3.1.6 Vegetation

According to the terms used in Chile, the Mapocho river basin, where the Project Area is located, originates in the "zona andina" where Andean shrubs grow and flows into the "zona mesomórfica". The latter area is further sub-divided into four sub-areas,i.e., hard-wood forest, hard-wood shrubs, thorny bushes and agricultural land.

Appendix Table A-6-1 gives the landuse of the Mapocho river basin. Natural vegetation covers 37.6% of the total catchment area of the Mapocho river. As would be expected, natural vegetation covers most of the upstream section of the Mapocho river, except the area above the timberline, EL + 2,000m. On the sunny open dry slopes, Espino is the dominant species. In drier areas, succulent plants are more abundant. In the valley area, Bollén, Colliguay, Quillary and Muchi are common trees. Frangel is found at a higher altitude.

The Study Area, generally speaking, has the soil and climate quite suitable for agriculture. The areas where surface water or groundwater are not available are mainly covered with thorny bushes, except the section converted into natural pasture or rain-fed agricultural land.

3.1.7 Water Quality

(1) Present Status of Water Quality

1) Water Quality Standard

The water quality standard for domestic and irrigation waters has been established by INN. The assessment of the waters in the Study was made based on this Standard.

For the items not specified in the standard of INN, Resolution No. 350 of Ministry of Health (Jan. 7, 1983), specifies the content of coliform groups in irrigation waters to be used for the cultivation of some raw-eating vegetables, and standards of USA and some other countries specify the contents of BOD and N (NH3-N). The standard limit of BOD and N is not yet established in Chile. The control of waste waters from factories, mines, etc. is not clear and these waters flow into rivers without any treatment.

The water quality standards for respective items used in the Study are summarized in Table 3-1-10.

Table 3-1-10 Water Quality Standard

Item	Unit	Maximum Limit for Irrigation
p^H		Normal Range 5.5 - 9.0
EC	ms/cm	750
SS	ppm	500
Cl	mg/ℓ	200
SO4	mg/ℓ	250
Na%	%	35
Cd	mg/ℓ	0.01
Cu	mg/ℓ	0.20
Mo	mg/ℓ	0.01
Ni	mg/ℓ	0.20
Zn	mg/ℓ	2.00
Coliform Groups	pcs/100 m	1,000
BOD	ppm	(20) 1/
NH3-N	ppm	(5) 1/

1/ Proposed by the Study Team

2) Present Status of Water Quality

The water quality test was conducted at 38 points in the Mapocho river basin (Fig 3-1-6).

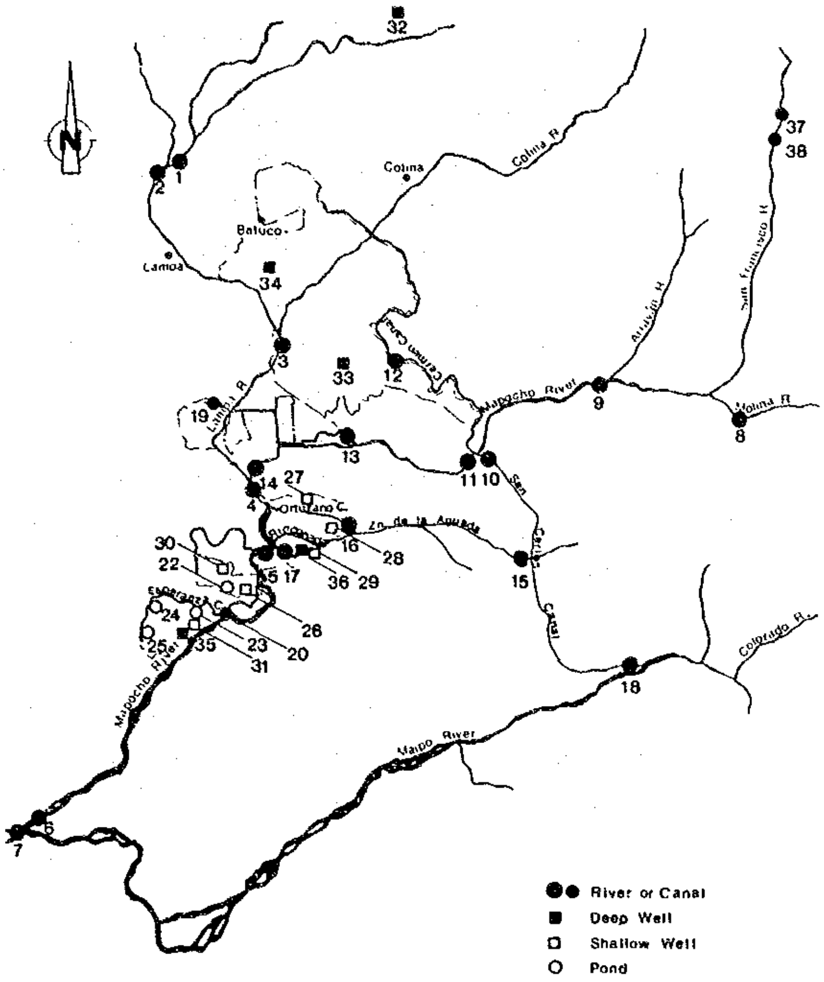


Fig 3-1-6 Observation Points

The existing water quality conditions based on the results of the laboratory analysis are as follows:

- Ions:

  The waters in the Mapocho river basin are almost all of uncarbonic-calcium type. In general, the origin of waters of such type is the waste waters from mine areas, and these waters should not be used for any purposes without treatment. On the other hand, groundwaters are of carbonic-calcium type which can be used without any treatment.

- SAR (Sodium Absorption Ratio) and EC (Electric Conductivity):

  The classification of irrigation waters was made based on EC and SAR as shown in Appendix Fig A-7-4.

  All waters taken from the Mapocho river basin are of S1 group (low sodium) for SAR, and of C1 group (low saline) or C3 group (high saline) for EC.

- Heavy Metals:

  Cu (Copper) contents are over the limit of the standard in Chile, according to the analysis conducted by the Study Team.

- SS (Suspended Solid):

  The waters at 8 survey points exceeded the limit. The waters in Zanjón de la Aguada and Carmen canal are highly contaminated with SS.

- BOD:

  The waters at survey points N^{o}s. 14, 16 and 17 exceeded the limit.

- Coliform Groups:

  The waters at only five survey points (Nos. 1, 2, 8, 9 and 18) were under the limit.

3) Classification of the Present Water Quality

The classification was conducted with the method of cluster analysis. The results of the water quality analysis with respect to pH, EC, SAR, Na%, BOD, Zn, Cu and Coliform groups were used. The results of classification are shown in Appendix Fig A-7-3.

The waters in the Study Area are classified into 3 clusters: a) natural water or diluted water in the Lampa and Mapocho rivers and San Carlos canal, b) water contaminated with the sewage from Santiago city (Zanjón de la Aguada) and c) water in the upper part of the Mapocho river which contains copper and other heavy metals.

4) Water Quality of Branch Irrigation Canals
Water networks of the Study Area are shown in Appendix Fig A-7-19. The results of the field survey are summarized in Appendix Table A-7-2. As shown in the table, Blocks-1 and 2 have many water quality problems due to the representative canals being Esperanza canal and Zanjón de la Aguada in Block-1 and 2, respectively.

(2) Mechanism of Water Pollution

1) Mechanism of Water Pollution
The causes of water pollution are classified into two factors: natural and man-made. In the Study Area, man-made factor is much more influential for the water pollution.

The main causes of water pollution in the Study Area are sewage from Santiago city and waste water from mining industries. The sewage waters from Santiago city consist of sewage from houses and industrial waste waters, and flow into the Mapocho river, Maipo river and Zanjón de la Aguada without any treatment. The ratio of the discharge into these rivers is estimated to be 42% to the Mapocho river, 6% Maipo river and 52% Zanjón de la Aguada.

These polluted waters are used as irrigation waters through the irrigation canals such as Carmen canal from the Maipo river through San Carlos canal, Punta and Esperaza canals from the Mapocho river, and Ortuzano, Loma Blanca, Encañado and Rinconada canals from Zanjón de la Aguada.

2) Sewage Treatment Plan for the 2010 Year

The sewage treatment plan for the 2010 year has been made by EMOS. According to the plan, three treatment plants will be constructed to process the sewage that flows into the Mapocho and Maipo rivers and Zanjón de la Aguada. Treated waters will be discharged into the Mapocho and Maipo rivers.

If this plan is completed, the sewage will be removed from the river and the canals in the Study Area and water quality in the Study Area will be improved to something like natural state. The basic plan of sewage treatment is shown in Appendix Fig A-7-13.

At present, the upland fields in Block-2 are irrigated with the waters from Zanjón de la Aguada. In the plan, these waters are to be discharged to the Mapocho river in its downstream section after treated. However, the substitute of the irrigation water source for Block-2 is not clarified.

(3) Assessment and Problems

The quality problems of the waters in the respective rivers and canals are summarized as follows (Appendix Fig A-7-12):

- The contents of Coliform groups as well as copper in the waters of the Mapocho river are very high.
- The water of San Carlos canal has high EC and SS contents. The content of the Coliform groups is high in the water in its downstream section of the confluence with the Mapocho river.
- The EC and Coliform groups are the main problems in the water of the Carmen canal.
- In the Punta canal, the contents of copper, SS and Coliform groups exceed the limit.

- The Zanjón de la Aguada has many problems to be solved in connection with the water quality such as EC, SS, Na%, BOD and Coliform groups.
- The water of Esperanza canal has the same problems as in Zanjón de la Aguada.

3.2 SOCIO-ECONOMIC CHARACTERISTICS

3.2.1 Population

Distinctively opposite flows of population movement have been taking place in the Study Area. The sections of the area very close to the urban part of Santiago have been encroached by the suburbs of the metropolis. On the other hand, there has been a so called rural exodus to the urban metropolis from the rural area of other sectors of the area.

The population growth in Maipú district of Block-2 and in Renca and Pudahuel districts of Block-3 is remarkable. The urban population density of Santiago has been decreasing since 1900s, when it was approximately 200 persons/km^2, to approximately 90 persons/km^2 today. The rural component of the population in the Metropolitan Region was small in 1985, and it will be negligible in 2000 (Appendix Tables A-8-1 to 3, Fig A-8-1).

3.2.2 Living Conditions

By growing cereals or vegetables, small-scale farmers (holding less than 12 ha of land) can expect an income of approximately Ch$210,000/ha with an expenditure of Ch$110,000/ha for production cost. In addition, they have to pay Ch$30,000/ha for land taxes, water charges, etc. If the farmers work 5 ha (average cultivated land) their disposable annual income will be Ch$350,000. At present, an agricultural labourer can earn Ch$350 - 400 per day. Since minimum monthly wage fixed by the Government is Ch$8,000, income that small holders get is commensurated with their means.

3.2.3 Farm Size, Land Tenure and Land Tax

(1) Farm Size

On a national scale, the small-scale farmers are over one million and occupies about 40% of the rural population. Farm size is obtained by measuring the mosaic photographical maps prepared by CIREN in 1979. These maps show that the number of total farmers in the Study Area is 1,540, of which their farm size less than 10 ha is 923, representing about 60% of the total farmers and about 14% of the total agricultural land. On the other hand, 44 farmers which are 3% of the total farmers hold about 41% of the total agricultural land (Appendix Table A-8-4).

(2) Land Tenure

Since 1978, when the Land Reform Law was replaced, the restrictions on the size of land holdings and ownership of farm lands by private corporations have been removed.

In the Study Area, most small farmers whose holdings range from 4 to 12 ha are beneficiaries of the Land Reform Law. They are the holders of title deeds of the land, while they are paying up the cost of the land by installment. There is a faily large number of holders of very small pieces of land (ie, less than 2 ha) for their subsistence agriculture. They work with the big land owners as agricudltural labourers, and in return, some of them receive farm land with houses.

(3) Land Tax

Agricultural land is classified into several categories for taxation purposes. Whether basic irrigation facilities are provided or not is the first division. The irrigated land is classified into four categories according to the gradient of the land, and the dry land into two categories, arable and non-arable. Arable land is further classified into four sub-classes according to the topography and soil. Non-arable land into three sub-classes according to pasture and forest. Appendix Table A-8-5 shows the prices of agricultural land of each category assessed by the tax office. Land tax on the agricultural land is fixed according to this assessment.

3.2.4 Farmers' Organization

The Agrarian Reform Cooperation has been dissolved, and those farmers who used to be members of one of the cooperations are called "ex-CORA". Each farmer manages his farm individually. There is no sub-organization even for an irrigation canal association. Therefore, each farmer must go to the head office to pay his irrigation fee once every three months. Even when a tertiary canal is newly excavated, interested holders of water rights will form an association to share the construction cost. If their mutual interest is interrupted, they work their farm land individually. This association will not extend its activities into other fields like marketing of agro-products. In the field of marketing of vegetables, fruits for export or milk, the exporters and processors take the initiative of making contracts with individual farmers, not with farmers' association. The same situation is applicable to the field of technology transfer.

3.3 SELECTION OF THE FEASIBILITY STUDY AREA IN THE SECOND PHASE

In the First Phase, the basic survey was conducted in the objective area of approx. 61,000 ha divided into eight (8) blocks based on the existing irrigation networks. Blocks -1, 2, 3 and 4 of approx. 36,000 ha in total were selected as the study area for the feasibility study in the Second Phase in consideration of the following:

a. The selected areas are agricultural ones located adjacent to Santiago city and are socio-economically very important due to their high agricultural potentiality. These areas are strongly affected, directly or indirectly, by the expansion of the Santiago city and the development of these areas balanced with the surrounding urban areas is expected;

b. The irrigation waters of the selected areas are contaminated and especially those of Blocks -1 and 2 are seriously contaminated due to inflow of the sewage water of Zanjón de la Aguada. Urgent counter-measures to improve this situation are required;

c. The productivity of agriculture in Blocks-3 and 4 is low due to problems such as inundation, poor drainage, problem soils and lack of irrigation water, in spite of the geographical advantage of these areas being located near a large consumption market for agricultural products. The counter-measures to improve its productivity and to effectively utilize the agricultural land are necessary;

d. The regional government of Santiago sets the main items to be expected from the Project as follows:

   i. Improvement of inundation problem and flood control
   ii. Improvement of agricultural production
   iii. Improvement of contaminated irrigation waters and problem soils

   The selected areas have there problems and urgent counter-measures are expected; and

e. Blocks -5, 6, 7 and 8 are located comparatively far from Santiago city and have less problems to be solved urgently compared to Blocks -1, 2, 3 and 4.

Therefore, urgent counter-measures to lessen the existing problems and for recovering high agricultural productivity in Blocks -1, 2, 3 and 4, are strongly needed.

3.4 LANDUSE

3.4.1 Present Landuse

The Study Area is 35,940 ha in total, of which 32,590 ha, 91% of the total, are presently used as agricultural land. About 50% of the agricultural land are upland fields and the rest are pastures. Most of the upland fields are ordinary ones and the rest are classified as orchards and vineyards. With the expansion of the urban area, remaining 9% of the Study Area have been urbanized. The present landuse is shown in Table 3-4-1 and Fig 3-4-1.

Table 3-4-1 Present Landuse

(Unit: ha)

Block No.	Agricultural Land							Others 2/	Grand Total
	Upland Field				Pasture	Others 1/	Sub-Total		
	Ordinary Field	Orchard	Vine-yard	Sub-Total					
1	1,690	30	40	1,760	900	90	2,750	120	2,870
2	3,180	120	430	3,730	660	200	4,590	320	4,910
3	2,030	100	170	2,300	2,760	120	5,180	480	5,660
4	7,430	520	650	8,600	11,020	450	20,070	2,430	22,500
Total	14,330	770	1,290	16,390	15,340	860	32,590	3,350	35,940

1/ includes farmhouses, farm roads, secondary and lateral irrigation canals, drainage canals, etc.

2/ includes urban areas, main roads, main canals, rivers, ponds, swamps, garbage disposal areas, etc.

3.4.2 Change of Landuse Category

Some portions of the Blocks-2 and 3 have become urbanized, conflicting their use with agricultural purpose; recently the transformation of agricultural lands into other use has remarkably observed. This phenomenon, including legal aspects, was studied referring to the following documents.

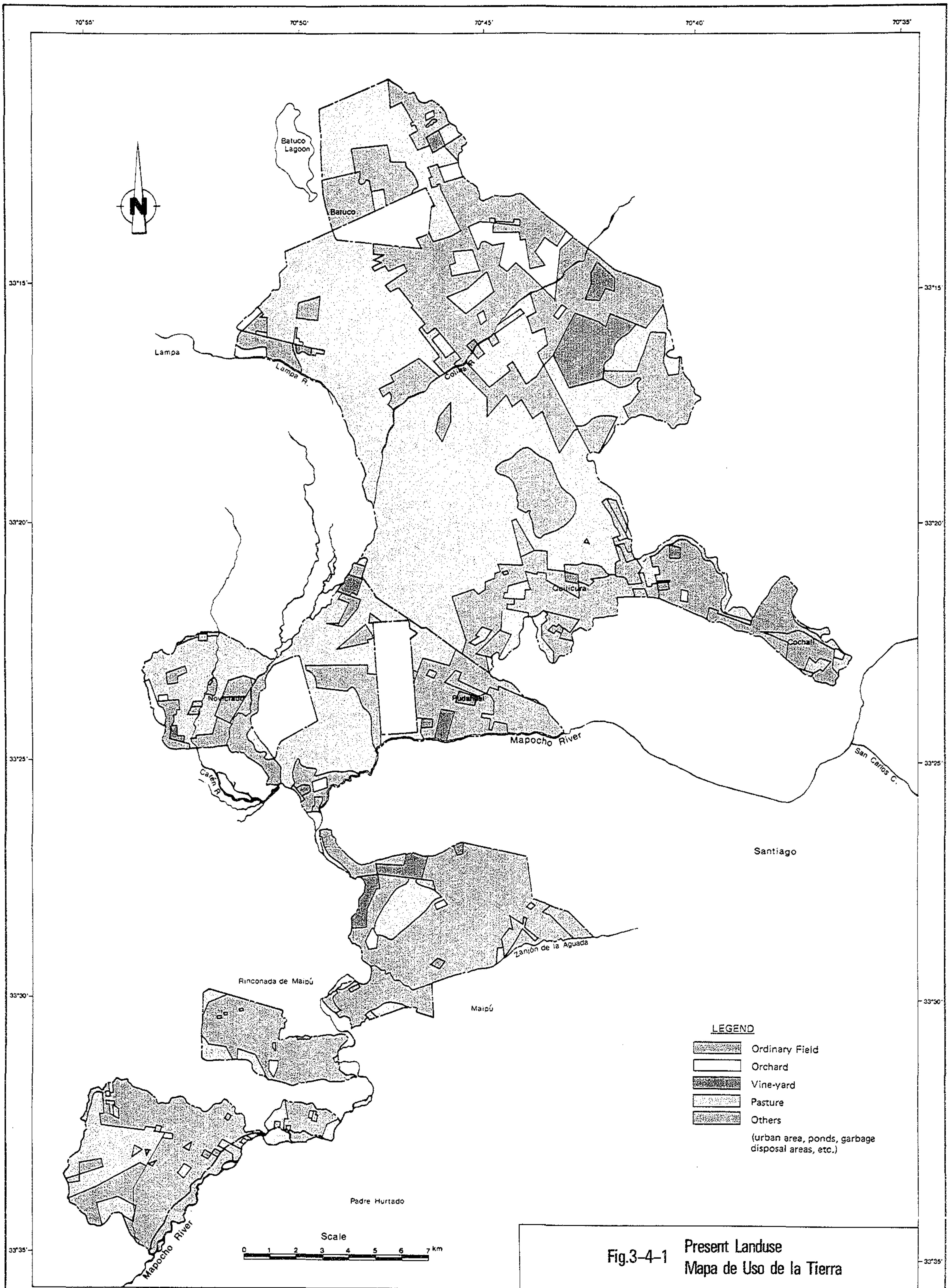


Fig.3-4-1 Present Landuse
Mapa de Uso de la Tierra

a. Decree No. 420 of MINVIU dated on Oct. 31, 1979 - "Modifica Plan Intercomunal de Santiago y Su Ordenanza" and attatched Drawings

b. "Plan Maestro, Alcantarillado del Gran Santiago, Período 1985-2010", EMOS

c. "Cartografía Básica para el Diagnóstico de la Cuenca del Río Mapocho", UCh

According to the said Decree, the Metropolitan Region is divided into three zones; namely 1) Urbanized zone, 2) Urban Expantion zone and 3) Conservation zone. The urbanized zone is the urbanized areas such as industrial and residential area, etc. The urban expantion zone corresponds to those lands with great potential capable to be urbanized, which extend between zones 1) and 3) mentioned above. This zone is required to be developed in compliance with regulations enacted by the MINVIU, etc. and its permission should be obtained before starting development. The conservation zone comprises those districts for natural environment protection, public utilities and rivers/irrigation canals conservation and lands which have high possibility of natural disasters. The development of this zone is prohibited in principle.

The document "b" predicts that the population of the Great Santiago will be growing year by year; the projection indicates its growth by 41% in 1995 and by 100% in 2010, both compared with the population of 1980. Keeping pace with the growth of population, the residential area of the Great Santiago will be expanding to the west and to the south; reaching to 74,816 ha in 2010 (a growth of 96% from actual area of 38,206 ha of 1980). With respect to the Study Area, the expansion of residential area is expected by 38% at Renca, 85% at Conchalí, 153% at Pudahuel and 329% at Maipú.

The document "c" predicts that during past 22 years until 1984, the acreage of the upland fields in the Mapocho river basin decreased slowly (0.25% p.a.) and that on the other hand, the urban area increased about 3.8 times (6.3% p.a.).

At present, the urban area in the Study Area is approximately 2,210 ha. In reference to a information of "Limite Intercomunal de Santiago" (MINVIU, 1983), the increasing tendency is forecast that the urban area will be increased by 3,980 ha, totaling to 6,190 ha by the year of 1991 (Appendix Table A-9-1).

3.5 AGRICULTURE

3.5.1 General

Agricultural activity in the Study Area has the characteristics of intensive suburban agriculture. It has the economic advantage of being situated relatively near the sea ports and next to the airport for export of agro-products.

The agricultural land is divided into upland field and pasture. The upland field is further divided into three categories; 1) ordinary fields for cereals, vegetables and forage crops, 2) vineyards and 3) orchards. The pasture is composed of artificial and natural ones.

The vegetable-planted area covers approximately 20% of upland field, which is one of the features of suburban agriculture. Small holders grow more vegetables per holding. Yet, the vegetable-planted area tends to be on the decline for four major reasons mentioned below:

a. Prices of vegetables are low compared with those of other tradicional crops;

b. Fertile field has been converted into non-farming area as a result of the growth of urban area of Santiago city;

c. Growing vegetables which are eaten without cooking has been prohibited in some areas due to organic contamination of irrigation water; and

d. Marketing difficulties.

On the other hand, the wheat-planted area for which the Government gives incentives and the area of fruit trees including grapes are planted whose export outshines other items are on the increase.

3.5.2 Agricultural Production

(1) Agriculture

Major crops in the Study Area are cereals such as wheat and maize, vegetables such as tomatoes, carrots and onions, fruits such as plums, nectarines, peaches, grapes for wine and table fruit, and fodders like alfalfa. Details of production by crop are described in the Appendix 10.

Although the technical level of small-scale farmers is generally regarded as low, average unit yield of major crops in the Metropolitan Region is generally higher than that of the national figure (Appendix Table A-10-4).

The following is the present situation of major crops in the Study Area:

1) Wheat

Total wheat production in the Metropolitan Region is approximately 99,000t, which is equivalent to 10% of the national production (1983/84). Average yield of the Region is 3.5 t/ha, which exceeds the national average of 2.1 t/ha. Average yields of provinces of Talagante, Santiago and Chacabuco, in which the Study Area is situated, are 4.4, 4.4 and 3.2 t/ha, respectively (1984/85).

According to the farmer's household survey carried out in the Study Area, the average yield of small- and medium-scale farmers (holding less than 100 ha of lands) is 3.5 - 4.0 t/ha, and that of large-scale mechanized farms (holding more than 100 ha of lands) is over 6.0 t/ha. Only in the northern part of Block-3, where floods are frequent, slightly less average yields of 3.0 -3.5 t/ha are recorded. Average yield of 7.8 t/ha and 7.9 t/ha are recorded among the technology transfer groups (TTG) of medium-scale farmers in Maipú and Colina districts who receive the extension services of INIA, respectively (La Platina N° 28, INIA, 1985).

Major varieties used are Millalen, Aurifen, SAN-1 and SAN-2. Seeding time of irrigated farm ranges between late May and early July, that of rainfed farm is May.

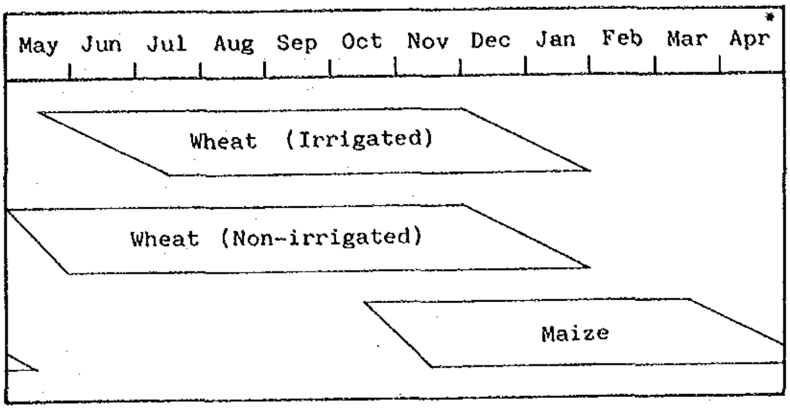
2) Maize

Total maize production in the Metropolitan Region is approximately 143,000 t, which is equivalent to 19% of national production (1984/85, ODEPA). Average yields of the Region is 5.9 t/ha, which exceeds slightly the national average of 5.2 t/ha (1984/85, ODEPA). Average yields of provinces of Talagante, Santiago and Chacabuco, in which the Study Area is located, are 6.7, 6.2 and 3.1 t/ha, respectively (1984/85). Like wheat, average yield of the northern part of the Study Area is less than that of the southern area.

According to the farmers' household survey, the maximum yield of approximately 8 t/ha was recorded in 1984 by a farm located in the northern part of Block-3. INIA experimental farm in Santiago city reported an average yield of 11 - 12 t/ha (La Platina N° 28 INIA, 1985).

Hybrid seeds of Pioneer and Tracy series are generally sown. Seeding time is between middle October and middle November.

Present cropping patterns of wheat and maize are shown in Fig 3-5-1.



Note : * Agricultural Year

Fig 3-5-1 Present Cropping Pattern

3) Vegetable

Major vegetables produced in the Study Area are tomatoes, carrots, onions, capsicum and corn. Raw eating vegetables such as lettuce, cabbage and celery are also widely grown. Vegetable production is mainly carried out by small- and medium-scale farmers. There are some small holders who grow vegetables on 70 - 80% of their holding.

4) Fruit Trees (except grapes)

Large part of fruit growing is done by medium- and large-scale farmers. They are scattered in the Study Area, except the northern part of Block-4 where many growers are found side by side.

Major fruits grown are peaches, plums, pears, nectarines, apricots and walnuts. Orchards of prickly pear are found in the western part of Blocks -3 and 4. Irrigation facilities are managed relatively well. Export of fresh fruits has rapidly increased recently. According to Ministry of Agriculture, yearly increase is 8 -9% in both value and volume.

5) Grapes

The area of vineyards for wine in the Study Area is on the decline. On the other hand, vineyards for table grapes which are mainly managed by large-scale farmers are on the increase.

Table grapes are mainly exported to USA and EEC. The value of grape export consists of about half of the total agro-product export at present. In addition, its growth rate is phenomenal.

Thompson seedless is a variety generally found in the Area. Some new varieties such as Red seedless, Flame seadless, Ruby seedless and Black seedless have recently been introduced for export.

Harvesting season is between December and April. Average yield is 16 - 20 t/ha and net profit ranges between US$8,000 and 12,000/ha. High profitability attracts new investment, and new plantation is mainly done as an extension to the existing vineyards.

Establishment of vineyard requires initial investment of Ch$300,000 - 500,000/ha, then the vineyard should be maintained for three years without income while the trees mature. Harvesting requires a large amount of manual labour. Therefore, to start the business, a fairly big amount of finance is required.

(2) Livestock Production

In the past, Chile's livestock production emphasized beef and sheep (both meat and wool) as is typical in Latin American countries. However, in recent times, production of pig, broiler and chiken egg have increased (Appendix Table A-10-29).

Specifically, the production of beef and pork have increased, while production of milk, chicken meat and egg have decreased since 1981; wool and mutton production has remained constant (Appendix Tables A-10-28 and 29). Productivity of modern breeds of major livestock animals is rather high.

Chile, as well as other Latin American countries, consumes a large amount of beef. The consumption of beef and pork has gradually increased in recent years, while that of mutton, chiken meat, egg and milk have decreased (Appendix Table A-10-30). The decline of chiken meat and egg consumption is caused by overproduction of large-scale mass integrated production systems by non-agricultural investors. As for milk, the cause is monopolization of the milk market by a few dairy processors, who fix its retail price.

Livestock production in the Study Area concentrates mainly on dairy farming and partially pig and poultry farming are carried out by large-scale farms. But it can be seen that livestock farming does not play a major role among agricultural sectors. Even through some small-scale farms raise milk cows, beef cattle, pigs, sheep, goats, bees and angora rabbits, the production seems to be very small and is mainly for home consumption and/or local consumption. Large differences in productivities between large- and small-scale farms can be seen.

A summary of the present status of livestock production in the Study Area is as follows:

1) Pasture

In the upland field, pasture crops (mainly alfalfa) is planted and its yield is comparatively high (about 10 - 15 t/ha per year, 5 cycle per year, with a moisture content of 15%). Most of the large-scale farms practice better management of pasture and have irrigation systems. Some producers sell dried pasture and pellets.

2) Dairy Farming

The majority of dairy farms consist of large-scale farms or investors living in Santiago. They have large pasture (more than 100 ha, maximum 480 ha) with irrigation facilities and milking installations. Major raising breeds are Holstein Friesian (USA and European origin). On large-scale farms, milking is mostly carried out by milking machine which provides high milk yield (4,000 - 6,000 ℓ/cow/year). Some farms have their own milk or dairy processing plants. Small-scale farms manually produce milk but production is only 2,000 - 3,000 ℓ/cow/year.

3) Pig Farming

Pigs are raised by rather small-scale land owners (not limited to farmers) in Blocks-3 and 4. As for feed, some grain (mainly corn) is cultivated in each farm and feed is formulated individually. Pig breeds such as Company Hybrid have also been introduced recently. Due to the depressed prices of milk, broilers and chicken eggs, many farmers are increasing their interest by pig farming.

4) Beef Cattle Farming

No systematic large-scale beef cattle farm was found in the Study Area or its vicinity. Most are small-scale farms engaging in raising of Holstein male calves. Most of them are entrusted by middlemen to be raised as beef cattle, but their productivity is low due to the bad quality of breeds and insufficient supply of feed of good quality.

5) Poultry Farming

Although there are broiler houses requiring large investment in Blocks-1 and 4, broiler houses in the Block-1 are presently out of operation (monthly 50,000 birds capacity), while monthly 17,000 birds production is carried out in Block-4. Egg production is conducted in Blocks-3 and 4. The products are sold directly to the Santiago market or local market.

6) Other Livestock
Although other livestock such as sheep, goats, horses, bees and angora rabbits are raised here and there, most of them are of small-scale (with a few exceptions) and do not have sufficient farm management or facilities.

7) Livestock Disease
Presently, in Chile, there is no occurence of seriously infectious animal diseases such Foot and Mouth Disease, African Swine Fever and Pseudo Rabies, which can be found in other South American countries.

3.5.3 Production Cost and Production Value

The mean direct production cost, yield and producer's price (farm gate price) of principal agricultural products in the Study Area are estimated as shown in Appendix Table A-10-15.

The production costs and yields of cereal products such as wheat and maize in Block-4 are lower than that of other blocks. On the other hand, the production quantities of vegetables and fruits are similar in each block, because the conditions for cultivation are good. The production costs of fruits and some vegetables are higher than those required for cereals. The labor costs occupy about 40 - 50% of production costs. The producer's prices of fruits for export are 1.4 - 3.2 times the domestic sales. Gross production values and net production values of principal products are shown in Appendix Table A-10-16.
The production value of fruit trees, especially those of fresh fruits for export, are high. Although the gross production values of vegetable products are high, the net production values are low. The production value of maize is the lowest among principal products.

3.5.4 Research, Extension and Training

(1) Research

On a national level, the Foundation for Research on Agriculture and Livestock (FIA) and the National Institute for Research on Agriculture and Livestock (INIA) coordinate the national research program.

FIA, which has formulated the research program for the three year agro-silvo-livestock development plan for 1985-1987, emphasizes the short-term strategic aspects; whereas INIA has been conducting basic research on all the aspects of agriculture and livestock. The creation of a commission to oversee the system of wholesalers of perishable products in the Great Santiago area is one of the results of this kind of research.

(2) Extension and Training

Extension and training work is being carried out on two levels.

1) Small Holders
INDAP is taking the responsibility of the extension and training activities to the small holders. INDAP entrusts the actual job to technical assistance companies and gives subsidies to the farmers for the cost of the services.

In the Study Area, farmers in the Colina district are receiving services from AGROCOLINA and in the comuna of Lampa from INACAP.

2) Medium- and Large-scale Farmers
INIA is in charge of the program. For this purpose, it organizes the farmers into groups (GTT) of 18 farmers in average, according to the size of the land and the

locality. Nationwide, so far 100 groups have been formed. INIA hopes that this kind of group activity will have a direct effect on 5 neighbouring producers, and a further indirect effect on 25 ones.

3.5.5 Input Supply, Credit, Processing and Marketing

(1) Input Supply

All the input supplies, such as fertilizers, seeds, pesticides and machinery, domestic as well as imported, are available in the market. No price control is done by the Government. ODEPA collects information on prices of input supplies as well as agro-products continuously and publishes a monthly bulletin on the subject.

(2) Credit

Short-term credits for the operation are channelled to farmers through "Banco del Estado", INDAP, CORFO, city banks, processors like millers and breweries, and marketing agencies, most of which are linked to conglomerates controlled by the financial clans. These private concerns make a contract of cultivation with each farmer individually. They provide the farmers with input supplies and collect the harvests. They even provide the farmers with technical services.

"Banco del Estado", INDAP, CORFO and city banks provide long-term credits for agricultural capital investments. The rescheduling of outstanding debts and further introduction of new credits from the foreign banks including the World Bank have been arranged through IMF.

For the development and economic support of small holders, INDAP gives long-term as well as short-term loans. It can be called a development package for small holders, as input supply and extension services are combined in the package.

(3) Processing

Many agro-processing factories are found in the industrial area of Santiago. Besides traditional mills, breweries, canning factories and dairies, there are factories of fruits, refrigerated vegetables and alfalfa pellets for export. These processors form groups of contract with farmers in the Study Area, providing input supplies and technical services and eliminating the marketing problems for them.

(4) Marketing

1) Agricultural Products

Agro-products of the Study Area reach consumers through various marketing channels. When producers have means of transport, they sell their products directly to consumers or to retailers at the market place of the neighbouring villages, or carry them to the central market of Santiago. Cereals like wheat and maize are carried directly to the mills.

If they do not have transport, as is the case with most of the small holders, transporters buy products from the farmers on a spot-cash basis. They in turn carry them to the big markets in Santiago and sell them to the wholesalers.

There are some instances in which exporters and supermarket chains advance operating capital as part of production-purchase based contracts with small-scale producers of export fruits and high quality vegetables.

Wheat is purchased by the Government purchasing agency, COPAGRO, at a price within the pre-announced price band, which is surely an incentive for wheat growers.

2) Livestock Products

Typically, the market for chicken meat and egg in Chile is handled by large-scale integrated enterprises which carry out integrated operation including hatchery, feed mill, production and processing. Milk is collected by large-scale dairy processors and the price for milk is fully controlled. Beef, pork and mutton have a rather complicated marketing channel. Middlemen and meat processors play an important role in price determination. Livestock meats are sold based on size and exterior features; no grading system is used. Slaughter houses only function for killing and treatment of carcass, and they just collect a slaughter charge.

Changes in the wholesale price of livestock products in Santiago are shown in Appendix Table A-10-31. Price escalation rates of chicken eggs and milk are highest among livestock products, followed by chicken meat.

This high escalation rate seems to have stagnated the demand for chicken egg and milk. By comparison of beef prices among major producting countries, the beef price in Chile is highest in South American countries (Appendix Table A-10-32).

3.6 EXISTING INFRASTRUCTURE FACILITIES

3.6.1 Flood Control and Resulting Damage

(1) Present Condition of Rivers

1) Existing Works

a. Mapocho River

The summary of the Mapocho river improvement works carried out in the Santiago city section is as follows:

- Stone with concrete bank (built at the beginning of this century), approx. 4km long along the central part of the city
- Gabion bank (being constructed after the 1982 flood), approx. 5km long
- Riprap and groyne; some sections

b. Lampa River

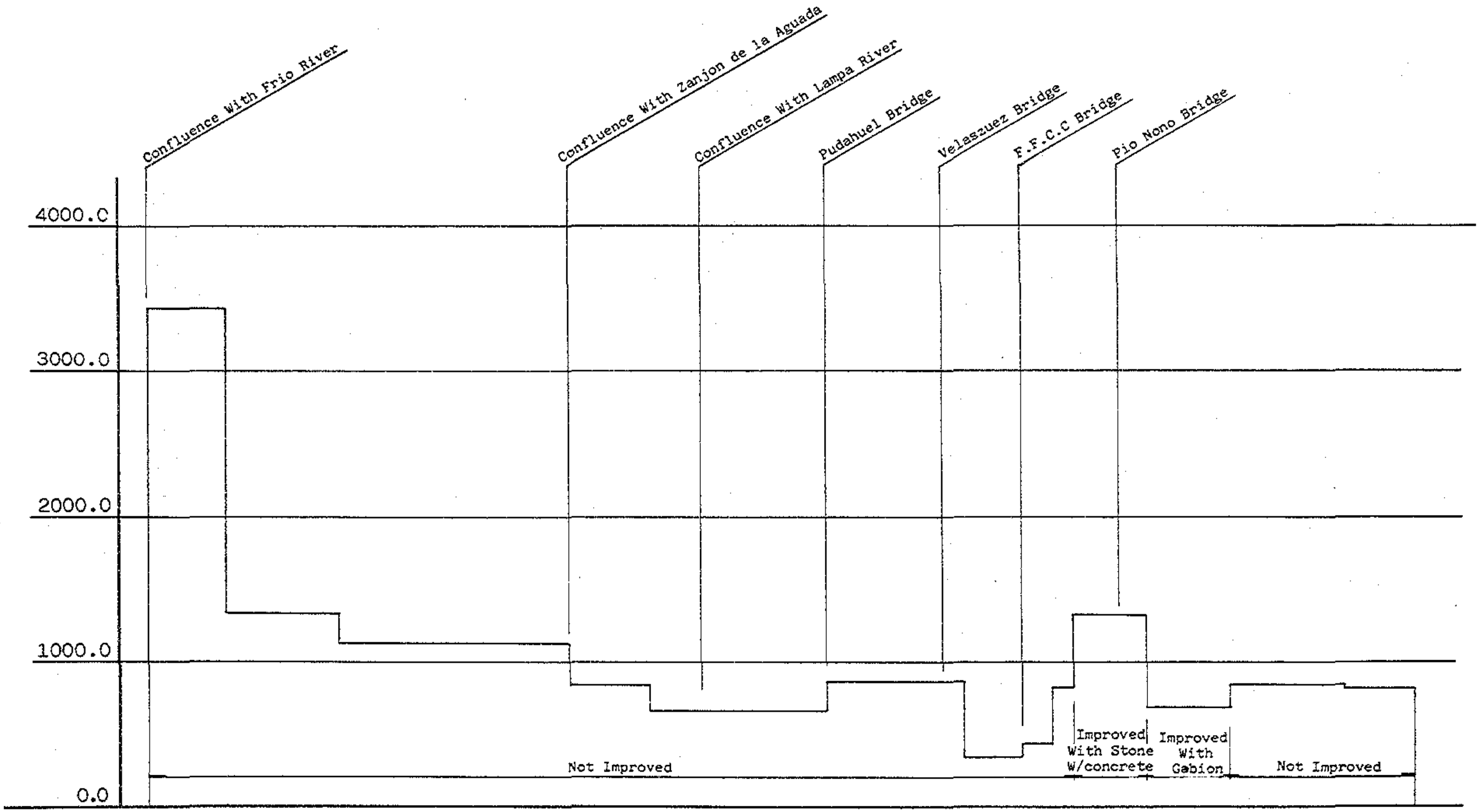
The Lampa river has been improved with groyne only in some sections around Lampa town.

c. Colina River

The Colina river has been improved with gabions at the delta head section immediately downstream of the mountainous area, and with groynes in the sections of Esmeralda and Colina towns.

2) Present Flow Capacity

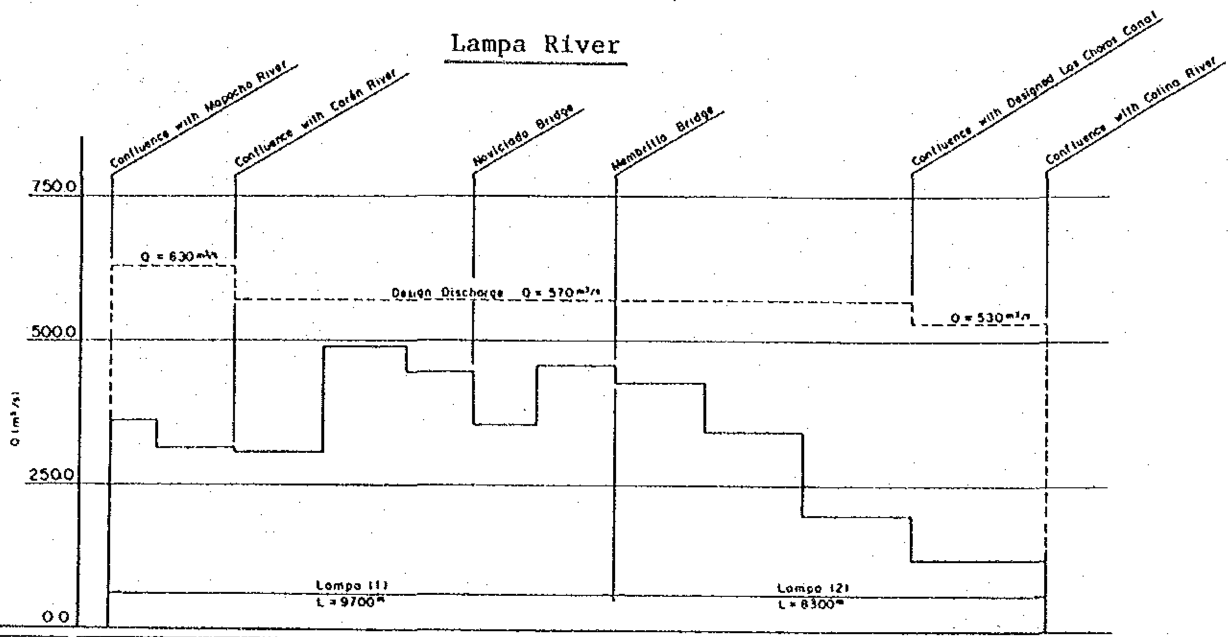
The present flow capacity of the main rivers in the Study Area is shown in Figs 3-6-1 and 2 (Details are shown in Appendix Table A-13-3).



DISCHARGE (m³/s)	3439	3439	1338	1338	1138	1138	1138	1138	842	842	660	660	865	326	434	822	1331	683	836	832	832
ACCUMULATED DISTANCE (Km)	-28.5	-25.0	-24.5	-20.0	-18.5	-15.0	-10.0	-8.0	-6.7	-5.0	-2.6	0.0	6.5	13.5	16.4	18.0	19.1	22.9	27.1	32.9	36.5
STATION	-3.0	-NO.5	-4.5	-NO.4	-3.0	-NO.3	-NO.2	-3.0	-1.7	-NO.1	-2.6	NO.0	NO.1 +1.5	NO.2 +3.5	NO.3 +1.4	+3.0	+4.1	NO.4 +2.9	NO.5 +2.1	NO.6 +2.9	NO.7 +1.5

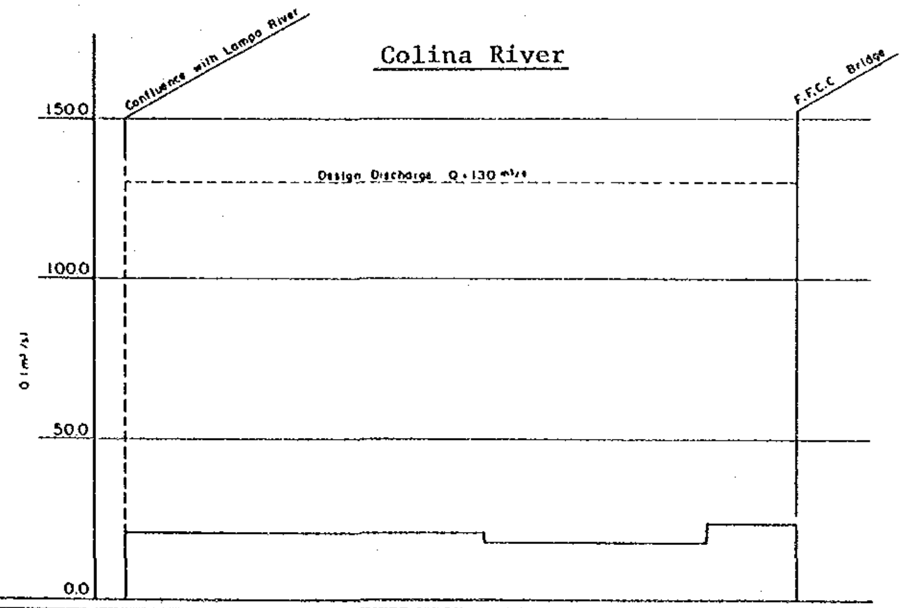
Fig 3-6-1 Present flow Capacity of Mapocho river

Lampa River



DISCHARGE (m³/s)	361	314	307	490	490	446	355	458	427	427	343	199	199	122	20
ACCUMULATED DISTANCE (km)	0.0	0.9	2.4	4.1	5.0	5.7	7.0	8.2	9.7	10.0	11.4	13.3	15.0	15.4	18.0
STATION	NO.0	+0.9	+2.4	+4.1	NO.1	+0.7	+2.0	+3.2	+4.7	NO.2	+1.4	+3.3	NO.3	+0.4	3.0

Colina River



DISCHARGE (m³/s)	21	18	24	24
ACCUMULATED DISTANCE (km)	0.0	3.4	5.5	5.9
STATION	NO.0	+3.4	NO.1 +0.5	+0.9

Fig 3-6-2 Present flow Capacity of Lampa and Colina Rivers

The present flow capacity of the Mapocho river in its improved section is 750 to 1,300 m^3/s, which corresponds to the flood discharge of 30 to 200 year return period (Appendix Fig A-13-8). However, its flow capacity in the bridge sections decreases by 30 to 80% due to the disturbance by the bridge girders against the flow area of the river (Appendix Table A-13-4).

(2) Flood Damage

1) Past Flood Damage

The flood damages included in the Mapocho river system have occurred mostly in the following three areas:

a. Santiago city along the Mapocho river
   - Cause: Overflow from the Mapocho river
   - Characteristics: Inundation period is short due to the high speed of the flood flow, but the damage is big.

b. Areas along San Carlos canal and Zanjon de la Aguada
   - Cause: Overflow from the rivers located at the eastern edge of Santiago city and San Carlos canal.
   - Characteristics: Same as for Item "a". In addition, the frequency of flooding is big.

c. Agricultural land along the Lampa and Colina rivers
   - Cause: Low capacity of the Lampa and Colina rivers, and low density of drainage canals.
   - Characteristics: Inundation period is long due to the slow speed of the flood flow caused by the flat topography of the area.

In the Mapocho river basin, the large flood damage occurred in June 1982 and July 1984.

The 1982 flood occured because of the snowmelt due to the high temperature in the upper basin in addition to the heavy rain in the watershed, causing the large flood damage mainly in the areas "a" and "b" mentioned above. This flood corresponds to the 30 year return period flood 1/, based on the Mapocho river discharge observed at Los Almendros.

The 1984 flood occured due to the heavy rain in the mountainous area of the Lampa river basin, causing the large flood damage in the area "c" mentioned above. The inundation in the area during that time continued for about 7 days. This flood corresponds to the 7 year return period flood 2/, based on the Lampa river simulated discharge.

Table 3-6-1 shows the observed rainfall during the 1982 and 1984 floods.

Table 3-6-1 Rainfall during Floods

Period	Rungüe (No.4)		Santiago (No.24)	
	Rainfall	Return Period	Rainfall	Return Period
June 1982	no data	-	100.4mm/ 2 days	10 Years
July 1984	236mm/ 3 days	15 years	77.6mm/ 3 days	3 years

1/ A 30 year return period peak discharge at Los Almendros estimated by CNR are 297 m^3/s. While the observed maximum discharge for the flood in June 1982 was 295 m^3/s.

2/ A 6.7 year return period peak discharge and the maximum discharge for the July 1984 rainfall estimated with our simulation analysis are 650 m^3/s and 622 m^3/s, respectively.

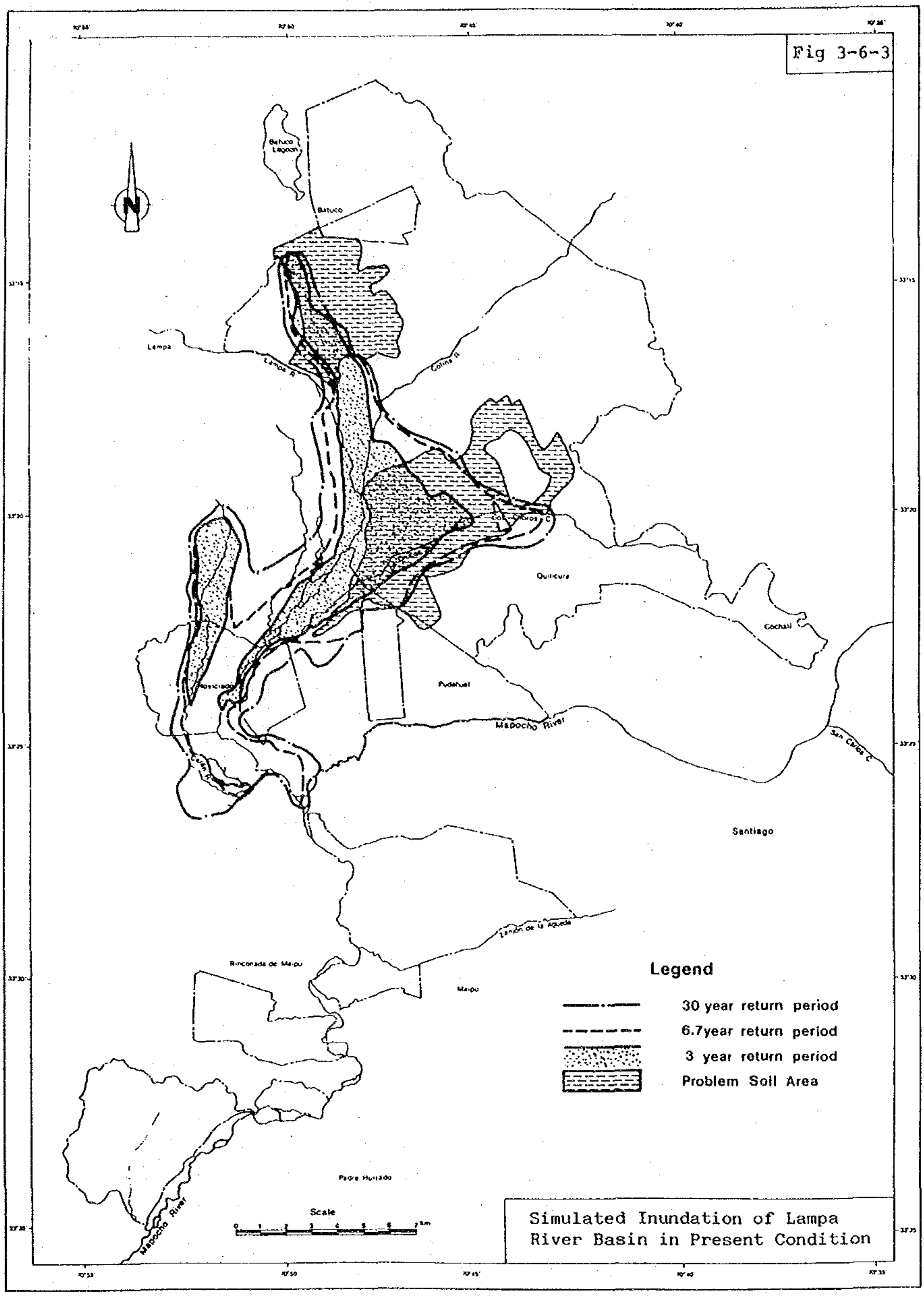


Fig 3-6-3
Batuco Lagoon
Batuco
Lampa
Lampa R
Colina R
Quilicura
Cochali
Pudahuel
Mapocho River
San Carlos C
Santiago
Rinconada de Maipu
Maipu
Padre Hurtado
Mapocho River
Scale
Legend
30 year return period
6.7year return period
3 year return period
Problem Soil Area
Simulated Inundation of Lampa River Basin in Present Condition

2) Inundation Area

Flood simulation analysis was conducted with the Storage Function Model method. The inundation area in the Lampa river basin under present conditions is estimated for each return period.

Fig 3-6-3 and Table 3-6-2 show the inundation area and its acreage, respectively.

Table 3-6-2 Inundation Area in Lampa River Basin

Flood	July 1984 Flood	Return Period (Year)		
		3	6.7	30
Inundation Area (ha)	7,780	4,300	7,640	10,180

(3) Erosion Damage

The vegetation in the upstream area of the Mapocho river basin is poor and the rocks are exposed in the slopes in many places. However, the progressing creeps and large landslides reaching the river stream are few. This is because of the small amount of rainfall, 400mm/year, and the scarece occurence of heavy rain in the basin. The amount of sediment produced in the Mapocho river basin at Los Almendros is estimated to be $70m^3$/year/km^2 (Appendix Table A-13-1).

3.6.2 Drainage Facilities and Related Problems

(1) Drainage Facilities

1) Block-1

Topographically speaking, Block-1 consists of a small basin (Appendix Figs A-12-2 and 3), and the water table in the Area is rather high, ranging from (-) 0.80m to (-) 1.2m. The land slope is gentle in the western part of Block-1 and there is a poorly drained area of about

300 ha. The only reliable drain in this block is Frío river. Since the slope of Frío river is rather steep and the average velocity exceeds 1.5 m/s, erosions of the canal are numberous. The density of drainage canals and rivers in this block is 6.8 m/ha.

2) Block-2

Irrigation canals in this block are well developed compared with those of other blocks, and they work also as drainage canals. Natural streams which cross the Zanjón de la Aguada and Rinconada de Maipú and flow east to west have important drainage function, too. The drainage conditions are comparatively good. The total length of drainage canals including rivers is 9.8 km. The density of them is 8.2 m/ha.

3) Block-3

Poorly drained areas prevail in the northwestern area of the airport and northern area of Noviciado. The density of drainage canals and rivers in this block is 4.2 m/ha. The Cruces river, a continuation of the Choros drainage canal, has been partially improved.

4) Block-4

Topographically speaking, the eastern part of Block-4 consists of an alluvial cone with land slope of about 1/10. Poorly drained areas are found in the area around Batuco and in the area surrounded by the Lampa and Colina rivers, as well as along Choros canal (Cruces river). The land slopes are gentle, the water tables are high in those areas and the soils of aquiclude and aquifuge distribute near the ground surface. The existing drainage canals in this block are Huechuraba, Choros, San Ignacio and others which are not specified. The large and small rivers function as drainage canals, too. The area where there are no drainage canals is classified as swampy areas. The density of the drainage canals and rivers in this block is 2.6 m/ha.

(2) Drainage Problems

As mentioned earlier, poorly drained areas exist in the following areas:

a. Northwestern area of Noviciado, in Block-3
b. Along Choros drainage canal, in Block-4
c. Northern area of the Auturo Merino Benitez airport, in Blocks-3 and 4
d. Terminal of Colina river, in Block-4
e. Near Batuco, in Block-4

The main causes of poor drainage in these areas may be attributed to centroclinal plain topography, existence of impervious soil, low density of drainage canal, poor maintenance of existing drainage canals, etc.

3.6.3 Irrigation Facilities and Water Balance

(1) Irrigation Facilities

In the Study Area, a total of 151.5 Km of main irrigation canals service a total agricultural area of 35,940 ha (Table 3-6-3). In addition, the area contains 29 reservoirs with a maximum capacity of 507,500 m^3 (Table 3-6-4). Present irrigation canal system is shown in Fig 3-6-4. Details of the irrigation facilities are discussed by block in the sections which follow.

1) Block-1

a. Intake Conditions

Irrigation water is drawn into Block-1 through the simple gabions or gravel metalled training dikes located in the Mapocho river. These intake structures are apt to be washed away easily by floods, but they can be easily reconstructed. It has been observed that a considerable amount of money has been spent annually to keep the structures in good condition.

b. Main Irrigation Canals

These canals are made of earth and no remarkable erosion of the canal has been observed.

c. Division Works

Division works, made of reinforced concrete, are located at the heads of main and branch canals. Irrigation water is divided by separation devices installed on the division works and no gates are provided on the devices.

d. Intakes

Steel-made sluice gates, with an average dimension of 60cm x 80cm x 5mm are provided at the intakes of irrigation canals. According to field observation, these gates are well maintained and functioning well.

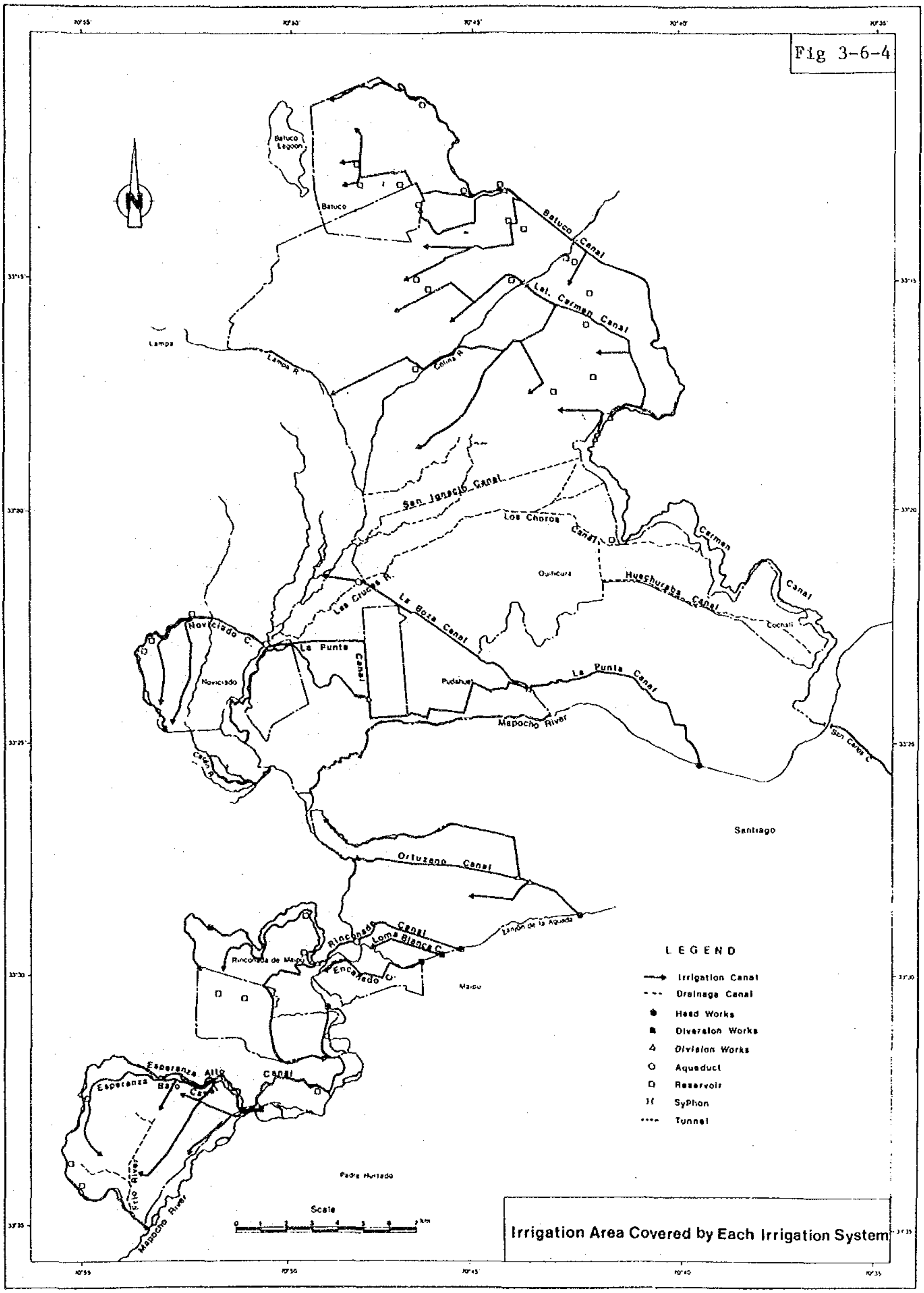
e. Reservoirs

There are four reservoirs in Block-1 and each is serving an area of 150 to 200 ha. Water is stored in these reservoirs during night and used for irrigation in the daytime. Water is not diverted from these reservoirs during the non-irrigation period.

Table 3-6-3 Main Irrigation Canals

Block	Name	Length(km)	Agricultural Land (ha)	Total Area(ha)
1	Esperanza Alto	16.2	1,220	1,330
	Esperanza Bajo	10.2	1,530	1,570
	Sub-total	26.4	2,750	2,870
2	Ortuzano	10.2	2,700	2,900
	Rinconada	16.8	1,185	1,265
	Loma Blanca	3.0	280	300
	Encañado	5.1	425	445
	Sub-total	35.1	4,590	4,910
3	La Punta	20.2	2,720	3,120
	Boza	8.0	1,050	1,090
	Noviciado	6.7	1,410	1,450
	Sub-total	34.9	5,180	5,660
4	Carmen	36.9	11,470	12,860
	Batuco	18.2	8,600	9,640
	Sub-total	55.1	20,070	22,500
Total	-	151.5	32,590	35,940

Fig 3-6-4



Irrigation Area Covered by Each Irrigation System

Table 3-6-4 Reservoirs

Block	Name of Canal	No. of Reservoirs	Max. Capacity (m^3)
1	Esperanza	4	88,000
2	Rinconada	2	62,000
3	Noviciado	3	101,500
4	Carmen	20	256,000
Total		29	507,500

2) Block-2

a. Intake Conditions

Irrigation waters of this block are drawn from Zanjôn de la Aguada through four intakes into the Ortuzano, Rinconada, Loma Blanca and Encanado main canals. The managemente of irrigation waters are controled by users' associations.

b. Main Irrigation Canals

These canals are made of earth and no remarkable erosion of the canals has been observed except for some portions of the Rinconada canal.

c. Division Works

Division works, made of reinforced concrete, are located at the heads of the main and branch canals. Irrigation water is divided by separation devices installed on the division works and no gates are provided on them.

d. Intakes

Steel-made sluice gates, with an average dimension of W 60cm x H 80cm x t 50mm are provided at the intakes of the irrigation canals. These gates are well maintained and functioning well.

e. Aqueduct

An aqueduct, made of reinforced concrete (W 0.8m x H 1.0m x L 110m), is located 2.7km upstream the Rinconada bridge.

f. Reservoirs

There are two reservoirs in Block-2 and each of them is serving an area of 150 and 200 ha. Water is not diverted from these reservoirs during the non-irrigation period. These reservoirs were constructed a few years ago and they are functioning well.

3) Block-3

a. Intake Conditions

Irrigation water is drawn from the Punta headworks over the Mapocho river located about 50 m upstream the Manuel Rodriguez bridge. This headworks is the stable concrete structure with gates, which secures the stable intake of irrigation waters with adequate gate operation.

b. Main Irrigation Canals

The total length of the Punta canal is 20.2km, of which 5.1km are lined with concrete. Noviciado canal which branches off from the Punta canal to west of the Arturo Merino Benitez airport has a total length of 6.7km, of which 4.0km are lined with concrete. Boza canal is made of earth. The average velocities in these canals are below 1.0 m/s, and no erosions of the canals have been observed.

c. Division Works

The same can be said, as mentioned earlier in the division works of Blocks-1 and 2.

d. Check Gates

Some parts of the Noviciado area are situated higher than the normal water levels of the irrigation canals. For this reason, steel made sluice gates (checks) are provided every 500 m to raise the water levels in the main canal as well as branch canals. The size of the gates is 0.6 m x 1.2 m in average.

e. Intakes

Steel-made sluice gates, with average dimensions of 60 cm x 80 cm x 5 mm are provided at the intakes of irrigation canals.

f. Aqueduct

An aqueduct, made of reinforced concrete (W 0.8m x H 1.0m x L 30m), is located 4.0 km west of the Arturo Merino Benitez airport.

g. Reservoirs

There are three reservoirs in Block-3. The reservoir identified as Noviciado Res. 1, which is located at the end of Noviciado canal, has been untouched for more than ten years and it is covered with weeds. In this reservoir, sands are deposited with a thickness of about 2.0 m.

4) Block-4

a. Intake Conditions

Irrigation water for this block is drawn into the San Carlos canal through La Obra headworks in the Maipo river. The intake for domestic water supply is constructed on the left margin of the river. The gateman always stays there and pays careful attentions to the proper operation of the gates.

b. Main Irrigation Canal

San Carlos canal has some irrigation branch canals in its section between the headworks and the confluence with the Mapocho river. It also supplies water to the Florida power station. The canal connects with the Carmen canal through the siphon over the Mapocho river. The total length of Carmen canal is 36.9 km, of which 30 km (from Cerro San Cristóbal to Cerro Pan de Azúcar) is a rock-excavated canal. Batuco canal branches off from the division works located on the western slops of Cerro Pan de Azúcar. Most sections of both canals are of earth and the velocities in the canals are below 1.0 m/s. Accordingly no erosion of the canals has been observed.

In the agricultural land served by Carmen and Batuco canals, especially in the area near the northern section of the Panamerican Highway(National road) and Batuco canal, and the area near the Colina station and Quilicura, the irrigation canal networks are well developed. The irrigation canal networks in other areas are generally in poor condition due to soil problems and year-round inundation in the area, thus resulting in limitation of cultivation.

c. Reservoirs

There are 20 reservoirs along the Carmen and Batuco canals in northern and northeastern parts of this block. The area of each reservoir ranges between 0.25 and 1.8 ha with maximum depth of 2 m. Waters are stored in the nighttime and used in the daytime. The operation and maintenance are carried out well by beneficiary's groups.

(2) Balance of Existing Irrigation Water

The simulation analysis for the balance of existing irrigation waters was conducted on a monthly basis using meteorological and hydrological data of forty (40) years from 1941/42 to 1980/81.

On the basis of the results, the water balance with an 85% probability year (=6.7 year return period), which is presently adopted by CNR in irrigation planning, was examined.

If the present single cropping pattern is adopted as the basis of analysis, the present available river water will be sufficient for supplying waters to the existing upland field, except in Block-1. However, shortage of waters will affect also Block-4 because of the present small capacity of the Carmen canal.

If the proposed double cropping pattern is adopted, the shortage of irrigation waters will occur in Blocks-1, 3 and 4. In Block-1, the available water itself will not be sufficient. In Block-3, the available water will be sufficient but the capacity of the Punta canal will not. In Block-4, both available water and canal capacity will not be sufficient. The details of calculation are presented in Appendix 11.

3.6.4 Road Systems

(1) National Roads and Provincial Roads

In the Study Area and surrounding areas, there are five national roads and some provincial roads. The national roads are:

a. Route 5, Panamericana Norte
b. Route 5, Panamericana Sur
c. Route 78, from Santiago to San Antonio
d. Route 68, from Santiago to Valparaíso
e. Route 57, from Santiago to Los Andes

There are also provincial roads which connect the cities, towns and villages around Santiago. The national and provincial roads are paved with concrete or asphalt and they are well maintained.

(2) Farm Roads and Farm Road Bridges

The farm roads in the Study Area have gravel pavement, but they are not well maintained. Most of the bridges on the farm roads are wooden made. Accordingly, it is difficult for heavy-duty trucks to cross them safely.

The densities of the existing farm roads are sufficient except in Block-4 as shown in Table 3-6-5.

Table 3-6-5 Present Farm Road Conditions

Block	Length of Existing Farm Roads (km)	Irrigable Area (ha)	Road Density (m/ha)	Number of Farm Road Bridges (unit)
1	61.8	2,660	23.2	48
2	89.3	2,920	30.6	55
3	88.0	3,150	27.9	8
4	177.0	11,450	15.5	50
Total	416.1	20,180	24.3 (Ave.)	161

CHAPTER 4 : THE PROJECT

CHAPTER 4: THE PROJECT

4.1 OBJECTIVES

The Project Area has serious agricultural problems such as inundation, shortage and/or contamination of irrigation waters, existence of alkaline/saline soils and insufficiency of farm roads. Agricultural land and water resources in the Project Area have not been effectively utilized due to the above problems.

The Project is formulated to obtain the following objectives in the Project Area:

a. Improvement of agricultural productivity;

b. Saving of payment for imported products and acquisition of foreign currency;

c. Creation of higher opportunity for employment;

d. Improvement of sanitary environment in the Metropolitan Region; and

e. Improvement of living standards for small-scale farmers

To obtain the above objectives earlier and more effectively, the following items should be promoted and/or implemented in accordance with the implementation schedule of the Project:

a. Protection of agricultural lands and urban areas from inundation by the construction of Sabo dam and river and canal improvement;

b. Increase of agricultural lands, introduction of more profitable crops, stable supply of foods to the Metropolitan Region and improvement of quality of agricultural products, through improvement/construction of irrigation/drainage facilities and river improvement;

c. Transference of surplus labour force into the increased labour demand in construction and agricultural production sectors;

d. Improvement of agricultural production environment by improving irrigation water quality;

e. Improvement of transport conditions for agricultural materials and products with the improvement of farm roads and bridges; and

f. Prevention of discharge of farmers into cities by securing stable income of farmers.

4.2 PROJECT FORMULATION

4.2.1 Basic Development Concept

The proposed agricultural development scheme is formulated on the basis of the following considerations:

a. Intention of the Metropolitan Government for the Project:

The development scheme is formulated paying attention to the intention of the Metropolitan Government for the Project.

b. Other Related Development Plans:

Other related development plans and studies are reviewed in the preparation of the development scheme.

c. Objective Farmer:

As the objective farmers, the small-scale farmers who are presently in low farming level are selected in agricultural production and farming schemes.

d. Agricultural Production Plan:

Substitutional crops for imported ones and exportable crops are selected from the crops presently cultivated in the Project Area.

e. Farming Plan:

The present farming system and agricultural technique in the Project Area is referred to in the preparation of the proposed farming system and cropping pattern.

f. Landuse Plan:

The future urbanization around Santiago city and soil suitability classification are considered in the preparation of landuse plan.

g. Water Resources Development:

Taking into account the high cost required for new water resources development and anticipated trouble in connection with water rights, the maximum utilization of existing water resources is severely considered in the planning of the development scheme.

h. Irrigation Plan:

The objective irrigation areas are set up based on the maximum utilization of available water resources.

i. Drainage Plan:

Gravity drainage system with the maximum utilization of existing rivers and canals is considered.

j. Improvement of Water Quality:

The existing irrigation water is to be improved to the good quality one only enough for agricultural purposes..

k. Farm Road Plan:

New farm roads are considered only in the low road-density area where smooth and effective transportation of agricultural production materials and products is prevented.

l. Project Cost:

The maximum utilization of the existing agricultural facilities and minimum investment to the Project are considered, taking into account that this Project is an agricultural redevelopment one.

4.2.2 Landuse Scheme

An appropriate landuse plan with which maximum benefits can be generated at the assumed completion time of Project construction (1991) is formulated in accordance with the following basis considerations:

a. Landuse plan is formulated focusing on irrigable areas and high suitability areas by the land classification;

b. The present agricultural lands are kept as far as possible;

c. Some agricultural lands are reallocated to urban areas in view of this reform being unavoidable by 1991 due to the rural-urban migration trend;

d. In such a zone as a conflict of landuse between agricultural lands and urban areas being observed, the priority of landuse is given to the former. Thus, the reallocation of agricultural lands to urban lands is eliminated in principle, and in case of need, it is facilitated by less capable agricultural lands; and

e. In the case that upland fields are reallocated to urban areas, the corresponding areas are compensated by reallocating pastures to upland fields.

The hectarage of unsuitable area corresponding to the above item "a" represents 5,960 ha in total, which will be utilized as pasture. The hectarage corresponding to the above item "c" is 3,980 ha, of which 3,870 ha is identified as upland fields and pasture and 110ha as lands for agricultural infrastructures. Consequently, the all hectarage of present agricultural lands of 32,590 ha will be reduced to 28,610 ha, of which 20,180 ha is identified as upland fields at the maximum level (19,390 ha at the average), 7,680 ha as pasture at the minimum level (8,470 ha at the average) and 750 ha as the area for agricultural infrastructures.

The proposed landuse is shown in Table 4-2-1 and Fig 4-2-1.

Table 4-2-1 Proposed Landuse

(Unit: ha)

Block		Agricultural Land						Others2/	Total
		Maximum/Minimum		Average		Others1/	Sub-Total		
		Upland Field	Pasture	Upland Field	Pasture				
1	Present	1,760	900	(1,760)	(900)	90	2,750	120	2,870
	Project	2,660	0	2,070	590	90	2,750	120	2,870
2	present	3,730	660	(3,730)	(660)	200	4,590	320	4,910
	Project	2,920	350	2,920	350	150	3,420	1,490	4,910
3	Present	2,300	2,760	(2,300)	(2,760)	120	5,180	480	5,660
	Project	3,150	1,290	3,150	1,290	110	4,550	1,110	5,660
4	present	8,600	11,020	(8,600)	(11,020)	450	20,070	2,430	22,550
	Project	11,450	6,040	11,250	6,240	400	17,890	4,610	22,500
Total	Present	16,390	15,340	(16,390)	(15,340)	860	32,590	3,350	35,940
	Project	20,180	7,680	19,390	8,470	750	28,610	7,330	35,940

1/ includes farmhouses, farm roads, secondary and lateral irrigation canals, drainage canals, etc.

2/ includes urban area, main roads, main canals, rivers, garbage disposal area, etc.

4.2.3 Flood Control Scheme

(1) General

The improvement works of the Mapocho river by MOP are progressing in the residential section. Hence, the security of Santiago city against flooding is improving step by step. In this connection, the study of the flood control within the Project Area was carried out with its focus on the inundation problems at the Lampa river basin and the eastern part of Santiago city.

The improvement of the Lampa and Colina rivers and the construction of a Sabo dam at the upper reach section of the Mapocho river are proposed as counter-measures against flooding in the Lampa river basin. On the other hand, the improvement of the San Carlos canal is proposed as the counter-measure against flooding in the eastern part of

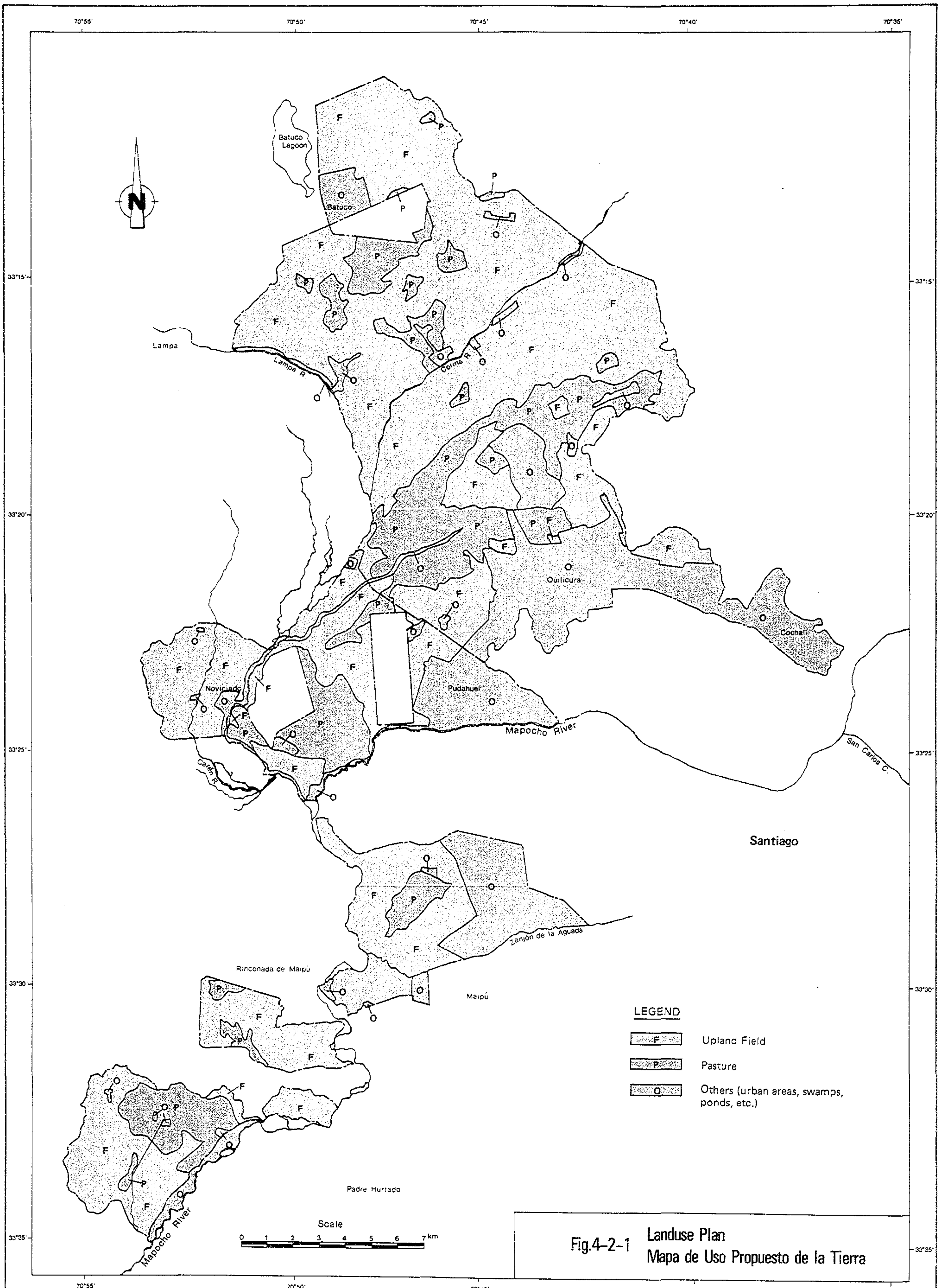


Fig.4-2-1 Landuse Plan
Mapa de Uso Propuesto de la Tierra

Santiago city. Improvement in the water conveyance efficiency is also expected from the improvement of the San Carlos canal.

(2) Basic Flood Discharge

1) Objective Rainfall

The objective maximum rainfall for the improvement plan was determined to be a rainfall of 6.7 year return period (85% probability) for the following reasons:

a. The flood control plan should be coordinated with the irrigation plan for 6.7 year return period, since the main inundation problem is within the agricultural areas.

b. Counter-measures against flood problems in the eastern part of Santiago should be considered within the limit of the improvement of the San Carlos canal proposed in the irrigation plan.

The objective rainfall used in the simulation analysis was determined to be a 3 day continuous rainfall of 6.7 year return period based on the hourly rainfall records in July 1984 as follows:

- Rungüe (No.4) : 175mm/3 days
- Santiago (No.24) : 100mm/3 days

The application of the above rainfalls in the objective watershed is:

- Mountainous area in the Lampa river basin:
  Rainfall at Station No. 4
- Plain areas in both Lampa and Mapocho river basins:
  Rainfall at Station No. 24
- Mountainous area in the Mapocho river basin:
  Rainfall adjusted with altitude based on the rainfall at Station No. 24

2) Basic Flood Discharge

The basic flood discharge (the estimated maximum discharge on the assumption that there will be no overflowing from rivers or canals) was obtained with Storage Function Method on the basis of the objective rainfall as shown in Fig 4-2-2.

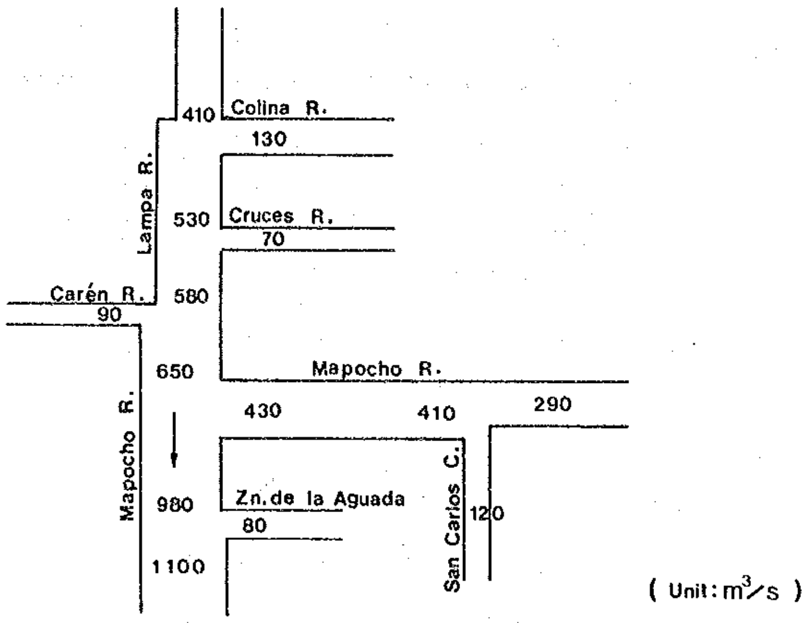


Fig 4-2-2 Basic Flood Discharge

(3) <u>Flood Control of Lampa River Basin</u>

1) Comparison of Alternatives

a. Introduction

Inundation in the Lampa river basin is mainly caused by limited capacity of the Lampa and Colina rivers and low density of the drainage canals. In order to address this problem, the following two alternatives were studied.

- To store the flood discharge
- To increase the flow capacity of the rivers

b. Storage Scheme

As alternatives of the storage scheme, a retarding basin1/ and a dam were analysed as shown in Table 4-2-2.

Table 4-2-2 Comparison of Retarding Basin and Lampa Dam Schemes

Item	Retarding Basin	Lampa Dam
Location	Confluence of Lampa and Colina Rivers	Immediately Upstream of Lampa town
Catchment Area (Km^2)	1,442	1,290
Peak Control Discharge (m^3/s)	420	360
Capacity of Reservoir (m^3)	40×10^6	62×10^6
Reservoir, Depth x Area (m x ha)	4 x 1,000	-
Dam, Height x Length (m x m)	-	27 x 1,350
Dam Volume (m^3)	-	2.3×10^6

c. River Improvement Scheme

The river (including main drainage canals) improvement scheme was studied on the basis of the inundation analysis 2/ for the two cases below:

Case 1: Improvement against flood of 6.7 year return period

Case 2: Improvement against flood of 3 year return period

1/ A basin or pond which reduces the flood discharge of a river to the downstream area by storing its peak discharge temporarily.

2/ Estimation of discharge, water level, area, duration during inundation was made based on the objective rainfall, using the Storage Function Method.

The improvement of rivers and drainage canals against flood of 6.7 year return period is proposed through comparison study for the following reasons:

i Present flow capacity of the Mapocho river in its immediately downstream section of the confluence with Lampa river, 660m^3/s, will cope with the flood discharge of 3 year return period. Therefore, the improvement against 3 year return period flood is recommended, if the river improvement for its whole system is the objective.

ii However, the inundation area will still be 4,960 ha for the objective rainfall even after the river improvement against 3 year return period flood.

iii The partial river bank improvement works of the Mapocho river in its downstream section will be a tentatively sufficient counter-measure against flooding caused by the improvement of the Lampa river against 6.7 year return period flood.

d. Comparison

The construction costs of the above alternatives are summarized as follows:

Alternatives	① Retarding Basin	② Lampa Dam	③ River Improvement
Construction Cost (10^9 Ch$)	9.2 (3.7)	11.7 (4.7)	2.5 (1)

Note: 1. ( ) shows the ratio of costs

2. In the case of Alternative ②, improvement of Lampa river in its downstream section is also necessary to increase its flow capacity (230 to 290 m^3/s).

3. Improvement works of existing drainage canals are not included in the comparison.

As shown in the table, the construction cost of Alternative ① or ② is 4 to 5 times that of Alternative ③; meaning that ① or ② is not practical in terms of its large investment cost.

2) Proposed Improvement Scheme

a. Design Discharge

The basic flood discharge of 6.7 year return period was adopted as the design discharge, since no retarding facilities are planned.

b. Improved Section

The sections of the rivers to be improved were determined based on the present inundation area as follows:

- The Lampa river: Confluence with the Mapocho river to confluence with the Lalo river (24 km)
- The Colina river: Confluence with the Lampa river to the cross with the Railway (5.9 km)

c. Dimensions of Proposed River Sections

The dimensions of proposed river sections were determined based on the Manning formula shown below:

$$Q = A \times v$$

$$v = \frac{1}{n} \times R^{\frac{2}{3}} \times I^{\frac{1}{2}}$$

$$R = A/P$$

where : Q: Flow capacity (m^3/s)
v: Velocity (m/s)
A: Flow Area (m^2)
n: Coefficient of roughness (= 0.035)
I: Slope of Energy Line
P: Wetted perimeter (m)
R: Hydraulic Radius (m)

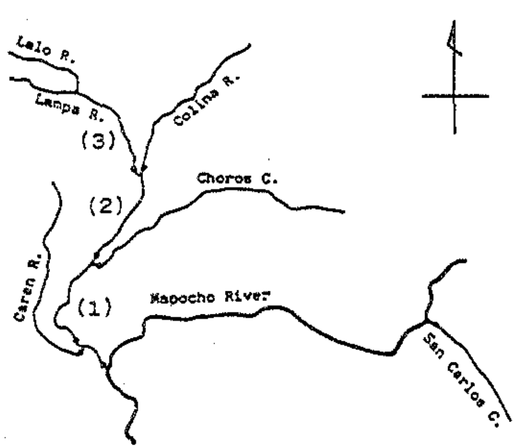
The determined dimensions are summarized in Table 4-2-3.

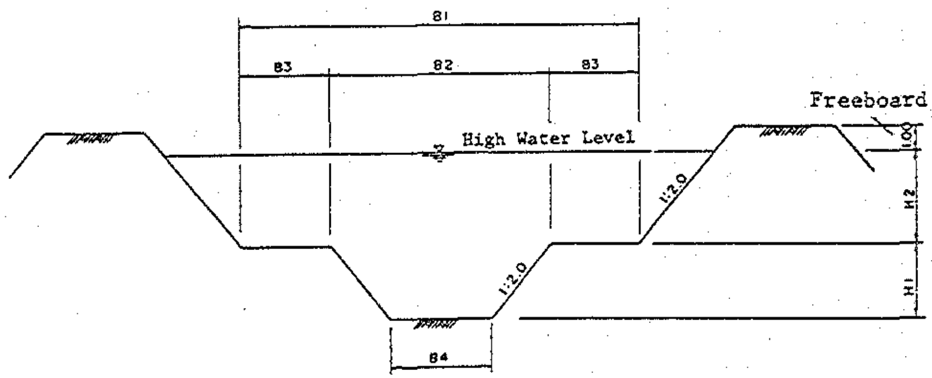
Table 4-2-3 Dimension of Proposed Section of River Improvement

River	Length (km)	Type	Catchment Area (km²)	Design Discharge (m³/s)	I	B1 (m)	B2 (m)	B3 (m)	B4 (m)	H1 (m)	H2 (m)	A (m²)	P (m)	R (m)	V (m/s)	Q (m³/s)
Lampa (1)	2.4	A	2,395	650	1/2,500	77.0	37.0	20.0	25.0	3.0	3.8	414.5	96.4	4.3	1.6	667.9
"	3.3	B	2,167	580	1/1,500	55.0	27.0	14.0	15.0	3.0	3.7	293.9	73.5	4.0	2.0	583.2
"	4.0	C	2,167	580	1/800	40.0	22.0	9.0	10.0	3.0	3.6	217.9	57.3	3.8	2.6	573.0
Lampa (2)	5.7	C	2,167	580	1/800	40.0	22.0	9.0	10.0	3.0	3.6	217.9	57.3	3.8	2.6	573.0
"	2.6	D	1,904	530	1/800	40.0	22.0	9.0	10.0	3.0	3.4	207.1	56.0	3.7	2.6	533.0
Lmapa (3)	4.0 1/	E	1,442	410	1/700	40.0	20.0	10.0	10.0	2.5	2.9	170.3	54.9	3.1	2.5	421.0
Colina	3.8	A	462	130	1/700	20.0	13.0	3.5	5.0	2.0	2.2	71.7	31.2	2.3	2.1	147.8
"	2.1	B	462	130	1/350	20.0	13.0	3.5	5.0	2.0	1.5	52.5	27.6	1.9	2.6	135.1

1/ Not includes 2 km of the transitional section from the confluence with the Lalo River.

Location Map





d. Improvement of Mapocho River

To cope with excess waters due to the improvement of the Lampa and Colina rivers against the design discharge, the improvement of the Mapocho river in its downstream section is necessary. The analysis shows that a river bank embankment of one (1) m height for 6.7 km from the confluence with the Lampa river to the confluence with the Zanjón de la Aguada will be sufficient for the design discharge of 980 m^3/s (Appendix Fig A-13-5).

e. Effect of Improvement

The effect of the improvement works of the Lampa and Colina rivers and drainage canals was estimated on the basis of the inundation as shown in Table 4-2-4.

Table 4-2-4 Proposed Inundation Area in Lampa River Basin

(Unit: ha)

Condition	Area		Rainfall of 6.7 year return period
Unimproved	Project Area	Block-3	1,650
		Block-4	3,990
	Out of Project Area		2,000
Improved for Design Discharge	Project Area		0
	Out of Project Area		0

(4) <u>Flood Control of the Eastern Part of Santiago City</u>

The improvement of the San Carlos canal is proposed in the irrigation scheme. As a counter-measure for reducing the amount of inundation in the eastern part of Santiago city, effective utilization of the improved San Carlos canal is planned.

a. Area of Improvement

The area for improvement was determined to be the area from the confluence with the Mapocho river to the confluence with Florida canal (17.4 Km).

b. Design Discharge

The flood discharge of San Carlos canal with 6.7 year return period is 120 m^3/s at the confluence with the Mapocho river, the watershed of which is 232 Km^2. Based on this, specific discharge is estimated to be 0.5 $m^3/s/km^2$. The design flood discharge for each section of the canal was determined using the specific discharge method as shown in Fig 4-2-3.

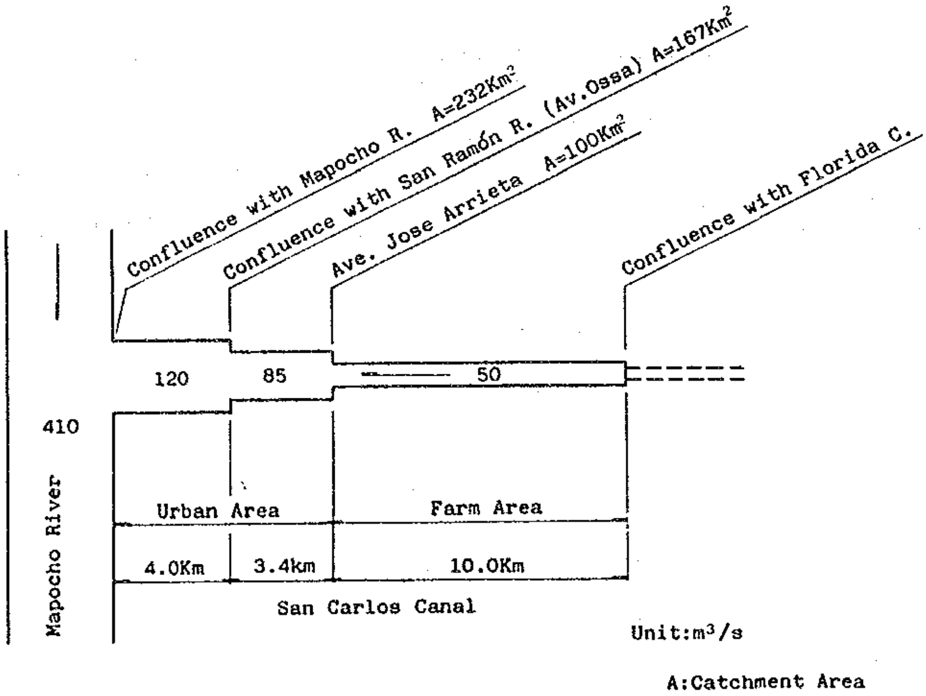


Fig 4-2-3 Distribution of Design Discharge in San Carlos Canal

c. Improvement of Streams

Most of the flood damage along San Carlos canal is caused by the heavy discharge from streams (such as San Ramón and Apoquindo) located along San Carlos canal.

San Carlos canal will have the capacity to flow the 6.7 year flood discharge with its improvement in the Project. However, to increase the efficiency of the flood control in the area, the improvement of stream channels (such as San Ramón and Apoquindo) will be necessary.

The improvement of the conduit of the Macul river crossing under San Carlos canal should be done after the improvement of Zanjón de la Aguada because of its limited capacity.

d. Environment

At present, both sides of San Carlos canal in the residential section are used as a park. Therefore, attention should be paid not to damage the environment of a park.

(5) Erosion Control Scheme

1) General

In general, big bed-load discharge, scouring and sedimentation of the rivers and streams in the Study Area and surrounding areas will not occur due to scarce annual rainfall and/or heavy rainfall.

However, the study of measures to prevent erosion in the Mapocho river was conducted due to the following reasons:

a. The gradient of the Mapocho river is steep up to the edge of Santiago urban area.

b. The annual rainfall is abundant compared with that of the Lampa river basin.

c. Slope failures are observed in some areas along the Mapocho river.

d. There is a possibility that bed-load discharge and sedimentation will take place during a heavy rain.

e. Consequently, the sediment will hinder the smooth flow of the Lampa river and will make the inundation situation along the Lampa river worse.

2) Counter-measures

a. Mapocho Sabo Dam

To control the riverbed movement by stopping the flowing-down of the bed-load discharge, Sabo dam is recommended in view of the steep gradient of the river and volume of bed-load discharge.

As the site for a proposed Sabo dam, the section near old Nilhue bridge, 13 km upstream of Santiago city, was selected, taking into account the topographic, geological and hydrological conditions. It will be possible to let the bed-load materials settle in the pocket of the dam for a period of about 10 years 1/. In addition, even after the filling-up of the pocket of the dam with the sediment, the gentle gradient of the river will be produced, and this will result in less bed-load discharge during floods.

This Sabo dam will be effective also for reducing the flood discharge, and this will result in the reduction

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1/ . Storage capacity: 440 x 10^3 m^3.
(with the condition that settling gradient be half of the river gradient)
. Assumed bed-load discharge: 50 - 100 m^3/year/km^2
. Watershed : 620 Km^2
. Filling-up Time: 440 x 10^3/(50 - 100) x 620 = 7-14 years

of the flood damage in Santiago city in case of heavy rain.

b. Ground Sill (A structure constructed across a river for stabilizing the river bed)

As an alternative, the installation of continuous ground sills was studied. The upper stream section of the Mapocho river from urban area was selected in consideration of the topographic, geological and hydrological characteristics.

The installation of ground sills is not recommended due to the following disadvantages:

i. The main purpose of a ground sill is to stabilize the riverbed movement in some specific sections, not to control the bed-load discharge.

ii. No remarkable riverbed movement is forecast that will require urgent counter-measures in the Santiago city section of the Mapocho river.

iii. The storage capacity of a ground sill will be 1/30 of that of a Sabo dam (15,000 m^3/440,000 m^3=1/30). This means that 30 units of ground sill will be necessary if the same sediment storage capacity is required from ground sills as that of a Sabo dam. It will be very difficult to acquire suitable construction sites.

iv. Raising of the river bank will be necessary in consideration of the existing bank height and increase of the water level caused by the installation of ground sills. It will require huge amount of embankment materials to be transported from some barrow-points.

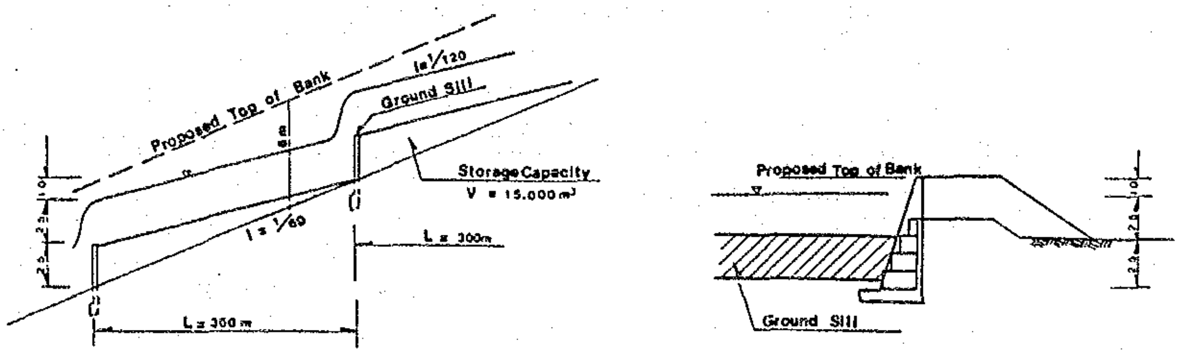


Fig. 4-2-4 Ground Sill

Table 4-2-5 Comparison of Alternatives for Erosion Control

Item	Sabo Dam	Ground Sills
1. Construction Cost (Ch$) (Ratio)	318×10^6 (1)	$1,931 \times 10^6$ 1/ (6)
2. Construction Site	Topographically and geologically good	Very difficult to acquire 30 construction sites

1/ This amount corresponds to 30 units. Detail is shown in Appendix Table A-13-8.

4.2.4 Drainage Scheme

(1) Objective Rainfall

The rainfall of 6.7 year return period was adopted as the objective rainfall for the simulation in coordination with the flood control plan.

(2) Design Unit Discharge

The design unit discharge was determined based on the basic flood discharge mentioned in Section 4.2.3 using specific discharge method with results as follows:

- Plains Area watershed: 3 ℓ/s/ha
- Mountain Area watershed: 4 ℓ/s/ha

(3) Drainage System

To improve the poor drainage in Blocks-1, 3 and 4, the improvement of the Frío river in Block-1, and improvement and/or construction of Canén rivers and Choros, C-1 and C-2 drainage canals in Blocks-3 and 4 are proposed.

The plan and profile of these drainage canals and rivers are determined in due consideration of the existing drainage system, topographic and geological conditions in the drainage areas and distribution of poor drainage areas.

1) Frío River
The improvement of the Frío river in its downstream section for 5 km from its confluence with the Mapocho river is planned in order to reduce the poor drainage (approx. 300 ha) by increasing its flow capacity.

2) Carén River
The enlargement and deepening of the Carén river in its mid-stream section for 5.8 km are planned in order to improve the poor drainage condition and to reduce flood damages.

3) Choros Drainage Canal
Its confluence point with the Lampa river is shifted to the upstream section by approx. 4.5 km from the present junction of the Lampa and Cruces rivers which is the continuation of the Choros canal. This move will reduce the inundation problems around the area due to the reduction of the watershed of the Choros canal resulting the reduction of flood discharge.

4) C-1 Drainage Canal

The downstream section of this canal has no clear channel. Construction of this section down to the confluence with the Choros canal is planned.

5) C-2 Drainage Canal

The inundation in the area between Batuco lagoon and the Lampa river is severe due to its basin-like topography and lack of drainage canals. A new drainage canal is planned to cope with this problem.

(4) <u>Design Drainage Volume</u>

The design drainage volume was estimated on the basis of the design unit discharge. The catchment area was also determined with the drainage canal system as shown in Table 4-2-6.

Table 4-2-6 Design Drainage Volume

Block	Name of Canal or River	Improvement (I) or Construction (C)	Length (km)	Catchment Area (ha)	Unit Discharge (/s/ha)	Design Drainage Volume (m^3/s)
1	Frío river	I	5.0	5,400	4	22
	Carén river (A)	I	1.0	22,700	4	90
	" (B)	I	4.8	15,300	4	61
3	Choros drainage canal (A)	I	3.5	23,900	3	72
and	" (B)	I	6.0	9,800	3	29
4	" (C)	I	2.9	2,700	3	8
	C-1 drainage canal	C	6.5	14,100	3	42
	C-2 drainage canal	C	10.0	11,700	3	35

4.2.5 Irrigation Scheme

(1) General

The objective of irrigation planning is to support introduction of double cropping agriculture into the Project Area through effective utilization of the existing available water and the supplemental water resources.

To cope with the shortage of irrigation waters, transfering of water rights, improvement of existing irrigation facilities and new water resources development were studied (Table 4-2-7).

Table 4-2-7 Irrigation Alternatives

Block	Transfering of Water Rights	Improvement of Existing Facilities	New Water Resources Development
1	-	o	o
3	-	o	-
4	o	o	o

Note: Present available water will be sufficient for the proposed irrigation in Block-2.

(2) Irrigation Plan

The irrigation planning was conducted in order to lesson the shortage of irrigation waters on the following procedures:

First step: To reduce the loss of irrigation waters by improving existing irrigation facilities

Second step: To assess the possibility of developing new water resources

The irrigation plan for Block-2 was not performed due to its sufficient irrigation water.

1) Block-1

a. Improvement of Facilities

The irrigable area will be increased by 240 ha from 950 ha at present to 1,190 ha by improving the existing intake facilities and main canals and also adopting strict water management (Table 4-2-8).

b. Water Resources Development

The shortage of irrigation water even after the improvement of facilities is 1.7 m^3/s for an objective irrigation area of 2,660 ha (Table 4-2-9).

In order to lessen this water shortage, the following measures were studied:

- Utilization of the surplus irrigation water during the winter;
- Utilization of the surplus water of Yeso dam;
- Development of groundwater including underflow water; and
- Development of surface water by a dam construction.

Table 4-2-8 Irrigable Area

(Unit: ha)

Block	① Objective Irrigation Area	② Present Irrigation Area	③ Irrigable Areas w/ Project	③ - ②	③ - ①
1	2,660	950	1,190	240	△1,470
2	2,920	2,920	2,920	0	0
3	3,150	2,170	3,150	980	0
4	11,450	4,740	10,080	5,340	△1,370
Total	20,180	10,780	17,340	6,560	△2,840

Note: △ shows the minus values

Table 4-2-9 Available Water

(Unit: m^3/s)

Block	① Gross Duty of Water w/ Project	② Present Available Water	③ Available Water w/ Project	③ - ①
1	3.1	1.4	1.4	△1.7
2	4.7	6.6	7.4	-
3	3.7	3.2 (7.4)1/	3.7	-
4	13.5	7.0 (8.2)1/	11.9	△1.6
Total	25.0	18.2	24.4	△3.3

1/ Values in ( ) shows the available waters obtainable from San Carlos canal with existing water rights.

i. Utilization of Surplus Water

The total volume of the surplus irrigation water for the period from April to September is 36 x 10^6 m^3 on the basis of a 6.7 year return period. On the other hand, the total volume of the shortage of irrigation water is 24 x 10^6 m^3 per year. The fact that the volume of surplus water is greater than that of shortage means that a recovery of irrigation water will be possible from a hydrological point of view.

The pond required for storing the surplus water will be 600 ha and 4 m deep (practical max. depth). It will not be practicable to store the surplus irrigation water as the main water source, considering the areas to be developed as upland field and required for pond construction site, and investment and operation/maintenance costs necessary for the facilities.

ii. Utilization of the Surplus Water of Yeso Dam

It was observed that it would be impossible to utilize the surplus water stored in Yeso dam due to other requirements by EMOS.

iii. Development of Groundwater

It will not be feasible from technical and economic points of view. However, it will be possible to supplementarily irrigate small-scale agricultural lands.

iv. Development of Surface Water by Construction of Dam

It will not be feasible at this stage to construct a dam from an economic point of view. However, it is proposed to study on the construction of a Mapocho high dam in consideration of higher development level of irrigation agriculture and flood control against floods of longer return period.

The irrigation scheme alternatives with construction cost and developable water amount are summarizd in Table 4-2-10.

Table 4-2-10 Comparison of Irrigation Scheme Alternatives

Alternatives Step	Works	Estimated Cost (10^6Ch$)	Developa-ble Water Amount (m^3/s)	Unit Develop-ment Cost (10^6Ch$/$m^3$)	Remarks
First Step	.Esperanza Headworks .Esperanza canal	392	0.8	490	Practicable
Second Step	1 Utilization of surplus water	34,900	1.7	20,500	Not-feasible
	2 Utilization of Yeso dam	-	-	-	Organiza-tionally impossible
	3 Development of groundwater (Operation cost is not included)	41	0.017	2,412	Not feasible
	4 Construction of a new dam (Mapocho dam-2)	9,123	3.3	2,765	Not feasible

2) Block-3

a. Improvement of Facilities

The water of Punta canal is contaminated because of intake from the Mapocho river, even though its water source is the Maipo river. To solve this problem, it is recommended to change the intake point. This will decrease the intake and conveyance losses of the canal.

The following two alternatives were compared and Case-B was adopted (11.6 of Appendix 11).

Case-A: Construction of a conduit along the Mapocho river

Case-B: Improvement of Carmen canal and construction of new Punta canal

Item	Case A	Case B
Roughly Estimated Construction Cost (Ch$)	1.7×10^9	1.0×10^9
Difficultiness of Construction Works	more difficult	easier

b. Water Balance

In Block-3, there will be a water surplus of 3.7 m^3/s, since available water obtainable with existing water rights is Qa=7.4 m^3/s compared with the maximum gross duty of water of Qdmax=3.7 m^3/s (Table 4-2-9).

3) Block-4

a. Water Rights Transfer

The Punta canal will have a surplus water of 3.7 m^3/s. Both the Punta and Carmen canals are controlled by the San Carlos canal. If the 3.7 m^3/s surplus water of the Punta canal is transferred to the Carmen canal, the available water of Block-4 will be increased from the present 8.2 m^3/s to 11.9 m^3/s (Table 4-2-9).

b. Improvement of Facilities

The present 7.0 m^3/s flow capacity of the Carmen canal is small compared with the gross duty of water of 13.5m^3/s. The enlargement and improvement of the San Carlos and Carmen canals are proposed to secure the required sectional area of Carmen canal and to increase the conveyance efficiency and flow capacity of San Carlos canal during flood.

c. Water Resources Development

To lessen the shortage of irrigation water, the following measures were studied.

- Utilization of surplus irrigation water during the winter
- Utilization of the surplus water of Yeso dam
- Development of groundwater
- Development of surface water by dam construction

i. Utilization of Surplus Water

The total volume of surplus irrigation water for the period from April to September is calculated as 28 x 10^6 m^3 (equivalent to 2.1 m^3/s in maximum) on the basis of a 6.7 year return period. The required pond to store the surplus water will be 700 ha and 4 m deep. It will be possible to increase the irrigable area by 1,780 ha with the utilization of surplus water. However, it will not be practicable to utilize the surplus water for irrigation for the reasons mentioned in Paragraph 1).

ii. Utilization of the Surplus Water of Yeso dam
Refer to Paragraph 1).

iii. Development of Groundwater
Though it is not feasible to develop the groundwater resources in large scale, it will be worthwhile to study on the possibility for utilizing sub-surface groundwater in small scale.

iv. Development of Surface Water by Constructing a Dam
Refer to Paragraph 1).

4) Tertiary Canals

The construction of tertiary canals is planned for the upland fields of midium- and large-scale farmers which are to be newly increased due to the improvement of irrigation facilities and decrease of inundation with the implementation of the Project. The average capacity and density of the canals are determined to be 0.01 m^3/s and 100 m/ha, respectively.

(3) Result

The following are the results of the irrigation planning based on the available water and crop water requirements of the 6.7 year return period (85% probability):

a. Irrigable area will be increased by 6,560 ha (Table 4-2-8).

b. Shortage of irrigation water, however, will still exist for an area of 2,840 ha based on an objective maximum irrigation area of 20,180 ha. This means a shortage of irrigation water of 3.3 m^3/s (Tables 4-2-8 and 9).

c. The objective maximum irrigation area will totally be irrigable up to the 1.4 (31% probability) and 3.7 (73% probability) return period years for Block-1 and 3+4, respectively (Appendix Table A-11-2).

d. In the return period year between 3.7 and 6.7 year for Blocks 3+4, and 1.4 and 6.7 year for Block-1, some irrigation areas should be used as single cropping upland field or temporary pasture due to the shortage of irrigation waters.

e. Measures to meet this water shortage, such as dam construction and use of groundwater, should be considered in the future, if necessary.

4.2.6 Water Quality Improvement Scheme

(1) General

Irrigation waters in the Project Area are contaminated principally with sewage from Santiago city. Improvement of water quality is required for better agricultural production. To improve the irrigation water quality, the construction of a treatment plant is recommended in the Project. Water treatment is necessary for Blocks-1 and 2 and not for Blocks-3 and 4 due to the following:

a. The quality of the irrigation water for Block-3 will be improved by changing the intake point of the Punta canal; and

b. The quality of the irrigation water for Block-4 will be improved with the improvement works to be conducted by EMOS in the near future (oral information).

(2) Number of Treatment Plants

The number of the treatment plants was determined based on construction cost, ease of operation and maintenance, complexity of works, reliability of drawing water, etc. as follows (Appendix Table A-7-9):

Block-1: One treatment plant for two intakes of existing Esperanza canal combined to one.

Block-2: One treatment plant for each intake of main irrigation canals; that is, four treatment plants in total.

(3) Selection of Water Treatment System

The Aerated Lagoon system was selected as the water treatment system in this Project for the following reasons (Appendix Table A-7-8):

a. The results for 48-hour laboratory tests on water samples collected from point 17 in the Project Area show that the water quality will reach acceptable levels except for EC and Na %, only by letting it sit untouched as it is for several hours. This fact shows that the Aerated Lagoon system will be effective for the Project.

b. This system is the most economical one among three alternative systems (Aerated Lagoon, Rotary Disk and Oxidation Ditch) that were studied for comparison.

c. Although this system requires a large plant area, such areas are available and there will be no fundamental limitation in the selection of construction areas for treatment plants.

(4) Determination of Treatment Time

On the basis of the results of 48-hr laboratory tests of water samples, it was concluded that 6-hr detention of contaminated water in a lagoon will be sufficient to obtain good quality irrigation water (Appendix Fig A-7-5).

(5) Summary of the Treatment Plant

Table 4-2-12 summarizes the features of the treatment plants planned.

Table 4-2-11 Features of Treatment Plant

Item \ Treatment Plant	Block-1	Block-2			
	Esperanza	Ortuzano	Loma Blanca	Encañado	Rinco-nada
Max.water volume (m^3/day)	270,000	120,000	45,000	45,000	170,000
(m^3/s)	3.1	1.4	0.5	0.5	1.9
Volume of Lagoon (m^3)	68,000	30,000	11,000	11,000	41,000
Area of Lagoon (m^2)	33,800	15,100	5,400	5,400	20,500
Effective Depth of Lagoon (m)	2.0	2.0	2.0	2.0	2.0
Required Plant Area (m^2)	39,000	18,000	8,000	8,000	26,000

(6) Sludge Removal

The removal of sludge which will sediment in the aerated lagoons is to be made every year by using bulldozer and dump trucks procured in the Project. The sludge will be excavated with bulldozer and transported to the designated disposal areas by dump trucks for burning it there (Appendix 7.2,(6),3)).

4.2.7 Farm Road Scheme

The farm road networks in the Project Area are well developed except for Block-4 as mentioned in 3.6.4, Chapter 3. Therefore, it is proposed to increase the density of farm roads in Block-4 to 20 m/ha, reasonable density in farm area. With this, the transportation of agricultural products to markets will be free from hindrance due to shortage of farm roads. At the same time, existing wooden bridges should be replaced with concrete ones or some new concrete bridges should be constructed in order to improve transportation of agricultural products. Proposed farm road density and numbers of farm road bridges to be improved or constructed are shown in Table 4-1-12 and 13, respectively.

Table 4-2-12 Proposed Farm Road Density

Block	Existing Farm Road (Km)	New Farm Road (Km)	Total (Km)	Agricultural Land (ha)	Road Density (m/ha)
1	61.8	-	61.8	2,660	23.2
2	89.3	-	89.3	2,920	30.6
3	88.0	-	88.0	3,150	27.9
4	177.0	52.0	229.0	11,450	20.0

Table 4-2-13 Proposed Farm Road Bridge

Block	Improvement of Existing Bridge	New Bridge	Total
1	16	-	16
2	18	-	18
3	5	-	5
4	20	11	31
Total	59	11	70

4.2.8 Soil Improvement

(1) Soils with Constraints on Agricultural Development

Soil which presents constraints on the development for agricultural production is:

a. that does not have an adequately effective thickness in its layer;

b. that contains salinity and alkalinity; and

c. that is featured by poor drainage.

The lands with soils classified in a) and with high saline and alkaline soils and part of class b) soils are excluded from the agricultural land in the project. The soil improvement was studied, therefore, for low saline and alkaline soils, part of class b) soils, and soils classified in c).

The common approach to the improvement of saline and alkaline soils is de-salinition by means of providing irrigation water or applying soil conditioner. In the case of the Study Area, low saline and alkaline soils are at the same time vested with poor drainage. Being the EC value at below 8 mmhos/cm and the ESP value at less than 15%, the desalination of these soils may be facilitated by the provision of adequate irrigation and drainage systems. The detailed information on the plan of drainage systems is presented in section 4.2.4 of the chapter.

In view of requiring vast investment for their improvement, high saline and alkaline soils were excluded within the context of the development plan for the Study; nevertherless, they may be used for agricultural production, if an appropriate method will be applied. For this purpose, it is recommended that field tests be carried out using soil conditioner. These field tests should comprise:

- Selection of a most suitable conditioner to the area;
- Establishment of a target ESP value;
- Application method, and
- An optimum volume of soil conditioner to be applied.

A trial calculation on an optimum application volume of soil conditioner represented by the land plaster is given in Appendix Table A-5-10. A recommendation is made that land with high saline concentration and alkaline saturation should be covered with grazing and/or other plants for their conservation until information for this purpose will be compiled.

(2) Contaminated Soil

Soils within the Project Area are contaminated mainly with the mixture of coliform groups and metal ions such as copper conveyed to the area through irrigation canals. The contaminated soils with coliform groups can be restored only by eliminating the source of contamination. In this regard, a proposal for the improvement in the quality of irrigation water from coliform groups is presented (refer to 4.2.6 Water Quality Improvement Scheme). On the other hand, in order to eliminate copper and other heavy metals which is accumulated in soils, the removal of contaminated soils and new soil dressing works should be made. Cost for these works is estimated at highest level.

Apart from the above-mentioned method, countermeasures against contamination of soils in the field level are to:

- Check the effect of measures for elimination of the source of further contamination,
- Establish an optimum volume of removal and dressing of soils,
- Set a target for the improvement,
- Search for an exotic plant which absorbs copper preferably, and
- Search for varieties of crops which are resistant to copper.

4.2.9 Future Schemes

The following schemes are proposed as the future projects in Phase-2 after the agriculture in the Project Area reaches the level objected in the Project:

(1) A Mapocho high dam other than the Sabo dam which are planned in the Project in consideration of its effects both on an advanced irrigation agriculture and flood control against floods of longer return period.

(2) Improvement of problem soils in case field tests for both soils and crops indicate that the improvement works are feasible for further advanced agriculture.

(3) Centralized control system of irrigation waters in case the farmers in a block agree to such control in their agricultural production.

4.3 PROPOSED DEVELOPMENT PLAN FOR AGRICULTURE

4.3.1 Agricultural Production Plan

(1) Agriculture

A development plan for higher production and income will be schemed by increasing the cropping area, multiplication of cropping pattern and selection of high-profitable crops. The pattern should be arranged in such a way that the excess peak of labour requirement is avoided.

1) Selection of Crops

Major crops considered are the following:

- Ordinary field: wheat, maize and vegetables
- Orchard : fresh fruits for export
- Vineyard : table grapes for export

The following are the basic reasons which underlie the selection.

a. Wheat

The self-sufficiency rate of wheat, one of the basic crops, was 50% and 959,000 t of wheat were imported in 1984. The Government has been encouraging farmers to grow more wheat by offering price guarantee.

This crop adapts well to the region. The fact that the present average yield in the Project Area far exceeds the national average shows that the producer's skills and natural conditions are appropriate in the Project Area.

The profitability of wheat is the highest among the basic crops in the Metropolitan Region (Informativo Agro-económico, Agosto 1985, Fundación Chile).

b. Maize

Maize, one of the basic crops, is used for human consumption as well as for cattle. 35,000 t of maize were still imported in 1984, though the self-sufficiency rate has improved.

The present average yield in the Project Area exceeds the national average, showing that it adapts to the region. According to Fundación Chile, the profitability of maize is next to that of wheat.

Though the market price is sluggish at present and production cost is higher than that of wheat, arise in future demand will be expected with the development of livestock farming in and around the Project Area.

c. Vegetables

Vegetables are the major crop for the small-scale farmers. The production technique has been established among them. Raw eating vegetable cropping is anticipated in the areas where improvement of water quality is attained.

As the cultivation of vegetables is possible throughout the year in the Project Area, new vegetable markets may be developed by increasing the varieties and producing them during the between crops season.

A study made by Universidad Católica forecasts that the volume of export vegetables will increase at a yearly rate of 10%, and the value of exports rise

2.6 times by 1995 (Inversiones Agrosilvicolas para la Exportación, Universidad Católica, 1985). The Project Area has the advantage of the locality for export. The exporting of vegetable seeds is another promissing areas to be developed.

d. Fruit Trees

The export of fresh fruits increases, while the rest of the mainly traditional export items are sluggish. Production of export fruits has good potentials, making use of the advantage of locality.

According to an investment analysis for the future establishment of orchards conducted by the Fundación Chile, cherries (Bing and Black Tartarian) and peaches show the highest profitability; closely followed by almonds, plums (Santa Rosa), oranges (Valencia), pears, apples, nectarines, plums (other varieties than Santa Rosa).

The Internal Rate of Return (IRR) of peach production is 27-29% and the Net Present Value (NPV) of cherry and peach is approximately Ch$ 2,000,000/ha at a discount rate of 15% (informative Agro-ecoñomico, Agosto de 1985, Fundación Chile).

Peaches, nectarines, plums and pears are suited for production in the Project Area.

e. Table Grapes

Export of table grapes outshines other export items. Its value reaches nearly half of the total export of agro-products. The same analysis mentioned above reveals that NPV of new establishment of vineyards for export table grapes is approximately Ch$ 3,000,000/ha at a discount rate of 15% and IRR 33%.

2) Cropping Plan

a. General

The main policy of the Government in agricultural sector is to improve the agricultural productivity. Although mechanized farming may solve the problem of low-productivity, it will concentrate the landholdings and reduce the opportunity for employment in the rural areas. On the other hand, large-scale farmers have their own initiative with ample financial maneuverability; whereas small-scale farmers have not. Therefore, the agricultural development concept about rural employment and incomes is to be established paying attention to the difference of incomes of different scale farmers.

The main objectives of the Project is to increase income level of small-scale farmers and to improve living standard of them. They receive the technological transfer and agricultural credit through INDAP to improve the agricultural productivity. INDAP's policy, including agro-product price policy, agrees with the Project objectives. Therefore, the proposed cropping plan is prepared focusing on the small-scale farmers which occupy about 70% of all farmers in the Project Area.

The proposed cropping pattern is given below:

- Not to change much the present type of farming which largely depends on vegetable cultivation;
- To increase cropping rate by fully utilizing the available irrigation water;
- To cultivate as main crops wheat in winter and maize in summer; and

- To introduce fresh fruits and table grapes for export in small scale.

The basic concepts of cropping plan are as follows:

- Adaptability of crops in natural and socio-economic coditions of the Project Area;
- Efficiency of crops in the increased upland fields;
- Adaptation in the present technical level;
- Limitation of cropping area for new crops; and
- Effective utilization of technological transfer and agricultural credit by INDAP.

b. Model Farmer

In the Project Area, the number of small-scale farmers with their farm size less than 12 ha is 1,050 representing about 70% of the total farmers and about 19% of the total agricultural land. The average farm size is approximately 6.0 ha, ranging between 6.9 ha in Block-3 in the maximum and 5.1 ha in Block-2 in the minimum.

Because the agrarian reform project is not implemented at present within the Project Area, the number of farmers has not been increased nor the farm size has been changed. In this context, the model farm size in the Project will be formulated so as to coincide with the actual average farm size. On the other hand, a decrease of 220 small-scale farmers is envisaged by 1991 due to the urbanization (Table 4-3-1).

Table 4-3-1 Farming Scale of Small-Scale Farmers

Block		Number of Farmer	Average Farm Size (ha)	Agricultural Land (ha)
1	Present	68	6.6	449
	Project	68	6.6	449
2	Present	184	5.1	938
	Project	128	5.1	653
3	Present	105	6.9	725
	Project	85	6.9	587
4	Present	693	6.0	4,158
	Project	549	6.0	3,294
Total	Present	1,050	6.0	6,270
	Project	830	6.0	4,983

Source: Actualizado Propiedades 1979, CIREN

c. Cropping Pattern

The model farmers allot about 30% of their land for pasture and agricultural infrastracture area such as farm houses, and the rest for upland field. The upland field are assigned to such crops as vegetables (75%), cereals (15%) and orchard and vineyard (10%). The cereals are composed of wheat and maize in the ratio of three to two. Owing to the profitable use of irrigation system in the Project, a part of pasture will be changed into the upland field.

Furthermore, export-oriented fruits and table grapes will be introduced in approximately 20% of the total upland field; the remaining area will take such cropping pattern as the rotation of vegetables and cereals production. In Block-1, 17% of the total agricultural land will remain as pasture. The proposed cropped area and cropping pattern are shown in Table 4-3-2 and Fig 4-3-1, respectively.

Table 4-3-2 Proposed Cropped Area of Model Farmers

(Unit: ha)

Block		Upland Field: Wheat	Upland Field: Maize	Upland Field: Vegetables	Upland Field: Fruits and Vineyard	Total Cropped Area	Total Cultivated Area	Pasture	Agricultural Infrastructure Area	Grand Total
1	Present	0.4	0.3	3.3	0.4	4.4	4.4	2.0	0.2	6.6
	project	2.5	1.7	4.2	1.1	9.5	5.3	1.1	0.2	6.6
2	Present	0.3	0.2	2.6	0.3	3.4	3.4	1.5	0.2	5.1
	Project	2.3	1.6	3.9	1.0	8.8	4.9	0	0.2	5.1
3	Present	0.4	0.3	3.4	0.5	4.6	4.6	2.1	0.2	6.9
	Project	3.2	2.2	5.4	1.3	12.1	6.7	0	0.2	6.9
4	Present	0.4	0.2	3.0	0.4	4.0	4.0	1.8	0.2	6.0
	Project	2.8	1.8	4.6	1.2	10.4	5.8	0	0.2	6.0

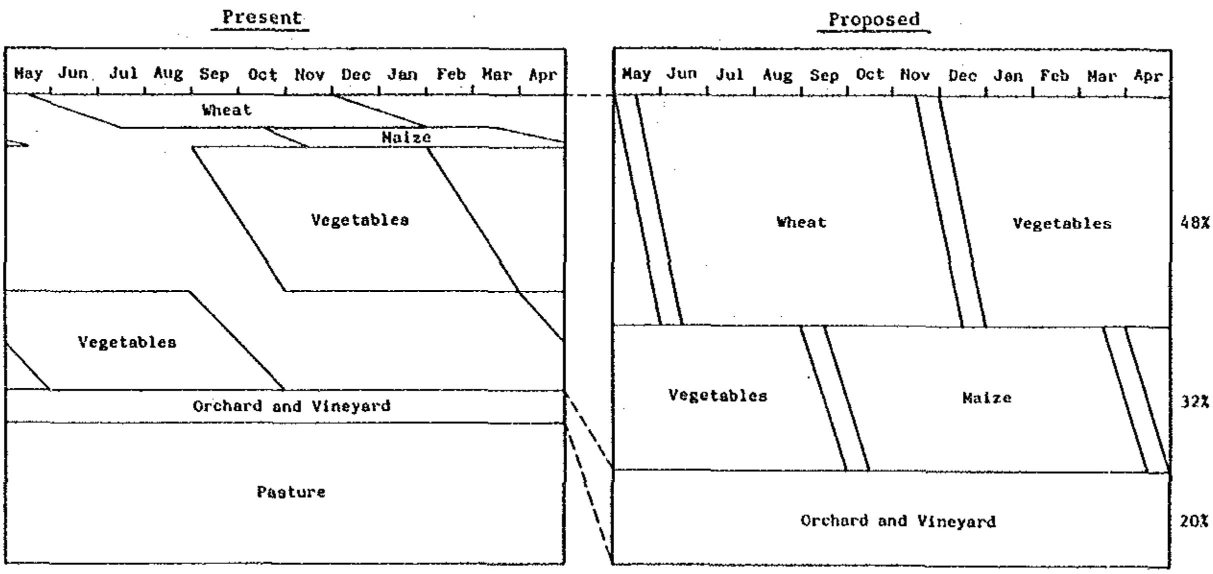


Fig 4-3-1 Cropping Pattern of Model Farmers

3) Production Costs and Production Values Plan

a. Yield

The level of yield for cereals has been improved in the country. According to the information obtained from MA, the yield of the cereals will be increased by 7% for wheat and 12% for maize within a couple of years. Besides, the crop production circumstances are expected to be improved with the implementation of the Project: the irrigation water will be increased, the poor drainage will be alleviated and the influence of saline and alkaline soils will be mitigated. In accordance with the results of farmer survey with questionnaire carried out by the Study Team and INIA's research, etc., proposed yields for the Project have been established as 50% up for wheat and 30% up for maize to compare with the present level (Table 4-3-3).

Table 4-3-3 Proposed Crop Yields

(Unit: t/ha)

Block	Wheat			Maize		
	Present	Without Project	With Projcet	Present	Without Projcet	With Project
1	4.2	4.5	6.3	6.7	7.5	8.7
2	4.3	4.6	6.5	6.2	6.9	8.1
3	4.3	4.6	6.5	6.2	6.9	8.1
4	3.2	3.4	4.8	4.8	5.4	6.2
Regional Mean	3.9	4.2	-	5.9	6.6	-

Source: Programa de Mejoramiento de las Estadísticas Agropecuarias (1984/85), INE, 1985

Programa Trienal 1985-1987, MA, 1985

The yield of vegetables, fruits and table grapes will be maintained in the current level, for these crops are actually cultivated in the optimum conditions and no substantial improvement is expected. The yields of fruits and table grapes to be newly introduced in the Project Area are summarized in Table A-10-18.

b. Direct Production Costs

In order to achieve the proposed yield, the direct production costs such as labor costs and inputs supply have been determined after investigating the actual level of farmers in the Project Area and information prepared by INIA, CIREN, etc.

The production of cereals in Blocks-1, 2 and 3 is to be made by means of additional application of fertilizer, insecticide and herbicide as well as the mechanization of harvest. Furthermore, a fungicide will be newly applied to wheat production. In Block-4, in which the cropping technique remains in the lower level than that of other blocks, the production level is to be increased to the present level equivalent to the other three blocks. The proposed direct production costs for wheat and maize are presented in Table 4-3-4.

Table 4-3-4 Proposed Direct Production Costs

(Unit: Ch$/ha)

Block	Wheat			Maize		
	Present	Without Project	With Projcet	Present	Without Project	With Project
1	65,000	65,000	81,300	84,500	84,500	96,000
2	65,000	65,000	81,300	84,500	84,500	96,000
3	65,000	65,000	81,300	84,500	84,500	96,000
4	51,300	51,300	65,000	73,000	73,000	84,500

Not being expected substantial improvement in the cropping technique of vegetables, fruits and table grapes, the direct production costs for these crops are to be equal to the present level. The planting and formation costs for such newly introduced crops as fruits and table grapes are shown in Appendix Table A-10-19. The breakdown of the direct production costs are presented in the Appendix Tables A-10-8 to 14.

c. Producer's Prices

The producer's prices have been estimated on the basis of the Ministry of Agriculture's projection prices, etc. The prices for vegetables have been established to coincide with the current producer's prices. The proposed producer's prices is summarized in Table 4-3-5.

Table 4-3-5 Proposed Producer's Prices

(Unit: Ch$/Kg)

Crop	Present	Project
Wheat	37.8	30.0
Maize	21.3	19.5
Peaches for export	80	77
Peaches for domestic	25	23
Lemons for export	30	30
Lemons for domestic	18	18
Nectarines for export	62	62
Nectarines for domestic	28	28
Plums for export	76	76
Plums for domestic	33	33
Pears for export	36	34
Pears for domestic	25	23
Table Grapes for export	74	69
Table Grapes for domestic	40	37

Source: Programa Trienal 1985 - 1987, MA, 1985
Informativo Agro-económico, Fundación Chile, 1985
Boletín Económico y de Mercado, SNA, 1985

d. Production Values

Appendix Table A-10-20 indicates mean production values for the production of representative ten vegetables and five fruits according to their cropped areas. The ratio of fresh fruits production between fruits and table grapes is established to be three to two. Besides, the ratio of comercialization for fruits between export and domestic supply will be converted from the current 2:8 to 8:2.

The expected gross and net production values calculated on the basis of the proposed yield, direct production costs and producer's prices are presented in Table 4-3-6.

Table 4-3-6 Expected Production Values

(Unit: Ch$/ha)

Crop		Gross Production Values		Net Production Values	
		Without Project	With Project	Without Project	With Project
Wheat	Block-1	135,000	189,000	70,000	107,700
	Blocks-2,3	138,000	195,000	73,000	113,700
	Block-4	102,000	144,000	50,700	79,000
Maize	Block-1	146,300	169,700	61,800	73,700
	Blocks-2,3	134,600	158,000	50,100	62,000
	Block-4	105,300	120,900	32,300	36,400
Mean of Vegetables		187,100	187,100	75,800	75,800
Mean of Fruits and Table grapes		518,300	781,100	357,000	619,800

The total net production value in the average farmer's level to respond to the cropping plan and the expected net production value for each crop are shown in Table 4-3-7 and Appendix Table A-10-21.

Table 4-3-7 Expected Net Production Values per Farmer

(Unit: Ch$)

Block	Condition	Total	per Unit Cultivated Area (ha)
1	Without Project	439,400	99,900
	With Project	1,394,800	263,200
2	Without Project	336,100	98,900
	With Project	1,276,100	260,400
3	Without Project	480,400	104,400
	With Project	1,715,200	256,000
4	Without Project	397,000	99,300
	With Project	1,379,200	237,800

As shown in the table above, by implementing the Project, the net production values will be increased in the range of 3.2 - 3.8 times compared with the situation without Project. If unit cultivated area is taken into account, this value will vary between 2.4 and 2.6 times.

(2) Livestock

1) Proposed Livestock Production

Pig production is recommended to be promoted in the Project Area above other livestock productions due to present conditions in the Project Area and surrounding areas, and consumption levels, prices and proximity of Santiago city which is the biggest market. The recommendation is based on the following:

a. Domestic consumption and market prices have been stable as against to those of other livestocks.

b. There is large potential for increasing productivity by introducing advanced technology, although existing management of pig production is rather low.

c. Pig production can be started with small investment with break-even returns in a relatively short period.

d. Since operation is not difficult, even a woman or old man can be employed. In addition, there is no large land requirements for pig production.

e. pig manure can be utilized as a good fertilizer for agricultural land.

2) Proposed production Plan

Based on the results of the study, between 18 and 20 piglets in a year can be produced from one sow in the Project Area (Appendix Table A-10-33). In addition, there is a pig breeding company (PIC-Pig Improvement Company from USA) producing and supplying hybrid breeding stocks. Based on their system for production, it is possible to introduce excellent breeding stocks which can produce more than 20 piglets per year from one sow. It is proposed to target only 18 piglets per year from one sow in the program at this stage.

3) Proposed Production Cost and Yield

The production costs for 1 kg liveweight of market hog is about Ch$100 when feed is fully procured from outside of the Project Area (Appendix Table A-10-34). When corn produced in the Project Area is used as feed, the cost can be reduced. Assuming the hog market price to be Ch$135 per 1 Kg liveweight, net production value of one head of market hog (liveweight of 95 Kg) is estimated as Ch$3,000(Ch$13,000 gross production value). About Ch$ 52,000 annual net profit is obtained per sow (producing 18 piglets per year).

Recommendations on developing pig production in the Project Area are described below:

a. The marketing channel of meats in Chile is rather complicated. In order to carry out stable and efficient marketing of hogs, it will be necessary to establish an appropriate marketing organization and/or channel, i.e. establishment of pig farmers' cooperations and association with an prospective meat processors in Santiago.

b. Comparing with dairy and poultry production, the management level of pig production is generally low. It will, therefore, be necessary to establish combined organization to take charge of providing technical services including disease control.

c. Establishment of meat grading system is very necessary to achieve progress in the meat industry. With this system, the quality of meat will be improved and its production amount will be increased.

d. It will be possible to increase the export of livestock including hogs to international markets when the meat grading system is well established.

4.3.2 Farm Household Economy Plan

(1) Labor Force Requirements

The average annual labor requirements for small-scale farmers are estimated to be 375 man-days: 300 man-days for farmer (annual working days: 300) and 75 man-days for family labor (annual working days: 150 x 0.5). The surplus labor is devoted to the crop production of the surrounding large farms and the deficient labor is compensated by the employment of petty farms with farm size less than 2 ha. Appendix Tables A-10-22 and 23 show the labor requirement in the Project development level.

To comply with the extension of cropping areas and the conversion of cropping patterns, the labor requirements will be increased such extent as to create new employment. Currently, the proportion of under-employment within the Project Area is supposed to be high and in this sense, the new employment for the Project will be procured from the surplus labor force existing in and surrounding the Project Area.

(2) Agricultural Income Plan

1) Indirect Production Costs

Indirect production costs to relate with crop production such as operation and maintenance costs of infrastructures and equipment, water charge and technical assistance cost are presented in Table 4-3-8 and Appendix Table A-10-24.

Table 4-3-8 Indirect Production Costs per Farmer

(Unit: Ch$)

Block	Condition	Total	per Unit Cultivated Area (ha)
1	Without Project	144,300	32,800
	With Project	151,300	28,500
2	Without Project	111,500	32,800
	With Project	138,300	28,200
3	Without Project	150,900	32,800
	With Project	186,900	27,900
4	Without Project	117,600	29,400
	With Project	162,600	28,000

In Blocks-1, 2 and 3, the water quality improvement will be benefitted to the Project in the context of cost reduction in the cleaning and maintenance of irrigation canals and farmlands.

2) Agricultural Net Returns

Agricultural net returns have been calculated deducting direct production costs from net production values (Table 4-3-9).

Table 4-3-9 Agricultural Net Returns per Farmer

(Unit: Ch$)

Block	Condition	Total	per Unit Cultivated Area (ha)
1	Without Project	295,100	67,100
	With Project	1,243,500	234,600
2	Without Project	224,600	66,100
	With Project	1,137,800	232,200
3	Without Project	329,500	71,600
	With Project	1,528,300	228,100
4	Without Project	279,400	69,900
	With Project	1,216,600	209,800

Expected agricultural net returns per farmer are anticipated to be increased in the range between 4.2 and 5.1 times the present development level; those per unit cultivated area will vary from 3.0 to 3.5 times.

3) Agricultural Incomes

The total agricultural outgoings have been calculated as follows:

(Direct Production Costs) - (Labor costs of self-employment) + (Indirect Production Costs)

The agricultural incomes have been thus calculated as the difference between total agricultural incomings (gross production values) and total agricultural outgoings (Table 4-3-10).

Table 4-3-10 Agricultural Incomes

(Unit: Ch$)

Block	Without Project	With Project
1	445,100	1,393,500
2	348,600	1,287,800
3	479,500	1,678,300
4	425,400	1,366,600

The expected agricultural incomes per farmer are to be multiplied up to 3.1 - 3.7 times the without project situation.

(3) Incomes of Farm Household Plan

Apart from agricultural incomes, non-agricultural incomes are taken into account in calculating incomes of farm household. Non-agricultural incomes are counted in Blocks-2 and 4 at present. However, with the implementation of the Project, farmers in these blocks will also not get non-agricultural incomes. Table 4-3-11 summarizes incomes of farm household.

Table 4-3-11 Incomes of Farm Household

(Unit: Ch$)

Block	Without Project	With Project
1	445,100	1,393,500
2	374,600	1,287,800
3	479,500	1,678,300
4	429,400	1,366,600

The incomes of farm household are expected to increase to the levels of 3.1 to 3.5 times multiplied in comparison with the without project situation level, which result in to be equivalent to 13.4 to 17.5 man-days of the minimum wages of the country (approximately Ch$ 96,000/year).

(4) Farmer's Economic Surplus Plan

Farmer's economic surplus is calculated deducting living costs from incomes of farm household. The living costs of the farmers in the Project Area are estimated to be about 60% of the incomes of farm household (AGROCOLINA). The proposed living costs of farmer have been established to be more than 1.5 times the without project situation. Summary of living costs and farmer's economic surplus is presented in Table 4-3-12 and Appendix Table A-10-26.

Table 4-3-12 Living Costs and Farmer's Economic Surplus

(Unit: Ch$)

Block	Item	Without Project	With Project
1	Living Cost	267,100	400,700
	Economic Surplus	178,000	992,800
2	Living Cost	224,800	337,200
	Economic Surplus	149,800	950,600
3	Living Cost	287,700	432,600
	Economic Surplus	191,800	1,246,700
4	Living Cost	257,600	386,400
	Economic Surplus	171,800	980,200

The expected farmer's economic surplus is anticipated to be increased in the range of more than 5.6 - 6.5 times the without project situation level.

4.3.3 Agricultural Supporting Services

For the effective implementation of an agricultural development project, the technical level of farmers (beneficiaries) in agricultural production is one of the important factors. In general, the new agricultural production techniques do not diffused due to the insufficient improvement of agro- and social-infrastructures and insufficient technology transferring system to the farmers. The intensive agriculture which requires comparatively new production techniques cannot be realized without improvement of infrastructures and agricultural supporting services to the farmers.

From the conventional viewpoint, farmers' organization such as agricultural cooperation is not familiar with in the Project Area. At present, a private company is rendering technical and managerial assistance and credit services to small farmers under the administration of the INDAP. It is advisable that this company be efficiently used in order to respond the increase of crop production after the implementation of the Project. Furthermore, an organization should be arranged so that achievement of the Groups of Technology Transfer (GTT) be consulted by the private technical assistance service company. On the other hand, in order to prepare sufficient funds with which agricultural credit could be made available for farmers, the consolidation of the banking institutions will be indispensable.

4.4 INFRASTRUCTURE FACILITIES PLANNED

4.4.1 Summary

The proposed infrastructure facilities are planned based on the results of the studies presented in section 4.2 of this Chapter. Tables 4-4-1 and 2 show the summary of the proposed counter-measures/facilities to mitigate present problems in the Project Area.

Table 4-4-1 Present Problems and Proposed Countermeasures

Objective Area	Inundation	Shortage of Irritation Water	Contamination of Irrigation Water	Saline/Alkaline Soil	Transportation
Project Area and Surrounding Areas including Santiago City	① ②	-	-	-	-
Block-1	⑧	③	⑥	-	⑨
Block-2	①	-	⑥	-	⑨
Block-3	② ⑦ ⑧	① ④ ⑤	④ ⑤	② ⑦ ⑧	⑨
Block-4	② ⑦ ⑧	① ④	-	② ⑦ ⑧	⑨

① Improvement of San Carlos Canal

② Construction of Sabo Dam

③ Construction of Headworks

④ Improvement of Carmen Canal

⑤ Construction of Punta Canal

⑥ Construction of Lagoon-type Treatment Plants

⑦ Improvement of Lampa and Colina Rivers

⑧ Improvement/Construction of Drainage Canals

⑨ Improvement/Construction of Farm Roads and/or Bridges

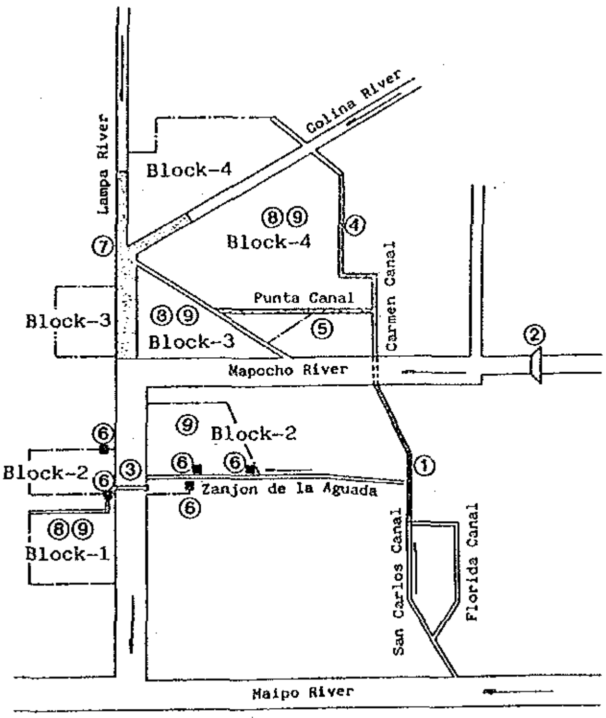


Table 4-4-2 Summary of Main Facilities Planned

Objective Area	Facilities Planned		
	Facilities	Construction (C) or Improvement (I)	Description
Blocks-2, 3 and 4 and Surrounding Areas including Santiago City	San Carlos Canal	I	17.0 km
	Sabo Dam	C	1 lot ($H=18^m$)
Block-1	Esperanza Headworks	C	1 lot ($W200^m$ x $H1.5^m$)
	Esperanza Irrigation Canal	C and I	C: 1.7 km, I:0.25 km
	Treatment Plant	C	1 location ($V=270{,}000m^3$/day)
	Frio River	I	5.0 km
	Farm Road Bridge	I	16 units
Block-2	Treatment Plant	C	4 locations (V total = $380{,}000m^3$/day)
	Farm Road Bridge	I	18 units
Block-3 and Block-4	Siphon	I	$L240^m$ x $W2.3^m$ x $H2.3^m$
	Carmen Irrigation Canal	I	27.4 km
	Punta Irrigation Canal	C	14.7 km
	Lampa River	I	24.0 km
	Colina River	I	5.9 km
	Carén River	I	5.8 km
	Choros Canal	I	12.4 km
	C-1 Drainage Canal	C	6.5 km
	C-2 Drainage Canal	C	10.0 km
	Farm Road	C	52.0 km
	Farm Road Bridge	C and I	C: 11 units, I: 25 units

4.4.2 Flood Control Facilities

(1) Improvement of Lampa and Colina Rivers

1) Plan

The improvement of the existing river channel was primarily considered. Construction of new river channels were planned only where no definitive river channel exists.

2) Profile

The profile of the proposed river channel follows the natural topography as much as possible. The design high water level is limited to below the existing ground level as much as possible in consideration of the safe flow of flood waters.

3) Cross-section

The cross-sections of the river channels were determined using the Manning formula to secure the cross-sectional areas for allowing the design floods discharges. In the analysis, the roughness coefficient of the river was assumed to be n=0.035. In addition, the river bank freeboard of one (1) m is provided to promote stable flowing of flood discharge.

Double cross-section is proposed for the following reasons:

a. To secure stable river channels by providing fixed water courses

The low cross-sectional area is determined to secure the flow-area to cope with the floods which will occur every year.

b. To secure the stability of river slope faces

4) Ancillary Works

The design flood level is higher than the existing ground level in Lampa river (3) section. In this connection, six (6) gate structures, three (3) for each side of the river bank, are proposed to allow the flood waters in the farm areas to flow into the river and also to prevent the river water from entering the farm areas during flood discharge.

(2) Improvement of San Carlos Canal

1) Plan
There is no change of canal route. Only improvement of the existing canal is considered.

2) Profile
Partial excavation of canal bed and enlargement of canal section are considered in order to maintain the existing high water level during the design flood discharge.

3) Cross-section
The design cross-sections of the canal were determined using Manning formula to secure the cross-sectional areas for allowing the design flood discharges. In the analysis, roughness coefficient of the canal was assumed to be n=0.015, since the canal is lined with concrete.

4) Specific Features
The specific features of the proposed San Carlos canal are shown in Table 4-4-3.

Table 4-4-3 Specific Features of San Carlos Canal

Item	Section A	Section B	Section C
Design Flood Discharge	120 m^3/s	85 m^3/s	50 m^3/s
Location	Inlet of Mapocho siphon - Confluence w/San Ramon river	Confluence w/San Ramon river - Ave.José Arrieta	Ave Jose Arrieta-Confluence w/ Florida canal
Length	3.6 Km	3.4 Km	10.0 Km
Gradient	1/500	1/500	1/500
Section	W 7.5m x H 4.0m	W 7.0m x H 3.0m	W 6.0m x H 2.5m
Structure	U-type reinforced concrete	- do -	- do -

Note: W : Width, H : Height

(3) Construction of Sabo Dam

1) Construction Site

The upstream section in the immediate area of the old Nilhue Bridge was selected as the construction site of proposed Sabo dam in consideration of topographic and geological conditions along the Mapocho river.

2) Dimensions

The dimensions of proposed Sabo dam are as follows (Appendix 13-5):

a.	Type	:	Concrete gravity
b.	Dam Height	:	28 m
c.	Dam Length	:	48 m
d.	Slope	:	Downstream side: 1: 0.2
			Upstream side : 1: 0.95
e.	Spillway	:	Width : 20 m
f.	Dam Volume	:	13 x 10^3 m^3
g.	Design Storage Capacity		440 x 10^3 m^3
h.	Related Structures	:	Sub-dam and Apron

4.4.3 Drainage Facilities

(1) General

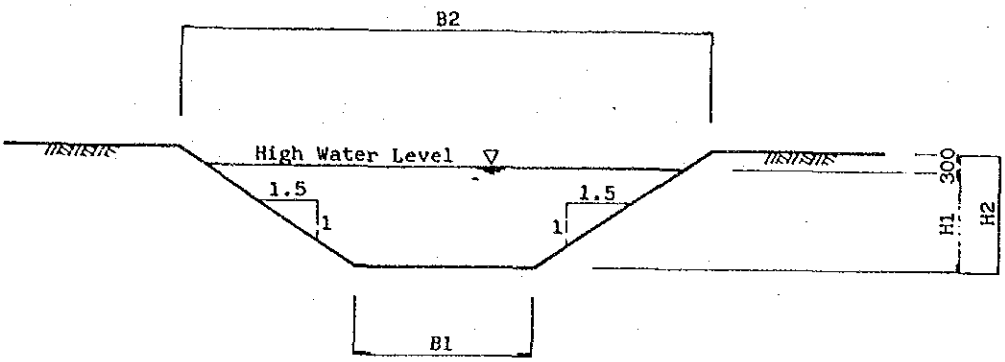
The drainage canals are planned as unlined. The hydraulic computation was conducted with Manning formula using roughness coefficient n=0.030.

Depth of canals is planned to be minimum 2 m to promote effective drainage in ordinary times. The profile of the canals is based on the existing topography.

(2) Proposed Drainage Canal/River

Proposed drainage canals are summarized in Table 4-4-4.

Table 4-4-4 Proposed Drainage Canals



Block	Drainage Canal	Catchment Area (ha)	Design Unit Discharge (l/s/ha)	Design Discharge (m^3/s)
Block-1	Frio River	5,400	4.0	22
Block-3	Caren River (A)	22,700	4.0	61
Block-3	Caren River (B)	15,300	4.0	90
Block-4	Drainage C-1	14,100	3.0	42
Block-4	Los Choros C.(A)	23,900	3.0	72
Block-4	Los Choros C.(B)	9,800	3.0	29
Block-4	Los Choros C.(C)	2,700	3.0	8
Block-4	Drainage C-2	11,700	3.0	35

n=0.030

Block	Drainage Canal	Length (m)	B1 (m)	B2 (m)	H1 (m)	H2 (m)	Slope	Area of Flow (m^2)	Velo-city (m/s)
Block-1	Frio River (A)	2,500	4.0	10.9	2.0	2.3	1/600	14.0	1.6
Block-1	Frio River (B)	2,500	2.0	8.9	2.0	2.3	1/200	14.0	2.5
Block-3	Caren River(A)	1,000	11.5	22.9	3.5	3.8	1/1,500	58.6	1.6
Block-3	Caren River(B)	4,800	7.0	18.4	3.5	3.8	1/1,500	42.9	1.5
Block-4	Drainage C-1	6,500	7.0	15.7	2.6	2.9	1/1,000	28.3	1.5
Block-4	Los Choros C.(A)	3,500	3.0	16.5	4.5	4.8	1/1,000	43.9	1.8
Block-4	Los Choros C.(B)	6,000	3.0	12.0	3.0	3.3	1/800	22.5	1.6
Block-4	Los Choros C.(C)	2,900	2.0	6.5	1.5	1.8	1/400	6.4	1.5
Block-4	Drainage C.-2	10,000	7.0	17.5	3.2	3.5	1/3,000	37.8	1.0

4.4.4 Irrigation Facilities

(1) Block-1

1) General

The construction of Esperanza headworks, Esperanza canal of 2.7 km and ancillary structures is planned.

2) Design Conditions

The design conditions of the above structures are as follows (Appendix 11.6 for details):

a. Intake volume: Maximum gross duty of irrigation water (= 3.1 m^3/s)

b. Intake water height: Same as the present water level (=EL+438.5^m)

c. Flood discharge: Flood discharge of 6.7 year return period (= 1,100 m^3/s)

d. Diversion: Esperanza Alto: 1.2 m^3/s, Esperanza Bajo: 1.9 m^3/s

3) Esperanza Headworks

a. Location

The site 200 m upstream of the existing Esperanza Alto intake was selected due to the following:

- Easy secure of the objective intake water height;
- Water course exists in the right side of the river near the intake structure; and
- A farm road exists near the site, which enable the easy operation and maintenance.

b. Foundation Type

The floating type foundation was adopted due to the geological conditions obtained from the boring test (Appendix Fig A-11-16).

c. Specific Features

The specific features of the proposed Esperanza headworks are as follows:

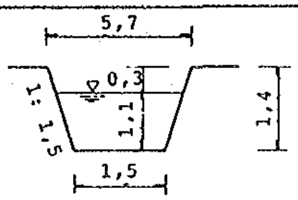
Item	Dimension
Fixed Weir Portion	L 192 m x H 1.5 m
Gated Portion	W 3.0 m x H 1.5 m - 2 sets
Intake	W 1.2 m x H 1.2 m - 2 sets

Note: L : Length, H : Height, W : Width

4) Esperanza Canal

The specific features of the Esperanza canal and its ancillary facilities are shown in Table 4-4-5. The existing tunnel, part of the Esperanza canal, is to be enlarged based on the design flow of 3.1 m^3/s.

Table 4-4-5 Specific Features of Esperanza Canal

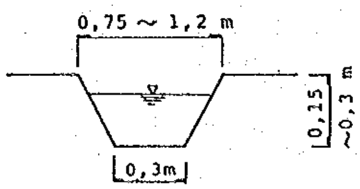
Facility	Item	Dimension	Remarks
Esperanza Canal	Length	2.7 km (Headworks - Existing canal)	
	Gradient	1/1,400	
	Section		Manning formula n = 0.023
	Lining	Earth lining	
Chute	Location	Division point to Esperanza Bajo canal	
	Deference of Elevation	20 m	
	Width	1.35 m	
	Length	40 m	
Division Works	Location	Junction of Esperanza Alto and Bajo canals	
	Division System	Parshall flume and gate	

5) Tertiary Canals

Total length : 17.9 km

Objective area : 179 ha

Section :



(2) Block-2

No improvement nor construction of irrigation facilities was planned due to the sufficient existing facilities.

(3) Block-3

1) General

The construction of Mapocho siphon, Punta canal of 14.7 km and ancillary structures, the improvement of existing Carmen canal of 12.6 km and construction of tertiary canals were planned.

2) Design Discharge

The design discharges for the objective canals were determined using the maximum gross duty of water as follows:

a. *Siphon:* 10.2 m^3/s

Flow capacity of existing siphon is 7.0 m^3/s. Therefore, total capacity will become 17.2 m^3/s.

b. Carmen canal (1): 17.2 m^3/s

c. Punta canal: 3.7 m^3/s

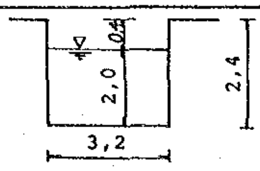
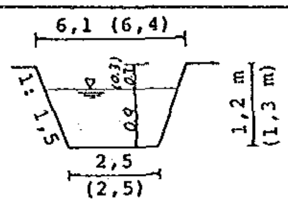
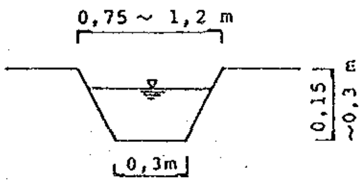
d. Division: Carmen canal (2): 13.5m^3/s

Punta canal: 3.7m^3/s

3) Proposed Facilities

The specific features of the proposed facilities are shown in Table 4-4-6.

Table 4-4-6 Specific Features of Proposed Irrigation Facilities in Block-3

Facility	Item	Dimension	Remarks
Mapocho Siphon	Location	Beside the existing siphon	
	Length	240 m	
	Section	W 2.3 m x H 2.3 m	
Carmen Canal(1)	Length	13.4 km (Outlet of Siphon - Diversion point to Punta canal)	
	Gradient	1/500	
	Lining	Concrete lining	
	Section		Manning formula n=0.015
New Punta Canal	Length	14.7 km (Conchalí - north edge of Airport)	
	Gradient	1/800 (1/1,500)	
	Lining	Earth lining	
	Section		Manning formula n=0.023
Division Works	Location	Junction of Carmen and Punta canals	
	Division System	Parshall flume and gate	
Drop		H = 2.0 m x 4 sets	
Chute		H = 68.9 m, W = 2.5 m, L = 630 m	
Tertially Canal	Total Length	111.0 km	
	Objective Area	1,110 ha	
	Section		

Note: The existing tunnel, part of the Carmen canal (1), is to be enlarged or new by path tunnel be constructed according to the site conditions based on the design flow.

(4) Block-4

1) General

The improvement of existing Carmen canal and construction of tertiary canals were planned.

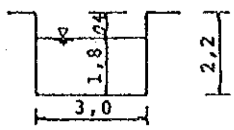
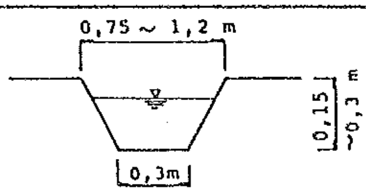
2) Design Discharge

The design discharge was determined to be 13.5 m^3/s.

3) Proposed Facility

The specific features of the proposed canal are as follows:

Table 4-4-7 Specific Features of Proposed Irrigation Facilities in Block-4

Facility	Item	Dimension	Remarks
Carmen Canal (2)	Length	13.2 km (Division works to New Punta canal - Division works to Batuco canal)	
	Gradient	1/550	
	Lining	Concrete lining	
	Section		Manning formula n=0.015
Tertiary Canal	Total Length	435.2 km	
	Objective Area	4,352 ha	
	Section		

Note: The existing tunnel, part of the Carmen canal (2), is to be enlarged based on the design flow.

(5) San Carlos Canal

The improvement plan of the San Carlos canal is shown in Section 4.4.2.

4.4.5 Water Quality Improvement Facilities

(1) General

Irrigation water is drawn to the Esperanza aerated lagoon from the Mapocho river through the integrated Esperanza headworks in Block-1. On the other hand, irrigation waters are drawn to respective Ortuzano, Rinconada, Loma Blanca and Encañado aerated lagoons independently from the Zanjón de la Aguada in Block-2.

The contaminated irrigation waters will be treated in these lagoons mainly by aeration. It is expected that good irrigation waters will be obtained with the proposed aerated lagoon treatment system.

(2) Design Conditions

The design conditions of the proposed lagoons and list of ancillary facilities to be equipped are shown in Tables 4-4-8 and 9, respectively.

Table 4-4-8 Design Conditions of Aerated Lagoon

Block	Name of Treatment Plant	Location	Effective Volume of Lagoon (m^3)	Dentention Time (hr)	Effective Depth (m)	Allowance for sludge (m)	Freeboard (m)
1	Esperangza	1.3 km downstream of the integrated Esperanza Headworks	68,000	6.0	2.0	1.0	1.0
2	Ortuzano	North of Las Pajaritos	30,000	6.0	2.0	1.0	1.0
	Loma Blanca	Immedertely downstream of division works	11,000	6.0	2.0	1.0	1.0
	Encañado	1.0 km downstream of the Encañado Intake	11,000	6.0	2.0	1.0	1.0
	Rinconada	10.5 km downstream of the Rinconada Headworks	41,000	6.0	2.0	1.0	1.0

Table 4-4-9 Proposed Ancillary Facilities

Block	Name of Treatment Plant	Aerator w/Float (N^{o})	Chlorinator (N^{o})	Capacity of Switch Gear (Kw)
1	Esperanza	9	5	135
2	Ortuzano	18	10	270
	Loma Blanca	7	5	105
	Encanado	7	5	105
	Rinconada	24	10	360
	Total	65	35	975

Other remarkable features are as follows:

- Water depth at the outlet of the lagoon was determined to be 20 cm in order only to discharge the surface water of the lagoon to the downstream canal.
- A outlet culvert (connected to a nearby drainage canal) was provided in order to spill out the retarding water during maintenance and removal of sludge.

4.4.6 Farm Road Facilities

(1) Farm Roads

The farm road construction is necessary only in Block-4 (Section 4.2.7). In consideration of the existing road system, two types of farm roads were designed as follows (Table 4-4-10):

Table 4-4-10 Farm Road Type

Item	Type-A	Type-B
Total Width (m)	9.0	4.0
Effective Width (m)	6.0	3.0
Type of pavement	Gravel	Gravel
Thickness of Pavement (cm)	20	20

The length of required new farm roads in Block-4 is 52.0 km in total, 17.3 km of which are to be constructed as of Type-A and 34.7 km as of Type-B.

(2) Farm Road Bridges

The replacement of existing wooden bridges with concrete ones and also the construction of some new bridges were planned. Due to the existing farm road conditions, three types of bridges were designed as follows (Table 4-4-11):

Table 4-4-11 Farm Road Bridge Type

Item	Type-A	Type-B	Type-C
Type of Bridge	Concrete Girder	"	"
Span (m)	8.0	6.5	4.2
Effective Width (m)	6.0	3.0	2.5

The farm road bridge improvement works are summarized as shown in Table 4-4-12.

Table 4-4-12 Farm Road Bridge

Block	Improvement of existing Bridge		Construction of new Bridge	
	No	Type	No	Type
1	6 10	B C	-	-
2	2 16	B C	-	-
3	2 3	B C	-	-
4	2 18	B C	1 3 7	A B C
TOTAL	12 47	B C	1 3 7	A B C

In addition, to make the proposed road facilities more effective and due to enlargement of river sections of the Lampa and Colina, improvement of five bridges over the above two rivers were considered to replace with new ones.
The dimensions and locations of the newly designed bridges are summarized as follows:

Table 4-4-13 New Bridge over the Lampa and Colina Rivers

Name of Bridge	Span (m)	Width (m)	Type	Distance from the junction of Lampa and Mapocho rivers
Noviciado	80.0	6.0	Reinforce concrete	7.0 km, over the Lampa river
Membrillo	70.0	6.0	"	9.7 km, over the Lampa river
Boza	60.0	6.0	"	15.4 km, over the Lampa river
Cacique Colina	40.0	6.0		21.8 km, over the Colina river
Primavera	40.0	6.0	"	23.9 km, over the Colina river

CHAPTER 5 : PROJECT IMPLEMENTATION AND OPERATION

CHAPTER 5 PROJECT IMPLEMENTATION AND OPERATION

5.1 CONSTRUCTION SCHEDULE

The overall construction period will be sixty (60) months, which consists of eighteen (18) months for detailed design phase and forty-two (42) months for construction phase. In the course of the detailed design phase, topo-survey and mapping of the Project Area, detailed design including geological and detailed topographic survey of proposed sites for main structures, preparation of tender documents, etc. will be carried out; land acquisition, tender evaluation, execution of construction works, procurement of equipment for operation and maintenance, etc. are to be envisaged during construction phase (Fig 5-1-1).

5.1.1 Detailed Design

In addition to the existing topographic map and geological data, the following supplemental surveys and investigations are necessary for the completion of the detailed design of the required facilities in the Project.

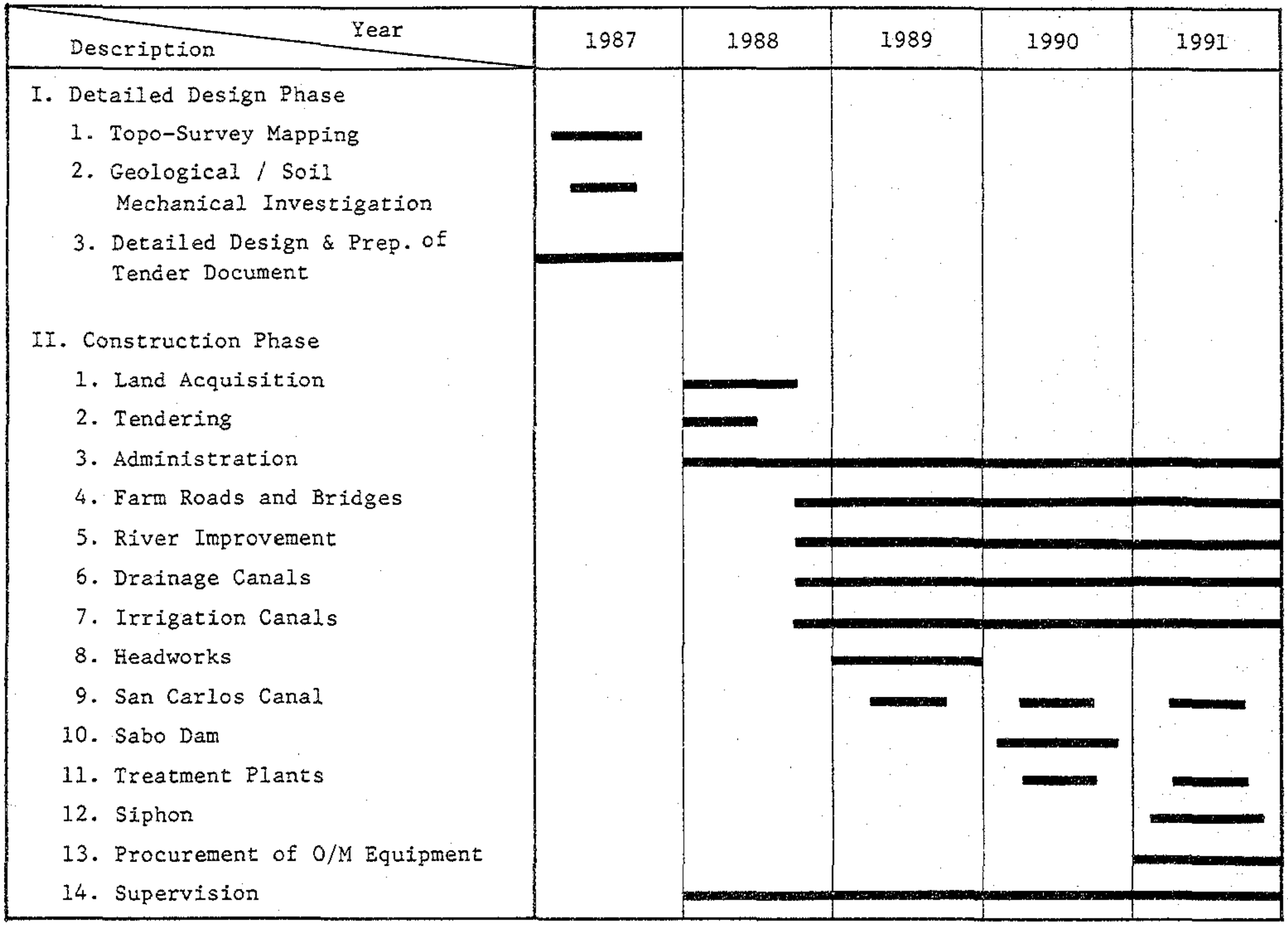
1) Topographic maps to cover the whole Project Area and topographical survey of the sites for the proposed main facilities such as Sabo dam, headworks, treatment plants, siphon and bridges.

2) Plans, profiles and cross sections necessary for the construction and improvement of proposed farm roads, rivers and canals.

3) Geological and soil mechanical investigation of the sites for proposed main structures.

On the basis of the above results, the detailed design of the Project facilities, the estimation of construction costs and preparation of tender documents will be carried out.

Fig 5-1-1 Programa Tentativo de Implementacion del Proyecto



5.1.2 Construction Works

(1) Land Acquisition

The land required for the construction of the facilities and structures such as headworks, treatment plants, new Punta canal, drainage canals, farm roads, etc. should be acquired by the Chilean Government before the commencement of the respective construction works.

(2) Contract

A contractor will be selected by means of international tendering for the execution of the construction works. The construction machinery and materials are to be procured from domestic and/or international markets under the responsibility of the contractor. Six months are allocated for tendering and tender evaluation.

(3) Construction Works

Construction works will be started in the second year after the commencement of the Project. Works are to be performed in the following order unless otherwise specified.

1) Farm road and bridge construction
2) River improvement
3) Drainage canal construction
4) Irrigation canal construction
5) Headworks construction
6) San Carlos canal improvement
7) Sabo dam construction
8) Treatment plant construction
9) Siphon Construction

Farm roads and bridges should be constructed at the initial stage of the construction works, because they are deemed to be used as access roads for the construction of other structures. And, with a view to minimize the economic loss of the Florida Power Station, the improvement of San Carlos and Carmen canals should be carried out in the winter seasons.

5.2 PROJECT EXECUTING AGENCY

5.2.1 Executing Agency

In order to facilitate the implementation and operation of the Project, the project-related tasks such as design, construction planning and supervision of construction works should be concentrated to one organization. In this connection, it is advised that the Water Resources Department of the MOP plays the leading role in organizing an executing agency, because irrigation and drainage systems constitute the mainstay of civil engineering works of the Project. Furthermore, with a view that the Project principally aims at the agricultural development, the MOP, in collaboration with the MA, should coordinate the implementation of the Project with other public institutions like: MINVIU, MBN, ODEPA, CNR, EMOS, CONAF, etc. In addition, the participation of the Metropolitan Government is expected with relation to governmental arrangements. It is necessary to budget for the operation of the Executing Agency. With the assistance of selected consulting firm, the Executing Agency will undertake the detailed design, tender evaluation and supervision of construction works.

5.2.2 Project Implementation

(1) Project Management Office

The Executing Agency will establish a Project Management Office which will be responsible for the supervision of construction works. Assisted by the Consultants, the Project Management Office will supervise the workmanship of the contractor and supply the Executing Agency with up-to-date information.

For the successful operation of the Project Management Office, it is proposed that the following nine (9) administrative staff be assigned during the full period of the construction works of the Project (Table 5-2-1).

Table 5-2-1 Proposed Administrative Staff

Personnel	Number
Officer in charge	1
Civil Engineer	2
Asst. Civil Engineer	2
Secretary	1
Driver	3

The building of the Project Management Office will be laid out so that it might be used at the same time as the building of the Operation and Maintenance Office of the Project after the completion of civil engineering works.

(2) Consultants

Consultants should be employed by the Executing Agency for rendering consulting services. The consulting services involve the detailed design in the detailed design phase and evaluation of tendering and supervision of construction works such as their workmanship, programming and safety control in the construction phase. The Consultants will be composed of highly qualified engineers and experts specialized in project planning, detailed design, construction, hydrology, geology, etc. The Consultants are also expected to undertake the technology transfer to local engineers of the Executing Agency. Above all, the quality control of workmanship and irrigation water management will be included in the scope of the consulting services.

The estimated man-months for consulting services are 356 M/M and 182 M/M for foreign and local components, respectively, totaling 538 M/M (Table 5-2-2).

Table 5-2-2 Estimated Man-months for Consulting Services

(Unit: M/M)

Detailed Design Phase			Construction Phase			Total		
Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
138	62	200	218	120	338	356	182	538

5.3 PROJECT COST

The Project cost consists of the construction cost, O/M equipment procurement cost, administration cost, consulting services cost, and physical and economic contingencies.

5.3.1 Conditions for Cost Estimates

Cost estimates of the Project are made subject to the following conditions:

(1) Basic Cost

Basic costs such as wages and materials and equipment costs are estimated on the basis of 1985 - September local market price.

(2) Price of Imported Items

Prices of the imported construction equipment and materials include CIF Valparaíso, domestic transportation cost, import tax (CIF x 0.3) and sales tax (CIF x 0.03).

(3) Unit Cost

Unit costs for respective work items are prepared with foreign and local components. The foreign component concerns CIF in 1985 and the local component is represented by current price of the same period.

(4) Indirect Cost

Indirect costs for construction works composed by overhead, profit, etc. of the contractor, are estimated to be 25% of the direct construction costs.

(5) Foreign Exchange Rate

The current exchange rates of US$ 1 = Ch$ 178 = ¥ 238 as of September 1985 are applied.

(6) Contingency

Physical contingency is estimated as 10% of the construction cost and other costs. Economic contingency is estimated as 17% per annum for 1985, 14% for 1986, 12% for 1987 and 10% for 1988 and succeeding years for local portion, and 1.6% for foreign portion.

5.3.2 Project Cost

(1) Construction Cost

Main construction works to be performed are as listed below:

Block-1:
Headworks, Irrigation canals, River improvement, Treatment plant and Bridges

Block-2:
Treatment plans and Bridges

Block-3+4 and Surrounding Area:
Siphon, Irrigation canals, Drainage canals, River improvement, Sabo dam, Farm roads and Bridges.

Total construction cost is Ch$15,842.5 x 10^6, of which the direct cost is Ch$12,674.0 x 10^6 and indirect cost Ch$3,168.5 x 10^6, and the foreign exchange portion occupies 70% and local component 30% (Table 5-3-1).

Land acquisition cost is included in the construction costs.

Table 5-3-1 Construction Cost

(Unit: 10^6Ch$)

Block	Irrigation Facilities	Treatment Plants	Drainage Facilities	Farm Roads and Bridges	Total (%)
1	379.7	355.6	34.3	13.5	783.1(5)
2	-	1,064.7	-	12.7	1,077.4(7)
3+4	7,529.0	-	5,956.5	496.5	13,982.0(88)
Total	7,908.7	1,420.3	5,990.8	522.7	15,842.5
(%)	(50)	(9)	(38)	(3)	(100)

Note: The above figures include indirect costs

(2) Costs for Procurement of O/M Equipment

Equipment required for the operation and maintenance of farm roads, canals, sludge disposal of treatment plants, etc. are bulldozers, back-hoes, dump trucks, etc. (Table 5-3-2).

Table 5-3-2 Required Equipment for Operation and Maintenance

Equipment	Capacity	Required Quantity	Purpose
Bulldozer	15 t 141 HP	2	Road repair, removal of dredged earth and sludge
Back Hoe	0.6 m^3	2	Dredging, loading earth
Motor Grader	3.7 m 130 HP	1	Road repair
Drag Line	0.6 - 0.8 m^3 105 HP	1	Dredging of main canal, earth loading
Dump Truck	8.0 t	6	Transport of earth, sludge and materials

The said equipment will be procured by the Executing Agency in the final year of the construction phase. Costs for the procurement of the equipment are estimated to be Ch$275.2 x 10^6, totally represented by foreign component (Table A-15-1).

(3) Administration Cost

The administration costs necessary for the operation of the Project Implementation Office involve rental for temporary office, construction of the office, procurement of office supplies, payment to the staff, general expenses, etc. These costs are summed to be Ch$88.6 x 10^6, and to be allotted locally (Table A-15-2).

(4) Consulting Services Cost

The costs for the provision of consulting services will be Ch$487.5 x 10^6 for the detailed design phase and Ch¢674.9 x 10^6 for the construction phase; the proportion of the foreign component is 76% and the local component 24% (Table 5-3-3).

Table 5-3-3 Estimated Cost for Consulting Services

(Unit: 10^6 Ch$)

Detailed Design Phase			Construction Phase			Total		
Foreign	Local	Total	Foreign	Local	Total	Foreign	Local	Total
369.4	118.1	487.5	519.4	155.5	674.9	888.8	273.6	1,162.4

(5) Project Cost

The total project cost excluding interest in the course of the construction period is estimated to be Ch$23,335.1 x 10^6 of which the foreign exchange portion represents Ch$14,397.1 x 10^6 (62%) and local portion Ch$8,938.0 x 10^6(38%).

Table 5-3-4 Project Cost

(unit: 10^6 Ch$)

	Description	F/C	L/C	Total
1.	Construction Cost	11,093.5	4,749.0	15,842.5
2.	Procurement of O/M Equipment	275.2	-	275.2
3.	Administration Cost	-	88.6	88.6
4.	Consulting Services	888.8	273.6	1,162.4
	Sub Total (1-4)	12,257.5	5,111.2	17,368.7
5.	Physical Contingency	1,225.8	511.1	1,736.9
	Sub Total (1-5)	13,483.3	5,622.3	19,105.6
6.	Economic contingency	913.8	3,315.7	4,229.5
	Total (1-6)	14,397.1 (62%)	8,938.0 (38%)	23,335.1 (100%)

The disbursement of the project cost will be made in 5 years from 1987 to 1991. The proportions of the disbursement for the respective years are: 3% for 1987, 4% for 1988, 27% for 1989, 33% for 1990, and 33% for 1991 (Table 5-3-5).

Table 5-3-5 Annual Disbursement Schedule

Item	1987			1988			1989			1990			1991			Total		
	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total
Construction Cost	-	-	-	463.8	214.4	678.2	3,249.8	1,479.3	4,729.1	3,806.2	1,601.6	5,407.8	3,573.7	1,453.7	5,027.4	11,093.5	4,749.0	15,842.5
Procurement of O/M Equipment	-	-	-	-	-	-	-	-	-	-	-	-	275.2	-	275.2	275.2	-	275.2
Administration Cost	-	14.4	14.4	-	31.0	31.0	-	14.4	14.4	-	14.4	14.4	-	14.4	14.4	-	88.6	88.6
Consulting Services	369.4	118.1	487.5	101.9	23.2	125.1	131.3	44.0	175.3	137.2	44.0	181.2	149.0	44.3	193.3	888.8	273.6	1,162.4
Sub Total	369.4	132.5	501.9	565.7	268.6	834.3	3,381.1	1,537.7	4,918.8	3,943.4	1,660.0	5,603.4	3,997.9	1,512.4	5,510.3	12,257.5	5,111.2	17,368.7
Physical Contingency (10%)	36.9	13.3	50.2	56.6	26.8	83.4	338.1	153.8	491.9	394.4	166.0	560.4	399.8	151.2	551.0	1,225.8	511.1	1,736.9
Sub Total	406.3	145.8	552.1	622.3	295.4	917.7	3,719.2	1,691.5	5,410.7	4,337.9	1,826.0	6,163.8	4,397.7	1,663.6	6,061.3	13,483.3	5,622.3	19,105.6
Economic Contingency	(x1.020) 8.1	(x1.189) 27.6	35.7	(x1.036) 22.4	(x1.332) 98.1	120.5	(x1.053) 197.1	(x1.465) 786.5	983.6	(x1.070) 303.6	(x1.612) 147.5	1,421.1	(x1.087) 382.6	(x1.773) 1,286.0	1,668.6	913.8	3,315.7	4,229.5
Total	414.4	173.4	587.8	644.7	393.5	1,038.2	3,916.3	2,478.0	6,394.3	4,641.4	2,934.5	7,584.9	4,780.3	2,949.6	7,729.9	14,397.1	8,938.0	23,335.1

5.4 OPERATION AND MAINTENANCE

5.4.1 Operation and Maintenance Agency

For the purpose that proposed facilities/structures may function adequately after their completion, an agency should be established to take the responsibility of the operation and maintenance of facilities/structures. As the case of the Project Executing Agency, the Water Resources Department of the MOP should undertake this function. For the operation of the Agency, it is requested that the MOP coordinates with such public organizations as MA, Metropolitan Government, EMOS and water users' association, and local farmers. The building of the Project Management Office will be used for the required building of O/M Office.

The operation and maintenance in the Project will include but not limit the following:

a. Operation and maintenance of the mechanical facilities of headworks, division works, siphons, gates and treatment plants.

b. Maintenance of irrigation and drainage canals, farm roads and bridges.

c. Overall water management in the Project Area.

Personnel necessary for proper operation of the O/M office proposed above are 26 in total (Table 5-4-1).

Table 5-4-1 Required Personnel for Operation and Maintenance

Personnel	Number
Officer in charge	1
Civil Engineer	2
Assistant Engineer	4
Secretary	2
Janitor	1
Driver	1
Operator	5
Assistant Operator including Plant Operator	10
TOTAL	26

5.4.2 Operation and Maintenance Costs

The annual operation and maintenance cost is Ch$88,747 x 10^3, of which 32% for operation of treatment plants, 36% for maintenance of facilities and 32% for administration (Table 5-4-2).

Table 5-4-2 Annual Operation and Maintenance Cost

(Unit: 10^3 Ch$)

Item	Block-1	Block-2	Blocks-3 and 4	Total
1. Operation of Treatment Plants	9,371	19,394	-	28,765
2. Maintenance of Facilities	4,195	4,985	22,690	31,870
3. Administration	3,803	6,032	18,277	28,112
Total	17,369	30,411	40,967	88,747

The durable years of some facilities will expire before the termination of the Project life. Therefore, they have to be replaced with new ones during the Project life. The costs to be incurred for this connection will be: Ch$ 559,347 x 10^3 for gates, aerators, and switch boards (20 years of durability) and Ch$ 437,177 x 10^3 for floats and chlorinators (10 years of durability).

Table 5-4-3 Replacement Cost

(Unit: 10^3Ch$)

Item	Durability (year)	Block-1	Block-2	Blocks-3 and 4	Total
1. Gate, Aerator and Switch Board	20	81,908	462,934	14,505	559,347
2. Float and Chlorinator	10	60,910	376,267	-	437,177