Diversion Water equirements	Proposed Capacity for Canal
		ha	1/sec/ha	m3/sec	%	m3/sec	m3/sec
Palpa-Caqui	Palpa	3,037	0.347	1.05	41	2.56	2.56
	Palpa Alto	767	0.347	0.27	51	0.53	1.06
	Teresa ***	338	0.347	0.12	51	0.24	0.86
	Castilla	123	0.347	0.04	41	0.10	*
	Sta Hermelinda	149	0.347	0.05	41	0.12	*
	Palpa Bajo (1)	2,270	0.347	0.79	51	1.55	1.55
	Palpa Bajo (2)	808	0.347	0.28	51	0.55	1.10
	Caqui (1)	1,462	0.347	0.51	51	1.00	2.00
	Caqui (2)	1.045	0.347	0.36	51	0.71	1.42
	Caqui Bajo	255	0.347	0.09	41	0.22	*
	Maria	69	0.347	0.02	41	0.05	*
San Jose	San Jose	847	0.345	0.29	50	0.58	1.16
MIra Flores	Mira Flores	443	0.345	0.15	50	0.30	*
	Mira Flores Alto	172	0.345	0.06	50	0.12	*
	Mira Flores Bajo	245	0.345	0.08	39	0.21	*
	Lat Mira Flores	23	0.345	0.01	39	0.03	*
Boza	Boza Alto	779	0.345	0.27	50	0.54	0.54
	Boza Bajo (1)	676	0.345	0.23	50	0.46	0.46
	Boza Bajo (2)	388	0.345	0.13	50	0.26	0.46

Table G-5-50 (5) Canal Capacity

Irrigation Block	Canal	Irrigation Area	Water Requirements	Net Water Requirements	Irrigation Efficiency	Diversion Water equirements	Proposed Capacity for Canal
		ha	l/sec/ha	m3/sec	%	m3/sec	m3/sec
Pasamayo	Pasamayo Alto	288	0.345	0.10	39	0.26	*
	Pasamayo Bajo (1)	651	0.345	0.22	50	0.44	0.44
	Pasamayo 1st Orden	190	0.345	0.07	39	0.18	*
	Pasamayo Bajo (2)	461	0.345	0.16	50	0.32	*
	Hanglar	72	0.345	0.02	39	0.05	*

Note : 1) The canal marked * will be lrft as it is (Refer to Table H-2-13 and 14)
2) The canal marked ** is newly constructed (Refer to Annex H-3-1-1)
3) The canal marked *** will be used for connecting canal
4) The study has been made based on the proposed irrigation system

Table G-5-51 Proposed Storage Capacity of Existing Reservoir

Name of Reservoir	Location	Existing Condition		Required Beneficial Area	Proposed Storage Capacity	Asamption		
		Storage Capacity (m^3)	Beneficial Area (ha)	(ha_1)	(m^3)	Crop	ETc (mm/day)	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)	10,000	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

Table G-5-51(2) Proposed Storage Capacity of Existing Reservoir

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 G-5-52 Capacity of Proposed Reservoir

Name of Reservoir	Location	Beneficial Area	Required Strage Volume	Assamption			
				Crop	ETc	Irrigation Efficiency	Diversion Requirement
		ha	m^3		mm/day	%	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 G-5-53 Calculation of Basic Intake Rate

Location : Quincha

Date : Nov. 7, 1984

Depth	Passing Time Interval	Passing Time Cumulate	Infiltration Value	Infiltration Cumulate	Intake Rate Value	Intake Rate Cumulate
cm	min.	min.	cm	cm	cm/hr	cm/hr
23.7	0	0	0.0	0.0	0.0	0.0
21.8	1	1	1.9	1.9	114.0	114.0
21.2	1	2	0.6	2.5	36.0	75.0
20.6	1	3	0.6	3.1	36.0	62.0
20.2	1	4	0.4	3.5	24.0	52.5
19.8	1	5	0.4	3.9	24.0	46.8
18.1	5	10	1.7	5.6	20.4	33.6
16.6	5	15	1.5	7.1	18.0	28.4
12.9	15	30	3.7	10.8	14.8	21.6
10.3	15	45	2.6	13.4	10.4	17.9
8.1	15	60	2.2	15.6	8.8	15.6
19.4	–	60	2.2	15.6	–	15.6
16.5	15	75	2.9	18.5	11.6	14.8
13.6	15	90	2.9	21.4	11.6	14.3
11.1	15	105	2.5	23.9	10.0	13.7
9.0	15	120	2.1	26.0	8.4	13.0

G-5-54 Caluculation of Basic Intake Rate

Location : Donoso

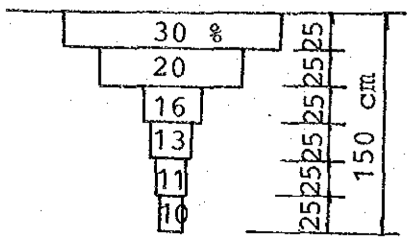
Date : Dec. 7, 1984

Depth	Passing Time Interval	Passing Time Cumulate	Infiltration Value	Infiltration Cumulate	Intake Rate Value	Intake Rate Camulate
cm	min.	min.	cm	cm	cm/hr	cm/hr
27.7	0	0	0.0	0.0	0.0	0.0
24.8	1	1	2.9	2.9	174.0	174.0
23.1	1	2	1.7	4.6	102.0	138.0
21.8	1	3	1.3	5.9	78.0	118.0
20.8	1	4	1.0	6.9	60.0	103.5
19.7	1	5	1.1	8.0	66.0	96.0
15.5	5	10	4.2	12.2	50.4	73.2
12.2	5	15	3.3	15.5	39.6	62.0
21.2	-	15	3.3	15.5	-	62.0
12.0	15	30	9.2	24.7	36.8	49.4
3.2	15	45	8.8	33.5	35.2	44.7
13.2	-	45	8.8	33.5	-	44.7
6.5	15	60	6.7	40.2	26.8	40.2
16.5	-	60	6.7	40.2	-	40.2
9.5	15	75	7.0	47.2	28.0	37.8

Table G-5-55 (1) Irrigation Water (TRAM) for Fruit

* Condition

- Root zone depth : D = 1.50 m
- Soil Moisture Extraction Pattern (SMEP) : Right Figure
- Max ETc = 3.1 mm/day



* Course Textured Soil

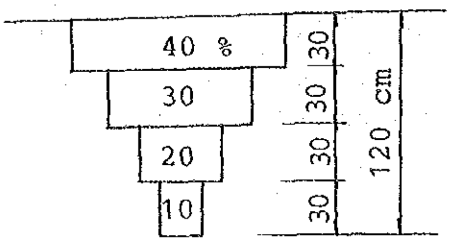
Layer	Depth cm	Em %	Sa	AM mm	Ra %	Cu	TRAM mm
1 st	0 - 25	3.5	1.44	12.60	30	42.00	42.00
2 nd	25 - 50	2.3	1.54	8.86	20	44.30	
3 rd	50 - 75	2.0	1.57	7.85	16	49.06	
4 th	75 - 100	2.0	1.57	7.85	13	60.38	
5 th	100 - 125	2.0	1.57	7.85	11	71.36	
6 th	125 - 150	2.0	1.57	7.85	10	78.50	
Total				52.86			

Note: Em; Effective moisture = (C.C - P.M.P) x 100
Sa; Apparent-specific gravity of soil
AM; Available moisture
Ra; Absorption ratio of moisture
Cu; Consumptive use

Table G-5-55 (2) Irrigation Water (TRAM) for Cotton

* Condition

- Root zone depth : D = 1.20 m
- Soil Moisture Extraction Pattern (SMEP) : Right Figure
- Max ETc = 3.8 mm/day



* Medium Textured Soil

Layer	Depth	Em	Sa	AM	Ra	Cu	TRAM
	cm	%		mm	%		mm
1 st	0 - 30	7.0	1.45	30.45	40	76.13	76.13
2 nd	30 - 60	5.0	1.50	22.50	30	75.00	
3 rd	60 - 90	5.0	1.50	22.50	20	112.50	
4 th	90 - 120	5.0	1.50	22.50	10	225.00	
Total				97.95			

* Course Textured Soil

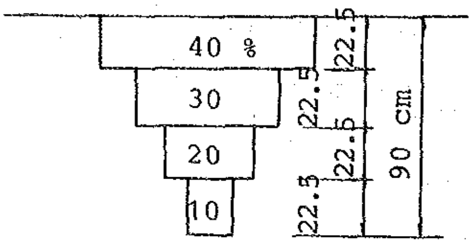
Layer	Depth	Em	Sa	AM	Ra	Cu	TRAM
	cm	%		mm	%		mm
1 st	0 - 30	6.0	1.34	24.12	40	60.30	60.30
2 nd	30 - 60	5.0	1.63	24.45	30	81.50	
3 rd	60 - 90	5.0	1.63	24.45	20	122.25	
4 th	90 - 120	5.0	1.63	24.45	10	244.50	
Total				97.47			

Note: Em; Effective moisture = (C.C - P.M.P) x 100
Sa; Apparent-specific gravity of soil
AM; Available moisture
Ra; Absorption ratio of moisture
Cu; Consumptive use

Table G-5-55 (3) Irrigation Water (TRAM) for Maize, Frijol, Papa

* Condition

- Root zone depth : D = 0.90 m
- Soil Moisture Extraction Pattern (SMEP) : Right Figure
- Max ETc = 3.3 mm/day



* Medium Textured Soil

Layer	Depth cm	Em %	Sa	AM mm	Ra %	Cu	TRAM mm
1 st	0 - 22.5	7.0	1.45	22.80	40	57.00	57.00
2 nd	22.5 - 45.0	5.7	1.48	19.00	30	63.33	
3 rd	45.0 - 67.5	5.0	1.50	16.90	20	84.50	
4 th	67.5 - 90.0	5.0	1.50	16.90	10	169.00	
Total				75.60			

* Course Textured Soil

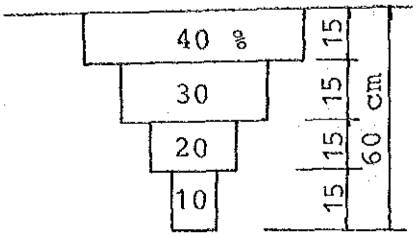
Layer	Depth cm	Em %	Sa	AM mm	Ra %	Cu	TRAM mm
1 st	0 - 22.5	6.0	1.34	18.09	40	45.23	45.23
2 nd	22.5 - 45.0	5.3	1.53	18.25	30	60.83	
3 rd	45.0 - 67.5	5.0	1.63	18.34	20	91.70	
4 th	67.5 - 90.0	5.0	1.63	18.34	10	183.40	
Total				73.02			

Note: Em; Effective moisture = (C.C - P.M.P) x 100
Sa; Apparent-specific gravity of soil
AM; Available moisture
Ra; Absorption ratio of moisture
Cu; Consumptive use

Table G-5-55 (4) <u>Irrigation Water (TRAM) for Vegetable</u>

* Condition

- Root zone depth : D = 0.60 m
- Soil Moisture Extraction Pattern (SMEP) : Right Figure
- Max ETc = 2.5 mm/day



* Medium Textured Soil

Layer	Depth	Em	Sa	AM	Ra	Cu	TRAM
	cm	%		mm	%		mm
1 st	0 - 15	7.0	1.45	15.23	40	38.08	38.08
2 nd	15 - 30	7.0	1.45	15.23	30	50.77	
3 rd	30 - 45	5.0	1.50	11.25	20	56.25	
4 th	45 - 60	5.0	1.50	11.25	10	112.50	
Total				52.96			

* Course Textured Soil

Layer	Depth	Em	Sa	AM	Ra	Cu	TRAM
	cm	%		mm	%		mm
1 st	0 - 15	6.0	1.34	12.06	40	30.15	30.15
2 nd	15 - 30	6.0	1.34	12.06	30	40.20	
3 rd	30 - 45	5.0	1.63	12.23	20	61.15	
4 th	45 - 60	5.0	1.63	12.23	10	122.30	
Total				48.58			

Note: Em; Effective moisture = (C.C - P.M.P) x 100
Sa; Apparent-specific gravity of soil
AM; Available moisture
Ra; Absorption ratio of moisture
Cu; Consumptive use

Table G-5-56 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 G-5-57 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/see	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

Table G-5-58 Comparison for Water Requirements

Description		Furrow %	Sprinkler, Drip %	Notes
Efficiency	Application	55 - 65	70 - 80	
	Irrigation	47 - 56	60 - 68	
Water Requirements		100	80	Assumed 100 % of Furrow Irrigation

Table G-6-1 Poor Drainage Area

(unit : ha)

Block	D0(>2.0^{m})	D1(1.5~2.0^{m})	D2(1.0~1.5^{m})	D3(0~1.0^{m})	Total
Quincha	200	410	390	420	1,420
Donoso	60	370	510	360	1,300
Boza	160	80	90	60	390
San Luis	180	60	130	120	490
Lunavilea	30	20	20	30	100
Palpa	20	30	50	-	100
Total	650	970	1,190	990	3,800
(%)	(17)	(26)	(31)	(26)	(100)

Table G-6-2 Present Condition of Poor Drainage Area

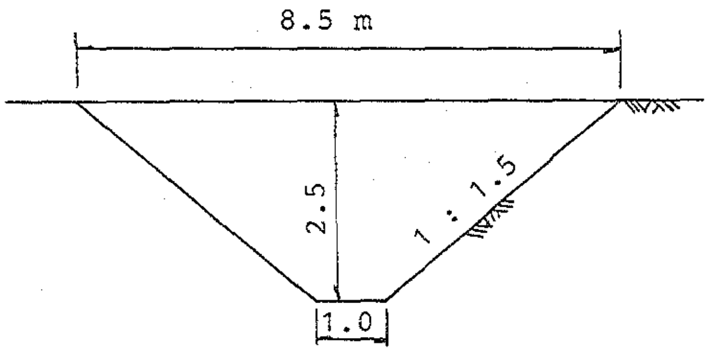
Block	Area (<1.5m)	Soil Texture	Salinity*	Pipe Drain	Leaching	Irrigation	Crops and Its Productivity
	ha		ha				
Quincha	810	CL ~ L	S2 = 273 S3 = 524 (Quincha and Donoso)	Some parts with shallow	After the harvest of cotton, if water remained	Some parts	Cotton only in high salinity soil
Donoso	870	C ~ CL		Some parts	Little	Little	Cotton 70^{qq}/ha ~ 10^{qq}/ha Tomato $6.5^{t} \sim 1.5^{t}$/ha
Boza	150	L ~ LS	S2 = 15 S3 = 130	Non	If water remained	Little in high groundwater level	
San Luis	250	L ~ SL	S2 = 168 S3 = 82	Non	If water remained	- do -	
Lunavilca (Salinas)	50	L ~ SL	S2 = 50	Non	Non	- do -	Maize $5^{t} \sim 10^{t}$/ha

* salinity class

S2 : ECe 8 ~ 15 ms/cm
S3 : ECe > 15 ms/cm

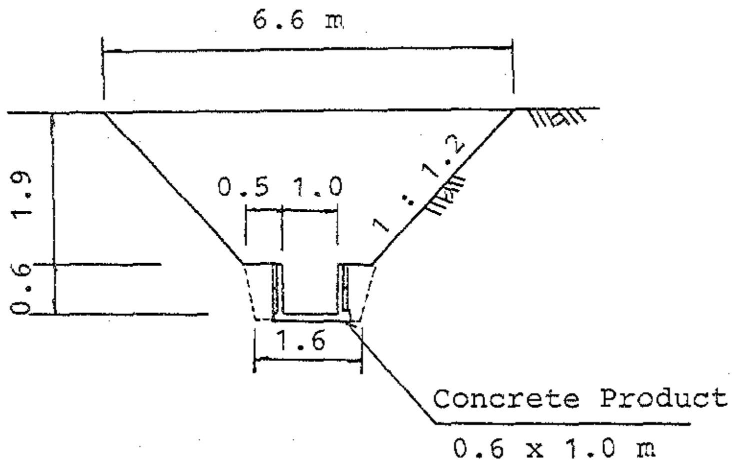
Table G-8-1 Cost Comparison for Drainage Canal

1. Unlined



Description	Q'ty	Unit Rate	Amount s/.
Excavation (Machine)	9.5 m^3	1,404	13,338
Excavation (Man-power)	2.4 m^3	15,363	36,871
Slope Treatment	9.0 m^2	1,016	9,144
Land Acquisition	8.5 m^2	140	1,190
Total			60,543

2. Linning



Description	Q'ty	Unit Rate	Amount s/.
Excavation (Machine)	7.4 m^3	1,404	10,389
Excavation (Man-power)	1.8 m^3	15,363	27,653
Backfile	0.4 m^3	1,820	728
Slope Treatment	5.9 m^2	1,016	5,994
Concrete Product	1.0 m	80,200	80,200
Land Acquisition	6.56 m^2	140	918
Total			125,882

Table G-8-2 Open Drain (1/2)

Drain	Length km	Catchment Area ha	Designed Discharge m3/sec	Notes
(Intercepting Canal)				
CA - 1	3.8	450	0.135	Return Ratio = 65%
CA - 2	2.2	400	0.120	"
CA - 3	1.0	130	0.039	"
Sub-total	7.0			
(Main drainage canal)				
PR - 1	2.2	390	0.271	
PD - 1	2.4	500	0.506	
PC - 1	1.8	250	0.174	
PS - 1	2.7	200	0.139	
Sub-total	9.1			
(Lateral drainage canal)				
E - 1	0.6	30	0.021	
E - 2	1.7	80	0.056	
E - 3	2.2	70	0.049	
R - 1	1.4	70	0.049	
R - 2	0.9	30	0.021	
R - 3	1.2	50	0.035	
R - 4	2.1	80	0.056	
Q - 1	1.5	90	0.062	
Q - 2	1.3	80	0.056	
Q - 3	0.8	40	0.028	
D - 1	3.2	170	0.118	
D - 2	0.9	70	0.049	
D - 3	1.5	60	0.042	
D - 4	1.7	100	0.069	
D - 5	0.7	30	0.021	
D - 6	0.3	20	0.014	
D - 7	1.2	100	0.069	