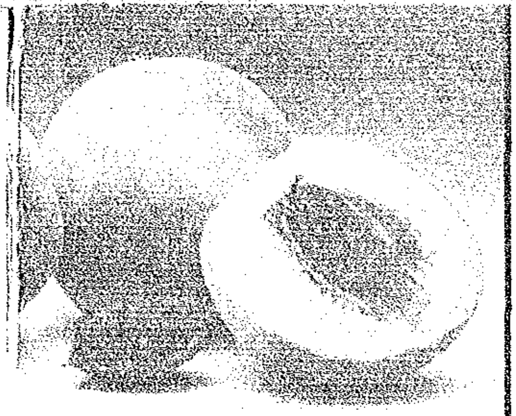
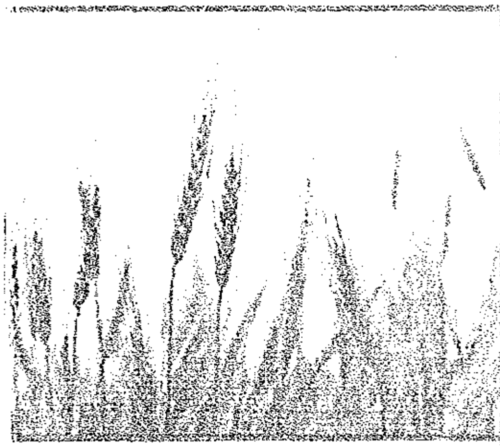
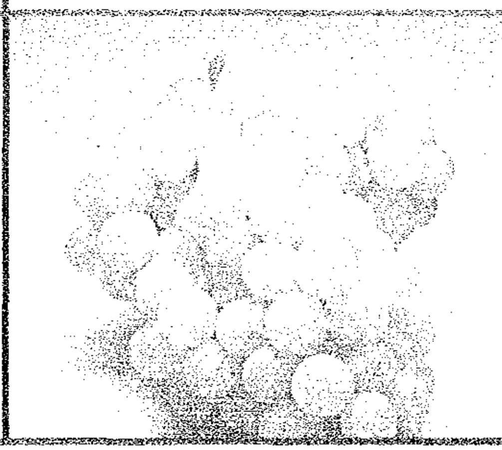


REPUBLIC OF CHILE

MINISTRY OF AGRICULTURE



FEASIBILITY STUDY ON MAPOCHO RIVER BASIN AGRICULTURAL DEVELOPMENT PROJECT



VOLUME II : APPENDIX

FEASIBILITY STUDY ON MAPOCHO RIVER BASIN AGRICULTURAL DEVELOPMENT PROJECT

VOLUME II: APPENDIX

JULY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

REPUBLIC OF CHILE

MINISTRY OF AGRICULTURE

FEASIBILITY STUDY
ON
MAPOCHO RIVER BASIN
AGRICULTURAL DEVELOPMENT PROJECT

VOLUME II :
APPENDIX

JULY 1986

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

Contents

Appendix 1: Background

LIST OF TABLES

Table A-1-1(1) GDP

(unit: 10^9 Ch$)

	1980	1981	1982	1983	1984
At Current Price	1,075.3	1,273.1	1,239.1	1,557.7	bl. US$ 19.261
At Constant Price (1977)	363.4	383.6	329.5	327.2	347.9
Percent Real Growth	7.8	5.5	-14.1	-0.7	6.3

Table A-1-1(2) GDP per Capita

(unit: Ch$)

At Current Price	96,870	112,767	107,845	135,984	US$ 1,654.97
At Constant Price (1977)	32,743	33,973	28,679	28,562	29,895
Percent Real Growth	6.0	3.8	-15.6	-0.4	4.7

Source: BCC, UN

Table A-1-2 GDP by Sector.

(unit: %)

	1980	1981	1982	1983	1984
Agriculture & Forestry	6.7	5.8	4.9	5.0	8.3
Fishing	0.5	0.5	0.7	0.7	1.0
Mining	8.6	5.6	7.7	10.1	8.7
Industry	21.4	22.3	18.9	20.6	20.7
Public Utilities	2.1	2.3	3.2	3.3	2.5
Construction	5.2	6.4	5.6	4.7	5.1
Commerce	16.3	15.0	15.6	15.0	16.9
Transport & Communications	4.9	4.9	4.6	4.5	5.4
Financial Sector	9.8	10.7	11.2	7.1	31.4
Others	24.5	26.5	27.6	29.0	
Total	100.0	100.0	100.0	100.0	100.0

Source: BCC

Table A-1-3 Expenditure on GDP (at Constant 1977 Prices)

	1980		1981		1982		1983		1984	
	bl. Ch$	%	bl. Ch$	%	bl. Ch$	%	bl. Ch$	%	bl. Ch$	%
Private Consumption	256.1	70.5	283.6	73.9	249.2	75.6	240.7	73.8		(71.6)*
Government Consumption	44.9	12.4	43.5	11.4	42.9	13.0	42.7	13.1		(14.2)
Increase in Stocks	22.7	6.2	31.1	8.1	-12.7	-3.8	-11.8	-3.6		(-2.2)
Fixed Capital Formation	64.1	17.6	74.8	19.5	49.4	15.0	41.1	12.6		(12.0)
Exports	86.1	23.7	78.4	20.4	82.1	24.9	82.6	25.3		(24.0)
Imports	-110.5	-30.4	-127.8	-33.3	-81.4	-24.7	-69.1	-21.2		(-21.3)
Total	363.4	100.0	383.6	100.0	329.5	100.0	327.2	100.0	347.9	100.0

* Tentative from GDP at current price

Source: BCC

Table A-1-4 Foreign Trade*

(unit: 10^6 US$)

	1980	1981	1982	1983	1984
Exports	4,705	3,836	3,706	3,827	3,650
Imports (-)	5,469	6,513	3,643	2,818	3,357
Balance	-764	-2,677	62	1,009	293

* FOB base, Balance of Payment Basis　　　Source: BCC

Table A-1-5 Major Commodities Exported*

(unit: 10^6 US$)

	1980	(%)	1981	(%)	1982	(%)	1983	(%)	1984	(%)
Mining	2,614.6	55.6	2,177.5	56.8	2,123.7	57.4	2,331.5	60.9	1,961.7	53.7
(Copper)	(2,124.7)	(45.2)	(1,737.8)	(45.3)	(1,684.6)	(45.5)	(1,871.0)	(48.9)	(1,603.8)	(43.9)
(Others)	(489.9)	(10.4)	(439.7)	(11.5)	(439.1)	(11.9)	(460.5)	(12.0)	(357.9)	(9.8)
Farm & Sea Products	339.9	7.2	365.4	9.5	374.9	10.1	327.5	8.6	428.3	11.7
(Agricultural)	(244.3)	(5.2)	(268.0)	(7.0)	(278.1)	(7.5)	(253.7)	(6.6)	(345.7)	(9.5)
(Livestock)	(36.9)	(0.8)	(29.1)	(0.8)	(33.5)	(0.9)	(26.4)	(0.7)	(28.9)	(0.8)
(Forestry)	(1.6)	(0.0)	(2.1)	(0.0)	(2.2)	(0.1)	(2.3)	(0.1)	(1.8)	(0.0)
(Fishing)	(57.1)	(1.2)	(66.2)	(1.7)	(61.1)	(1.6)	(45.1)	(1.2)	(51.9)	(1.4)
Industry	1,750.8	37.2	1,293.6	33.7	1,207.1	32.5	1,167.6	30.5	1,260.3	34.6
(Fish Meal)	(233.7)	(5.0)	(202.0)	(5.3)	(256.0)	(6.9)	(307.0)	(8.0)	(275.7)	(7.6)
(Wood)	(286.2)	(6.1)	(121.0)	(3.1)	(122.3)	(3.3)	(116.4)	(3.1)	(116.3)	(3.2)
(Paper, Cellulose)	(297.2)	(6.3)	(254.3)	(6.6)	(219.6)	(5.9)	(208.0)	(5.4)	(259.3)	(7.1)
(Others)	(933.7)	(19.8)	(716.3)	(18.7)	(609.2)	(16.4)	(536.2)	(14.0)	(609.0)	(16.7)
Total	4,705.3	100.0	3,836.5	100.0	3,705.7	100.0	3,826.6	100.0	3,650.3	100.0

* FOB base　　　Source: BCC

Table A-1-6 Imports of Goods

(unit: 10^6 US$)

	1980	(%)	1981	(%)	1982	(%)	1983	(%)	1984	(%)
(non-food) Consumer Goods	1,271.5	20.7	1,904.0	26.0	894.4	21.9	494.1	15.6	552.4	14.8
Foods	799.0	13.0	823.0	11.2	589.8	14.4	523.3	16.6	492.0	13.1
Intermediate Goods	2,800.5	45.6	3,144.0	43.0	1,912.8	46.7	1,747.1	55.3	2,097.0	56.1
Capital Goods	1,273.7	20.7	1,447.0	19.8	696.9	17.0	393.4	12.5	597.4	16.0
Total (CIF)	6,144.7	100.0	7,318.0	100.0	4,093.9	100.0	3,159.9	100.0	3,738.8	100.0
Freight+Insurance	675.9		805.0		450.6		342.1		382	
Total (FOB)	5,468.8		6,513.0		3,643.3		2,817.8		3,357	

Source: BCC

Table A-1-7 Major Countries of Trade Destination and Origin

(unit: %)

	Export to			Import from		
	1982	1983	1984	1982	1983	1984
o ALADI	19.0	11.7	14.7	26.9	25.7	25.9
(Brazil)	(8.3)	(4.3)	(6.2)	(8.7)	(6.4)	(8.5)
(Argentina)	(4.1)	(3.1)	(3.2)	(5.1)	(6.8)	(4.6)
(Venezuela)	(1.2)	(0.8)	(1.1)	(6.8)	(7.6)	(7.2)
(Others)	(5.4)	(3.5)	(4.2)	(6.3)	(4.9)	(5.6)
o U.S.A.	21.6	28.2	26.0	30.8	23.7	21.5
o EEC	31.3	32.5	24.3	20.2	15.1	11.3
(W. Germany)	(11.5)	(12.6)	(10.0)	(7.2)	(6.2)	(6.2)
(U.K.)	(5.0)	(5.5)	(5.4)	(2.6)	(2.0)	(2.3)
(France)	(4.1)	(4.6)	(4.5)	(3.3)	(2.8)	(2.8)
(Italy)	(4.7)	(4.4)	(4.4)	(1.9)	(1.7)	
(Others)	(6.0)	(5.4)		(5.2)	(2.4)	
o Spain	2.3	1.9		5.0	2.2	
o Japan	11.9	9.1	11.1	7.7	5.4	9.0
o Others	13.9	16.6		9.4	27.9	
Total	100.0	100.0	100.0	100.0	100.0	100.0

Table A-1-8 Balance of Payments

(unit: 10^6 US$)

	1980	1981	1982	1983	1984
Current Account	-1,971	-4,733	-2,304	-1,073	-2,060
Goods & Services	-2,084	-4,841	-2,413	-1,165	-2,159
Trade Balance	-764	-2,677	63	1,009	293
(Exports [FOB])	(4,705)	(3,836)	(3,706)	(3,827)	(3,650)
(Imports [FOB]) (non-financial)	(-5,469)	(-6,513)	(-3,643)	(-2,818)	(-3,357)
Services	-390	-701	-555	-471	-497
Financial Services	-930	-1,463	-1,921	-1,703	-1,955
Transfer	113	108	109	92	99
Capital Account	1,921	4,631	2,380	1,029	1,953
Capital	3,165	4,698	1,215	488	1,970
Foreign Investment	170	362	384	148	67
Other Capital	2,995	4,336	831	340	1,886
Reserves	-1,244	-67	1,165	541	-17
Errors & Ommissions	50	102	-76	44	107
Balance	1,244	67	-1,165	-541	17

Source: BCC

Table A-1-9 Foreign Debt

(unit: 10^6 US$)

End of Year	1980	1981	1982	1983	1984
Public Foreign Debt* (Long Term)	4,725	4,498	5,233	6,828	n.a.
Debt Service Ratio	21.9%	29.6%	20.0%	18.3%	n.a.

* maturity of over one year

Table A-1-10 Gross Capital Formation

(unit: 10^6 Ch$, 1977)

ESPECIFICACION/Item	1978	1979	1980	1981	1982(*)	1983(*)	1984(*)
FORMACION BRUTA DE CAPITAL Gross Capital Formation	51 235	66 164	86 812	105 925	36 734	30 281	53 133
Variación de Existencias Increase in Stocks	6 226	13 571	22 707	31 077	-12 714	-11 810	7 263
Formación Bruta de Capital Fijo Gross Fixed Capital Formation	45 009	52 593	64 105	74 847	49 448	42 091	45 870
Construcción/Construction	21 122	25 945	32 211	38 333	28 639	(-)	(-)
Edificación Habitacional Residential Building	8 124	11 062	15 669	19 711	12 385	(-)	(-)
Edificación no Habitacional Non-Residential Building	4 337	4 729	5 560	6 296	5 171	(-)	(-)
Obras de Ingeniería y Otras Obras(**) Engineering and Other Works(**)	8 660	10 154	10 982	12 326	11 083	(-)	(-)
Plantaciones y Mejoras de Tierras Plantation and Land Improvement	2 619	2 312	2 443	2 266	2 146	(-)	(-)
Ganado Reproductor de Leche y de Trabajo Breeding, Dairy and Work Cattle	370	376	350	278	62	(-)	(-)
Nacional/Domestic	358	355	339	190	26	(-)	(-)
Importado/Imported	12	21	11	88	36	(-)	(-)
Equipo de Transporte Transport Equipment	6 834	9 302	11 865	14 444	5 730	(-)	(-)
Nacional/Domestic	1 695	788	984	906	601	(-)	(-)
Importado/Imported	5 139	8 514	10 881	13 538	5 129	(-)	(-)
Maquinaria y Equipo Machinery and Equipment	14 064	14 658	17 236	19 527	12 871	(-)	(-)
Nacional/Domestic	1 749	2 071	2 331	2 467	1 360	(-)	(-)
Importado/Imported	12 315	12 587	14 905	17 060	11 511	(-)	(-)

(1) Cifras correspondientes a la versión actualizada del Sistema de Cuentas Nacionales
These figures correspond to the updated version of the National Accounts System.

(*) Cifras provisionales/Provisional figures.

(**) Incluye las obras de regadío y de control de inundaciones/Includes irrigation and flood control works.

(-) No se dispone de información/No information available.

Source: BCC

Table A-1-11 Public and Private Gross Capital Formation by Sector (programa 1985 - 1987)

(unit: 10^6 Ch$, 1984)

SECTOR	1984	1985	Δ% 85/84	1986	Δ% 86/85	1987	Δ% 87/86
1.- SILVOAGROPECUARIO	4,868	9,356	92.2	7,738	-17.3	6,545	-15.4
Pública	668	449	-32.8	442	-1.6	448	1.4
Privada	4,200	8,907	112.1	7,296	-18.1	6,097	-16.4
2.- PESCA	7,913	4,400	-44.4	3,700	-15.9	3,000	-18.9
Pública	-	-	-	-	-	-	-
Privada	7,913	4,400	-44.4	3,700	-15.9	3,000	-18.9
3.- MINERIA	44,053	52,086	18.2	56,804	9.1	64,108	12.9
Pública	26,920	37,600	39.7	41,870	11.4	42,360	1.2
Privada	17,133	14,486	-15.4	14,934	3.1	21,748	45.6
4.- INDUSTRIA	57,204	60,791	6.3	75,186	23.7	90,589	20.5
Pública	714	782	9.5	5,699	628.8	11,076	94.3
Privada	56,490	60,009	6.2	69,487	15.8	79,513	14.4
5.- ENERGIA	36,584	35,542	-2.8	33,442	-5.9	31,342	-6.3
Pública	35,500	34,000	-4.2	31,900	-6.2	29,800	-6.6
Privada	1,084	1,542	42.3	1,542	0.0	1,542	0.0
6.- VIVIENDA	42,571	49,838	17.1	54,425	9.2	64,907	19.3
Pública	17,018	25,929	52.3	20,600	-20.6	20,600	0.0
Privada	25,553	23,909	-6.4	33,825	41.5	44,307	31.0
7.- OBRAS PUBLICAS	23,600	32,800	40.0	30,700	-6.4	29,200	-4.9
8.- TRANSPORTE	3,631	1,688	-53.5	8,615	410.4	10,904	26.6
Pública	2,205	1,423	-35.5	2,564	80.2	2,215	-13.6
Privada	1,426	265	-81.4	6,051	-	8,689	43.6
9.- TELECOMUNICACIONES	4,606	5,536	20.2	4,973	-10.2	4,703	-5.4
Pública	4,025	4,410	9.6	4,150	-5.9	4,190	1.0
Privada	581	1,126	93.8	823	-26.9	513	-37.7
PUBLICA	110,650	137,393	24.2	137,925	0.4	139,889	1.4
PRIVADA	114,380	114,644	0.2	137,658	20.1	165,409	20.2
SUBTOTAL	225,030	252,037	12.0	275,583	9.3	305,298	10.8
RESTO INVERSION	8,785	2,663	-69.7	14,775	454.8	42,622	188.5
FORMACION BRUTA CAPITAL FIJO REAL	233,815	254,700	8.9	290,358	14.0	347,920	19.8

Source: Min. de Economia

Table A-1-12 Price Indices

	unit	1980	1981	1982	1983	1984
Consumer Price Index	1980 = 100	100.0	119.7	131.6	167.5	200.8
	average variation in 12 months	35.1	19.7	9.9	27.3	19.9
Wholesale Price Index (incl. imported goods)	1980 = 100	100.0	109.1	117.0	170.2	211.5
	annual	39.6	9.1	7.2	45.5	24.3

Source: BCC

Table A-1-13(1) Forestry, Farming, Livestock and Fishing Statistics

a) Sown Land

(unit: 10^3 ha)

RUBROS / Item	Año Agrícola(*) Agricul-tural year(*) 1980-81	Variación anual Annual Variation %	Año Agrícola(*) Agricul-tural year(*) 1981-82	Variación anual Annual Variation %	Año Agrícola(*) Agricul-tural year(*) 1982-83	Variación anual Annual Variation %	Año Agrícola(*) Agricul-tural year(*) 1983-84	Variación anual Annual Variation %	Año Agrícola(*) Agricul-tural year(*) 1984-85	Variación anual Annual Variation %
TOTAL	1 079	-12.8	945	-12.4	871	-7.8	1 051	20.7	1 083	3.0
Cereales / Cereals										
Trigo / Wheat	432	-20.9	374	-13.4	359	-4.0	471	31.2	506	7.4
Avena / Oats	80	-13.1	68	-15.0	85	25.0	96	12.9	85	-11.5
Cebada / Barley	46	-6.1	58	26.1	38	-34.5	33	-13.2	35	6.1
Centeno / Rye	9	12.5	6	-33.3	5	-16.7	4	-20.0	5	25.0
Arroz / Rice	31	-24.4	37	19.4	30	-18.9	40	33.3	39	-2.5
Maíz / Corn	126	8.6	107	-15.1	118	10.3	138	16.9	131	-5.1
Leguminosas y Papas Legumes and Potatoes										
Frejoles / Beans	118	6.3	122	3.4	86	-29.5	85	-1.2	83	-2.4
Lentejas / Lentils	48	-9.4	39	-18.8	23	-41.0	24	4.3	36	50.0
Arvejas / Peas	18	0.0	12	-33.3	10	-16.7	10	0.0	6	-40.0
Garbanzos / Chickpeas	16	-23.8	10	-37.5	8	-20.0	12	50.0	11	-8.3
Papas / Potatoes	90	1.1	77	-14.4	67	-13.0	81	20.9	63	-22.2
Cultivos Industriales Industrial Crops										
Remolacha / Sugarbeet	37	236.4	22	-40.5	36	63.6	48	33.3	44	-8.3
Maravilla / Sunflower	5	-84.4	3	-40.0	3	0.0	5	66.7	20	300.0
Raps / Rape Seed	24	-52.0	10	-58.3	3	-70.0	4	33.3	19	375.0

(*) Se entiende por año agricola el periodo en que la siembra se efectúa en el año n y la cosecha en el año n + 1
An agricultural year is the period between sowing in year n and harvesting in year n + 1.

Fuente: Instituto Nacional de Estadísticas / Source: National Bureau of Statistics.

Table A-1-13(2) Forestry, Farming, Livestock and Fishing Statistics

b) Harvests

(unit: 10^5 kg)

RUBROS / Items	Año Agrícola(*) Agricultural year(*) 1980-81	Variación anual Annual Variation %	Año Agrícola(*) Agricultural year(*) 1981-82	Variación anual Annual Variation %	Año Agrícola(*) Agricultural year(*) 1982-83	Variación anual Annual Variation %	Año Agrícola(*) Agricultural year(*) 1983-84	Variación anual Annual Variation %	Año Agrícola(*) Agricultural year(*) 1984-85	Variación anual Annual Variation %
Cereales / Cereals										
Trigo / Wheat	6 860	-29.0	6 505	-5.2	5 860	-9.9	9 883	68.7	11 647	17.9
Avena / Oats	1 307	-24.2	1 176	-10.0	1 463	24.4	1 630	11.4	1 704	4.5
Cebada / Barley	914	-13.0	1 179	29.0	732	-37.9	735	0.4	850	15.7
Centeno/ Rye	92	-11.5	61	-33.7	45	-26.2	44	-2.2	115	161.4
Arroz / Rice	997	4.5	1 312	31.6	1 156	-11.9	1 650	42.7	1 566	-5.1
Maíz / Corn	5 182	27.9	4 841	-6.6	5 116	5.7	7 214	41.0	7 718	7.0
Leguminosas y Papas Legumes and Potatoes										
Frejoles / Beans	1 382	64.1	1 625	17.6	844	-48.1	941	11.5	1 007	7.0
Lentejas / Lentils	177	-34.0	158	-10.7	138	-12.7	160	15.9	247	54.4
Arvejas / Peas	110	-19.1	74	-32.7	57	-23.0	63	10.5	63	0.0
Garbanzos / Chickpeas	64	-44.8	41	-35.9	32	-22.0	69	115.6	92	33.3
Papas / Potatoes	10 073	11.5	8 416	-16.5	6 836	-18.8	10 362	51.6	9 086	-12.3
Cultivos Industriales Industrial Crops										
Remolacha / Sugarbeet	14 605	224.4	9 630	-34.1	16 428	70.6	21 940	33.6	21 244	-3.2
Maravilla / Sunflower	74	-80.7	54	-27.0	46	-14.8	74	60.9	325	339.2
Raps / Rape Seed	269	-63.4	132	-50.9	29	-78.0	41	41.4	319	678.1

(*) Se entiende por año agrícola el periodo en que la siembra se efectua en el año n y la cosecha en el año n + 1
An agricultural year is the period between sowing in year n and harvesting in year n + 1.

Fuente: Instituto Nacional de Estadísticas / Source: National Bureau of Statistics.

Table A-1-13(3) Forestry, Farming, Livestock and Fishing Statistics

c) Yields

(unit: 10^2kg/ha)

RUBROS / Items	AÑO AGRICOLA (*) / Agricultural year (*)				
	1980-81	1981-82	1982-83	1983-84	1984-85
Cereales / Cereals					
Trigo / Wheat	15.9	17.4	16.3	21.0	23.0
Avena / Oats	16.3	17.2	c/17.2	16.9	20.1
Cebada / Barley	19.9	20.5	19.2	22.2	24.3
Centeno / Rye	10.5	11.0	9.1	12.9	22.8
Arroz / Rice	31.8	35.5	38.0	41.4	40.8
Maíz / Corn	41.3	45.2	43.4	52.1	59.1
Leguminosas y Papas Legumes and Potatoes					
Frijoles / Beans	11.7	13.4	9.8	11.1	12.1
Lentejas / Lentils	3.7	4.1	6.0	6.8	6.8
Arvejas / Peas	6.3	6.1	5,9	6.5	9.8
Garbanzos / Chickpeas	4.0	4.0	4.1	5.8	8.1
Papas / Potatoes	112.0	108.7	101.8	127.3	144.5
Cultivos Industriales Industrial Crops					
Remolacha / Sugarbeet	397.4	438.7	461.3	458.7	481.5
Maravilla / Sunflower	14.5	15.8	16.0	15.1	16.3
Raps / Rape seed	11.3	12.8	10.8	9.7	16.7

(*) Se entiende por año agrícola el período en que la siembra se efectúa en el año n y la cosecha en el año n + 1
An agricultural year is the period between sowing in year n and harvesting in year n + 1.

Fuente: Instituto Nacional de Estadísticas /
Source: National Bureau of Statistics.

Table A-1-14 Planned Investment in the Agro-Silvo-Livestock Sector

National (unit: 10^6 Ch$ in 1984 Price)

	1984 *	1985	1986	1987
Fruits Culture	2,214.6	1,950.3	1,677.4	1,469.3
Livestock	133.5	2,527.4	2,048,5	1,721.1
Pasture	1,037.8	3,525.7	3,012.4	2,432.2
Forestry	1,481.7	1,352.9	999.4	922.3
Total Investment	4,867.6	9,536.3	7,737.7	6,544.9
Public Culture	668	449	442	448
Private	4,200	8,907	7,296	6,097
From Other Sectors	0	180	0	0

Metropolitan Region

Fruits Culture	380.3	566.2	510.2	457.7
Livestock	40.4	187.1	139.6	124.3
Pasture	139.9	331.0	249.7	208.0
Forestry	39.5	14.2	19.5	25.8
Total	600.1	1,098.5	919.0	815.8

* actual

Table A-1-15 Summary of Targets Set for the Agro-Silvo-Livestock Sector (1985-1987)

	1985	1986	1987	average	cumulative
1. GDP Annual Rate of Increase (in 1977 price) (%)	9.7	5.3	5.0	6.6	21.3
2. Employment No. (end of year) 1,000 Person	501.0	520.2	530.5		
Rate of Increase (%)	9.7	3.8	2.0	5.1	16.2
3. Foreign Trade					
Export (10^6 US$)	906.8	995.1	1,080.5		
Import (10^6 US$)	345.5	324.5	302.5		
Balance	561.3	670.6	778.0		
Rate of Increase (%)	60.3	19.5	16.0	30.5	122.2

Source: ODEPA + Ministry of Economy

Table A-1-16 Projection for Agricultural Credit

Fund Allocated (unit: 10^6 Ch$)

	1985	1986	1987
Operators	3,703	4,596	7,287
Investors	819	886	883
Small Farmers	41.6	41.4	41.4
Total	4,563.6	5,523.4	8,211.4

Beneficiaries (unit: persons)

	1985	1986	1987
Operators	35,482	37,130	37,228
Investors	1,946	2,870	2,772
Small Farmers	2,925	3,000	3,000
Total	40,353	43,000	43,000

Per unit amount (unit: 10^3 Ch$)

	1985	1986	1987
Operators	104.4	123.8	195.7
Investors	420.9	308.7	318.5
Small Farmers	14.2	13.8	13.8

Appendix 2: Topography and Geology

2.1 Supplemental Information by Block

LIST OF FIGURES

2.1 Supplemental Information by Block

(1) Block-1

This block corresponds to a morphology of small basin, which is limited by mountain chain of the Coastal Range and the Mapocho river. The terrestrial slope diminishes gradually from the piedmont down to the center of the basin, varying from 1.3 to 0.5%. This area is sorrounded by hills formed mainly by volcano-clastic rocks.

The flat basin is composed by a platform of volcanic ash and layers of sand-gravel of the eastern sector. There are four levels of fluvial terraces formed by layers of sand-gravel of poor selection. There are many springs with a good flow at the foot of the terraces, presenting a partial water stagnation.

(2) Block-2

Rinconada de Maipú has a morphology of small basin adjacent to Block-1. Its gradient diminishes gradually from the piedmont down to the Mapocho river, fluctuating the range between 1.0 - 0.3%. The geology of the area is constituted by layers of sand-gravel, hard volcanic ash layers and platforms of volcanic ash. There appear fluvial terraces formed of sand-gravel in the outskirts of the Mapocho river.

At the area of Maipú, there develops a terrain with a slight inclination (approx. 0.5%) to the west and its lithology is very variable, showing an pelitic and sand-gravel layers. Generally there is a predominance of sand-gravel layers coming from the eastern part of the Mapocho river. There are platforms of volcanic ash of approx. 20 m tall from the surface level, with a complicated erosive morphology.

(3) Block-3

It develops a morphology of slight slope to the west, diminishing from 0.3 to 0.1% and its formation has a fluvial and glaciofluvial origin of the Mapocho river. The flat terrain around Noviciado town has a gradient of 0.1% to the south, where it develops an alluvial formation of the Lampa and Carén rivers. Immediately to the south of this area, there is a "bottle neck" that is surrounded by a platform of volcanic ash and to the west, the hills formed of andesitic rocks. There exist some alluvial cones formed by small riveres with ground slope, fluctuating between 1.0 and 1.3% to the east.

The geology of this block is characterized by a predominance of sand-gravel layers at the eastern and western sectors, also with argillaceous layers around the Lampa river. The layer of volcanic ash has a light beige colour and contains many rounded or sub-rounded gravels of andesitic characteristics. The upper column of this formation corresponds to a soft layer, which has a lower resistance against erosion and a better permeability. The lower one is a hard layer with fluidal texture and poor permeability.

(4) Block-4

It widely develops a flat terrain with a gradually diminishing gradient between 1.0 and 0.2% to the Lampa river. There is a slope less than 0.1% around the confluence between the Lampa and Colina rivers. The lower course, where the water is poorly drained, has saline and alkaline soils and is developing layer of sand-gravel. It has a slope over 1.0% around the main courses and develops argillaceous layers in the flat terrains.

There are argillaceous layers with lacustrine origin in the area of Batuco and Conchalí. An outstanding morphology in the flat terrain corresponds to isolated hills of intrusive body, with a terrestrial height varying between 20 and 50 m. Their lithologies are andesitic and porphyritics.

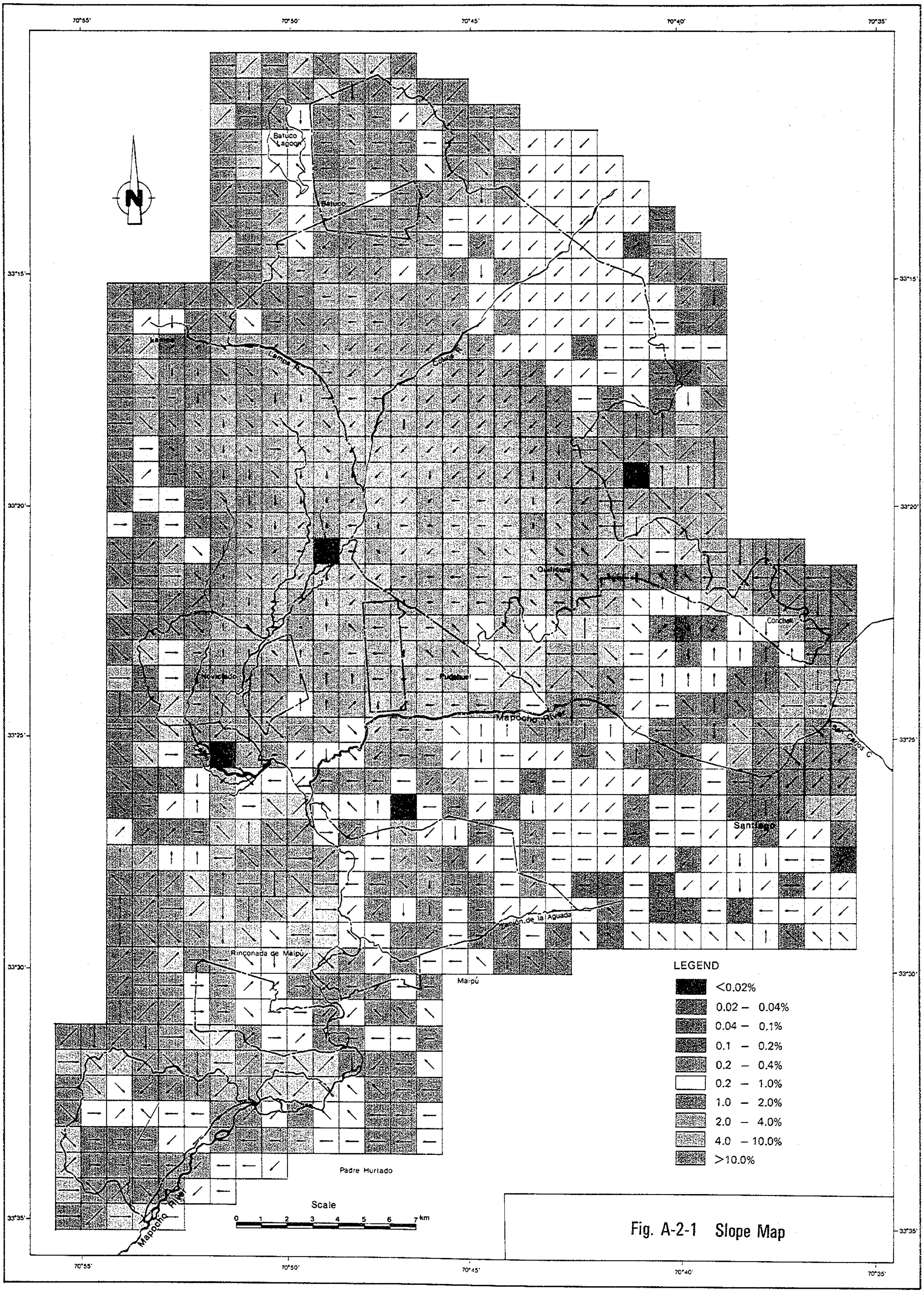


Fig. A-2-1 Slope Map

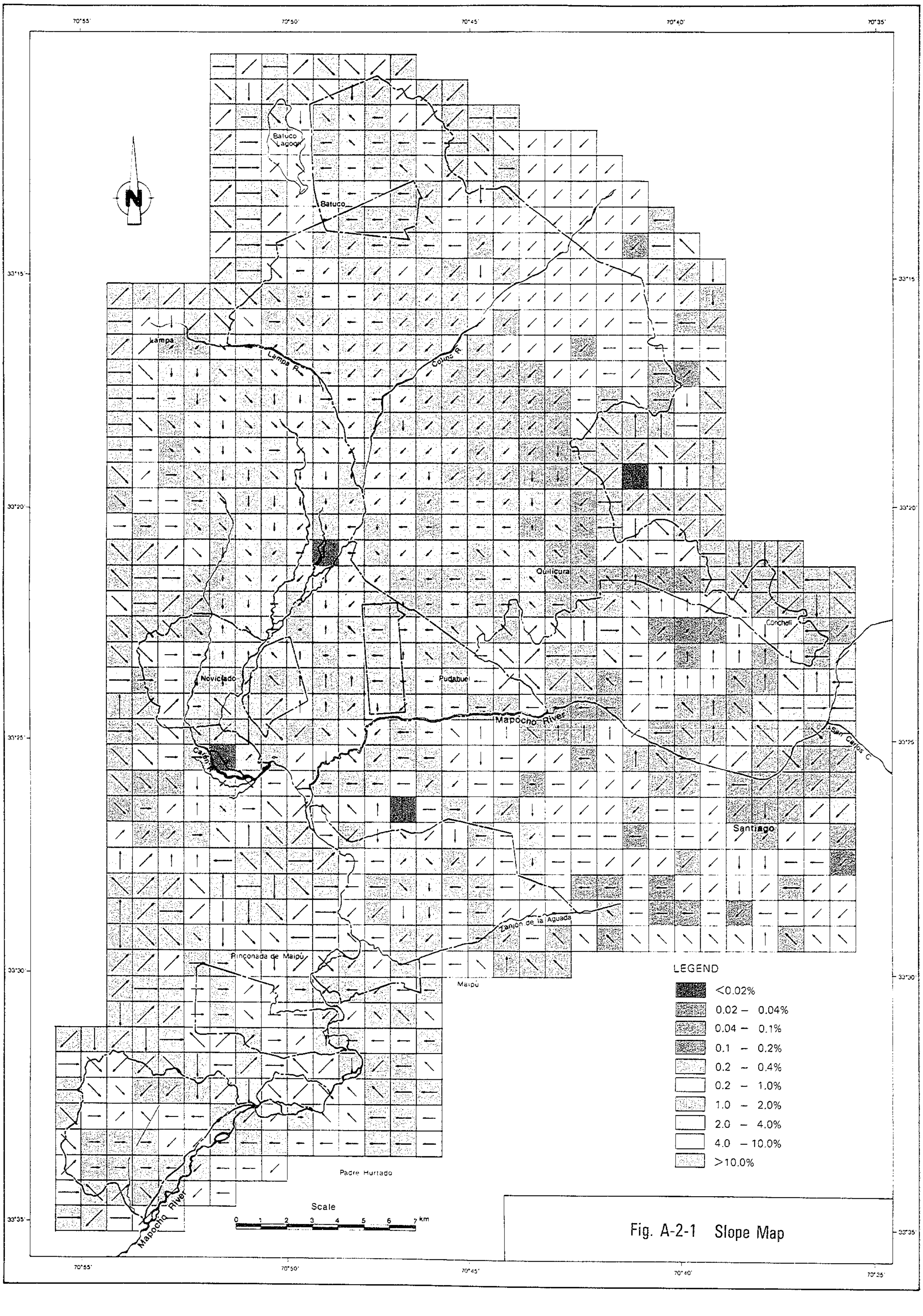


Fig. A-2-1 Slope Map

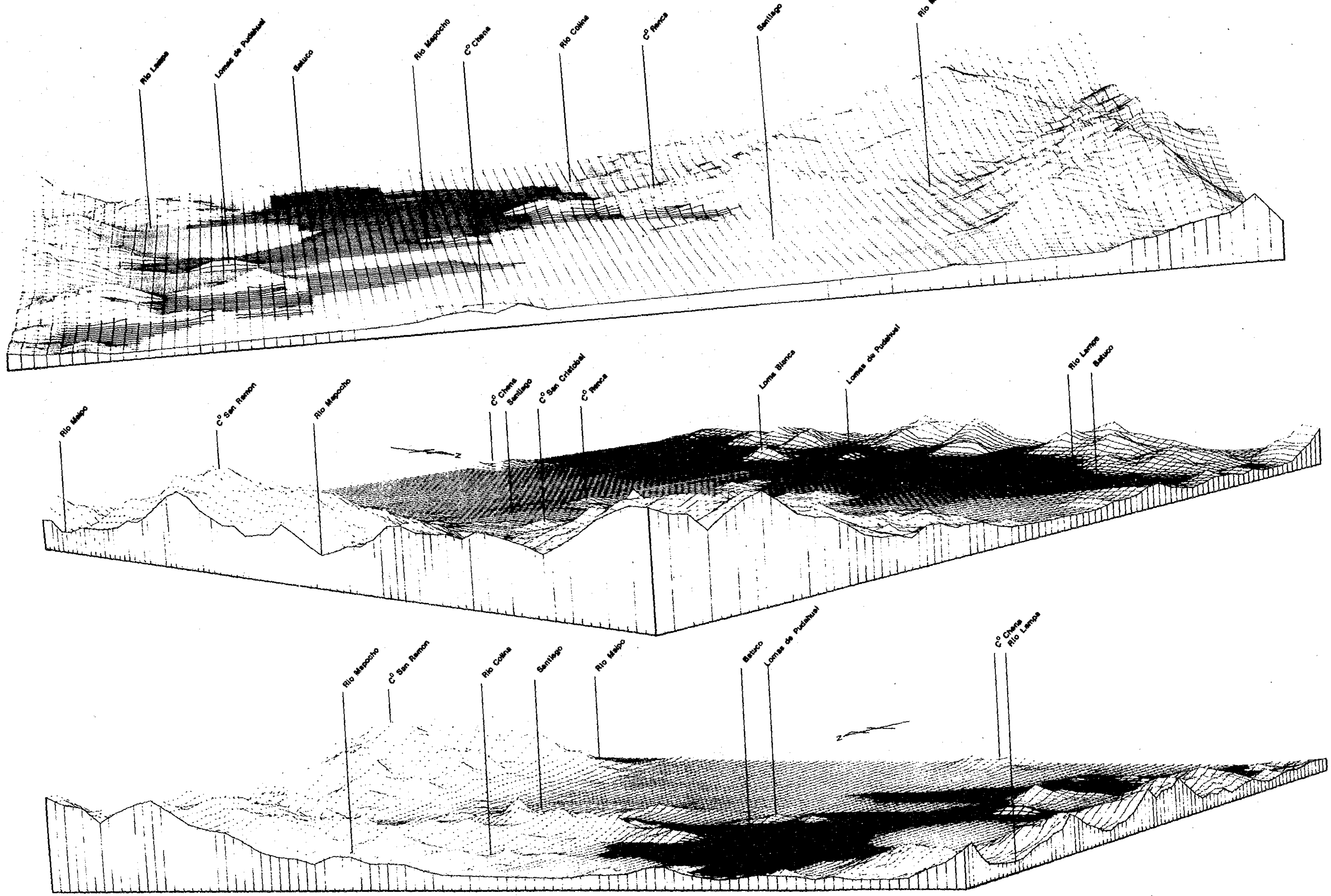


Fig. A-2-2 Bird's-Eye View

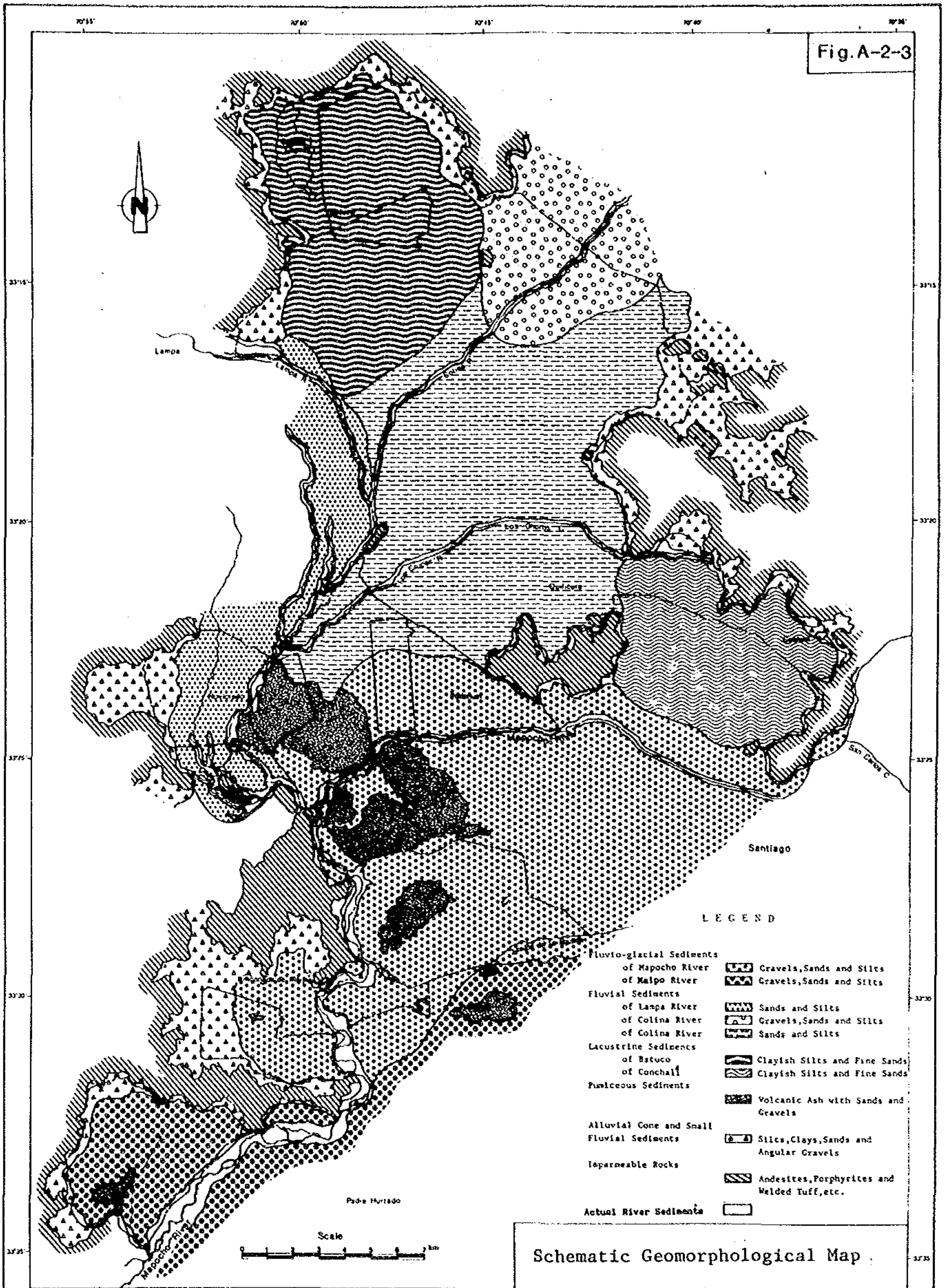


Fig.A-2-3

Schematic Geomorphological Map

Appendix 3: Meteorology and Hydrology

3.1 Meteorological Characteristics

3.2 Characteristics of River Discharge

LIST OF TABLES

LIST OF FIGURES

3.1 Meteorological Characteristics

The comparison of meteorological characteristics of the Lampa, Mapocho (Santiago city area) and Maipo (mountainous area) basins was conducted based on the records of the stations of Rungüe (N^o 4), Santiago (N^o 24) and El Yeso (N^o 53), respectively, because of their comparatively long records (Fig. A-3-1). The comparison of the duration of bright sunshine, wind and snowfall in respective river basins, however, could not be made because of lack of data and the concentration of the snowfall data in the Maipo river basin.

a. Rainfall

The volume of rainfall diminishes as the distance to the Maipo river increases.

b. Evaporation

The characteristics of evaporation are not so clear due to the lack of records of El Yeso station. The following are the main features observed:

i. The evaporation rate in the Mapocho river basin is less than that of the Lampa river basin.

ii. The volume of evaporation is correlated directly to temperature and inversely to relative humidity.

c. Temperature

The temperature in El Yeso is comparatively low because of its high altitude. It is reported by CNR that the temperature diminishes by 0.7°C every 100 m of altitude. The daily temperature amplitudes in El Yeso and Rungüe/Santiago are 10°C and 15 - 20°C, respectively.
The seasonal changes of temperature in Rungüe, Santiago and El Yeso diminish in the same order.

d. Relative Humidity

The relative humidity values in El Yeso and Rungüe/Santiago are 45% and 60 -70%, respectively. The seasonal changes of relative humidity in Rungüe and El Yeso are small because of its topographic characteristics.

e. Bright Sunshine

The record of the duration of bright sunshine is available for El Yeso only. The annual mean value based on the records from 1974 to 1981 is 6.2 hr/day. The summer and winter (June and July with comparative heavy rain) average values are 7-9 hr/day and 3-4 hr/day, respectively.

f. Wind

The records of La Platina from 1965 to 1977 show that the mean wind speeds in day-time and night-time are 2.2 m/s and 1.1 m/s, respectively. Seasonally, the wind speed in summer is higher than in winter. The basic maps for the diagnosis of the Mapocho river basin prepared by the University of Chile show that the wind directions in summer and winter are usually southwest to northeast and south to north, respectively.

g. Snowfall

Snowfall records were collected from five stations, one in the Mapocho river basin (EL + 3,350 m) and the rest in the Maipo river basin (EL + 2,100 to + 2,768 m). The records show that the snowfall in regular years, except 1968, is approximately 500 mm.

The method for measuring accumulated snowfall is to collect snow samples at regular intervals, measure the depth and weight of collected samples and then convert it to the water depth.

3.2 Characteristics of River Discharge

The discharge characteristics of the Maipo, Mapocho and Lampa rivers were obtained by observing the correlation among rainfall, temperature and discharge as follows:

(1) Maipo River

1) Fig A-3-2 shows that the discharge at La Obra has high correlation with temperature. The discharge is maximum when the temperature is highest from December to January. The discharge in winter is minimum and its correlation with the rainfall is not clear. The discharge of this river is mainly controlled by snowmelt in the basin.

2) The annual mean discharge of 1968/69 was 36 m^3/s being the lowest value in the period of 1912-80. It corresponds to the annual low discharge of a return period of 60 years.

3) Fig A-3-3 shows the comparison of the discharges of three gauging stations in the basin. The difference between the discharges of San Alfonso and El Manzano (or La Obra) is not very high, despite the fact that the difference of their watersheds is 2,000 km^2.

   Sometimes the discharge of San Alfonso (located upstream) is bigger than that of El Manzano. This means that the inflow of snowmelt between these two gauging stations is small.

(2) Mapocho River

1) Fig A-3-4 shows that the change in the discharge at Los Almendros correlates to temperature variations but that this correlation is not so strong. The discharge of this river is controlled mainly by snowmelt but also by the rainfall in the basin.

2) The discharge at Rinconada de Maipú (located downstream) has no influence from snowmelt but correlates to rainfall.

(3) Lampa River

1) Fig A-3-5 shows that the discharge at Estero Polpaico en Chicauma is correlated to rainfall, but not to snowmelt.

2) The annual mean discharge of this station is only 1.0 m^3/s (0.08 mm/day by the depth of runoff).

The causes of the low discharge are:

a. There is no snowmelt in the basin;
b. The rainfall is scarce; and
c. *The flow of this river goes underground near this gauging* station.

Table A-3-1 Collected Meteorological Data

Basin	No.	Station	Latitude (°S)	Longitude (°W)	Altitude (m.A.S.L)	Monthly Records								Daily Records			
						Rainfall	Evap.	Temp.	Solar Radiation	Sunshine Hour	Relative Humidity	Wind Speed	Snowfall	Rainfall	Evap.	Temp.	Relative Humidity
Lampa Basin	1	Rincon de Los Valles	32 57	70 46	950	1957 ~81											
	3	Caleu	33 00	71 00	1,120	1957 ~81								1959 ~84			
	4	Rungue	33 02	70 54	710	1957 ~79	1965 ~81	1965 ~81			1965 ~81			1943 ~84	1965 ~83	1965 ~83	1966 ~75
	5	Til-Til	33 06	70 56	578	1941 ~71											
	10	Batuco-Retén	33 15	70 49	484	1938 ~81											
	12	Fundo Valle Hermoso	33 17	70 38	244	1957 ~81											
Mapocho Basin (around Santiago)	14	Fundo Huingnal	33 20	70 30	830	1956 ~79											
	16	Cerro Calan	33 23	70 32	900	1976 ~81		1976 ~81	1964 ~66			1978 ~79		1976 ~84	1976 ~83	1976 ~83	
	20	Cerro San Cristobal	33 25	70 30		1965 ~69		1958 ~69			1955 ~74						
	22	Terrenza D.G.A.	33 26	70 39	600	1960 ~82			1962 ~65					1960 ~84			
	23	Tobalaba	33 27	70 34	640	1946 ~71											
	24	Santiago	33 27	70 42	530	1866 ~1980	1963 ~81	1950 ~81	1963 ~81		1958 ~81						
	27	Campo San Joaquin	33 30	70 37	554	1978 ~81		1978 ~81									
	29	Los Cerrillos	33 30	70 42	500	1952 ~79		1958 ~81			1958 ~81						
	30	U. de Chile Maipu	33 32	70 46	488	1965 ~68		1964 ~67			1964 ~67						
	37	El Bosque	33 34	70 37	580	1961 ~80		1966 ~70	1966 ~72		1966 ~70						
	370	La Platina	33 34	70 37	625	1965 ~77	1967 ~81	1965 ~81	1974 ~81		1965 ~81	1965 ~77					
	41	Sn. Bernardo Seminario	33 35	70 43	573	1912 ~79											
	1	Barros Negros	33 19	70 17	3,350								1965 ~84				
Upper Stream of Maipo Basin	32	Maitenes Planta	33 33	70 16	1,140	1929 ~80											
	40	La Obra de Maipo	33 35	70 30	799	1913 ~80											
	43	Rio Colorado	33 36	70 23	910	1942 ~71											
	50	San Jose de Maipo	33 39	70 22	1,060	1918 ~81		1965 ~70			1966 ~70						
	51	Pirque	33 39	70 35	670	1976 ~81	1978 ~81	1977 ~81	1972 ~73		1977 ~81						
	53	El Yeso	33 40	70 07	2,475	1962 ~81	1968 ~81	1977 ~81	1978 ~81	1974 ~81	1978 ~81	1962 ~70					1962 ~70
	70	Qualtehue Chilectra	33 49	70 12	1,365	1929 ~80											
	74	Las Melosas	33 51	70 12	1,600	1963 ~81		1978 ~81	1969 ~81					1962 ~84			
	2	Rodeo Alfaro	33 36	70 18	2,200								1967 ~84				
	3	Laguna Negra	33 40	70 06	2,768								1965 ~84				
	4	Las Gunas	33 48	70 02	2,380								1977 ~84				
	5	El Zorro	33 52	70 10	2,100								1967 ~84				

Table A-3-2 Collected Discharge Records

Basin	Station No.	Code No.	Name	Latitude (S)	Longitude (W)	Altitude (m.A.S.L.)	Area (Km²)	1940	'41	'42	'43	'44	'45	'46	'47	'48	'49	'50	'51	'52	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68	'69	'70	'71	'72	'73	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83
Lampa	②	15104	Estero Polpaico en Chicauma	33° 13'	70° 55'	500	1,098				▲	●	▲	▲	●	●	●	▲	●	▲							▲	●	●	●	●	●	▲	●	▲	●	●	▲		▲	▲	▲	▲	▲	●	●	●	●	●	●	●
Maipo	③	15127	Maipo en Cabimbao	33° 46'	71° 32'	35	15,040	○	○	○	○	△											△	△	△	○	△	○	○	○	○	○	○	○	○	○	○	○	○	○	△	△	△	△	○	○	△	○	●	●	●
Mapocho	④	15101	Estero Arrayán en La Montosa	33° 21'	70° 28'	880	219			△	△									▲	●	●	●	●	●	▲	▲	▲	●	●	▲	●	●	●	●	●	●	●	●	▲		▲	▲	●	▲	▲	●	●	●	●	●
"	⑤	15102	Mapocho en Los Almendros	33° 23'	70° 28'	1,024	620									▲	●	●	▲	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	▲				○	△	○	○	△	△	○	●	●	●	●	●
Canal	⑥	15115	San Carlos en Desembocadura Mapocho	33° 26'	70° 36'	580	—																							▲	●	●	●	●	▲	▲	▲									▲	●	●	●	▲	
"	⑥⑥	15131	San Carlos en Principe de Gales	33° 25'	70° 35'	579	—																																								△	○	△		
"	⑦	15118	Zanjón de la Aguada en Pajaritos	33° 30'	70° 49'	430	—																								▲	●	●	▲	●	▲	▲														
"	⑦⑦	15126	Zanjón de La Aguada en Puente Particular	33° 28'	70° 43'	450	—																																△	○	○	○	△	○	○	○	△	○	△	△	
"	⊖	—	Bocatoma Las Vertientes (La Obra)	—	—	—	—																															●	●	●	●	●	●	●	●	●	●	●	●	●	●
"	⊖	—	Derivadora a Canal Florida	—	—	—	—																															●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mapocho	⑧	15103	Mapocho en Rinconada Maipú	33° 31'	70° 51'	420	4,068																					●	●	●	●	●	●	●	●	●	●	▲	▲	●	▲	●	●	●	●	●	●	●	●	●	●
Maipo	⑨	15128	Olivares antes Junta Colorado	33° 29'	70° 08'	1,500	531																								△	△	○	○	△	○		○	△	△	○	○	△		△	△	○	○	○	●	●
"	⑩	15129	Colorado antes Junta Olivares	33° 30'	70° 08'	1,500	834																								○	○	△	○	○	○	○	○	○	○	△	△			△	△	○	△	△	●	▲
"	⑪	15111	Colorado en Desembocadura	33° 37'	70° 22'	890	1,713	▲	●	●	●	●	●	▲	●	●	▲	▲	●	●	▲	▲	●	●	●	●	●	▲					▲	▲	▲	▲	●	●	●	●	●	▲	●	●	●	●	●	▲	▲	●	●
"	⑫	15108	Yeso Embalse	33° 40'	70° 05'	2,475	353						△	△	○	△	△	○	○	○	△	△	○	○	○	△				▲	●	●	●	▲	▲	●	●	●	○	●	●	○	●	●	●	●	○	○	○	▲	○
"	⊖	15109	Yeso Desembocadura	33° 48'	70° 12'	1,240		▲	●	●	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	▲																									
"	⑬	15121	Maipo en Las Melosas	33° 50'	70° 13'	1,527	1,488																										△	○	○	○	△	○	△	○			△	△	△	○	△	△	△	●	●
"	⑭	15107	Volcán en Queltehues	33° 49'	70° 13'	1,365	523	△						△	○	○	△	○	○	△	○	○	○	○	△	△	△	○	△	△		△	△	○	△	△	△	△	△	△			△	△	△	○	△		▲	▲	
"	⑮	15110	Maipo en San Alfonso	33° 45'	70° 18'	1,108	2,850	△	△	△	△	○	○	○	○	○	○	○	△	○	○	○	○	○	○	△	●	●	●	●	●	▲	●	●	▲	▲	●	●	●	▲	▲		●	●	●	●	●	●	●	●	●
"	⑯	15112	Maipo en El Manzano	33° 36'	70° 24'	850	4,987								○	○	○	○	○	○	○	△	○	○	○	○	●	●	▲	●	●	●	▲	▲	▲	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	▲
"	㉒	—	Maipo en La Obra	33° 35'	70° 27'	775	5,036	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Note: Monthly Mean Discharge ○: complete △: incomplete
Daily Mean Discharge ●: complete ▲: incomplete

Table A-3-3 Evaporation

(unit: mm)

Item \ Station	Rungüe (Lampa)	Santiago (Mapocho)	El Yeso (Maipo)
Annual Total	(1,702) 1,786	(1,214) 1,286	(1,512) -
Record Period	1965-81	1963-81	1968-81

Note: Values in brackets show ten-month totals not including the values of July and August, because of no records for these months in El Yeso.

Table A-3-4 Temperature

(unit: °C)

Item \ Station	Rungüe	Santiago	El Yeso
Annual Mean	14	15	10
Record Period	1965-81	1950-81	1977-81

Table A-3-5 Relative Humidity

(unit: %)

Item \ Station	Rungüe	Santiago	El Yeso
Annual Mean	58	70	45
Record Period	1965-81	1958-81	1978-81

Table A-3-6 Accumulated Snowfall

(unit: mm)

River Basin	Mapocho	Maipo			
Station	Barros Negros	Rodeo Alfaro	Laguna Negra	Las Arenas	El Yeso
Annual Max. Mean	454	365	599	1,085	357
Record Period	1965-84	1967-84	1965-84	1977-84	1967-84
Annual Max. in 1968	26	1	2	-	0

Table A-3-7 Result of Correlation Analysis

Station \ Item	P (mm/year)	P' (mm/year)	$E = \frac{P-P'}{P} \times 100$ (%)	r	Record Period
Fundo Valle Hermoso (No.12)	279	247	11	0.965	1957-79
Santiago (No.24)	363	346	5	0.995	1866-79
Queltehues Chilectra (No.70)	558	634	14	0.962	1929-79

where:

$$r = \frac{\sum_{1}^{n}(Pi-P)x(Pi'-P')}{(n-1)xSpxSp'}$$

P : Mean annual rainfall in all stations concerned
P' : Mean annual rainfall in each station
E : Relative error
r : Correlation coefficient
Sp, Sp' : Standard deviation
Pi : Mean monthly rainfall in all stations concerned
Pi' : Mean monthly rainfall in each station

stations concerned :

1. Fundo valle Hermoso (No.12) : Nos 1, 4,5,10 and 12
2. Santiago (No.24) : Nos 14,22,23,24,29,37 and 41
3. Queltehues Chilectra (No.70) : Nos 32,40,43,50,53,70 and 74

Table A-3-8 Probable Minimum Discharge

(unit: m^3/s)

Item	Gauging Station(No.)	Return Period (year)			
		2	5	6.7	10
Annual Minimum Discharge	Estero Polpaico en Chicauma(No.2)	0.32	0.19	0.16	0.13
	Mapocho en Los Almendros (No.5)	1.75	1.35	1.30	1.25
	Mapocho en Rinconada de Maipu (No.8)	9.6	5.8	5.0	4.2
	Maipo en La Obra (No.22)	39.0	29.0	27.0	25.5
Minimum Discharge in Rainy Season	No.2	0.42	0.31	0.27	0.25
	No.5	1.75	1.35	1.23	1.18
	No.8	11.6	8.2	7.6	7.0
	No.22	37.0	29.0	27.0	20.0
Min. Discharge in Snowmelt Season	No.2	0.35	0.20	0.18	0.14
	No.5	2.85	1.90	1.70	1.58
	No.8	10.6	6.2	5.2	4.6
	No.22	75.0	55.0	50.0	45.0

Table A-3-9 Probable Rainfall Intensity
Santiago (No. 24): 1917-62

(unit: mm/hr)

Duration (hr) \ Return Period (year)	10	25	50	100
1	12.0	13.6	15.0	16.0
2	9.7	10.8	11.8	12.6
4	7.9	9.0	10.0	10.8
6	6.9	8.1	8.9	9.7
8	6.0	7.0	7.9	8.6
10	5.3	6.2	7.0	7.8
12	4.8	5.7	6.2	6.9
14	4.5	5.1	5.8	6.5
18	3.9	4.5	5.0	5.5
24	3.1	3.8	4.1	4.7

Source: "Curvas Generalizadas de Intensidad Duración Frecuencia de Lluvias", Eduardo Varas C. et al. (1984)

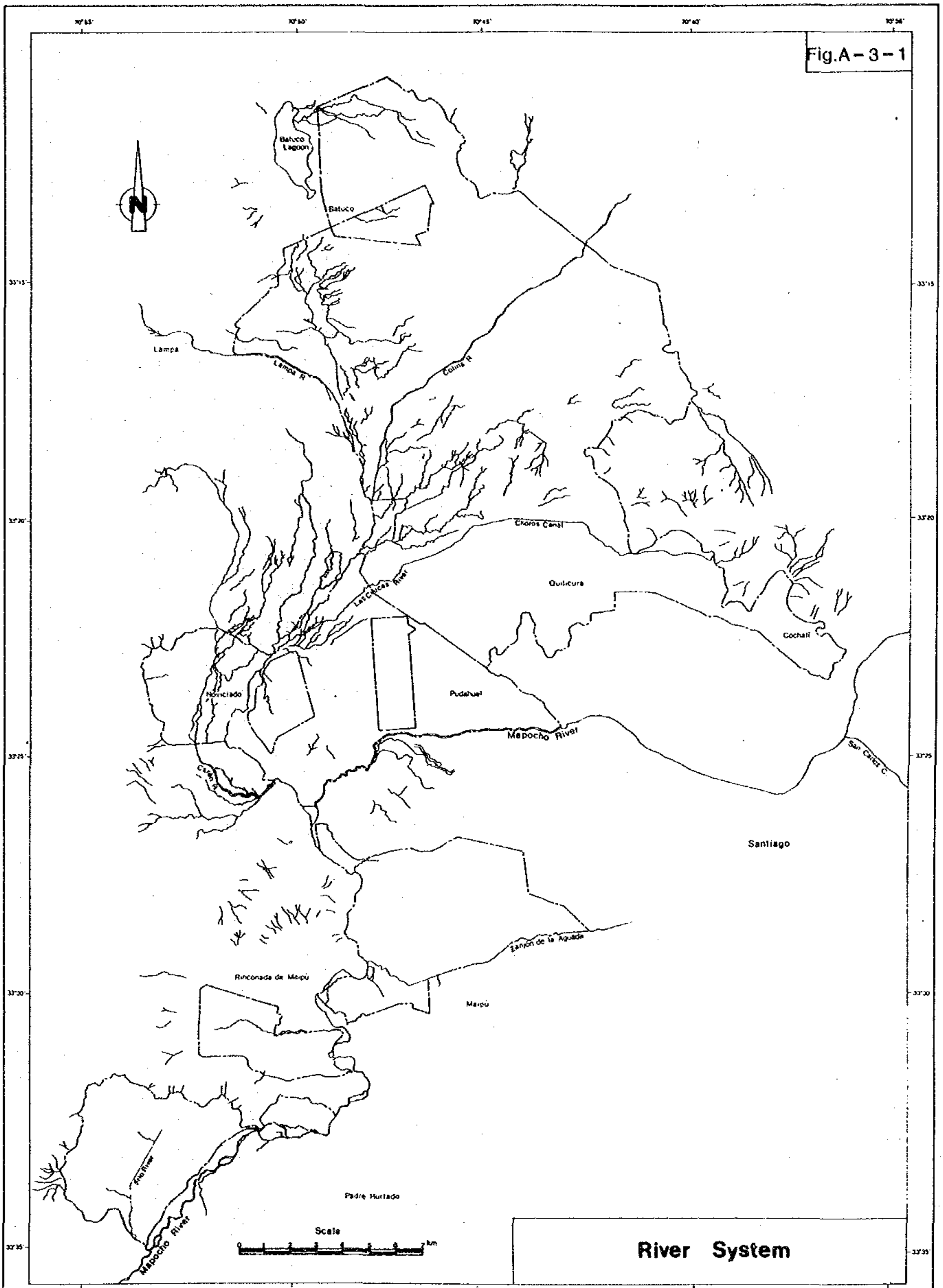


Fig.A-3-1

River System

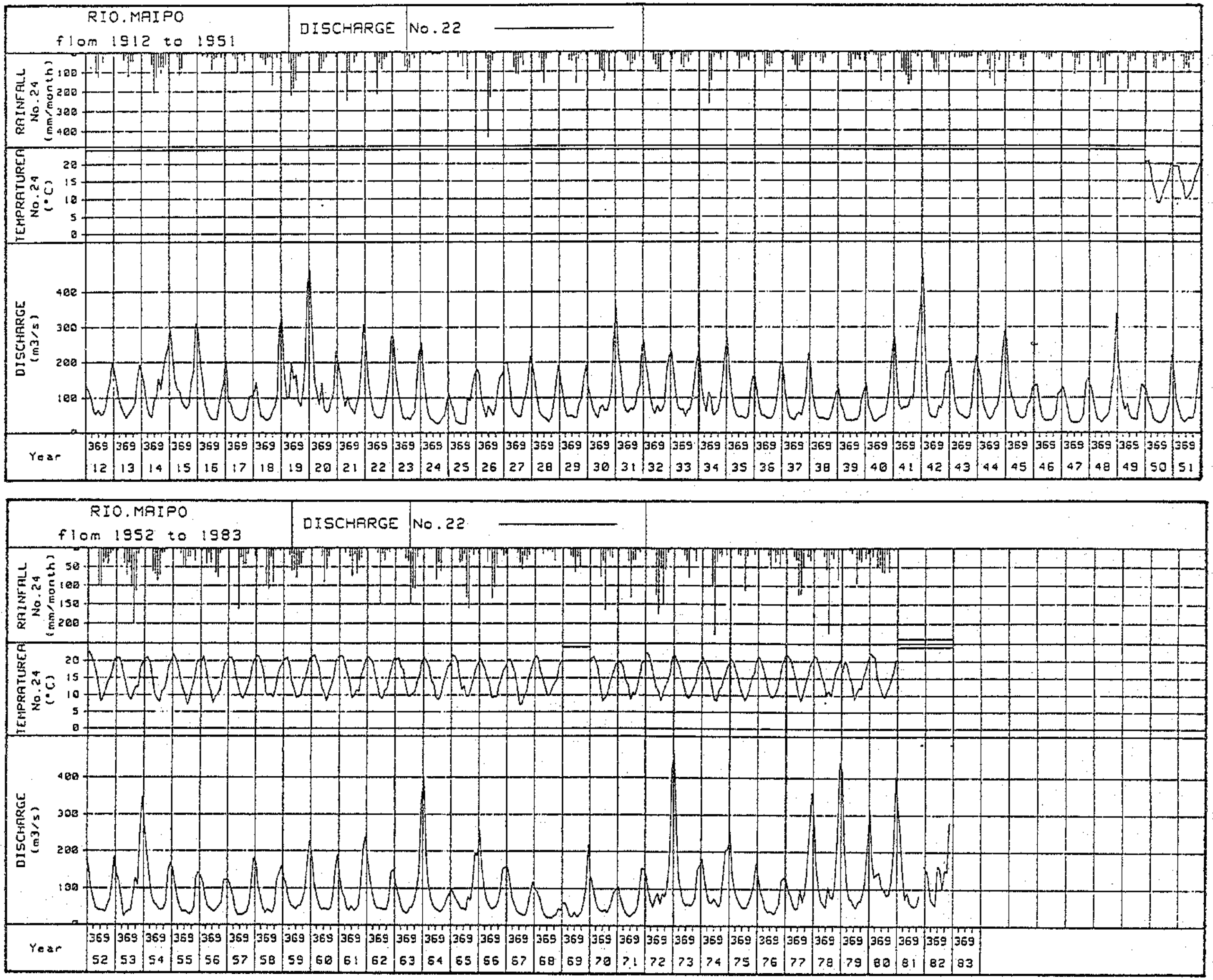


Fig A-3-2 Runoff Characteristics of Maipo River (1)

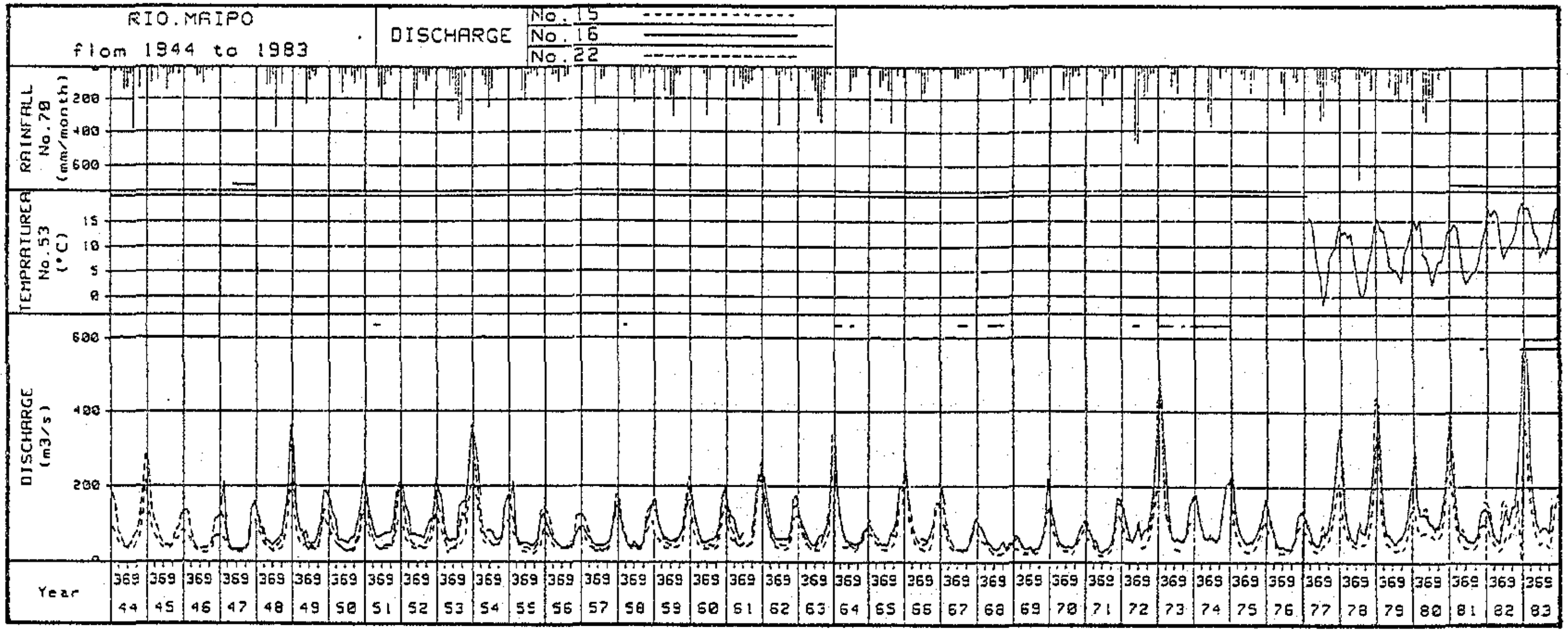


Fig A-3-3 Runoff Characteristics of Maipo River (2)

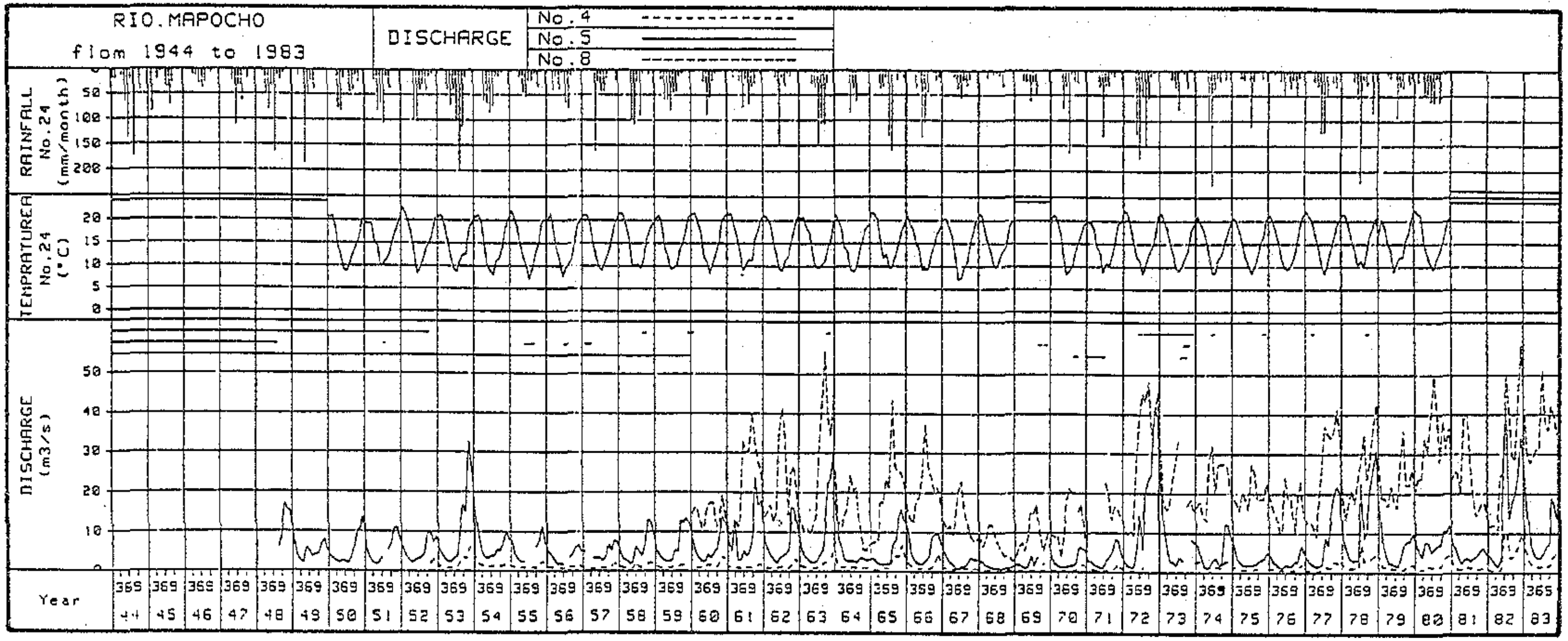


Fig A-3-3 Runoff Characteristics of Mapocho River

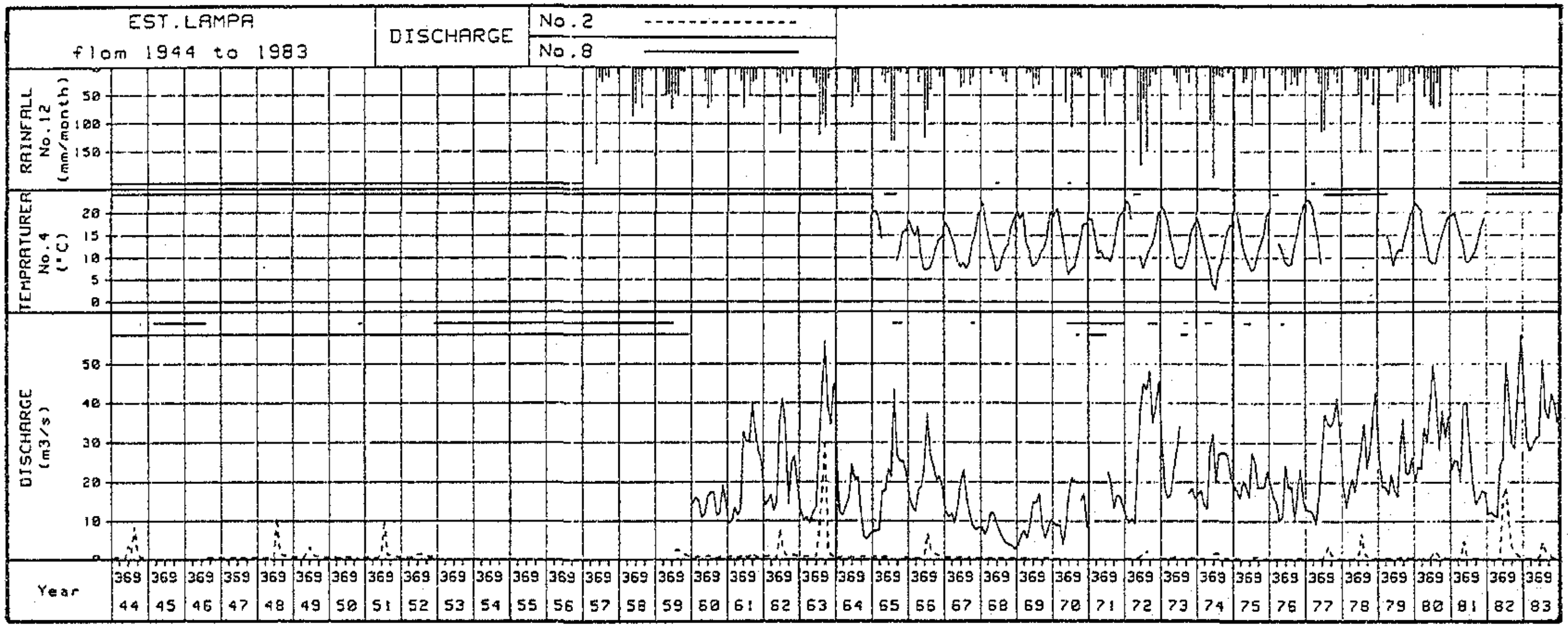


Fig A-3-5 Runoff Characteristics of Lampa River

Appendix 4: Hydrogeology

4.1 Present Groundwater Use and Groundwater Level

4.2 Hydraulic Properties of Permeable Layers

4.3 Study on Groundwater Development

4.4. Consideration and Recommendation

LIST OF FIGURES

4.1 Present Groundwater Use and Groundwater Level

(1) Block-1

There exists an exploitation of non-confined or slightly confined groundwater by means of hand dug wells. The depth of well corresponds to less than 3 m from the terrestrial surface at the flat terrain and to 10 m around the piedmont. The groundwater level is lower than 1 m around the piedmont, deepening gradually towards the east (Mapocho river) up to approx. 9 m. At the foot of the fluvial terrace there are springs. Every exploitation is for domestic use, and for many of them electric pumps are installed.

The groundwater level varies between 20 and 30 cm during the year. There are some wells whose groundwater level rises more than 1 m during summer (irrigation period) within 200 m of distance from Esperanza canal because of the water infiltration. There is a expectancy for the exploitation around the Mapocho river, because it has enough flow and a good quality of water. There is, however, less possibility of exploitation at the inner basin.

(2) Block-2

There are non-confined, semi-confined and confined wells in order of number. The first two types are shallow hand dug wells with a maximum depth of 7 m, and the last one corresponds to deep wells with a depth varying between 50 and 60 m.

In the area of Rinconada de Maipú the groundwater level has about 0.5 m from the surface next to a small stream and raises up to 5 m to the south and to the north; approximately 2 m around the Mapocho river. By the town area of Maipú, it has about 10 m to the eastern side, and approximately 2 m at the central and western sides. This level suddenly decreases down to 3 or 4 m in the surroundings of the Mapocho river, due to the predominance of permeable layers. This level can be found approximately at 5 m from the foot of the volcanic ash hill.

Most of this resources are for domestic use. Many of them are extracted by means of electric small pumps. Only three agricultural families extracts the flow between 60 and 70 l/s of groundwater using medium electric pumps in the eastern limit of the block; this flows are used for irrigating vegetables for crude consumption, which are forbidden to cultivate because they are irrigated with sewage waters. The electric consumption of a medium pump is approximately Ch$ 6,000/month (8hr/day). Related to the fluctuation of the groundwater level, it rises between 0.2 and 1 m at the well located at a distance of 300 m from the canals during summer (irrigation period) and the rest of the wells maintains their level during the whole year. Some shallow wells located nearby the canals, have had smelling waters and bacterium which produce some digestive diseases.

(3) Block-3

Most of the existing wells correspond to shallow well, that collect no-confined and/or slightly confined water. The maximum depth of the wells is about 6 m from the surface in flat terrain and approximately 10 m near the piedmont. The groundwater level is approximately at 3 m to the eastern side of the block and as it goes west, rises up to 1 m in alluvial terrain composed by Las Cruces, Lampa and Carén rivers. On the other hand, the groundwater level decreases down to 5 m at the western sector of Noviciado.

The groundwater is used for domestic and cattle raising purposes. For approximately half of the wells, electric pumps are installed. At the piedmont near the Carén river, exists an exploitation of this resource by means of deep wells. This exploitation is used for the small scale sprinklar irrigation in the wheat or alfalfa fields. The shallow wells located on flat terrain are salt-contaminated, that makes the use very limited, since this location corresponds approximately to the area of water stagnation and of saline and alkaline soil. The shallow wells located near about 200 m inside the canals receive direct infiltration from them, and have a maximum level difference of about 1 m between summer and winter.

(4) Block-4

There is an exploitation of non-confined and semi-confined groundwater by means of shallow wells of less than 3 m depth. On the other hand, there is a development of confined waters by means of deep wells between 60 and 90 m depth in alluvial sediments area of the Lampa and Colina rivers and some areas of Batuco. The groundwater level corresponds to less than 1 m from the surface at the flat terrain in the area between Batuco and Quilicura and varies between 2 and 5 m at the alluvial cones of the Colina and Lampa rivers. The areas of a high groundwater level correspond to problem soil area such as the surrounding of Batuco, Las Cruces river-Los Choros canal, Conchalí and the confluence between the Lampa and Colina river. The main use of this resource is for domestic nature. The deep wells are only for irrigating fruit tree, wheat, alfalfa and vegetables, by some agricultural and capitalist units of a higher agricultural importance, whose capted flow varies between 60 and 150 l/s, and the electric consumption a medium pump fluctuates between Ch$ 1500 and 1800 ha/month (8hr/day).

During the summer (irrigation period), the groundwater level rises up to approximately 0.5 m in shallow wells located at a distance of less than 500 m from the irrigation canals. Nevertheless, the majority of the shallow wells receives direct influence from surface waters and pelitic soil condition, showing a level increase. Between 0.2 and 0.3 m during winter. The shallow wells in plain terrain have a limitation in their use due to the salt contamination and the low permeability to groundwater.

4.2 Hydraulic Properties of Permeable Layers (CORFO-11G,1970 and CNR-1PLA,1984)

In order to make a quantitative evaluation of groundwater resources, the hydrogeologic characteristics of the permeable layers were examined and the results are described below:

(1) Coefficient of Transmissibility (Fig. A-4-7)

Along the present flows of the Colina and Lampa rivers and the old flow of the Mapocho river a high coefficient of transmissibility is found. The highest values between 1,500 and 3,000 m^2/day are in the eastern parte of Block-2 in a strip stretching in a northeast-southwest direction.

Toward the west side of this strip, the values gradually decreases to between 100 and 400 m^2/day except for the around of the Mapocho river channel. Around the middle of the Colina river, there is a gradient higher than 0.4% and values vary between 400 and 800 m^2/day.

The value varies from 100 to 400 m^2/day on flat terrains to below 100 m^2/day in the areas that have water stagnation and saline and alkaline soils.

Along the present flow of the Lampa river there is a strip with values from 800 to 1,500 m^2/day, decreasing toward the east and west to lower than 400 m^2/day.

(2) Coefficient of Permeability

The area with higher coefficient of permeability (10^{-3}m/s) coincides with the good development of permeable layers, such as the surroundings of the middle river course and the beginning of the slight gradient of the Colina river (boundary of Alluvial cone) and the middle channel of the Lampa river. However, the area with lower values of this coefficient (10^{-5}m/s) coincides with a predominance of pelitic soils with less thick permeable layers, such as the surroundings of Batuco and down current of the Colina river, Las Cruces river-Los Choros canal in Quilicura, the Carén river and the Lampa river at Noviciado.

Most of the Study Area shows a uniform coefficient of 10^{-4}m/s.

(3) Specific Discharge

Specific discharge shows a distribution similar to the transmissibility factor. The sectors with a relatively high value (between 10 and 20 l/s/m), correspond to surroundings of the present and old channels of the main rivers due to a predominance of permeable layers.

Nevertheless, most of the Study Area has a value lower than 5 l/s/m. In the small groundwater collector basin in the sector where pelitic layers and lacustrine formations predominate, the value is lower than 2 l/s/m.

(4) Coefficient of Storage

The coefficient of storage in Block-1 is estimated low due to small watershed and poor development permeable layers. In Block-2 around of Maipú town, the range of this coefficient is shown between 0.15 and 0.18 due to relatively good hydraulic characteristic. Blocks-3 and 4 show a value of the coefficient of storage which ranges between 10^{-3} and 10^{-1} due to the presence of the predominance of impermeable layers with little confined groundwater.

4.3 Study on Groundwater Development

(1) Objectives

The objectives of the study in this section were to examine the possibility of the groundwater development to supplement the shortage of existing irrigation waters from the technical and economic view point.

(2) Boring

The boring site was selected on the high fluvial terrace located at the eastern edge of Block-1 along the Mapocho river due to the shortage of irrigation water in this block and hydrological advantages. The boring was carried out with percussion drill and the depth of bore hole was 30 m. The boring log and other collected date are shown in Fig A-4-8.

Rock facies components are mainly gravel and sand. Electric resistibity of the groundwater varies 7.82 to 8.06 ohm-m.

The groundwater levels were -4.10 m in the bore hole and -4.70 m in a domestic well located about 100 m far from the bore hole.

(3) Pumping Test

Ordinarily, the pumping test is conducted using two wells; observation well and pumping well. However, the test was carried out using one well, which is commonly applied in Chile.

In order to obtain reasonable pumping test result,preparatory pumping tests were carried out twice before conducting final pumping test.

The following are the final pumping test result:

Item	Final Pumping Test (Nov.18,1985)
Duration of Pumping (min)	600
Ave. discharge (m^3/hr) (l/s)	37.8 (10.5)
Static water level (m)	-4.10
Water level during pumping (m)	-4.60
Drawdown (m)	0.50

Based on the results of final pumping test, the coefficients of transmissibility and permeability can be obtained with the following formula widely used in Chile.

$$T = \frac{1}{2\pi} \times \log e\left(\frac{R}{r}\right) \times \frac{Q}{\Delta} \times \frac{86,400}{1,000}$$

$$K = \frac{T}{d} \times \frac{1}{86,400}$$

where:

- T: Coefficient of transmissibility (m^2/day)
- K: Coefficient of permeability (m/s)
- R: Radius of influence (=220 m)
- r: Effective radius of well (=0.2 m)
- Q: Discharge (l/s)
- Δ: Drawdown (m)
- d: thickness of permeable layer (=25.9 m)

Therefore,

$$T = \frac{1}{2\pi} \times \log e\left(\frac{220}{0.2}\right) \times \frac{Q}{\Delta} \times \frac{86,400}{1,000}$$

$$= 96.26 \times \frac{Q}{\Delta}$$

$$= 96.26 \times \frac{10.5}{0.5}$$

$$\fallingdotseq 2,000 \ m^2/day$$

$$K = \frac{T}{d} \times \frac{1}{86,400}$$

$$= \frac{2,000}{25.9} \times \frac{1}{86,400} \fallingdotseq 8.9 \times 10^{-4} \ m/s$$

(4) Development of Groundwater

T value obtained (2,000 m^2/day) is in the retatively high zone (1,500 - 3,000 m^2/day) which distributes from the south of Santiago city to Padre Hurtado and others. K value obtained (8.9×10^{-4} m/s) is the similar values observed in the Study Area.

On the same terrace, EMOS also carried out the pumping test by boring a well of 30 m deep. The test result by EMOS is similar to that of ours. The water volumes being developed in Maipú range from 80 to 150 l/min per well (ø100).

Judging from the observations at the site and hydrogeological conditions around the area along the Mapocho river,it may be possible to develop groundwater of $1m^3$/min (ø 200mm) per well in Block-1. However, the development of about $0.5m^3$/s groundwater and/or underflow water will be the limit due to the limited watershed and permeable water from the Mapocho river.

(5) Development Cost (for $1m^3$/min)

The groundwater development cost was estimated for reference as fallows:

1) Construction cost (Fig. A-4-10)

a.Conditions
-Boring depth :50 m
-Bore hole :ø200 mm

-Submergeble pump : ø100 mm
-Discharge pipe : ø200 mm
-Distribution distance :1.5 Km (average)

-Difference of elevation between well and existing Esperanza Alto canal : 20 m

b.Estimation

	(10^3 Ch$)
-Boring operation (90×10^3/m x 50 m) (including temporary works,boring, installation of casing pipe,pumping test, hauling excavated materials etc)	:4,500
-Transportation	: 500
-Installation of distribution pipe 2,000 /m x 1,500 m	: 3,000
-Installation of pump unit	: 500
.Casing pipe (12×10^3 /m x 1,500 m)	: 600
.Pump unit	: 1,500
.Distribution pipe including attatchment (15×10^3 /m x 1,500 m)	:22,500
Sub-total	33,100
-Indirect cost (25%)	8,275
Total	41,375

2) Operation and Maintenance

a. Conditions

- Cleaning of well, Arrangement of pumping facilities and Distribution pipes,

b. Estimation (per year) (10^3 Ch$)

- Direct cost	:	1,300
- Indirect cost (30%)	:	390
Total		1,690

4.4 Consideration and Recommendation

(1) Consideration

To determine the developable water amount, the pumping tests with the ordinary method, detailed by hydrogeological survey and the detailed analysis using the data obtained from the above tests and survey. In general, the groundwater potenciality in this block will be low due to existing few and thin permeable layers.

The ground settlement has been observed in the areas where the groundwater development is being conducted excessively. Therefore, the careful attention should be paid to the groundwater development of great amount from the technical, social and environmental view points.

(2) Recommendation

1) The legal systems to clarify the relationship between land tenure and groundwater rights and regurations to control the development of groundwater should be established urgently.

2) In order to utilize the valuable groundwater effectively and to control its use, an organization should be established.

3) It is recommended to collect tax from the users of groundwater, which shall be utilized for the conservation and control of groundwater resources.

4) Subsurface groundwater should be used supplimentally for small-scale irrigation (20 - 30 ha) due to its limited amount.

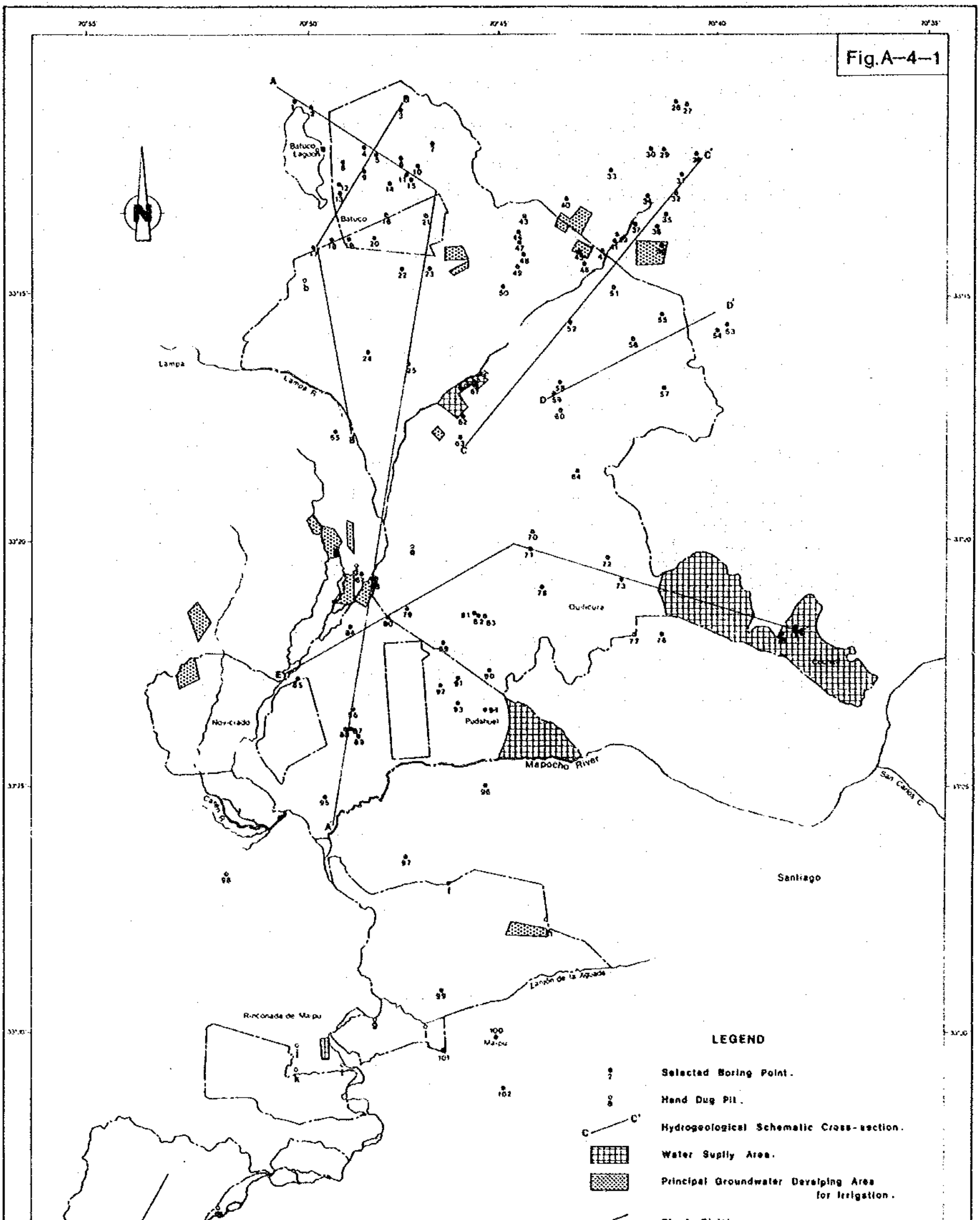
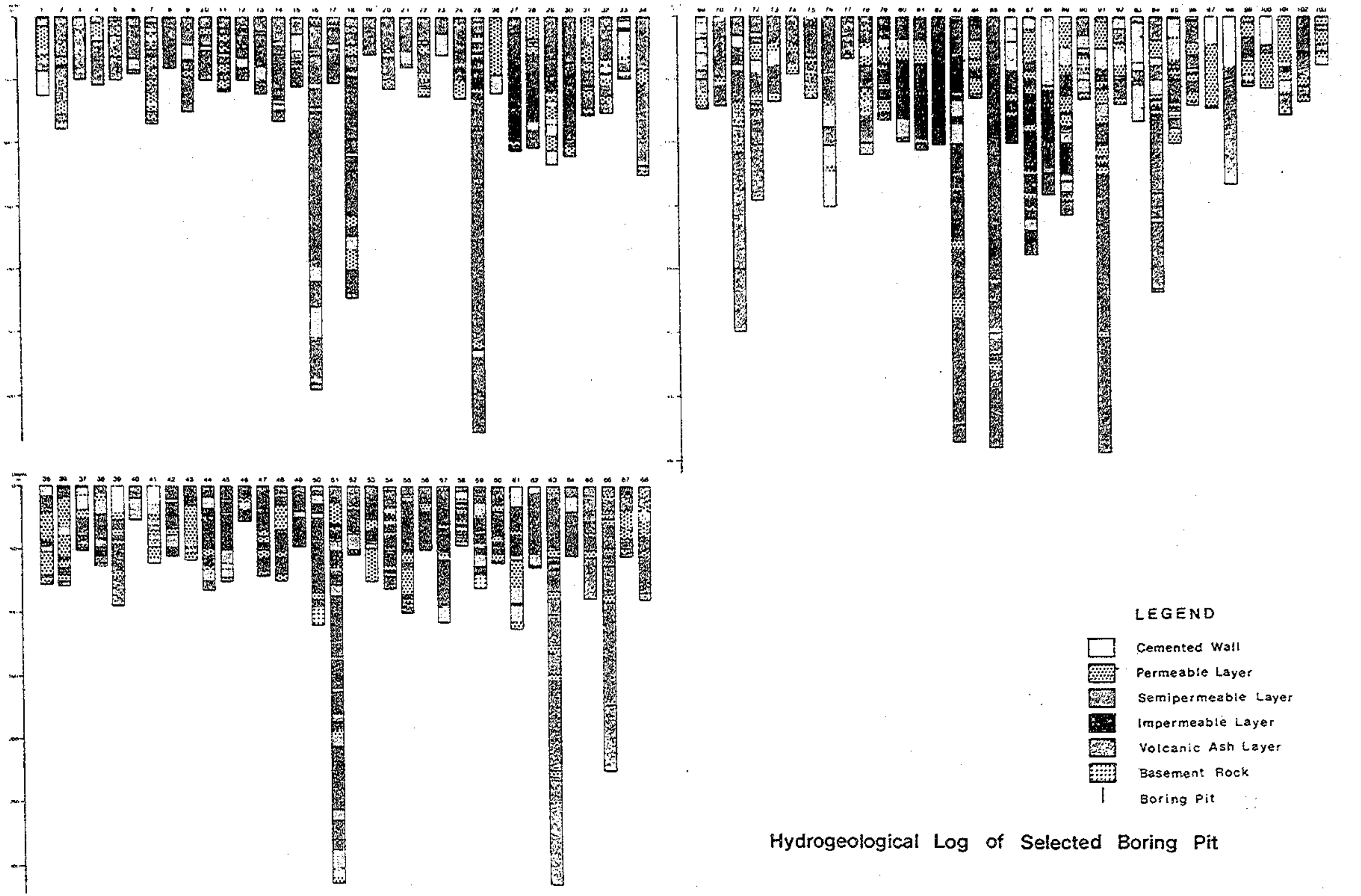


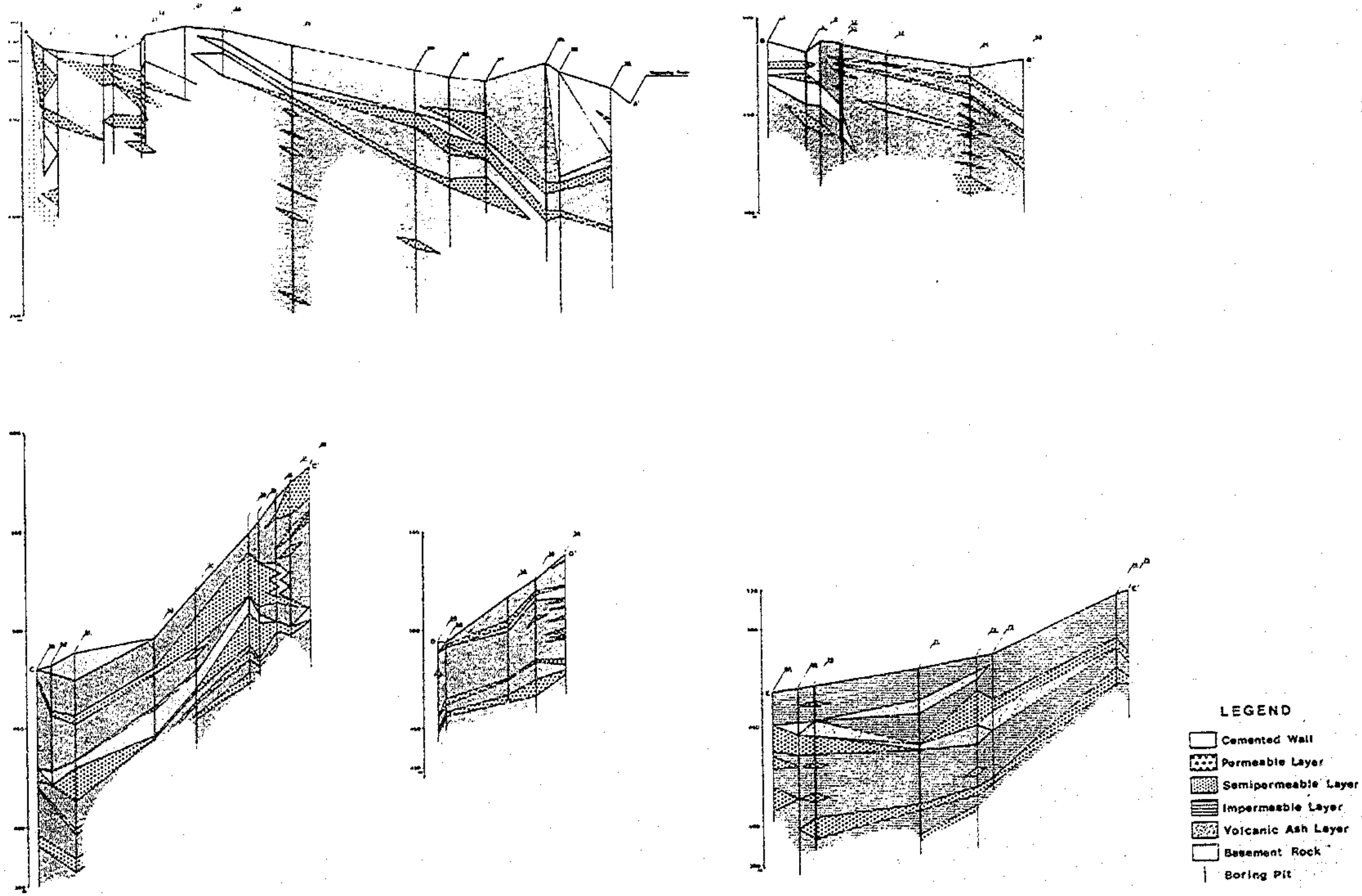
Fig.A–4–1
Batuco Lagoon
Batuco
Lampa
Lampa R.
Quilicura
Noviciado
Pudahuel
Mapocho River
San Carlos C.
Santiago
Zanjón de la Aguada
Rinconada de Maipu
Maipu
Padre Hurtado
Mapocho River
Scale
LEGEND
Selected Boring Point.
Hand Dug Pit.
Hydrogeological Schematic Cross-section.
Water Suplly Area.
Principal Groundwater Develping Area for Irrigation.
Block Division.
Location Map of Boring Points

Fig. A-4-2



Hydrogeological Log of Selected Boring Pit

Fig. A—4—3



Shematic Hydrogeolgical Cross Section

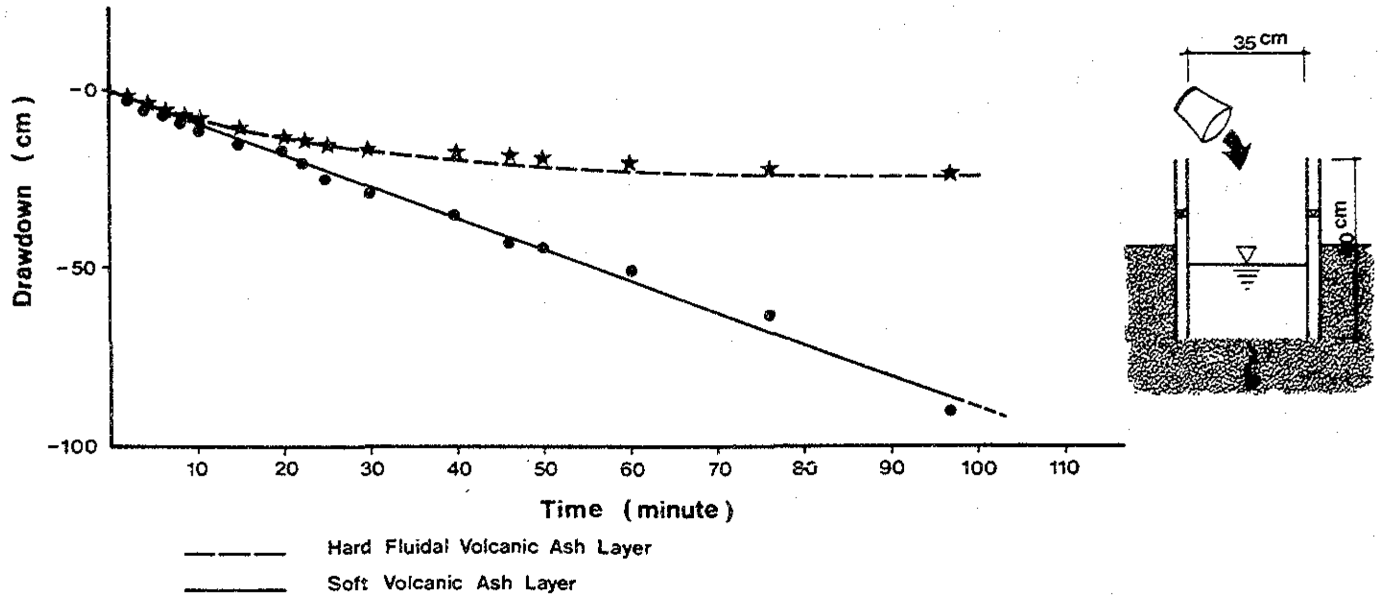


Fig. A–4–4 **Infiltration Characteristic of Volcanic Ash**

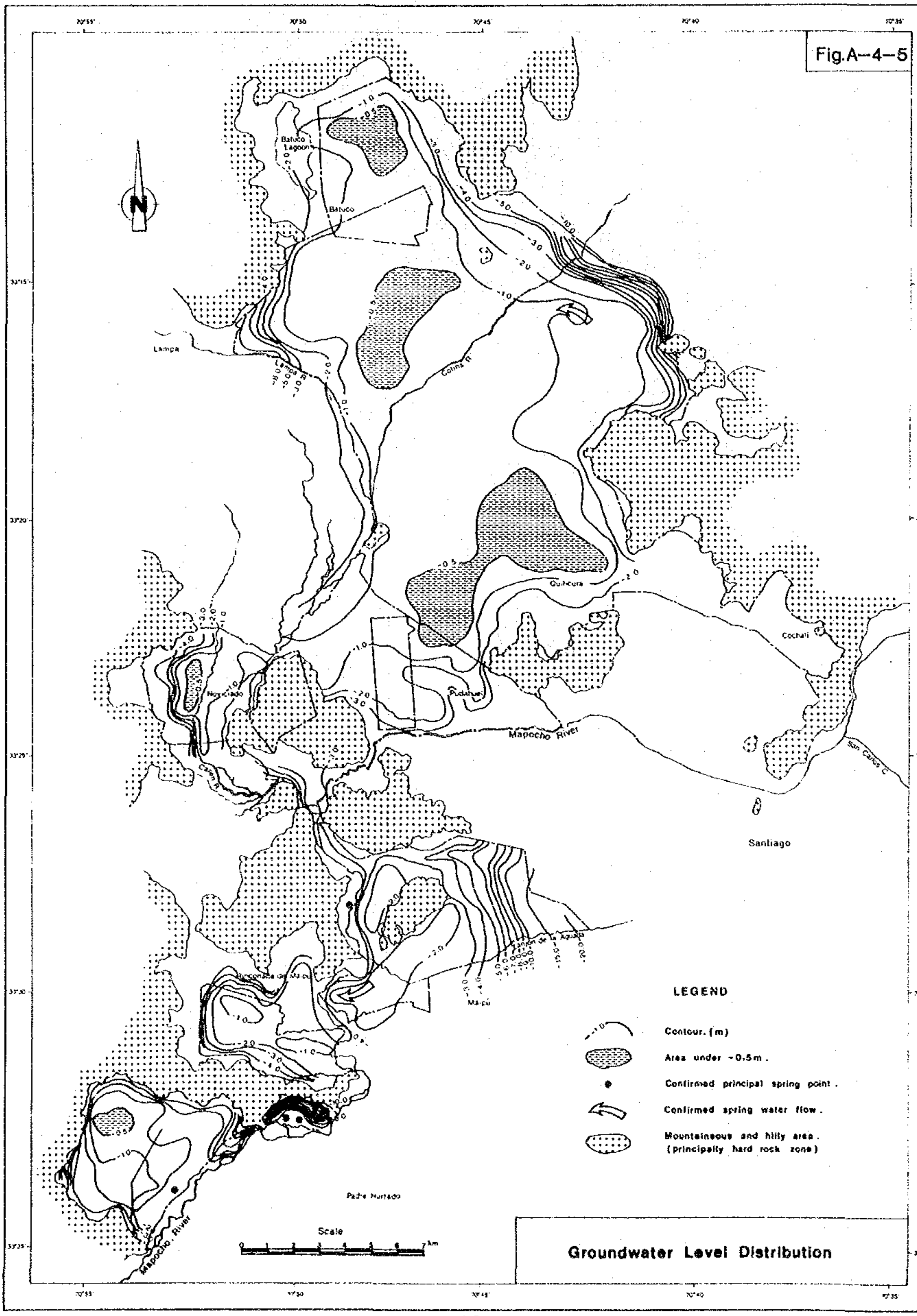


Fig.A-4-5
Batuco Lagoon
Batuco
Lampa
Lampa R.
Colina R.
Noviciado
Quilicura
Cochali
Pudahuel
Mapocho River
Carén R.
San Carlos C.
Santiago
Rinconada de Maipú
Cañon de la Aguada
Maipú
Padre Hurtado
Mapocho River
Scale
LEGEND
Contour. (m)
Area under -0.5m.
Confirmed principal spring point.
Confirmed spring water flow.
Mountaineous and hilly area. (principally hard rock zone)
Groundwater Level Distribution

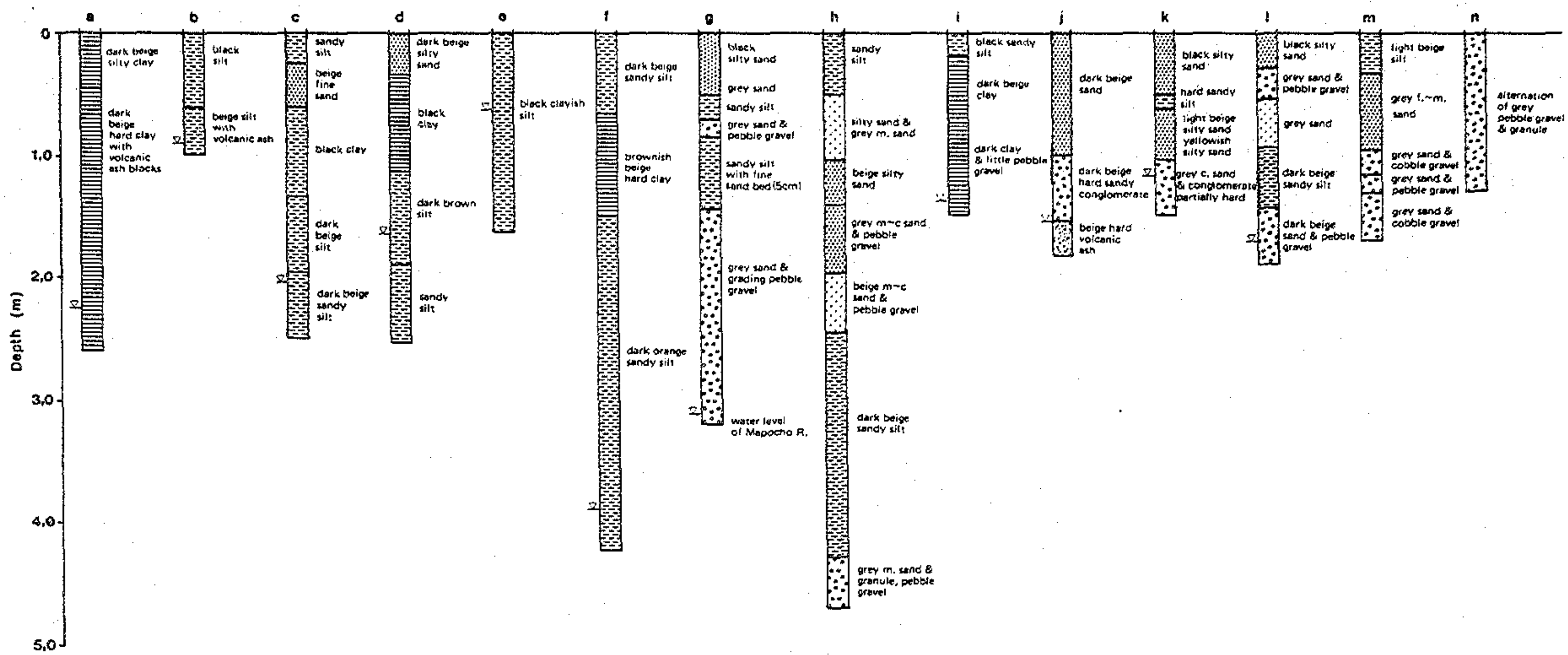
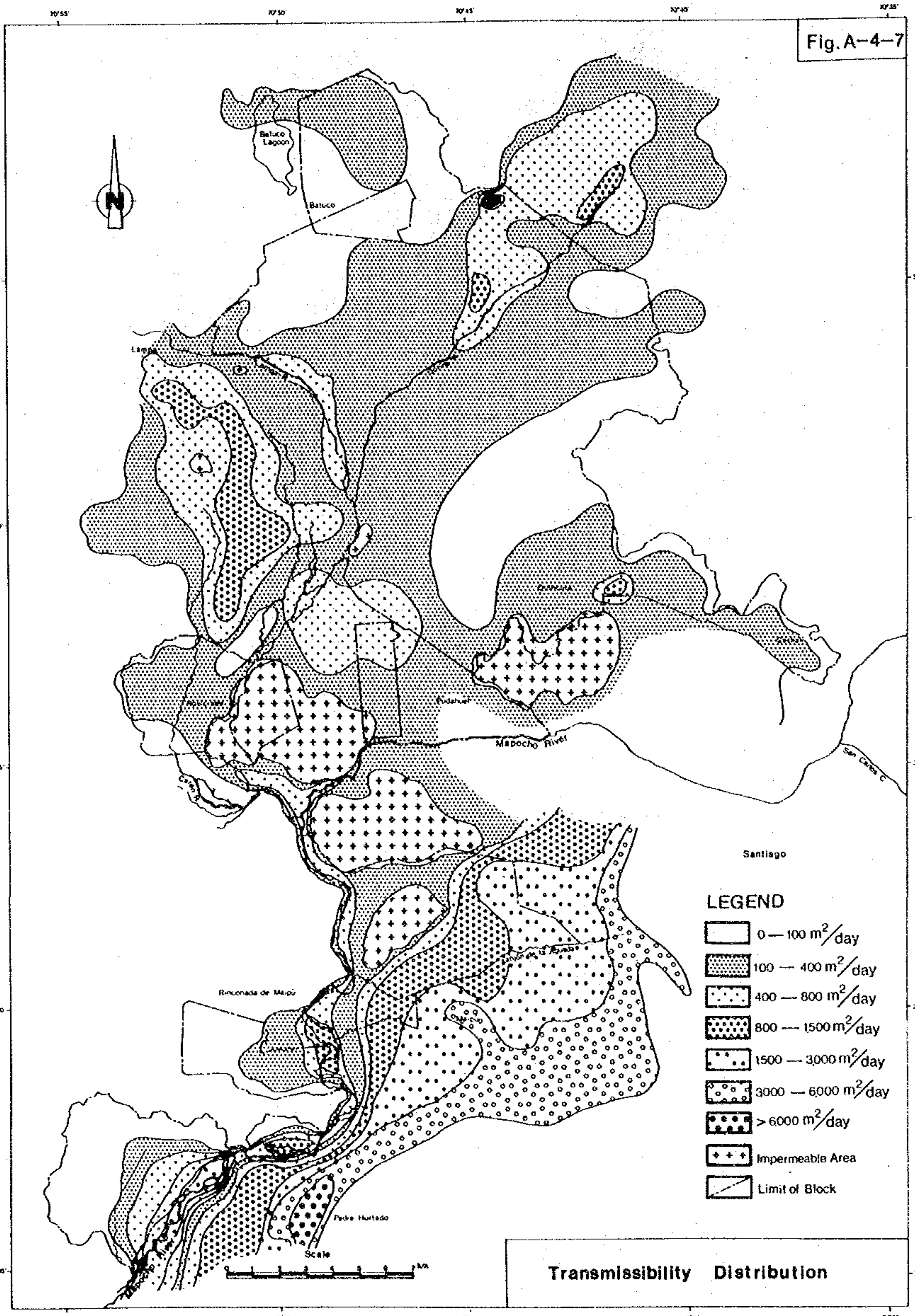


Fig A-4-6 Hand Dug Pit Columnar Section

Fig. A-4-7



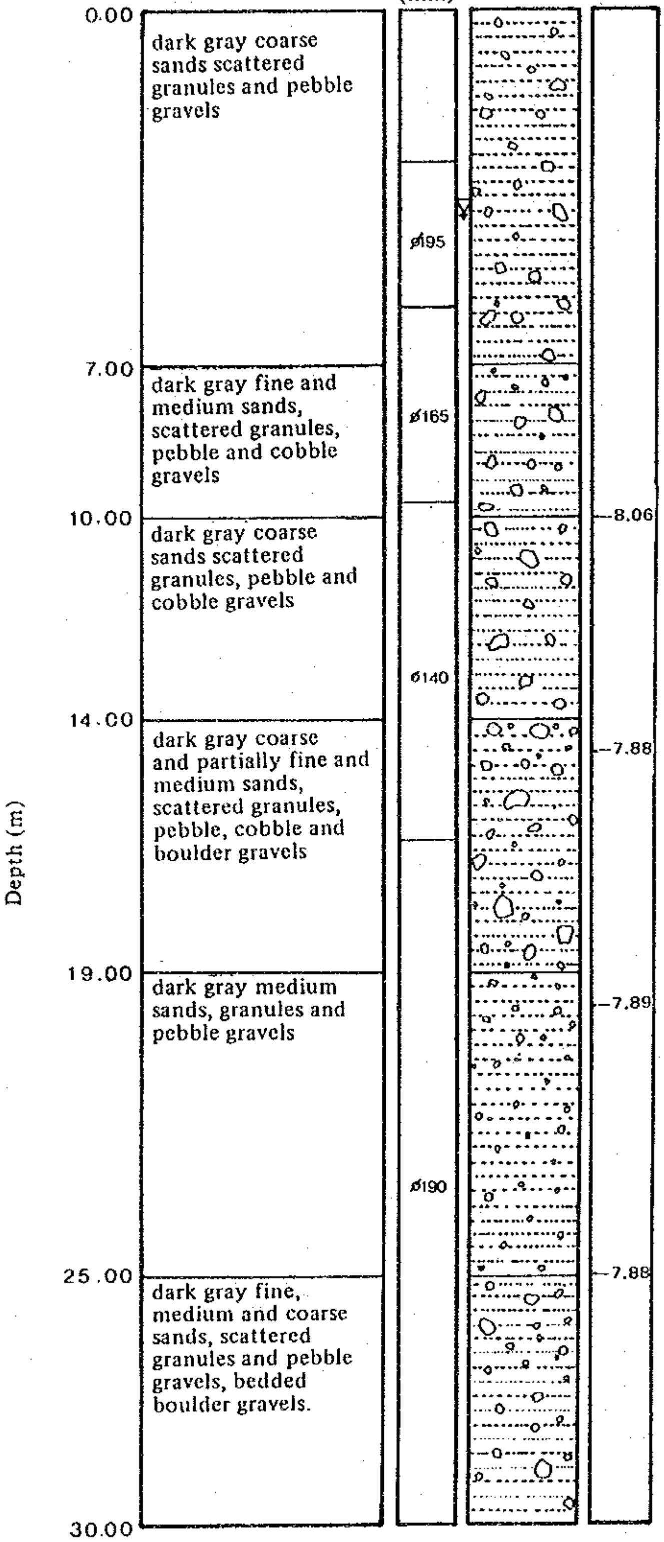
Transmissibility Distribution

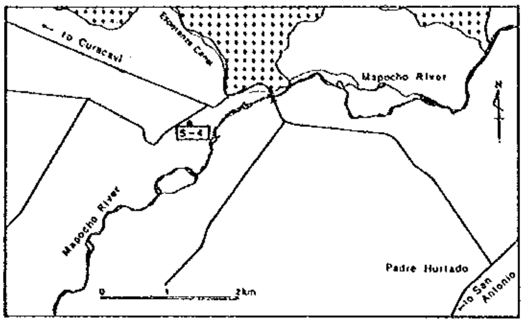
Fig. A-4-8 Boring Log at Padre Hurtado

Study Name : Boring for groundwater development
Boring Point : Padre Hurtado Sector

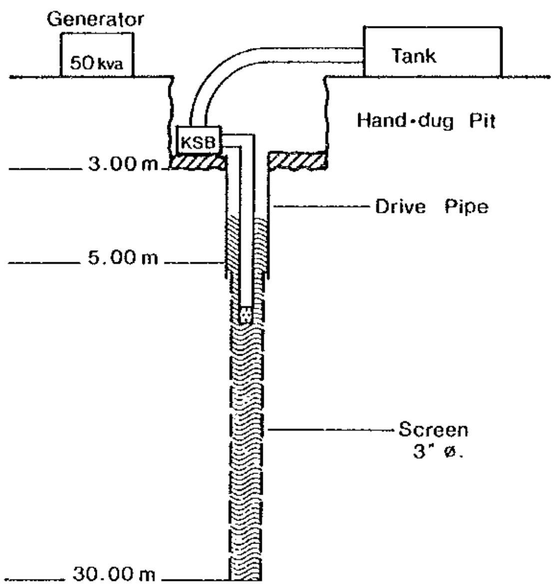
Depth (m)	Observation	E.R Ω-m
0.00 – 7.00	dark gray coarse sands scattered granules and pebble gravels	
7.00 – 10.00	dark gray fine and medium sands, scattered granules, pebble and cobble gravels	
10.00 – 14.00	dark gray coarse sands scattered granules, pebble and cobble gravels	8.06
14.00 – 19.00	dark gray coarse and partially fine and medium sands, scattered granules, pebble, cobble and boulder gravels	7.88
19.00 – 25.00	dark gray medium sands, granules and pebble gravels	7.89
25.00 – 30.00	dark gray fine, medium and coarse sands, scattered granules and pebble gravels, bedded boulder gravels.	7.88

Caliber (mm): ø195, ø165, ø140, ø190





Location Map



Scheme of Installation

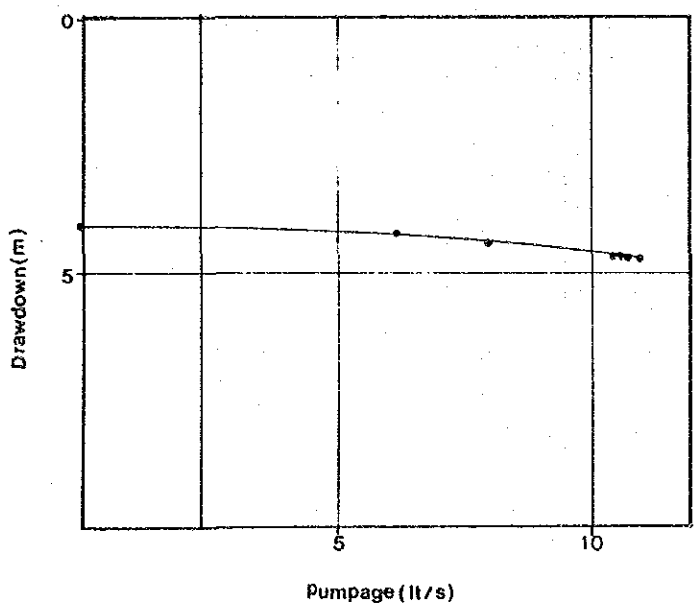
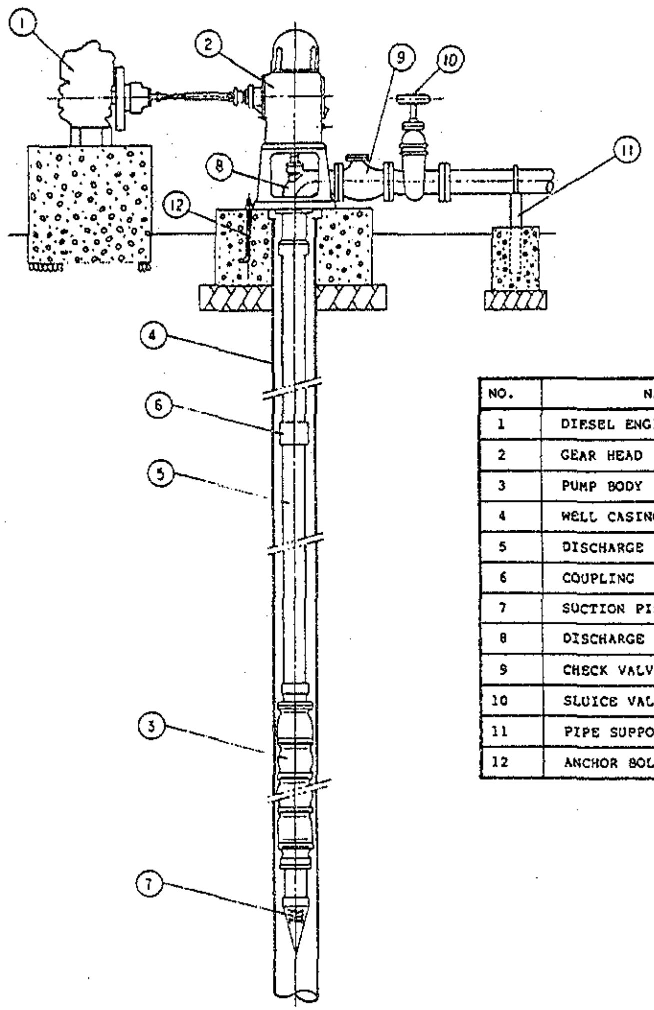


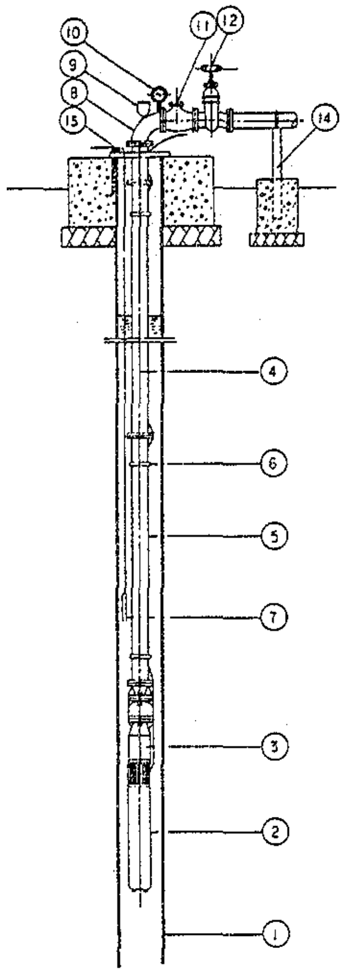
Fig.A-4-9   Pumping Curve of Final Pumping Test

INSTALLATION OF VERTICAL TURBINE PUMP



NO.	NAME
1	DIESEL ENGINE
2	GEAR HEAD
3	PUMP BODY
4	WELL CASING
5	DISCHARGE PIPE
6	COUPLING
7	SUCTION PIPE
8	DISCHARGE ELBOW
9	CHECK VALVE
10	SLUICE VALVE
11	PIPE SUPPORT
12	ANCHOR BOLT

INSTALLATION OF SUBMERSIBLE PUMP



NO.	NAME
1	WELL CASING
2	SUBMERSIBLE MOTOR
3	PUMP BODY
4	DISCHARGE PIPE
5	SUBMERSIBLE CABLE
6	CABLE CLIP
7	WATER LEVEL ELECTRODE
8	90° BEND PIPE
9	AUTO AIR VALVE
10	PRESSURE GAUGE
11	CHECK VALVE
12	SLUICE VALVE
13	WELL COVER
14	PIPE SUPPORT

Fig. A-4-10 **Type of Pump Station**

Appendix 5: Soil

5.1 Description of Soil Properties of Soil Classification

5.2 Contaminated Soil

5.3 Soils-land Classification

5.4 Gypsum Requirement

LIST OF TABLES

LIST OF FIGURE

5.1 Description of Soil Properties.

The soils in the study area are classified into 13 soil sub-orders. The soil characteristics are shown in Table A-5-1. The brief description is as follow.

(1) CALCIXEROLLIC XEROCHREPTS

This type soil spreads in the middle part of the Block-1 area.The soil consists mainly of soil, of which effective thickness is ranging from 40 cm to 70 cm. The pH value of the soil is approximately 8.2 which means medium or slightly basic. Electric conductivity shows 1.0 mmhos/cm in top layer and 1.5 mmhos/cm in lower layer. Permeability of the soil is in medium grade. The land of this soil is used as upland field or pastures.

(2) XERIC DURANDEPTS

The soil of this type is originated from volcanic ash and located in hilly area of Blocks-1,2 and 3 Soil texture is of sandy loam, of which pH value is between 6.8 and 7.0. The area dominated by this soil in the Block-1 is partly of poor drainage. However, in the Blocks-2 and 3 soil has a relatively y good permeability and is of well-drained. Therefore, the area in vicinity of the University in the Block-2 currently being used as upland field while the remaining area is mostly utilized as pastures.

(3) MOLIC HAPLAQUEPTS

The soils are mainly found in Block-1. The soil property of this type is of clay loam, of which effective thickness varies from 40 cm to 70 cm, pH value of the soil shows from 7.5 to 8.1 and electric conductivity is o to 2.0 mmhos/cm and slightly higher than normal. The area is of poor drained and low permeability. Presently, the area is being used as pastures or upland cultivation.

(4) TYPIC XEROCHREPTS

This soil is widely distributed in the area, scattered in the Blocks-1,2,3 and 4. The soil is mainly composed of sandy loam or clay loam except the soil belongs to the Lampa soil series found in the Block-1, which is composed of loamy sand. Effective thickness is mostly over 40 cm, pH value varies from 8.5 to 9.0 incresing by the depth and electric conductivity is generally less than 1.0 mmhos/cm. Most of the area is presently being used as upland field, while the area of Lampa soil series is being utilized as pastures.

(5) VERTIC XEROCHREPTS

The area of the soil is 5,660 ha in the Study Area, which is located along the Mapocho River and its neighboring area. The soil is clay loam, effective thickness is more than 70 cm. The pH value is neutral and its electric conductivity is in level of 1.5 mmhos/cm. Most of the area is being used as upland field because the top-soil is of rich in organic matter.

(6) TYPIC DUROCHREPTS

The soil spreads in the Blocks-2 and 3 covering only 320 ha. The soil is mainly distributed in periphery of the land of CALCIXEROLLIC XEROCHREPTS. The soil property is of clay loam, of which effective depth is ranging from 20 cm to 70 cm. The pH value is 5.7 - 6.6 whick means high acidity. The electric conductivity is low at 0.5 mmhos/cm. Currently, the area is being utilized as pastures.

(7) FLUVENTIC XEROCHREPTS

The soil of this type is distributed in the area 1,480 ha, and consists of mostly clay loam. The pH value is nearly neutral . The electric conductivity is high as 4 - 10 mmhos/cm for the surface layer while low as 4-3 mmhos/cm for the lower layer. Effective soil depth is more than 70 cm and its permeability is relatively high and imperfectly to moderately well drained. Presently, most of the area is used as upland field.

(8) TYPIC HAPLOXERALFS

The soil of this type is distributed in the area of 1,180 ha, on the western side of a airport and along the Mapocho River. The nature of the soil is of mostly loam, more than 90 cm for the effective depth, around 7.5 and neutral for the pH value, 0.9 - 1.3 mmhos/cm for the electric conductivity and imperfect to well drained. Currently, the most of the area is being used as upland field.

(9) PALEXEROLLIC CHROMOXERERTS

The soil of this type is distributed in the area of 7,100 ha , which is located in vicinity of urban area of Batuco in the Block-4 and western side of the Pan American Highway in the Block-3 . The nature of the soil is of fine texture, mostly 40 to 90 cm for the effective depth, more than 9.0 for the pH value and 2 - 12 mmhos/cm with high basic for the electric conductivity. The saline soil is mainly distributed in the area north from the city of Batuco and along the Colina River. The permeability is low and generally poor drained. The vegetation is scarce except low bushes such as acasia in the area. Therefore, most of the area is occupied by natural grass land.

(10) CHROMIC PALLOXERERTS

The soil of this type is distributed in the area of 1,520 ha,which is located in southern parts of the military base of the Block-4. The nature of the soil is clay, more than 8.5 of the pH value EC of 4 - 8 mmhos/cm and comparatively imperfectly well drained. So me saline and aklaline soils are found on the poor drained land . The land of saline and alkaline soil is being used as pastures and rest of the area is as upland field.

(11) TYPIC PELLOXERERTS

The soil of this type is distributed in the area of 3,530 ha,which are located in the neighboring area of the Pan American Highway and the Colina River in Block-4. The pH value of the soil is 8.5-9.5 and the electric conductivity is 0 - 8 mmhos/cm, both of which increase higher as the area being far from the Colina River. The soil is clay loam to clay, and effective depth of the soil is over 70 cm of the areas is covered by poor drained soil and vulne rable to flooding. Therefore, this area is being used as natural pastures.

(12) TYPIC HAPLAQUENTS

The soil of this type is distributed in the area of 180 ha, which is located in the area between the Pan American Highway and north easterns parts of Quilicura in the Block-4. The soil consists of loam, and effective depth of the soil layer is mostly about 70 cm. The pH value of the soil is ranging between 9.5 and 10.0 and elec tric conductivity is 8 - 12 mmhos/cm. Presently, the area is being utilized as pastures.

(13) AERIC HAPLAQUENTS

The soil is distributed in the area of 1,800 ha, which is located along the Pan American Highway, eastern part of the military zone in the Block-4. The soil is mainly loam. Effective depth of the soil layer is 20 to 90 cm and pH value is 7.7 - 8.0. The permea bility is medium level. Currently, most of the area is being used as upland field. Location of survey points are given in Fig. A-5-1 and the areas are presented in Table A-5-2. Table A-5-3 shows the result of soil physico-chemical analysis and area of the problem soil, i.e. *saline-alkaline soil and contaminated soil,are* presented in Tables A-5-4, A-5-5 and section 5.2.

Table A-5-1 Soil Charecteristics of the Study Area.

Symbol	Soil Sub-Group	Soil Series	Topography	Soil Properties						
				Texture	Drainage	Gravel content (%)	Effective Depth (cm)	Salinity (mmhos/cm)	Alkali Value (Na %)	Available Water Capacity (cm)
FL	Fluventic Xerochrepts	Quilicura (QLC)	Flat Alluvial plain	CL	Imperfect	Negligible	70 - 90	4 - 8	10 - 25	9.5 - 18
		Taqueral (TAQ)			Moderate			0 - 12	10 - 15	
TYX	Typic Xerochrepts	Piedmont cuesta de Lo Vial (PTB)	Flat alluvial land	SL	Well			0 - 2	0 - 10	
		Terrazas Aluviales Estratificadas (TE2)		L	Moderate		40 - 70			
		Colina (CNA)		CL - L	Well	15% >	70<			
		Santiago (STG)		SL		Negligible	40 - 70			
		Lampa (LMP)		LS			20 - 90	0 - 8		
		Liray (LRA)					90<	0 - 2		
		Rinconada de Lo Vial (RLV)		CL	Moderate		40 - 90			
		Maipo (MAO)		L	Well		90<			
		Chicauma (CHC)	Gentle Alluvial land	C			70 - 90			
CA	Calcixerollic Xerochrepts	Agua de Gato (AGO)	Flat	CL	Imperfect		40 - 70			
TYD	Typic Durochrepts	Pudahuel (PUD)	Alluvial land		Moderate		20 - 70			
VE	Vertic Xerochrepts	Mapocho (MPC)			Well to moderate		70<	2 - 4		
MO	Mollic Maplaquepts	Valdivia de Paine (VAP)	Flat Alluvial land or depression		Imperfect		40 - 70	0 - 2		
TYH	Typic Haplaquents	Cotuba (COU)			Poor			8 - 12	15 - 40	
AE	Aeric Haplaquents	Chape (CHE)		L	Moderate to imperfect		20 - 90	2 - 4	0 - 10	
PA	Palexerollic Chromoxererts	Batuco (BTC)	Flat alluvial land	SiC-SC			70 - 90	2 - 12	0 - 40	9.5 >
		Totoral (TTR)			Poor		40 - 70	8 - 12	40 <	9.5 - 18
		Peralillo (PRE)		C	Poor to imperfect			0 - 12	0 - 40	
		La Vilana (VLA)		SiC-SC	Poor		70 - 90	4 - 12	15 - 40	
TYP	Typic Pelloxererts	Urraca (URR)		C-CL	Poor to well		70 <	0 - 8	0 - 25	
CH	Chromic Palloxererts	Chincolante (CLT)		SiC-C	Imperfect		70 - 90	4 - 8	15 - 25	9.5 >
TY	Typic Haploxeralfs	Barrancas (BRR)		L	Imperfect to well		90 <	0 - 2	0 - 10	9.5 - 18
XE	Xeric Durandepts	Alhue (AHE)	Flat to gentle Upland	SL	Moderate to well		20 - 90			

Table A-5-2 Area of Classifield Soil

(unit: ha)

Symbol	Classification	Block				TOTAL
		1	2	3	4	
CA	Calcixerollic Xerochrepts	810	-	-	-	810
XE	Xeric Durandepts	140	820	775	-	1.735
MO	Mollic Haplaquepts	1.020	-	-	-	1.020
TYX	Typic Xerochrepts	690	1.260	340	3.470	5.760
VE	Vertic Xerochrepts	-	2.100	390	3.010	5.500
TYD	Typic Durochrepts	-	210	140	-	350
FL	Fluventic Xerochrepts	-	-	710	770	1.480
TY	Typic Haploxeralfs	-	-	1.105	-	1.105
PA	Palexerollic Chromoxererts	-	-	1.560	5.400	6.960
CH	Chromic Pelloxererts	-	-	-	1.420	1.420
TYP	Typic Pelloxererts	-	-	-	3.650	3.650
TYH	Typic Haplaquents	-	-	-	170	170
AE	Aeric Haplaquents	-	-	-	1.770	1.770
SW	Swamp or swampy land	-	-	250	890	1.140
-	Others *	90	200	120	450	860
U	Urban area	120	320	270	1.500	2.210
	T O T A L	2.870	4.910	5.660	22.500	35.940

*Note: * The land includes farm house, farm road, canal, etc.*

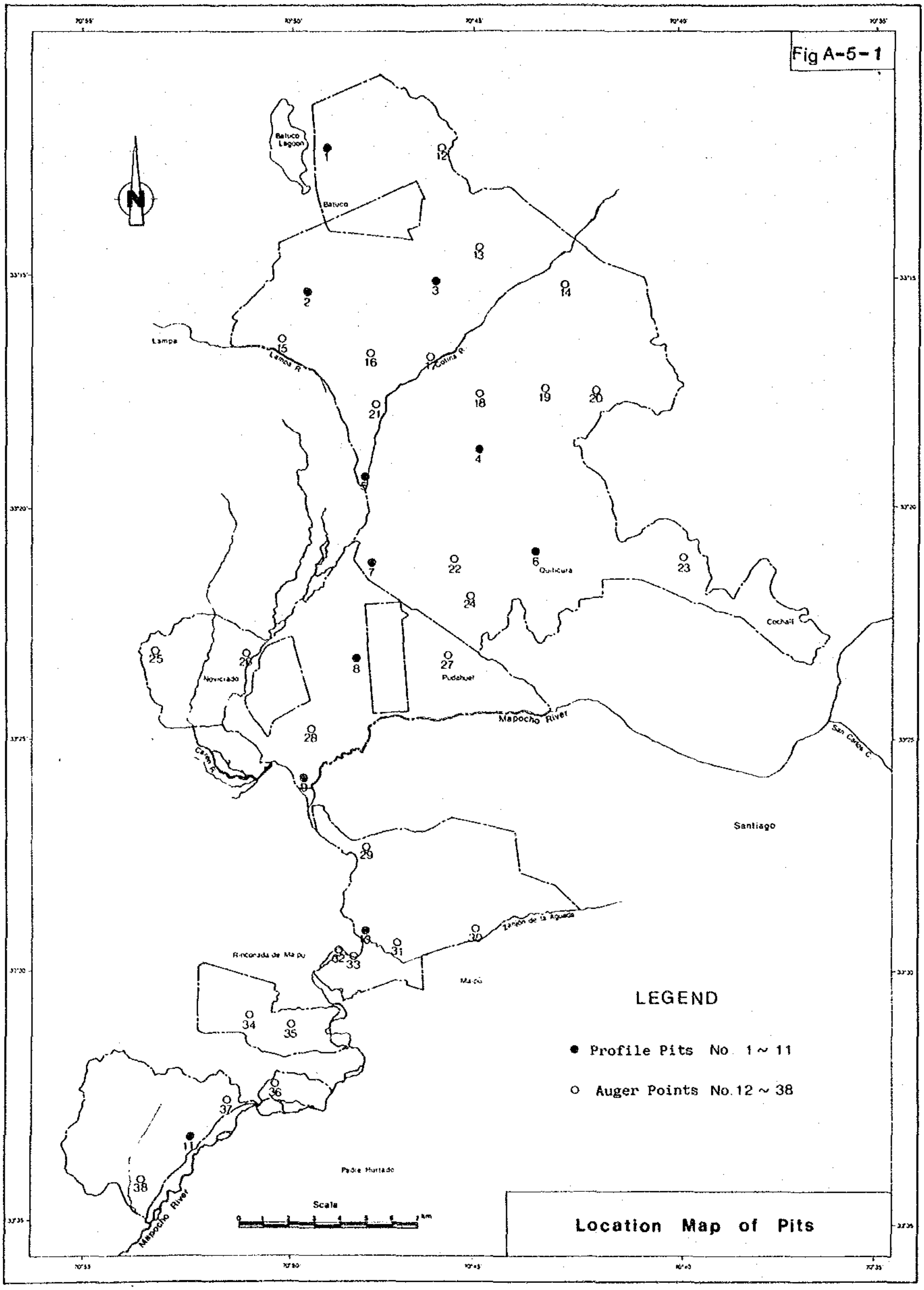


Fig A-5-1
Batuco Lagoon
Batuco
Lampa
Lampa R.
Colina R.
Quilicura
Cochali
Novicrado
Pudahuel
Mapocho River
San Carlos C.
Santiago
Zanjon de la Aguada
Rinconada de Maipu
Maipu
Padre Hurtado
Mapocho River
Scale
LEGEND
Profile Pits No. 1 ~ 11
Auger Points No.12 ~ 38
Location Map of Pits

Table A-5-3 Physical and Chemical Properties

Soil Classification	Pits No.	Depth (cm)	Particle Size Distribution (%) Sand	Silt	Clay	Texture	Permeability[1/] (cm/sec)	Apparent Specific Gravity (g/cm^3)	Humus (%)	pH	EC (mmhos/cm)	Exchangeable Cations Ca	Mg	K	Na	Available P_2O_5	T/N
1. Calcixerollic Xerochrepts	14	0-20	15.7	53.4	30.9	SL	1.7×10^{-2}	1.5	5.9	7.9	1.0	-	-	1.0	2.3	0.1	0.3
		20-50	25.4	41.2	33.4	SL	3.3×10^{-2}	1.3	13.0	8.2	1.5	-	-	0.1	2.1	-	-
	27	20	-	-	-	SL	"	-	5.9	7.9	1.4	-	-	1.0	2.3	0.1	0.3
2. Xeric Duranpts	13	0-20	58.5	24.7	16.8	CL	3.7×10^{-2}	1.6	-	7.0	0.5	-	-	0.3	0.3	-	-
		20-50	69.7	19.5	10.8	CL	6.7×10^{-2}	1.5	-	6.8	0.5	-	-	0.2	0.3	-	-
3. Molic Haplaquepts	15	0-20	30.4	58.3	11.3	SL	1.7×10^{-2}	1.7	-	8.1	1.0	-	-	0.7	0.5	-	-
		20-50	23.8	56.1	20.1	SCL	3.3×10^{-2}	1.5	-	7.5	2.0	-	-	0.3	1.8	-	-
4. Typic Xerochrepts	10	0-20	43.8	39.5	16.7	L	6.7×10^{-2}	1.7	-	8.0	0.9	-	-	0.3	0.2	-	-
		20-40	25.6	45.0	29.4	L	1.0×10^{-1}	1.7	-	7.9	0.7	-	-	0.2	0.9	-	-
		40-60	41.2	34.0	24.8	CL		1.8	-	7.5	0.6	15.4	1.6	0.2	0.6	-	-
		60-80	51.4	26.9	21.7	L		1.8	-	7.5	0.6	14.3	1.7	0.2	0.5	-	-
	3	0-10	-	-	-	CL	2.0×10^{-3}	1.3	4.1	-	0.7	16.9	4.5	0.4	0.6	0.01	0.3
		10-20	33.9	33.2	33.9	CL		1.3	2.0	8.5	0.5	16.8	4.5	0.3	0.6	0.2	0.1
		20-45	38.8	33.8	27.4	CL		1.1	1.1	9.0	0.3	12.2	3.1	0.2	0.6	0.3	0.1
		45-70	30.3	36.7	33.0	CL		1.3	0.7	9.0	0.5	-	-	0.2	1.2	0.3	0.1
	19	20	-	-	-	L	3.3×10^{-2} ~ 6.7×10^{-2}	-	2.1	7.8	1.0	-	-	0.5	2.1	0.3	0.1
	20	20	-	-	-	SL	2.0×10^{-3}	-	1.1	8.1	1.1	-	-	0.4	0.6	0.2	0.1
	25	20	-	-	-	L	6.7×10^{-2} ~ 1.0×10^{-2}	-	8.0	7.9	0.6	-	-	0.6	0.6	0.5	0.5
5. Vertic Xerochrepts	11	0-20	20.3	39.1	40.6	L	6.7×10^{-2}	1.7	3.4	7.8	1.0	-	-	1.7	1.5	0.1	0.3
		20-45	21.4	35.2	43.4	L	1.0×10^{-1}	1.8	2.7	7.7	0.8	-	-	2.1	1.4	-	0.1
		45-60	23.2	34.8	42.0	L		1.8	1.4	7.7	0.8	-	-	1.3	1.3	0.3	0.1
		60-80	21.5	39.5	39.0	CL		1.7	0.8	8.1	1.0	-	-	1.5	1.4	0.3	0.1
		80-100	63.4	12.0	24.6	-		1.7	0.5	8.2	0.8	-	-	1.3	1.5	0.3	0.1
	23	20	-	-	-	L	6.7×10^{-2} ~ 1.0×10^{-2}	-	2.8	7.9	0.7	-	-	1.1	5.5	0.6	0.3
	24	20	-	-	-	L	"	-	1.4	7.6	1.0	-	-	0.3	10.0	0.3	0.1
	26	20	-	-	-	L	"	-	1.8	7.9	1.0	-	-	0.5	0.5	0.1	0.3

(continue)

Soil Classification	Pits No.	Depth (cm)	Particle Size Distribution (%)			Texture	Permeability 1/ (cm/sec)	Apparent-Specific Gravity (g/cm^3)	Humus (%)	pH	EC (mmhos/cm)	Exchangeable		Cations		Available P_2O_5	T/N
			Sand	Silt	Clay							Ca	Mg	K	Na		
6. Typic Durochrepts	12	0– 5	49.1	37.4	13.5	SCL	3.3×10^{-2} ~	–	–	6.6	0.5	8.3	2.4	0.9	0.2	–	–
		5–20	49.0	34.7	16.3	SCL	6.7×10^{-2}	–	–	5.7	–	6.6	2.8	0.5	0.2	–	–
		20–30	19.0	11.6	69.4	CL		–	–	5.7	–	15.6	6.0	0.5	0.7	–	–
		30–55	84.1	12.6	3.3	SCL		–	–	6.6	–	11.2	3.0	0.8	0.6	–	–
7. Fluventic Xerochrepts	8	0–20	–	–	–	S	3.3×10^{-2} ~	–	–	8.2	8.0	–	–	1.3	2.8	–	–
		20–40	–	–	–	S	6.7×10^{-2}	–	–	7.9	10.0	–	–	0.4	2.8	–	–
		40–65	–	–	–	S		–	–	7.9	10.0	–	–	0.2	1.5	–	–
		65–85	–	–	–	SC		–	–	8.0	3.9	–	–	0.4	1.0	–	–
	21	20	–	–	–	SL	1.7×10^{-2} ~ 3.3×10^{-2}	–	2.0	8.1	3.0	–	–	1.6	5.4	0.4	0.2
	22	20	–	–	–	SL	3.3×10^{-2} ~ 6.7×10^{-2}	–	5.9	8.2	3.0	–	–	1.3	2.8	0.5	0.3
8. Palexorollic Chromoxererts	1	0–25	13.3	43.9	42.8	LiC	2.0×10^{-3}	–	0.9	9.7	32.2	–	–	1.7	27.2	0.4	0.1
		25–40	5.6	39.9	54.5	HC		–	0.4	10.0	9.5	–	–	1.2	37.5	0.3	0.1
		40–70	6.9	22.6	70.5	HC		–	0.2	10.1	5.3	–	–	0.6	39.0	0.2	0.1
		70–100	7.3	8.9	83.8	HC		–	0.1	10.0	2.8	–	–	0.5	29.0	0.3	0.1
	16	10	–	–	–	S	2.0×10^{-3}	–	0.7	9.8	16.1	–	–	2.0	30.0	0.1	0.1
	7	0–10	11.5	38.2	50.3	HC		–	1.6	9.0	14.4	–	–	3.9	13.2	0.4	0.1
		10–35	8.9	33.5	57.6	HC		–	0.8	9.7	12.0	–	–	2.2	27.1	0.3	0.1
		35–75	8.5	34.3	57.2	HC		–	0.3	9.4	12.3	–	–	0.8	29.0	0.3	0.04
		75–90	17.5	37.8	44.7	LiC		–	0.3	–	16.8	–	–	0.2	12.8	0.2	0.1
9. Chromic Pelloxererts	2	0–10	13.3	43.9	42.8	CL	1.7×10^{-2} ~	1.1	1.5	8.5	3.0	–	–	1.8	4.9	0.02	0.2
		10–25	5.6	39.9	54.5	HC	3.3×10^{-2}	1.2	0.6	9.2	3.0	–	–	1.3	11.4	0.4	0.1
		25–40	6.9	22.6	70.5	HC		1.1	0.3	9.5	3.9	–	–	0.7	21.5	0.3	0.1
		40–70	7.3	8.9	83.8	HC		1.0	0.1	9.6	8.0	–	–	0.4	14.4	0.2	0.1
		70–90	–	–	–	LiC		–	0.1	9.1	8.0	–	–	0.3	23.1	0.4	0.1
10. Typic Pelloxererts	5	0–20	–	–	–	S	2.0×10^{-3}	–	1.8	8.5	4.0	–	–	1.0	9.6	0.4	0.3
		20–30	–	–	–	SC		–	1.1	8.8	4.0	–	–	1.0	27.7	0.4	0.1
		30–60	–	–	–	SC		–	1.1	8.8	6.0	–	–	1.3	33.4	0.3	0.1
		60–100	–	–	–	CL		–	1.1	9.0	6.0	–	–	1.2	36.4	0.5	0.1

(continue)

Soil Classification	Pits No.	Depth (cm)	Particle Size Distribution (%) Sand	Silt	Clay	Texture	Permeability[1/] (cm/sec)	Apparent-Specific Gravity (g/cm^3)	Humus (%)	pH	EC (mmhos/cm)	Exchangeable Cations Ca	Mg	K	Na	Available P_2O_5	T/N
11. Aeric Haplaquents	4	0-15	36.8	40.5	22.7	L	3.3×10^{-2} ~	-	-	7.7	-	-	-	0.5	1.9	-	-
		15-30	39.2	40.3	20.5	CL	6.7×10^{-2}	-	-	7.9	2.5	-	-	0.4	1.8	-	-
		30-40	58.1	30.2	11.7	CL		-	-	7.9	1.9	-	-	0.2	1.6	-	-
		40-50	39.9	39.0	21.1	CL		-	-	7.8	2.2	-	-	0.2	2.1	-	-
		50-90	16.6	42.6	40.8	-		-	-	7.6	1.8	-	-	0.4	2.6	-	-
	17	20	-	-	-	CL	3.3×10^{-2} ~6.7×10^{-2}	0.8	8.0	2.5	-	-	0.4	2.5	0.5	0.1	
	18		-	-	-	CL		-	1.0	8.0	2.0	-	-	1.0	7.5	0.5	0.1
12. Typic Haplaquents	6	0-15	-	-	-	CL	1.7×10^{-2} ~	-	-	10.0	-	-	9.3	0.9	23.3	-	-
		15-25	-	-	-	CL	3.3×10^{-2}	-	-	10.0	15.0	-	3.6	0.7	38.5	-	-
		25-40	-	-	-	CL		-	-	9.8	7.7	-	8.6	0.5	39.2	-	-
		40-55	-	-	-	-		-	-	9.8	8.0	-	8.8	0.4	36.2	-	-
		55-85	-	-	-	-		-	-	9.5	8.2	-	4.4	0.7	31.3	-	-
13. Typic Haploxerales	9	0-20	42.0	38.5	19.5	L	3.3×10^{-2} ~	-	-	7.8	1.3	-	-	0.9	0.6	-	-
		20-40	41.0	39.6	19.4	L	6.7×10^{-2}	-	-	7.9	0.9	-	-	0.7	0.7	-	-
		40-55	31.2	37.8	31.0	L		-	-	7.8	0.7	-	-	0.8	0.9	-	-
		55-80	30.9	39.4	29.7	CL		-	-	7.8	0.6	-	-	0.6	1.6	-	-
		80-90	28.7	42.0	29.3	CL		-	-	7.9	0.7	-	-	0.4	1.8	-	-

1) According to the "Estudio de Suelos del Proyecto Maipo, 1981, CNR" Report

1/: Estudio de Suelos del Proyecto Maipo, 1981, CNR

Table A-5-4 Area of Saline and/or Alkaline Soils *

(Unit : ha)

Block	Medium Alkaline Soil (Na %: 15% - 25%)	High Alkaline Soil (Na % : 25% <)	Total
1	-	-	-
2	-	-	-
3	210	-	210
4	3,495	2,185	5,680
TOTAL	3,705	2,185	5,890

* The Soils have EC of more than 12 mmhos/cm and/or ESP of over 15%.

Table A-5-5 Properties of Contaminated Soil

Pit No.	Depth (cm)	Heavy Metal (Total mg/kg)					Coliform Groups	
		Cd	Cu	Ni	Pb	Zn	Total N.M.F	Fecales N.M.P.
28	0- 5	0.6	125.0	3.0	9.0	84.0	350	4
	5-15	0.9	128.0	-	-	82.0	14	2
	15-50	1.3	121.0	2.0	-	77.0	-	-
	50-70	0.6	76.0	-	-	63.0	-	-
29	0- 5	0.9	133.0	-	5.0	88.0	130	11
30	0- 5	2.0	346.0	27.0	45.0	283.0	110	<2
	5-15	1.5	229.0	14.0	76.0	125.0	110	23
	15-25	2.3	203.0	17.0	89.0	128.0	-	-
	25-40	1.0	169.4	7.0	37.0	86.0	-	-
	40-60	1.3	191.0	4.0	15.0	85.0	-	-
	60-75	1.0	198.0	4.0	6.0	81.0	-	-
31	0- 5	1.0	505.0	16.0	14.0	240.0	350	70
32	0- 5	1.1	162.0	22.0	84.0	269.0	>1,600	>1,600
	5-15	1.0	185.0	16.0	42.0	257.0	>1,600	>1,600
	15-25	0.8	216.0	7.0	19.0	141.0	-	-
	25-35	0.9	490.0	9.0	5.0	160.0	-	-
	35-60	1.9	643.0	12.0	10.0	174.0	-	-
33	0- 5	2.2	185.0	14.0	36.0	236.0	>1,600	350
34	0- 5	2.0	278.0	24.0	65.0	278.0	>1,600	920
35	0- 5	0.7	172.0	8.0	19.0	160.0	>1,600	240
36	0- 5	0.9	113.0	5.0	16.0	97.0	>1,600	130
37	0- 5	0.8	84.0	7.0	18.0	110.0	>1,600	23
38	0- 5	0.3	71.0	3.0	18.0	108.0	-	-

5.2 Contaminated Soil

A water quality analysis of each irrigation canal network has revealed that all the agricultural land in Blocks-1, 2 and 3, i.e., approximately 12,500 ha, has been contaminated. The block- wise distribution of soils contaminated is given in Table A-5-6 and Fig A-5-3 and 4.

Table A-5-6 Distribution of Contaminated Soils

(Unit : ha)

Block \ Category	Coliform Groups and Copper			Total Area	Irrigation Network
	Low	High	Extremely		
1	2,750	-	-	2,750	Esperanza Bajo/Alto
2	-	1,020	3,570	4,590	Rinconada, Encañado, Loma Blanca, Ortuzano
3	5,180	-	-	5,180	Boza, Punta, Noviciado
4	-	-	-	-	Batuco, Carmen
Total	7,930	1,020	3,570	12,520	

Assessment of contaminated soil is based upon the following criteria, as the standard has not been established in Chile.

(1) Coliform Groups :	No problem	< 100 unit/g.soil
	Low contaminated	100 - 350 unit/g.soil
	Highly contaminated	350 - 1.000 unit/g.soil
	Extremely highly Contanimated	> 1.000 unit/g.soil

(2) Copper :	No problem	< 80 mg/kg. soil
	Low contaminated	80 - 125 mg/kg. soil
	Highly contaminated	125 - 250 mg/kg. soil
	Extremely highly Contaminated	> 250 mg/kg. soil

5.3 Soils-Land Classification

The soils capability of the Study Area is classified into the following eight classes according to the SAG standard.

- Class I — The soil belongs to this Class has almost no constraints of land utilization. Reasonable yield of crops is expected by the proper in - put.

- Class II — Land utilization of the soil belongs to the Class has a little restriction compared with the Class I. Major factor of the restriction is effective depth of the soil layer.

- Class III — It is necessary to select suitable crops for cultivation, due to many restrictions in land utilization. Major constraints are water holding capacity, slope of the land, gravel contents and effective depth of the soil layer.

- Class IV — It is necessary to select suitable crops for cultivation, due to so many constraints in land utilization. In addition, it is difficult to keep proper soil conservation and maintenance. Major constraints are water holding capacity, slope of the land, effective depth of the soil layer and drainability.

- Class V — The soil belongs to this Class is difficult to be used for cultivation due to so many restrictions for land utilization.

- Class VI — The area composed of this soil can not be used for cultivation except grazing.

- Class VII — The soil belongs to this Class is of the poorest for cultivation, and can be used as only grazing with restriction.

- Class VIII — It is impossible to use this soil for arable land.

The land irrigability classes on the basic of the criteria shown in Table A-5-7 are given below.

Class I — Lands that have few limitations for sustained use under irrigation:

Lands of this class are capable of producing sustained and relatively high yields of a wide range of climatically adapted crops at reasonable cost. There are few or no limitation of soil, topography or drainage. The soils of this dass, have deep effective rooting depth, favourable permeability, texture, tilth and good available moisture holding capacity.

Class II — Lands that have moderate limitations for sustained use under irrigation:

Lands have moderate limitation of either soil or topography or drainage when used for irrigation. Limitation may include singly or in combination the efecct of a) slope, b) less than ideal soil depth, texture, permeability etc., c) moderate salinity or alkali when in equilibrium with the irrigation water.

Class III — Lands that have severe limitations for sustained use under irrigation:

These have severe limitations of either soil, topography or drainage when put under irrigation. The limitations may be unfavourable soil depth, texture permeability or moderately severe salinity or alkali when in equilibrium with irrigation water.

Class IV — Lands that are marginal for sustained use under irrigation because of very severe limitation:

The very severe limitations may include singly or in combination the effects of a) moderately steep slope, b) very unfavourable soil depth, texture, permeability, available moisture holding capacity, c) severe salinity or alkali when in equilibrium with irrigation water, d) unfavourable topography or drainage condition.

Classes V, VI and VII — Lands that are temporarily classed as not suitable for sustained use under irrigation:

These have very severe limitations either singly or in combination, the level of which is to be investigated locally, as such under current suitability classification these are not suitable.

Class VIII Lands not suitable for sustained use under irrigation:

The lands do not meet the minimun requirements for lands of other classes or these are not susceptible to delivery of irrigation water.

Source : FAO (1979) " Land Evaluation Criteria for Irrigation " world soil Resources Reports N° 51.

Table A-5-7 Criteria of Land Classification for Field Irrigation.

Class	Slope Gradient (%)	SOIL						
		Texture	Drainage	Gravel content (%)	Effective Depth (an)	Salinity (mmhos/cm)	Alkali Value (%)	Available water holding capacity (cm)
I	0 - 2	SL - SiCL	Well	0	90<	0 - 2	0 - 10	18<
II	2 - 4	LS - C	Well to Mod.	5 - 15	70<	2 - 4	10 - 15	12 - 18
III	4 - 8	S - C	Well to Imp.	15 - 35	40 - 90	4 - 8	15 - 25	9.5 - 12
IV	8 - 15	Coarse S-C	Well to poor	15 - 40	20 - 90	8<	25<	5 - 9.5
V	0 - 6	ditto	Well to very poor.	-	20 - 70	ditto	ditto	-
VI	6 - 30	ditto	ditto	35 - 50	20 - 40	ditto	ditto	-
VII	30 - 50	ditto	ditto	50<	>20	ditto	ditto	-
VIII	Non - arable land for Agriculture							

Note: *Lands of class V, VI and VII are only suitable for pasture and forest of variable density.*

Source: *SAG (1981) " Pauta Para Estudio de Suelos ".*

Table A-5-8 Soil Suitability Classification and Its Limiting Factors

Symbol	Sub-group	Soil Series	Soil Suitability Class	Limiting Factor 1/
FL	Fluventic Xerochrepts	Quilicura	III, IIIsa, IV	D, Dpt, S*, A*
		Taqueral	II, III, IV	D, Dpt, S+, A
TYX	Typic Xerochrepts	Piedmont cuesta Lo Vial	II	Dpt*
		Terrazas Aluviales Estratificadas	III	Dpt*
		Colina	I, II	Dpt*
		Santiago	III	Dpt*
		Lampa	II, III, IV	Dpt*, S
		Liray	II	D+
		Rinconada de Lo Vial	II, III	D, Dpt*
		Maipo	I	
		Chicauma	II	Tfine, Dpt
CA	Calcixerollic Xerochrepts	Agua del Gato	IV 2/	P*
TYD	Typic Durochrepts	Pudahuel	III, VI	Dpt*
VE	Vertic Xerochrepts	Mapocho	I, II	Dpt*
MO	Mollic Haplaquepts	Valdivia de Paine	III	D, Dpt*
TYH	Typic Haplaquents	Cotuba	IV, IVsa	D, S*, A*
AE	Aeric Haplaquents	Chape	II, III, IV	D, Dpt*, S
PA	Palexerollic Chromoxererts	Batuco	II, III, IV, IVsa	D, S, A*
		Totoral	IVsa	D, A*
		Peralillo	III, IV, IVsa	D, S, A*
		La Vilana	IV, IVsa	D, S, A*
TYP	Typic Pelloxererts	Urraca	I, II, III, IIIsa, IV	D, A*
CH	Chromic Pelloxererts	Chincolante	III, IIIsa	D, S, A*
TY	Typic Haploxeralfs	Barrancas	I, II, III	D*
XE	Xeric Durandepts	Alhué	III, IV, VI	Dpt*

Note: 1/ D - Drainage, T - Texture, Dpt - Soil Depth, S - Salinity A - Alkali value, P - Pan and "*" shows major factor.

2/ The soils are rated as class IV of suitable but have pan in the profile.

Table A-5-9 Suitable Area for irrigation.

(Unit: ha)

Suitability Class	Block - 1				Block - 2				Block - 3				Block - 4				TOTAL			
	Gross	Unsuitable *1	Unavailable *2	Usable *3	Gross	Unsuitable	Unavailable	Usable	Gross	Unsuitable	Unavailable	Usable	Gross	Unsuitable	Unavailable	Usable	Gross	Unsuitable	Unavailable	Usable
I	-	-	-	-	880	-	680	200	510	-	260	240	1,390	-	615	775	2,770	-	1,555	1,215
II	30	-	-	30	2,180	-	380	1,800	1,210	-	320	890	5,250	-	1,400	3,850	8,670	-	2,100	6,570
III	1,670	-	-	1,670	870	-	80	790	1,200	-	30	1,170	4,885	1,845	20	3,020	8,625	1,845	130	6,650
IV	960	-	-	960	130	-	-	130	1,060	210	-	850	7,725	3,835	85	3,805	9,875	4,045	85	5,745
VI	-	-	-	-	300	300	-	-	1,090	1,090	-	-	250	250	-	-	1,640	1,640	-	-
VII	-	-	-	-	30	30	-	-	-	-	-	-	120	120	-	-	150	150	-	-
VIII	-	-	-	-	-	-	-	-	210	-	210	-	930	-	930	-	1,140	-	1,140	-
Others *4	90	-	90	-	200	-	200	-	120	-	120	-	450	-	450	-	860	-	860	-
U	120	-	120	-	320	-	320	-	270	-	270	-	1,500	-	1,500	-	2,210	-	2,210	-
TOTAL	2,870	-	210	2,660	4,910	330	1,660	2,920	5,660	1,300	1,210	3,150	22,500	6,050	5,000	11,450	35,940	7,680	8,080	20,180

Note: *1 *The areas are considered to be unsuitable for field irrigation on account of saline-alkali soils.*

*2 *The areas are unavailable for agriculture because of urban areas (1991), swamps and/or flooding.*

*3 *The lands are net usable areas for irrigation.*

*4 *The lands include farm house, farm roads, secondary and lateral irrigation canals, drainage canals, etc.*

5.4 Gypsum Requirement

Exchangeble sodium percentages were investigated to calculate gypsum requirement.

The estimation is made under the bellow conditions:

- The exchageble sodium percentage of the soils in o to 30 cm deep range from 10% to 30% (= 20% in average) for Medium Alkaline soil and from 35% to 60% (= 50% in average) for high Alkaline soil, by reference to "Estudio de Suelos del Proyecto Maipo " , CNR (1981).

- CEC of the upper 30 cm soils ranges also from 35 meg/100 g to 60 meg/100 g in average) for both medium and high alkaline soil.

- Unit cost of gypsum is US$50/t

Amendments needed for exchangeble sodium replacement are derived from bellowing formula:

$$GR = \frac{(ESs - ESf)}{100} \times CEC \times 2.8$$

(Agriculture Handbook N° 60 of USDA, 1961)

GR = Gypsum requirement (/ha)

ESs = ESP of the soil

ESf = Desirement to reduce the ESP (= 10%)

1 mg of gypsum per 100 g equels 860 ppm (= 8.6×10^{-4}/t)

The amount of gysum requirement per ha, equivalent to 1 meg/100g is therefore calculated as bellows:

8.6×10^{-4}x weight of the treatment soil

$= 8.6\times10^{-4} \times 0.3\times10^{4} \times 1.1$

= 2.8t/ha

(Bulky density (= 1.1)
(Treatment depth (= 30 cm)

The results are presented in Table A-5-10.

Medium alkali soil will be necessary to apply gypsum of 14t/ha (US$700/ha) to reduce the exchangeble sodium percentage to 10%.

Table A-5-10 Gypsum Requirement for Replacement of Exchangeable Sodium.

	Area (ha)	ESP (%)	CEC (me/100g)	Gypsum requi-rement (t/ha)	Cost (US$) (/ha)	(Total)
Medium Alkaline Soil	3,705	20	50	14	700	2.593,500
High Alkaline Soil	2,185	50	50	56	2.800	6.118,000
TOTAL	5,890	-	-	-	-	8.711,500

Appendix 6: Vegetation

LIST OF TABLE

Table A-6-1 Present Landuse of Mapocho River Basin

(Unit : ha)

Kind	Area
Natural Vegetation	
1. Scanty Thicket of Shrubs	71,660
2. Dense Thicket of Shrubs	31,610
3. Scanty Acacia Caven Scrub	27,340
4. Dense Acacia Caven Scrub	8,600
5. Scanty Thicket of Trees	2,670
6. Dense Thicket of Trees	2,600
7. High Mountain Vegetation	26,300
8. Thicket of Succulents	21,380
9. Bare Land	5,240
10. Southern Beech	890
Sub-Total	198,290 (38%)
Urban Area	
1. Urban Area	40,200
2. Urban Area (less dense)	8,420
Sub-Total	48,620 (9%)
Agricultural Land	
1. Annual Crops	96,420
2. Perennial Crops	16,530
3. Pasture	43,500
4. Forest (man-made)	5,260
Unusable Land	161,710 (31%)
Sub-Total	118,610 (22%)
Total Area	527,230 (100%)

Source: Cartografía Básica para el Diagnóstico de la Cuenca del Río Mapocho, Universidad de Chile ,1984

Appendix 7: Water Quality

7.1 Procedures of Analysis

7.2 Water Quality Improvement Scheme

7.3 Problem caused by Trihalometham

LIST OF FIGURES

LIST OF TABLE

7.1 Procedures of Analysis

To clarify the existing state of water quality in the Mapocho river basin, the following work was performed:

a. Collection of available information and data
b. Field survey and water sampling
c. Laboratory analysis of the samples

Data and information were mainly collected from INIA, MOP, EMOS, University of Chile, etc.

The field survey and water sampling were made in the following five different type of water:

a. Water in rivers and main canals
b. Groundwater
c. Water in ponds
d. Water in mining area
e. Water in irrigation branch canals

The sites of water sampling were selected at rivers and main canals considering the following points (Fig A-7-1):

a. Complete coverage of the Mapocho river basin;
b. Comparison between contaminated water and upstream water;
c. Examination of water quality before and after the confluence of the main streams; and
d. Continuous and systematic analysis of the change of water quality.

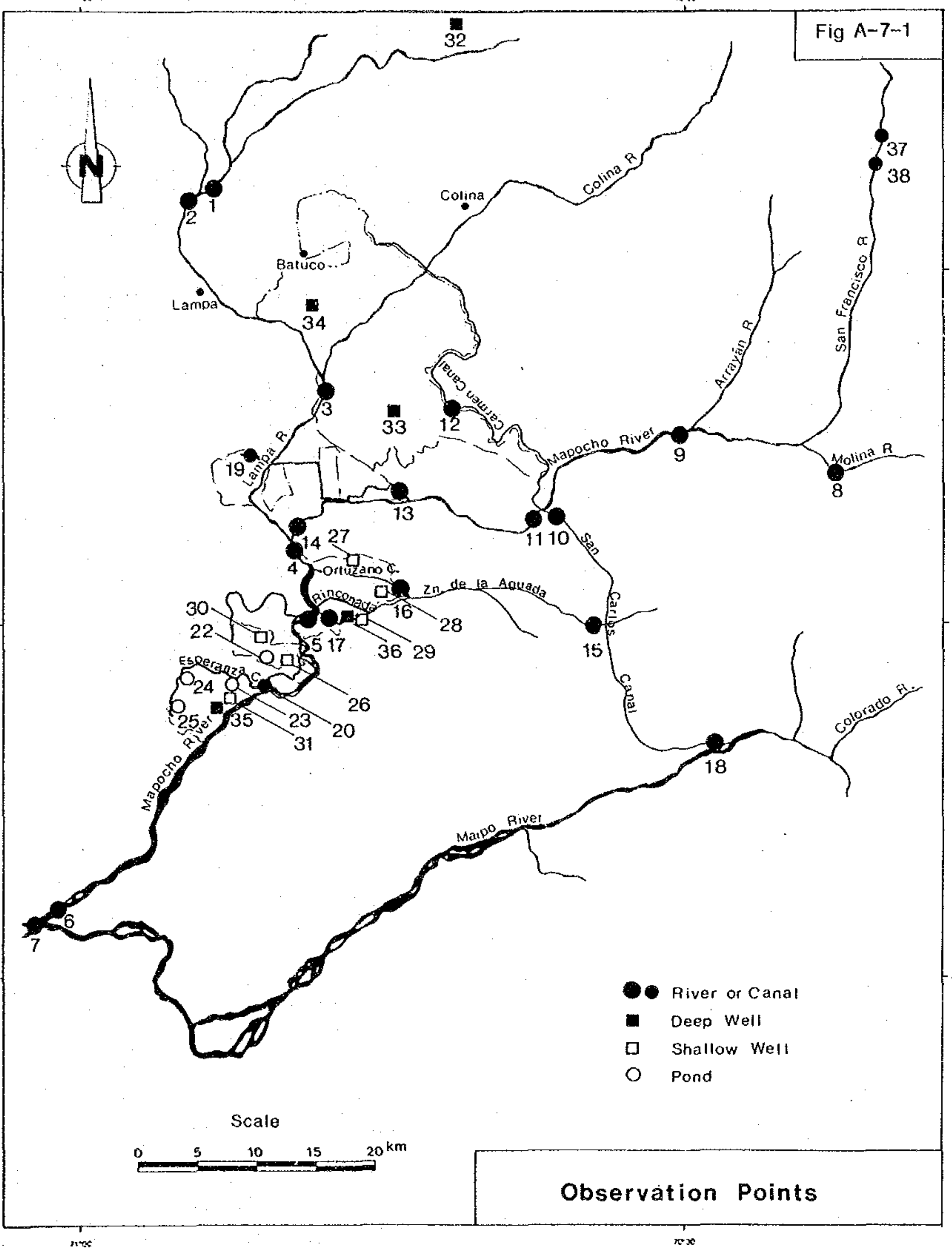
Outline of the laboratory analysis are as follows:

Site	:	18 points
Sampling time	:	February 1985 (First observation) March (Second observation) September (Third observation) October (Fourth observation)
Items of analysis	:	pH, EC, SS, BOD, K-N Coliform groups Cation (Ca, Mg, Na, K) Anion (Cl, SO4, CO3, HCO3) Heavy metals (Cd, Cu, Ni, Pb, Zn, Mo)
Laboratory	:	ISP (for Coliform Groups) INIA (for other items)

At point N^{o} 17 in the Zanjón de la Aguada, the water samples were collected every three hours for 24 hours. The same analysis was applied for these collected samples. Furthermore, the collected water were left alone for 24 hours and 48 hours, and only the upper parts of the water samples were analysed.

Eleven samples of groundwater were collected in the area of pump irrigation and shallow wells, and analysed in the same manner. Moverover, 4 samples from ponds and a few samples of surface waters were examined in the same manner. The results are presented in Table A-7-6.

On the other hand, the waters in branch irrigation canals in the area irrigated by the Zanjón de la Aguada, Punta canal, Carmen canal, etc., were measured in the field for the items of pH, EC, and Coliform groups (Table A-7-7).



Observation Points