Table A-7-1(1) Water Quality at Selected Sites

Site [No 1]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.900	7.800	6.800	8.200	7.675
2) EC	666.000	671.000	610.000	759.000	676.500
3) S-TOT	438.000	475.000	482.000	-	465.000
4) SO4	221.000	123.000	133.000	125.000	150.500
5) Cl	33.000	32.000	27.000	39.000	32.750
6) SAR	2.510	2.580	2.350	2.260	2.425
7) Na%	46.900	48.500	46.600	44.000	46.500
8) NH3-N	0.770	0.560	0.560	0.140	0.508
9) N-Org	1.260	0.700	1.050	2.240	1.313
10) TK-N	2.030	1.260	1.610	2.380	1.820
11) Pb	0.033	0.084	0.020	0.020	0.039
12) Cu	0.023	-	0.020	0.020	0.021
13) Zn	0.002	0.004	0.280	-	0.095
14) BOD	5.000	5.000	-	5.000	5.000
15) C-T	16E+02	20E-01	92E+01	16E+02	10E+02
16) C-G	10E-01	20E-01	54E+01	24E+01	20E+01
17) SO4--	4.600	2.560	2.770	2.600	3.133
18) Cl-	0.930	0.900	0.760	1.100	0.923
19) HCO3-	2.500	2.600	3.100	1.900	2.525
20) Ca++	2.740	2.900	2.500	3.000	2.785
21) Mg++	1.110	1.000	0.980	1.000	1.023
22) Na+	3.480	3.600	3.100	3.200	3.345
23) K+	0.095	0.080	0.080	0.080	0.084

Site [No 3]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.800	7.600	7.800	8.000	7.800
2) EC	1128.000	1118.000	2073.000	1890.000	1552.250
3) S-TOT	920.000	961.000	1537.000	-	1139.330
4) SO4	207.000	360.000	530.000	442.000	384.750
5) Cl	133.000	5.000	118.000	188.000	111.000
6) SAR	2.420	2.120	3.890	2.940	2.843
7) Na%	36.700	34.000	44.700	37.200	38.150
8) NH3-N	1.400	0.520	1.330	0.280	0.883
9) N-Org	0.560	1.330	1.400	0.070	0.840
10) TK-N	1.960	1.270	2.730	0.280	1.560
11) Pb	0.080	0.080	0.030	0.020	0.053
12) Cu	0.077	0.081	0.060	0.080	0.075
13) Zn	0.008	0.017	0.260	0.290	0.144
14) BOD	5.000	5.000	-	5.000	5.000
15) C-T	35E+03	35E+03	70E+03	16E+03	39E+03
16) C-G	92E+02	35E+02	21E+02	16E+03	77E+02
17) SO4--	4.310	7.500	11.030	9.200	8.010
18) Cl-	3.750	0.140	3.330	5.300	3.130
19) HCO3-	2.100	2.000	5.000	3.900	3.250
20) Ca++	6.480	6.480	9.000	9.000	7.740
21) Mg++	2.050	1.810	2.300	3.000	2.290
22) Na+	5.000	4.320	9.250	7.200	6.443
23) K+	0.100	0.100	0.140	0.130	0.118

Site [No 2]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	8.100	7.800	7.300	7.900	7.775
2) EC	616.000	569.000	603.000	656.000	611.000
3) S-TOT	391.000	405.000	378.000	-	391.333
4) SO4	187.000	84.000	89.000	84.000	111.000
5) Cl	16.000	21.000	16.000	19.000	18.000
6) SAR	1.530	1.560	1.520	1.310	1.480
7) Na%	35.300	35.300	35.400	31.100	34.275
8) NH3-N	2.030	0.350	0.420	0.500	0.825
9) N-Org	-	0.980	0.770	0.070	0.607
10) TK-N	2.030	1.330	1.190	0.500	1.263
11) Pb	0.047	0.042	0.020	0.020	0.032
12) Cu	0.013	0.008	0.020	0.020	0.015
13) Zn	0.002	0.002	0.340	0.010	0.089
14) BOD	5.000	5.000	-	12.000	7.333
15) C-T	35E+02	35E+02	14E+01	35E+02	27E+02
16) C-G	10E-01	35E+00	79E+00	28E+01	99E+00
17) SO4--	3.890	1.750	1.830	1.750	2.305
18) Cl-	0.450	0.590	0.450	0.540	0.508
19) HCO3-	2.300	2.500	3.850	2.400	2.763
20) Ca++	2.740	2.900	2.500	3.000	2.785
21) Mg++	1.150	1.100	1.310	1.200	1.190
22) Na+	2.140	2.200	2.100	1.900	2.085
23) K+	0.030	0.025	0.020	0.010	0.021

Site [No 4]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.300	7.500	7.200	7.800	7.450
2) EC	780.000	728.000	1508.000	1366.000	1095.500
3) S-TOT	758.000	1890.000	1178.000	-	1275.330
4) SO4	356.000	228.000	370.000	307.000	315.250
5) Cl	64.000	106.000	171.000	128.000	117.250
6) SAR	1.290	1.100	2.820	2.270	1.870
7) Na%	27.100	24.200	39.400	35.000	31.425
8) NH3-N	1.470	0.980	4.000	4.060	2.628
9) N-Org	0.840	2.840	5.560	0.560	2.450
10) TK-N	2.310	3.820	9.560	4.620	5.077
11) Pb	0.038	0.140	0.040	0.020	0.060
12) Cu	0.479	0.888	0.060	0.140	0.392
13) Zn	0.022	0.263	0.130	0.050	0.116
14) BOD	8.000	10.000	-	7.000	8.333
15) C-T	96E+06	92E+04	16E+08	95E+05	43E+07
16) C-G	45E+05	16E+04	54E+05	11E+05	28E+05
17) SO4--	7.410	4.750	7.700	6.390	6.563
18) Cl-	1.810	2.990	4.820	3.610	3.308
19) HCO3-	1.000	0.900	3.300	2.200	1.850
20) Ca++	5.000	4.990	7.500	7.000	6.123
21) Mg++	0.820	0.740	1.230	1.600	1.098
22) Na+	2.200	1.860	5.900	4.700	3.665
23) K+	0.095	0.090	0.330	0.130	0.161

Table A-7-1(2) Water Quality at Selected Sites

Site [No 5]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.100	7.200	7.300	7.200	7.200
2) EC	879.000	825.000	1508.000	1721.000	1233.250
3) S-TOT	693.000	1101.000	1127.000	-	973.667
4) SO4	361.000	228.000	346.000	360.000	323.750
5) Cl	75.000	69.000	189.000	166.000	124.750
6) SAR	1.400	1.310	2.750	2.270	1.933
7) Na%	27.600	26.500	38.300	31.900	31.075
8) NH3-N	1.470	2.100	5.700	7.630	4.225
9) N-Org	1.190	1.120	2.280	3.710	2.075
10) TK-N	2.660	3.220	7.980	11.340	6.300
11) Pb	0.070	0.070	0.040	0.050	0.058
12) Cu	0.432	0.480	0.050	0.100	0.266
13) Zn	0.029	0.154	0.240	0.010	0.108
14) BOD	9.000	8.000	-	126.000	47.667
15) C-T	54E+06	16E+06	18E+07	16E+08	46E+07
16) C-G	21E+05	16E+06	28E+06	16E+08	41E+07
17) SO4--	7.520	4.750	7.200	7.500	6.742
18) Cl-	2.120	1.950	5.330	4.680	3.520
19) HCO3-	1.600	1.200	2.500	3.200	2.125
20) Ca++	5.480	5.490	7.500	9.000	6.868
21) Mg++	0.990	0.900	2.000	2.300	1.548
22) Na+	2.520	2.340	6.000	5.400	4.065
23) K+	0.125	0.110	0.150	0.210	0.149

Site [No 7]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.900	7.700	7.000	7.900	7.625
2) EC	982.000	882.000	1179.000	1316.000	1089.750
3) S-TOT	850.000	1495.000	956.000	1003.000	1076.000
4) SO4	385.000	262.000	370.000	288.000	326.250
5) Cl	78.000	75.000	98.000	121.000	93.000
6) SAR	1.460	1.280	1.600	1.540	1.470
7) Na%	27.600	24.900	27.700	26.000	26.550
8) NH3-N	0.980	0.280	0.630	0.700	0.648
9) N-Org	0.210	0.770	1.300	0.070	0.588
10) TK-N	1.190	1.050	1.930	0.700	1.218
11) Pb	0.080	0.122	0.040	0.030	0.068
12) Cu	0.021	0.075	0.020	0.020	0.034
13) Zn	0.067	0.217	0.240	0.060	0.146
14) BOD	7.000	5.000	-	8.000	6.667
15) C-T	-	92E+03	16E+02	39E+02	33E+03
16) C-G	-	28E+03	92E+01	16E+02	10E+03
17) SO4--	8.160	5.450	7.700	6.000	6.828
18) Cl-	2.200	2.120	2.760	3.410	2.623
19) HCO3-	2.300	1.500	1.500	2.000	1.825
20) Ca++	5.990	6.240	6.700	7.500	6.608
21) Mg++	1.230	1.030	1.800	1.900	1.490
22) Na+	2.780	2.440	3.300	3.340	2.965
23) K+	0.080	0.080	0.130	0.110	0.100

Site [No 6]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.900	7.400	8.400	8.200	7.975
2) EC	1114.000	1025.000	1372.000	1492.000	1250.750
3) S-TOT	840.000	950.000	1067.000	-	952.333
4) SO4	204.000	240.000	312.000	293.000	262.250
5) Cl	109.000	104.000	142.000	143.000	124.500
6) SAR	1.620	1.550	2.350	1.420	1.735
7) Na%	27.800	27.700	36.100	22.900	28.625
8) NH3-N	1.400	1.540	0.630	1.680	1.313
9) N-Org	0.420	1.540	0.280	0.070	0.578
10) TK-N	1.820	3.080	0.910	1.680	1.873
11) Pb	0.080	0.084	0.040	0.020	0.056
12) Cu	0.073	0.178	0.020	0.020	0.073
13) Zn	0.064	0.446	0.230	0.240	0.245
14) BOD	6.000	8.000	-	18.000	10.667
15) C-T	17E+03	22E+05	24E+00	17E+03	56E+04
16) C-G	70E+02	17E+05	24E+00	24E+01	43E+04
17) SO4--	4.250	5.000	6.500	6.100	5.463
18) Cl-	3.070	2.930	4.010	4.030	3.510
19) HCO3-	2.500	2.400	3.500	2.600	2.750
20) Ca++	7.000	6.480	6.300	9.000	7.195
21) Mg++	1.560	1.480	2.000	2.100	1.785
22) Na+	3.350	3.100	4.800	3.340	3.648
23) K+	0.130	0.140	0.200	0.120	0.148

Site [No 8]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.500	7.800	7.600	7.700	7.650
2) EC	110.000	141.000	125.000	128.000	126.000
3) S-TOT	167.000	118.000	118.000	1995.000	599.500
4) SO4	24.000	19.000	55.000	24.000	30.500
5) Cl	4.000	7.000	4.000	3.200	4.550
6) SAR	0.030	0.350	0.370	0.340	0.273
7) Na%	2.000	19.000	21.100	19.200	15.325
8) NH3-N	0.910	0.420	0.700	0.560	0.648
9) N-Org	0.070	0.490	1.050	0.070	0.420
10) TK-N	0.980	0.910	1.750	0.560	1.050
11) Pb	0.002	0.103	0.020	0.020	0.036
12) Cu	0.009	0.010	0.020	0.020	0.015
13) Zn	0.002	0.006	0.010	0.070	0.022
14) BOD	5.000	5.000	-	5.000	5.000
15) C-T	-	30E+00	35E+01	16E+02	66E+01
16) C-G	-	10E+00	17E+00	16E+02	54E+01
17) SO4--	0.500	0.400	1.150	0.500	0.638
18) Cl-	0.110	0.200	0.110	0.090	0.128
19) HCO3-	0.300	0.300	0.500	0.650	0.438
20) Ca++	0.790	0.900	0.750	0.800	0.810
21) Mg++	0.160	0.200	0.170	0.200	0.183
22) Na+	0.020	0.260	0.250	0.240	0.193
23) K+	0.006	0.010	0.020	0.010	0.012

Table A-7-1(3) Water Quality at Selected Sites

Site [No 9]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.000	7.000	7.300	7.400	7.175
2) EC	279.000	307.000	284.000	272.000	285.500
3) S-TOT	282.000	523.000	226.000	117.000	287.000
4) SO4	130.000	118.000	92.000	66.000	101.500
5) Cl	4.000	7.000	6.000	3.300	5.075
6) SAR	0.020	0.030	0.380	0.390	0.205
7) Na%	1.000	1.300	15.400	15.400	8.275
8) NH3-N	0.350	0.490	0.980	1.680	0.875
9) N-Org	0.070	0.420	0.350	0.070	0.227
10) TK-N	0.420	0.910	7.330	1.680	2.585
11) Pb	0.005	0.089	0.020	0.020	0.034
12) Cu	5.016	5.422	1.600	1.400	3.360
13) Zn	0.151	0.160	0.280	0.620	0.303
14) BOD	5.000	5.000	-	5.000	5.000
15) C-T	-	49E+00	17E+02	47E+03	16E+03
16) C-G	-	33E+00	18E+01	14E+03	47E+02
17) SO4--	2.710	2.460	1.920	1.370	2.115
18) Cl-	0.110	0.200	0.170	0.090	0.143
19) HCO3-	0.300	0.350	0.780	1.400	0.708
20) Ca++	1.690	1.900	1.700	1.800	1.773
21) Mg++	0.360	0.410	0.400	0.400	0.393
22) Na+	0.020	0.030	0.390	0.410	0.213
23) K+	0.025	0.040	0.040	0.050	0.039

Site [No 11]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.700	7.700	7.600	7.100	7.525
2) EC	665.000	692.000	942.000	1002.000	825.250
3) S-TOT	935.000	1114.000	745.000	741.000	883.750
4) SO4	313.000	221.000	228.000	250.000	253.000
5) Cl	62.000	57.000	115.000	100.000	83.500
6) SAR	1.230	1.090	2.380	1.620	1.580
7) Na%	26.100	25.100	42.800	30.000	31.000
8) NH3-N	0.770	1.190	1.700	0.070	0.933
9) N-Org	-	1.400	1.400	0.070	0.957
10) TK-N	0.770	2.590	3.100	0.070	1.633
11) Pb	0.070	0.108	0.030	0.030	0.060
12) Cu	0.471	0.303	0.240	0.270	0.321
13) Zn	0.157	0.091	0.070	0.100	0.105
14) BOD	5.000	10.000	-	10.000	8.333
15) C-T	-	16E+06	45E+04	22E+03	55E+05
16) C-G	-	16E+06	28E+03	22E+03	54E+05
17) SO4--	6.520	4.600	4.750	5.200	5.268
18) Cl-	1.380	1.610	3.240	2.820	2.263
19) HCO3-	0.600	0.400	1.450	1.300	0.938
20) Ca++	4.490	4.490	4.000	6.000	4.745
21) Mg++	0.660	0.700	0.900	0.900	0.790
22) Na+	1.800	1.760	3.730	3.000	2.573
23) K+	0.060	0.070	0.100	0.090	0.080

Site [No 10]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.900	7.900	7.900	7.900	7.900
2) EC	775.000	794.000	1427.000	1337.000	1083.250
3) S-TOT	773.000	1303.000	1093.000	914.000	1020.750
4) SO4	351.000	252.000	480.000	336.000	354.750
5) Cl	52.000	62.000	120.000	179.000	103.250
6) SAR	1.190	1.210	3.000	2.160	1.890
7) Na%	25.400	25.300	42.900	33.800	31.850
8) NH3-N	0.280	0.560	1.260	0.070	0.543
9) N-Org	-	0.490	0.560	0.070	0.373
10) TK-N	0.280	1.050	1.820	0.070	0.805
11) Pb	0.089	0.089	0.040	0.040	0.065
12) Cu	0.036	0.040	0.020	0.020	0.029
13) Zn	0.311	0.006	0.100	0.080	0.124
14) BOD	5.000	5.000	-	5.000	5.000
15) C-T	-	54E+02	17E+03	28E+02	84E+02
16) C-G	-	11E+02	17E+03	28E+02	70E+02
17) SO4--	7.310	5.250	9.990	7.000	7.388
18) Cl-	1.470	1.750	3.390	5.050	2.915
19) HCO3-	0.700	1.400	2.000	1.600	1.425
20) Ca++	5.230	5.490	6.500	7.500	6.180
21) Mg++	0.700	0.780	1.230	1.200	0.978
22) Na+	2.040	2.140	5.900	4.500	3.645
23) K+	0.070	0.060	0.110	0.100	0.085

Site [No 12]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.600	7.500	7.700	8.000	7.700
2) EC	832.000	798.000	1204.000	1420.000	1063.500
3) S-TOT	914.000	104.000	979.000	1118.000	778.750
4) SO4	356.000	256.000	327.000	307.000	311.500
5) Cl	49.000	59.000	137.000	168.000	103.250
6) SAR	1.120	1.000	2.410	2.240	1.693
7) Na%	25.700	24.800	38.600	34.000	30.775
8) NH3-N	0.420	1.000	1.000	0.070	0.623
9) N-Org	0.070	1.100	0.910	0.070	0.538
10) TK-N	0.490	1.070	1.910	0.070	0.885
11) Pb	0.070	0.090	0.040	0.040	0.060
12) Cu	0.032	0.037	0.030	0.020	0.030
13) Zn	0.260	0.010	0.060	0.090	0.105
14) BOD	5.000	5.000	-	10.000	6.667
15) C-T	-	11E+05	47E+04	47E+05	21E+05
16) C-G	-	54E+04	40E+04	16E+04	37E+04
17) SO4--	7.410	-	6.810	6.390	6.870
18) Cl-	1.750	-	3.700	4.740	3.397
19) HCO3-	0.600	-	1.550	2.000	1.383
20) Ca++	5.230	-	6.000	8.000	6.410
21) Mg++	0.700	-	1.150	1.200	1.017
22) Na+	2.120	-	4.550	4.800	3.823
23) K+	0.060	-	0.100	0.100	0.087

Table A-7-1(4) Water Quality at Selected Sites

Site [No 13]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.500	7.600	7.500	7.600	7.550
2) EC	676.000	688.000	1065.000	1028.000	864.250
3) S-TOT	931.000	1066.000	1019.000	775.000	947.750
4) SO4	322.000	218.000	420.000	247.000	301.750
5) Cl	45.000	55.000	98.000	103.000	75.250
6) SAR	1.120	1.070	2.550	1.680	1.605
7) Na%	25.200	24.400	43.000	30.500	30.775
8) NH3-N	1.120	1.610	1.960	2.940	1.908
9) N-Org	0.070	1.610	2.480	2.870	1.758
10) TK-N	1.190	3.220	4.440	5.810	3.665
11) Pb	0.126	0.098	0.050	0.040	0.079
12) Cu	0.475	0.482	0.520	0.210	0.422
13) Zn	0.361	0.295	0.210	0.050	0.229
14) BOD	6.000	10.000	-	17.000	11.000
15) C-T	-	35E+05	24E+06	22E+06	17E+06
16) C-G	-	11E+05	24E+06	16E+05	89E+05
17) SO4--	6.700	4.540	8.740	5.140	6.280
18) Cl-	1.270	1.550	2.760	2.910	2.123
19) HCO3-	0.600	1.750	1.300	1.300	1.238
20) Ca++	4.490	4.740	4.500	6.000	4.933
21) Mg++	0.660	0.660	0.980	1.100	0.850
22) Na+	1.800	1.760	4.220	3.160	2.735
23) K+	0.060	0.065	0.110	0.100	0.084

Site [No 15]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.800	7.900	7.900	8.000	7.900
2) EC	748.000	806.000	1576.000	1446.000	1144.000
3) S-TOT	988.000	1245.000	1170.000	1008.000	1102.750
4) SO4	361.000	266.000	490.000	360.000	369.250
5) Cl	62.000	68.000	170.000	153.000	113.250
6) SAR	1.190	1.270	3.920	2.310	2.173
7) Na%	25.400	25.900	49.400	34.500	33.800
8) NH3-N	5.650	0.070	0.560	0.770	1.763
9) N-Org	0.350	0.210	0.280	0.420	0.315
10) TK-N	6.000	0.280	0.840	1.190	2.078
11) Pb	0.089	0.103	0.060	0.030	0.071
12) Cu	0.020	0.045	0.020	0.020	0.026
13) Zn	0.030	0.092	0.250	0.260	0.158
14) BOD	5.000	5.000	-	9.000	6.333
15) C-T	-	16E+03	54E+02	17E+02	77E+02
16) C-G	-	28E+02	54E+02	92E+01	30E+02
17) SO4--	7.520	5.540	10.200	7.500	7.690
18) Cl-	1.750	1.920	4.800	4.320	3.198
19) HCO3-	0.900	0.550	1.000	2.000	1.113
20) Ca++	5.230	5.740	6.500	8.000	6.368
21) Mg++	0.700	0.780	1.310	1.400	1.048
22) Na+	2.040	2.300	7.750	5.000	4.273
23) K+	0.050	0.065	0.130	0.100	0.086

Site [No 14]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.200	7.500	7.600	7.900	7.550
2) EC	837.000	726.000	1398.000	1179.000	1035.000
3) S-TOT	695.000	1124.000	1096.000	929.000	961.000
4) SO4	351.000	228.000	331.000	274.000	296.000
5) Cl	56.000	53.000	161.000	131.000	100.250
6) SAR	1.440	1.070	2.710	2.040	1.815
7) Na%	30.100	23.900	39.800	33.800	31.900
8) NH3-N	4.710	0.840	5.900	0.070	2.880
9) N-Org	3.780	1.330	7.100	5.900	4.528
10) TK-N	8.490	2.170	13.000	5.900	7.390
11) Pb	0.066	0.098	0.040	0.030	0.059
12) Cu	0.398	0.526	0.060	0.170	0.289
13) Zn	0.059	0.363	0.520	0.080	0.256
14) BOD	16.000	9.000	-	9.000	11.333
15) C-T	96E+06	16E+04	28E+07	16E+08	49E+07
16) C-G	54E+06	16E+04	54E+06	18E+05	27E+06
17) SO4--	7.310	4.750	6.890	5.700	6.163
18) Cl-	1.580	1.500	4.540	3.700	2.830
19) HCO3-	1.300	0.700	2.800	1.800	1.650
20) Ca++	4.490	4.900	6.000	6.500	5.473
21) Mg++	0.820	0.740	1.500	1.200	1.065
22) Na+	2.340	1.800	5.250	4.000	3.348
23) K+	0.125	0.090	0.430	0.130	0.194

Site [No 16]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.500	7.400	7.000	6.800	7.175
2) EC	1134.000	1481.000	1763.000	1554.000	1483.000
3) S-TOT	990.000	1087.000	1156.000	1172.000	1101.250
4) SO4	136.000	235.000	302.000	322.000	248.750
5) Cl	144.000	160.000	244.000	183.000	182.750
6) SAR	2.800	2.160	3.690	2.780	2.858
7) Na%	44.200	35.500	45.700	38.500	40.975
8) NH3-N	0.350	31.570	43.720	22.890	24.633
9) N-Org	5.810	18.130	19.780	17.150	15.218
10) TK-N	6.160	49.700	63.500	40.040	39.850
11) Pb	0.084	0.103	0.090	0.070	0.087
12) Cu	0.048	0.126	0.300	0.170	0.161
13) Zn	0.200	0.358	0.780	0.580	0.480
14) BOD	16.000	50.000	-	400.000	155.333
15) C-T	-	16E+06	16E+08	16E+08	11E+08
16) C-G	-	16E+06	35E+07	16E+08	66E+07
17) SO4--	2.830	4.890	6.290	6.700	5.178
18) Cl-	4.060	4.510	6.880	5.160	5.153
19) HCO3-	2.300	3.550	4.800	2.800	3.363
20) Ca++	5.000	5.900	6.800	8.000	6.425
21) Mg++	0.900	0.990	2.000	1.300	1.298
22) Na+	4.800	4.000	7.750	6.000	5.638
23) K+	0.155	0.380	0.400	0.280	0.304

Table A-7-1 (5) Water Quality at Selected Sites

Site [No 17]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.100	7.100	7.400	8.200	7.450
2) EC	1254.000	1282.000	1633.000	1488.000	1414.250
3) S-TOT	824.000	1045.000	1126.000	1107.000	1025.500
4) SO4	134.000	230.000	324.000	274.000	240.500
5) Cl	186.000	154.000	198.000	163.000	175.250
6) SAR	2.210	2.590	3.230	2.620	2.663
7) Na%	34.000	40.000	42.500	37.400	38.475
8) NH3-N	8.050	13.060	27.400	24.360	18.218
9) N-Org	13.230	12.780	18.130	4.830	12.243
10) TK-N	21.280	25.840	45.530	29.190	30.460
11) Pb	0.070	0.094	0.070	0.020	0.064
12) Cu	0.045	0.085	0.180	0.040	0.088
13) Zn	0.014	0.159	0.450	-	0.208
14) BOD	20.000	50.000	-	72.000	47.333
15) C-T	16E+07	16E+07	35E+07	16E+08	57E+07
16) C-G	16E+07	16E+07	35E+07	92E+07	40E+07
17) SO4--	2.790	4.790	6.750	5.700	5.008
18) Cl-	5.250	4.340	5.590	4.600	4.945
19) HCO3-	4.200	3.250	4.300	3.800	3.888
20) Ca++	6.000	5.900	7.000	7.500	6.600
21) Mg++	2.630	1.150	1.840	1.600	1.805
22) Na+	4.600	4.860	6.800	5.600	5.465
23) K+	0.285	0.250	0.360	0.290	0.296

Site [No 18]

ITEM/DATE	Feb.	Mar.	Sep.	Oct.	Mean
1) pH	7.900	7.900	7.900	8.100	7.950
2) EC	751.000	1223.000	1370.000	1366.000	1177.500
3) S-TOT	1050.000	1196.000	1100.000	1084.000	1107.500
4) SO4	375.000	266.000	360.000	350.000	337.750
5) Cl	60.000	64.000	156.000	131.000	102.750
6) SAR	1.230	1.130	2.530	2.050	1.735
7) Na%	26.200	22.700	38.700	32.100	29.925
8) NH3-N	0.840	0.350	0.420	0.630	0.560
9) N-Org	0.350	0.490	0.520	0.070	0.358
10) TK-N	1.190	0.840	0.940	0.630	0.900
11) Pb	0.070	0.080	0.040	0.030	0.055
12) Cu	0.018	0.033	0.020	0.020	0.023
13) Zn	0.088	0.162	0.230	0.110	0.148
14) BOD	6.000	5.000	-	150.000	53.667
15) C-T	-	35E+01	22E+02	16E+02	14E+02
16) C-G	-	17E+01	22E+02	16E+02	13E+02
17) SO4--	7.810	5.540	7.500	7.290	7.035
18) Cl-	1.690	1.810	4.400	3.700	2.900
19) HCO3-	0.800	0.700	1.700	2.000	1.300
20) Ca++	5.230	6.490	6.500	8.000	6.555
21) Mg++	0.700	0.740	1.310	1.200	0.988
22) Na+	2.120	2.140	5.000	4.400	3.415
23) K+	0.050	0.060	0.110	0.100	0.080

Table A-7-2 Water Quality of Branch Irrigation Canals

Block	Canal	pH	EC (ms/cm)	DO (ppm)	Turbidity (ppm)	Coliform Groups (pcs /ml)
1	Esperanza Alto	7.7-8.0	1.1-1.4	0.4-2.5	350-677	>10,000
	Esperanza Bajo	7.5-7.7	0.9-1.3	0.9-4.5	27-150	130-560
2	Ortuzano	7.0-7.4	1.0-1.5	0.8-1.5	210-520	>10,000
	Loma Blanca	7.2-7.5	1.2-1.4	0.5-2.5	150-362	>10,000
	Encañado	7.2-7.4	1.1-1.3	1.0-3.6	220-420	>10,000
	Rinconada	7.1-7.3	1.0-1.2	2.5-4.0	89-231	>5,000
3	Punta	7.7-8.2	1.2-1.7	5.6-8.9	33- 69	150-500
	Boza	7.6-8.0	1.0-1.3	6.0-9.5	25- 50	80-130
	Noviciado	7.7-8.1	1.1-1.6	5.5-7.6	36- 70	120-300
4	Carmen	7.8-8.3	1.2-1.5	2.3-9.0	1- 51	38-560
	Batuco	7.8-8.1	1.1-1.4	3.5-8.5	10- 35	120-200
	Lag. Batuco	8.9	2.0	9.9	6	300

Table A-7-3
Quality of Water Collected every 3 hours at Point No.17

Item/Hour		6	9	12	15	18	21	0	3	6	9
pH	(Mar.)	7.1	7.2	7.0	6.9	6.9	7.0	-	-	-	-
	(Oct.)	-	8.2	8.0	8.0	7.9	7.9	7.8	8.0	8.1	8.1
EC	(Mar.)	1223	1300	1287	1456	1287	1223	-	-	-	-
	(Oct.)	-	1488	1488	1775	1639	1506	1539	1420	1074	1012
SS	(Mar.)	38	28	498	590	454	246	-	-	-	-
	(Oct.)	-	339	464	515	447	397	520	243	199	220
So4	(Mar.)	230	240	216	226	228	226	-	-	-	-
	(Oct.)	-	274	240	194	194	269	206	235	242	242
Cl	(Mar.)	121	129	122	172	140	129	-	-	-	-
	(Oct.)	-	163	167	224	192	178	174	163	150	174
RAS	(Mar.)	2.33	2.33	2.38	2.91	3.02	3.44	-	-	-	-
	(Oct.)	-	2.62	2.84	3.93	3.83	2.93	2.91	2.63	0.41	0.38
Na%	(Mar.)	36.1	35.3	36.7	42.1	44.0	48.2	-	-	-	-
	(Oct.)	-	37.4	39.6	47.7	47.4	40.7	40.3	38.3	8.8	7.9
N-NH3	(Mar.)	12.04	14.98	21.14	33.32	19.88	15.61	-	-	-	-
	(Oct.)	-	24.36	25.62	38.99	26.81	22.33	17.43	10.01	19.83	23.3
N-Org	(Mar.)	2.24	3.43	12.95	16.94	15.89	12.04	-	-	-	-
	(Oct.)	-	4.83	8.59	10.43	14.14	4.69	10.15	4.76	3.64	4.20
TK-N	(Mar.)	14.28	18.41	34.09	50.26	35.77	27.65	-	-	-	-
	(Oct.)	-	29.19	39.16	49.42	40.95	27.02	27.58	15.77	22.47	27.2
Cu	(Mar.)	0.015	0.020	0.117	0.224	0.190	0.073	-	-	-	-
	(Oct.)	-	0.04	0.16	0.22	0.45	0.15	0.37	0.11	0.03	0.02
Pb	(Mar.)	0.080	0.066	0.126	0.131	0.145	0.066	-	-	-	-
	(Oct.)	-	0.02	0.08	0.09	0.08	0.07	0.19	0.02	0.03	0.02
Zn	(Mar.)	0.007	0.008	0.343	0.348	0.254	0.738	-	-	-	-
	(Oct.)	-	0.05	0.53	0.95	0.47	0.36	0.73	0.50	0.10	0.04
BOD	(Mar.)	25	32	>200	>200	175	138	-	-	-	-
	(Oct.)	-	72	218	195	205	225	150	68	42	22

Table A-7-4 Change of Water Quality after 24 hr and 48 hr in quiet Condition (at Point No.17)

Hour / Item		0	after 24 hr	after 48 hr
pH	(Mar.)	7.0	7.0	7.0
	(Nov.)	8.0	8.1	8.1
	(Mean)	7.5	7.6	7.6
EC	(Mar.)	1287	1218	1233
	(Nov.)	1488	1549	1640
	(Mean)	1388	1384	1437
SS	(Mar.)	498	57	41
	(Nov.)	436	66	48
	(Mean)	467	62	45
SO4	(Mar.)	216	228	240
	(Nov.)	240	259	245
	(Mean)	228	244	243
Cl	(Mar.)	122	47	118
	(Nov.)	167	160	169
	(Mean)	145	104	144
SAR	(Mar.)	2.38	2.35	2.29
	(Nov.)	2.84	2.97	2.83
	(Mean)	2.61	2.66	2.56
Na%	(Mar.)	36.7	36.8	36.0
	(Nov.)	39.6	40.5	38.3
	(Mean)	38.2	38.7	37.2
NH3-N	(Mar.)	21.14	19.25	18.76
	(Nov.)	25.62	22.89	23.24
	(Mean)	23.38	21.07	21.00
N-Org	(Mar.)	12.95	4.48	3.99
	(Nov.)	8.54	5.11	<0.07
	(Mean)	10.75	4.80	2.03
TK-N	(Mar.)	34.09	23.73	22.75
	(Nov.)	34.16	28.00	23.29
	(Mean)	34.13	25.87	23.02
Cu	(Mar.)	0.117	0.016	0.009
	(Nov.)	0.16	0.02	0.01
	(Mean)	0.139	0.018	0.01
Pb	(Mar.)	0.126	0.080	0.047
	(Nov.)	0.08	0.04	0.03
	(Mean)	0.103	0.060	0.039
Zn	(Mar.)	0.343	0.081	0.048
	(Nov.)	0.53	0.26	0.09
	(Mean)	0.437	0.171	0.069
BOD	(Mar.)	230	57	44
	(Nov.)	218	122	50
	(Mean)	224	90	47

Table A-7-5 Water Quality of Groundwater and Pond Water etc.

ITEM/SITE	No 19	No 20	No 21	No 22	No 23
pH	7.800	7.800	7.900	7.600	7.900
EC	1069.000	1463.000	1463.000	1380.000	1423.000
S-T	0.000	1084.000	1084.000	0.000	1051.000
SO4	242.000	322.000	293.000	307.000	302.000
Cl	104.000	160.000	140.000	147.000	156.000
SAR	1.660	2.070	2.020	2.060	2.240
Na%	30.400	31.400	30.900	32.100	33.800
NH3-N	0.070	6.440	3.360	8.960	9.590
N-Org	0.560	0.070	1.750	0.070	3.010
TK-N	0.560	6.440	5.110	8.960	12.600
Cu	0.000	0.040	0.020	0.030	0.000
Pb	0.000	0.020	0.020	0.020	0.030
Zn	0.000	0.270	0.030	0.000	0.080
BOD	7.000	5.000	5.000	9.000	5.000
C-T	92E+03	17E+06	24E+03	16E+08	28E+07
C-G	16E+03	16E+06	21E+03	62E+06	47E+06
SO4--	5.040	6.700	6.100	6.390	6.290
CL-	2.930	4.510	3.950	4.150	4.400
HCO3-	1.400	2.600	3.200	2.000	2.200
Ca++	6.000	8.000	8.000	7.500	7.500
Mg++	1.000	1.900	1.900	1.600	1.700
Na+	3.100	4.600	4.500	4.400	4.800
K+	0.009	0.170	0.160	0.210	0.220

ITEM/SITE	No 29	No 30	No 31	No 32	No 33
pH	8.100	8.300	8.300	7.500	7.800
EC	4194.000	2095.000	2346.000	775.000	392.000
S-T	0.000	0.000	0.000	546.000	260.000
SO4	816.000	394.000	432.000	125.000	79.000
Cl	582.000	221.000	299.000	26.000	10.000
SAR	3.080	3.040	3.520	1.810	1.450
Na%	28.600	37.100	38.500	35.200	38.900
NH3-N	0.070	0.070	0.070	0.070	0.140
N-Org	0.070	0.070	0.070	0.210	0.210
TK-N	0.070	0.070	0.070	0.280	0.350
Cu	0.050	4.720	0.080	0.005	0.004
Pb	0.100	0.100	0.040	0.056	0.052
Zn	0.360	1.230	0.260	0.003	0.003
BOD	5.000	5.000	5.000	5.000	5.000
C-T	32E+01	54E+06	62E+03	0E+00	0E+00
C-G	20E-01	22E+04	16E+02	0E+00	0E+00
SO4--	16.990	8.200	8.990	2.600	1.640
CL-	16.420	6.230	8.430	0.730	0.280
HCO3-	2.700	3.400	2.600	4.000	2.600
Ca++	23.500	11.000	7.500	4.490	1.890
Mg++	5.800	2.100	5.600	1.030	0.620
Na+	11.800	7.800	9.000	3.000	1.620
K+	0.160	0.130	1.250	0.010	0.030

ITEM/SITE	No 24	No 25	No 26	No 27	No 28
pH	7.900	8.000	8.100	8.400	8.100
EC	1507.000	1497.000	2422.000	2856.000	1268.000
S-T	1062.000	0.000	0.000	0.000	0.000
SO4	322.000	317.000	696.000	600.000	217.000
Cl	160.000	160.000	250.000	312.000	125.000
SAR	2.160	2.070	1.890	4.580	2.540
Na%	32.200	31.200	26.500	45.400	38.600
NH3-N	0.070	7.420	0.070	0.070	0.070
N-Org	0.070	3.010	0.070	0.070	0.070
TK-N	0.070	10.430	0.070	0.070	0.070
Cu	0.020	0.020	0.020	0.020	0.370
Pb	0.030	0.030	0.050	0.040	0.050
Zn	0.050	0.050	0.000	0.090	0.220
BOD	28.000	5.000	5.000	5.000	5.000
C-T	62E+04	26E+04	54E+02	17E+02	40E+02
C-G	33E+04	26E+04	24E+01	79E+00	20E-01
SO4--	6.700	6.600	14.490	12.490	4.520
CL-	4.510	4.510	7.050	8.800	3.530
HCO3-	2.600	2.600	2.000	4.200	3.200
Ca++	8.000	8.000	10.000	9.500	6.000
Mg++	1.900	1.900	3.600	3.800	1.500
Na+	4.800	4.600	4.920	11.800	4.920
K+	0.220	0.220	0.050	0.890	0.320

ITEM/SITE	No 34	No 35	No 36	No 37	No 38
pH	8.000	8.000	8.100	0.000	0.000
EC	2520.000	2728.000	1772.000	0.000	0.000
S-T	0.000	0.000	0.000	0.000	0.000
SO4	504.000	588.000	480.000	0.000	0.000
Cl	307.000	421.000	202.000	0.000	0.000
SAR	2.940	3.490	6.380	0.000	0.000
Na%	35.100	38.600	58.200	0.000	0.000
NH3-N	0.070	0.070	0.070	0.000	0.000
N-Org	2.520	0.560	0.490	0.000	0.000
TK-N	2.520	0.560	0.490	0.000	0.000
Cu	0.020	0.020	0.020	27.672	19.470
Pb	0.070	0.070	0.050	0.066	0.038
Zn	0.000	0.080	0.030	0.732	0.621
BOD	9.000	5.000	5.000	0.000	0.000
C-T	0E+00	0E+00	0E+00	0E+00	0E+00
C-G	0E+00	0E+00	0E+00	0E+00	0E+00
SO4--	10.490	12.240	9.990	5.750	6.000
CL-	8.660	11.880	5.700	0.170	0.390
HCO3-	2.200	1.800	1.900	0.000	0.080
Ca++	8.000	11.000	6.000	3.000	3.490
Mg++	6.100	4.200	3.800	0.820	0.860
Na+	7.800	9.630	14.130	0.250	0.620
K+	0.330	0.140	0.340	0.050	0.150

[Note]
S-T : Suspended Total
N-Org: Organic Nitrogen
TK-N : Kjeldahl Nitrogen [NH3-N + N-Org]
C-T : Coliform Total
C-G : Coliform Group
SAR : Sodium Adsorption Ratio
SAR = Na/ (Ca+Mg)/2
Na% : Na/(Na+Ca+Mg+K) %

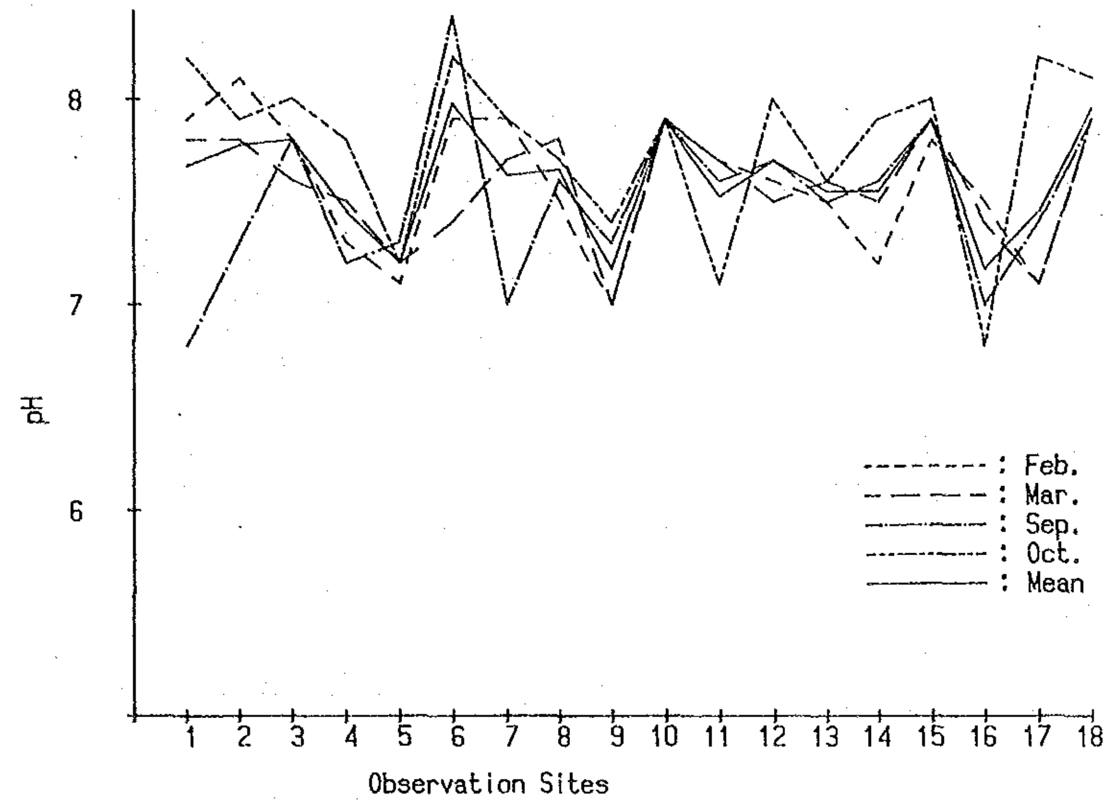


Fig.A-7-2(1) Present Water Quality (Present Status of pH)

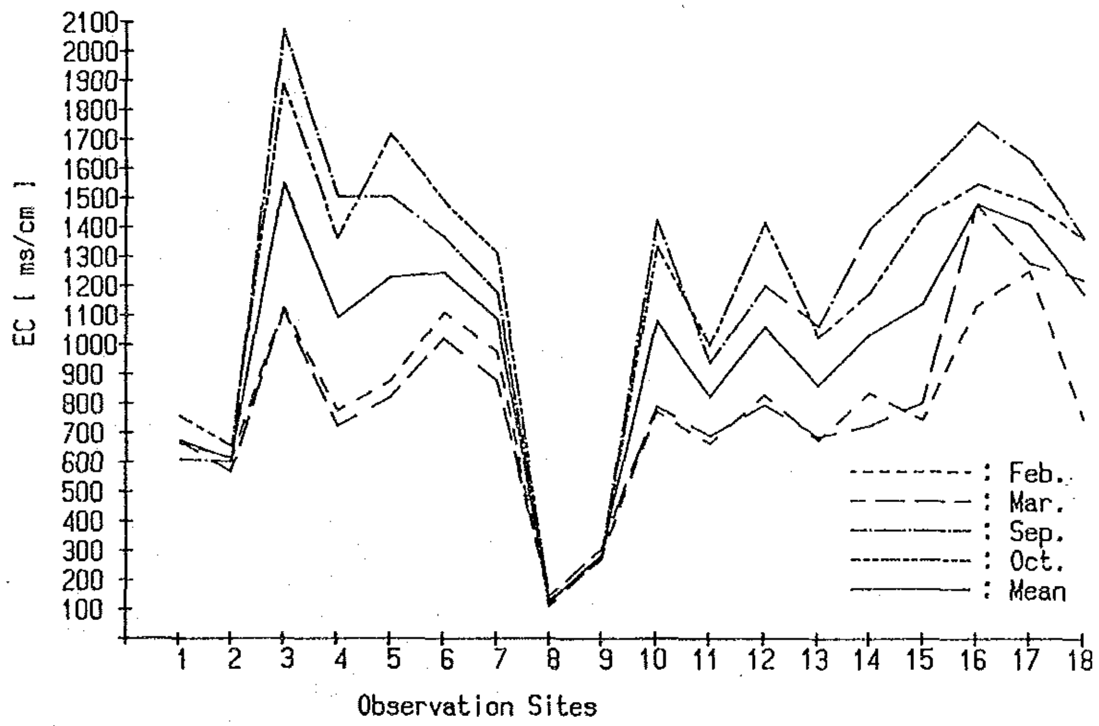


Fig.A-7-2(2) Present Water Quality (Present Status of EC)

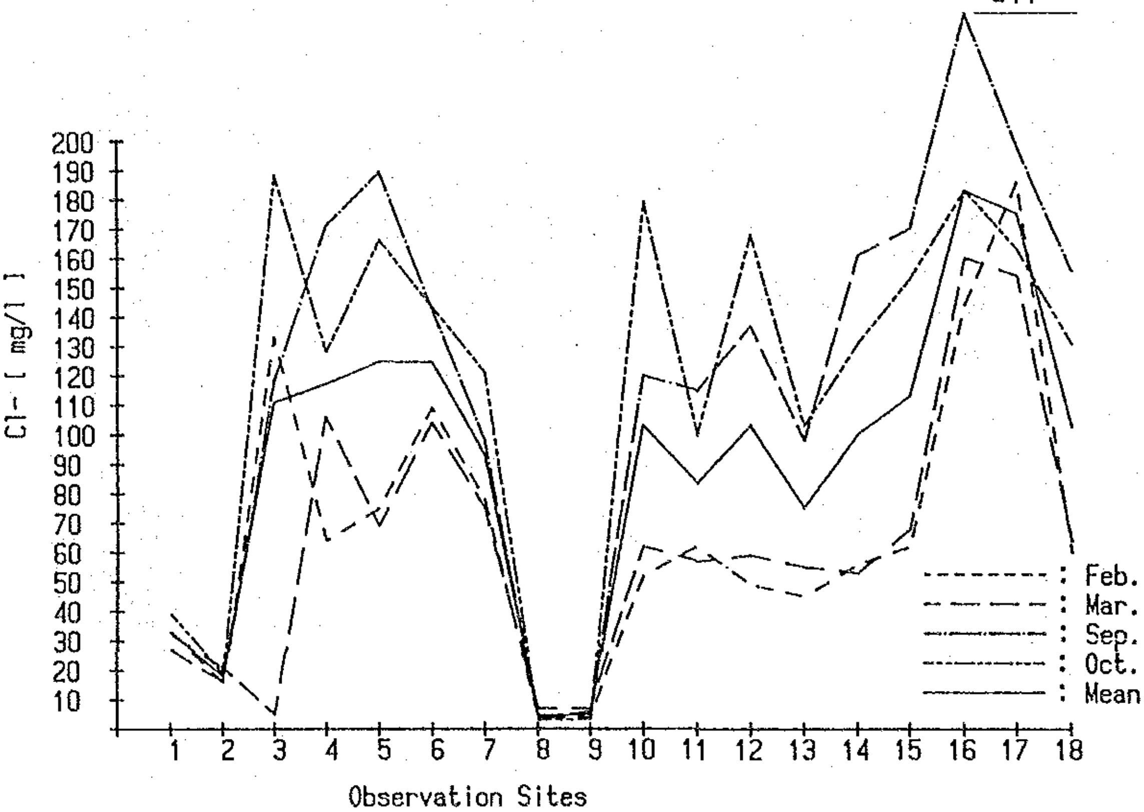


Fig.A-7-2(3) Present Water Quality (Present Status of Cl)

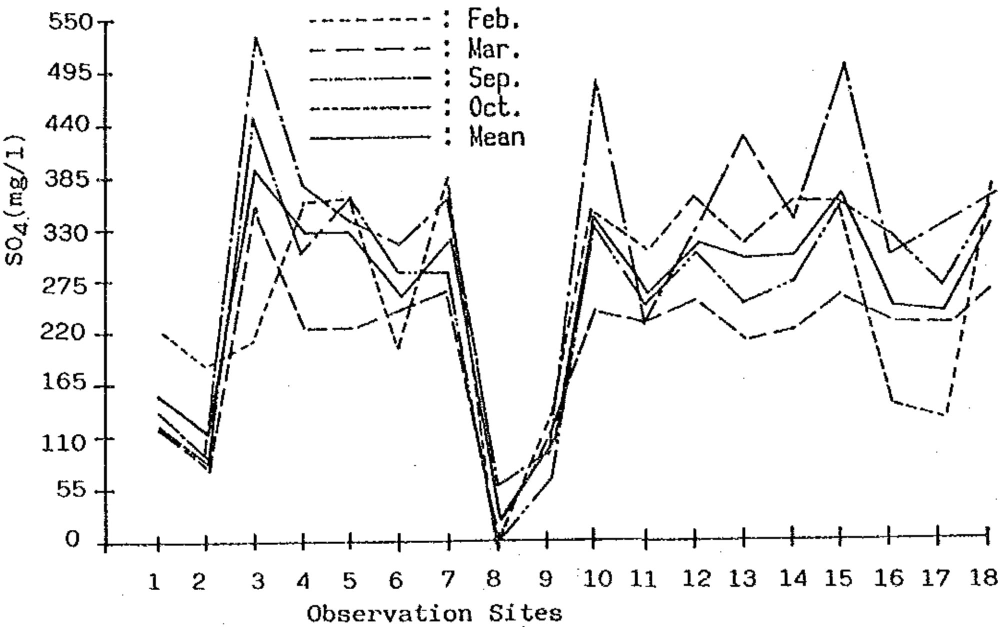


Fig.A-7-2(4) Present Water Quality (Present Status of SO_4^{--})

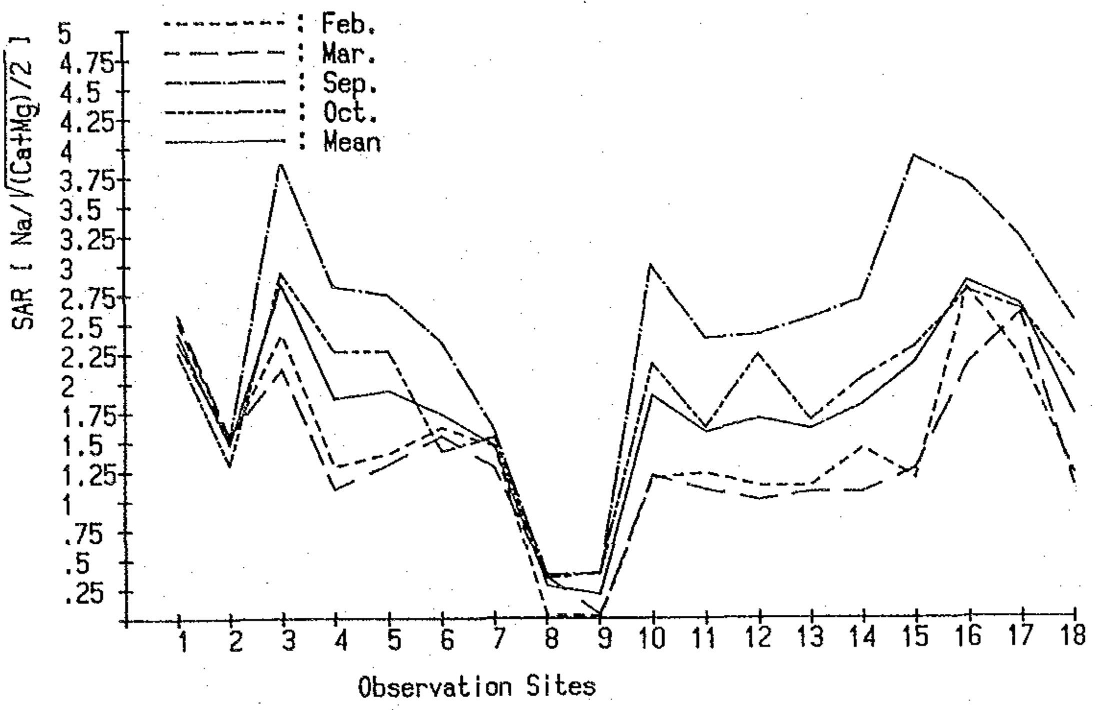


Fig.A-7-2(5) Present Water Quality (Present Status of SAR)

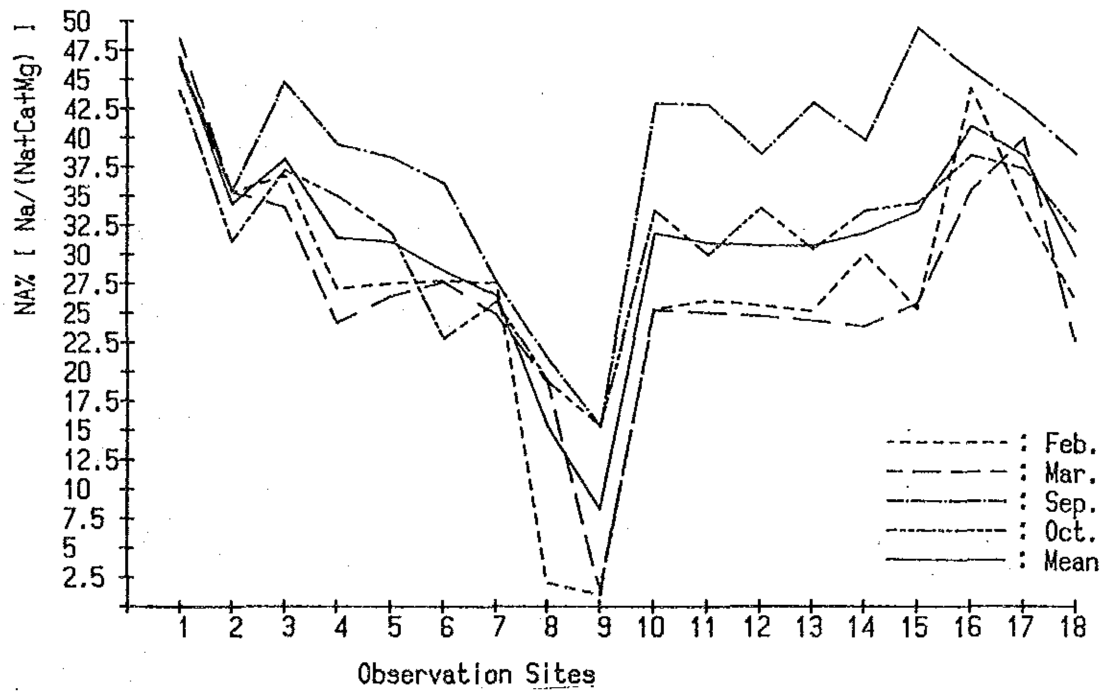


Fig.A-7-2(6) Present Water Quality (Present Status of Na%)

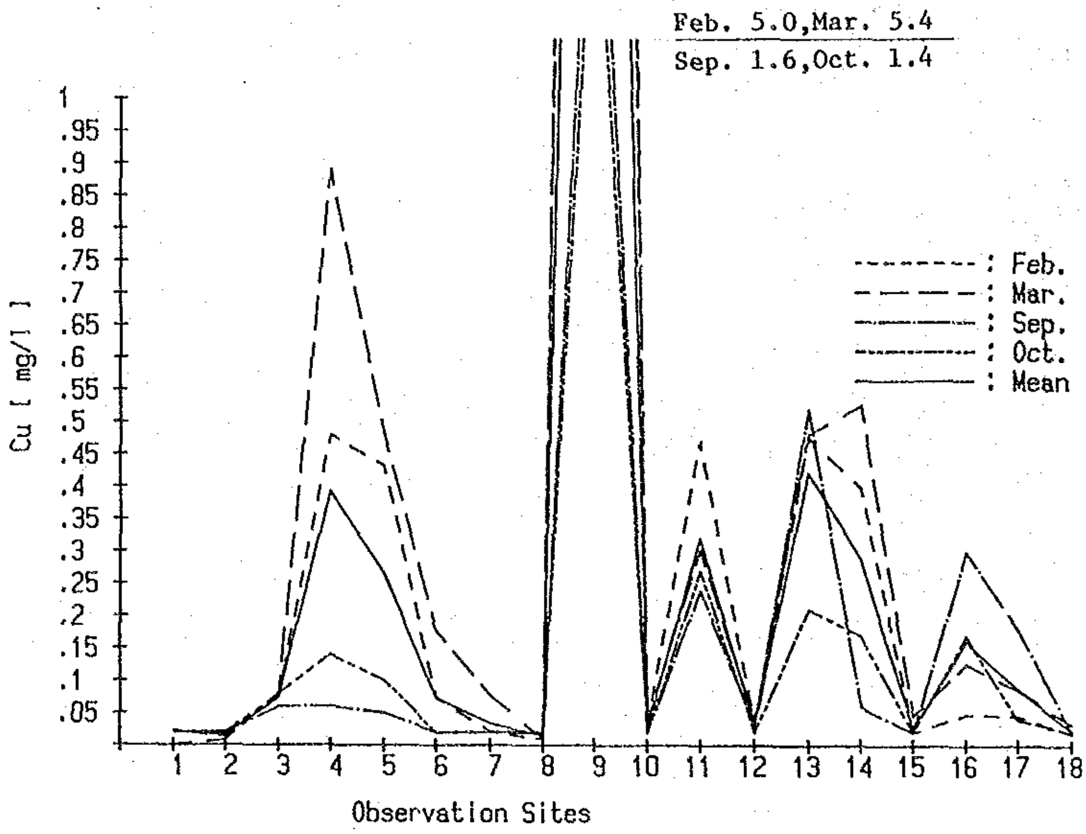


Fig.A-7-2(7) Present Water Quality (Present Status of Cu)

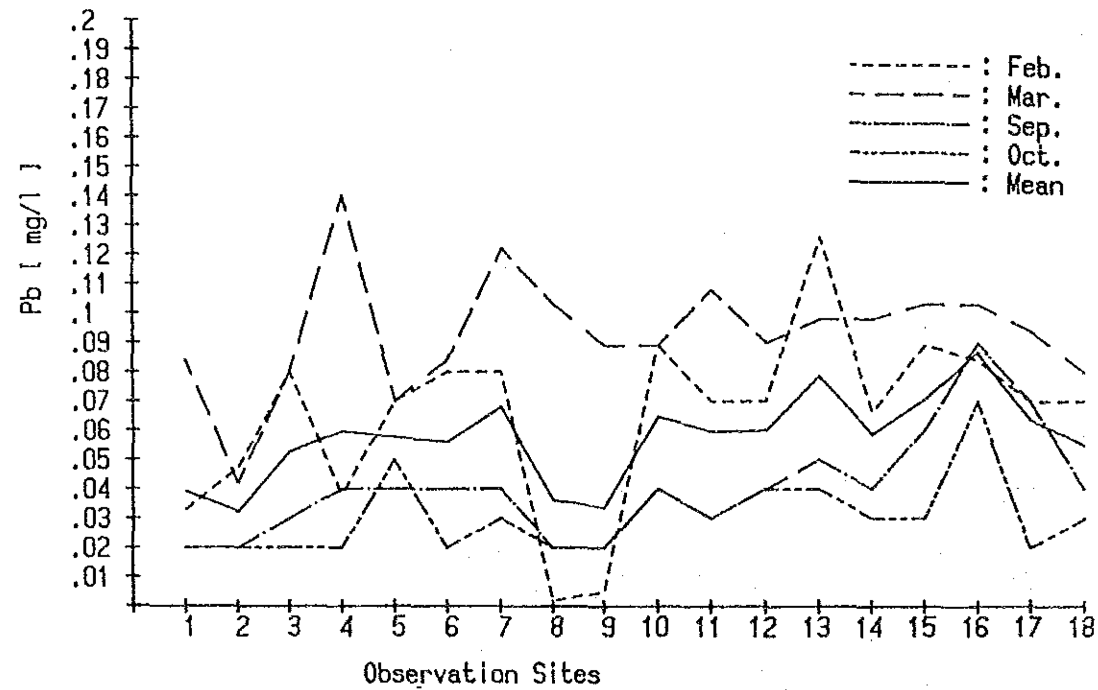


Fig.A-7-2(8) Present Water Quality (present Status of Pb)

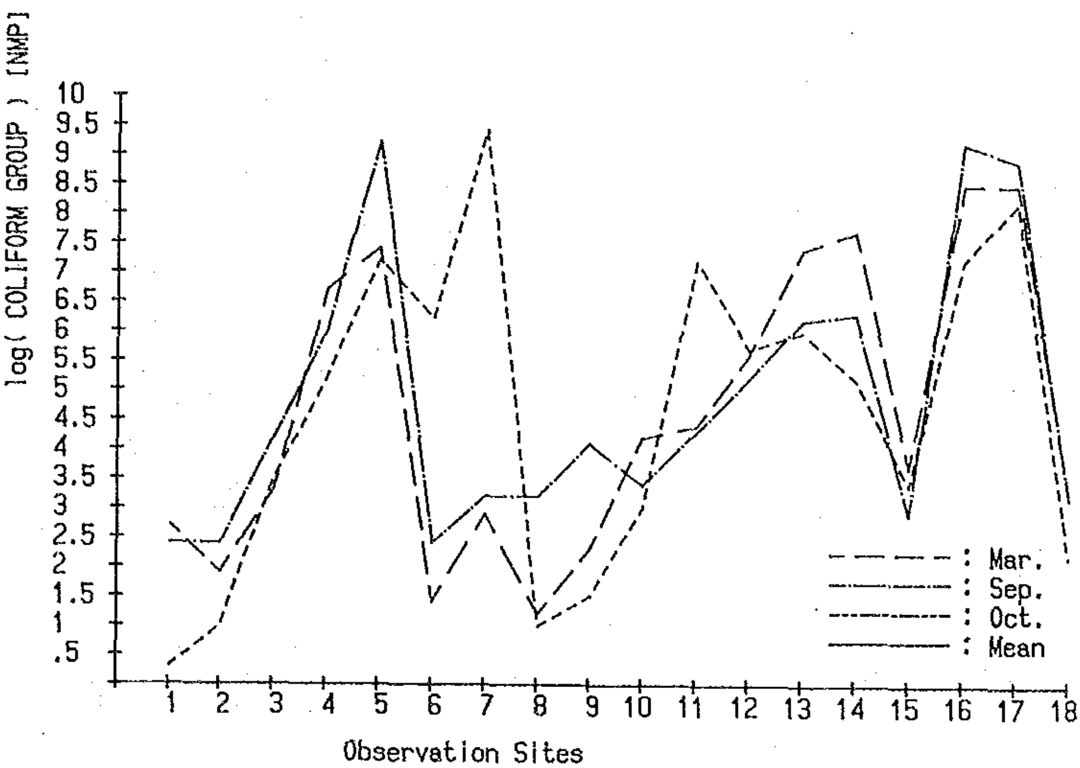


Fig.A-7-2(9) Present Water Quality
(present Status of Coliform Groups)

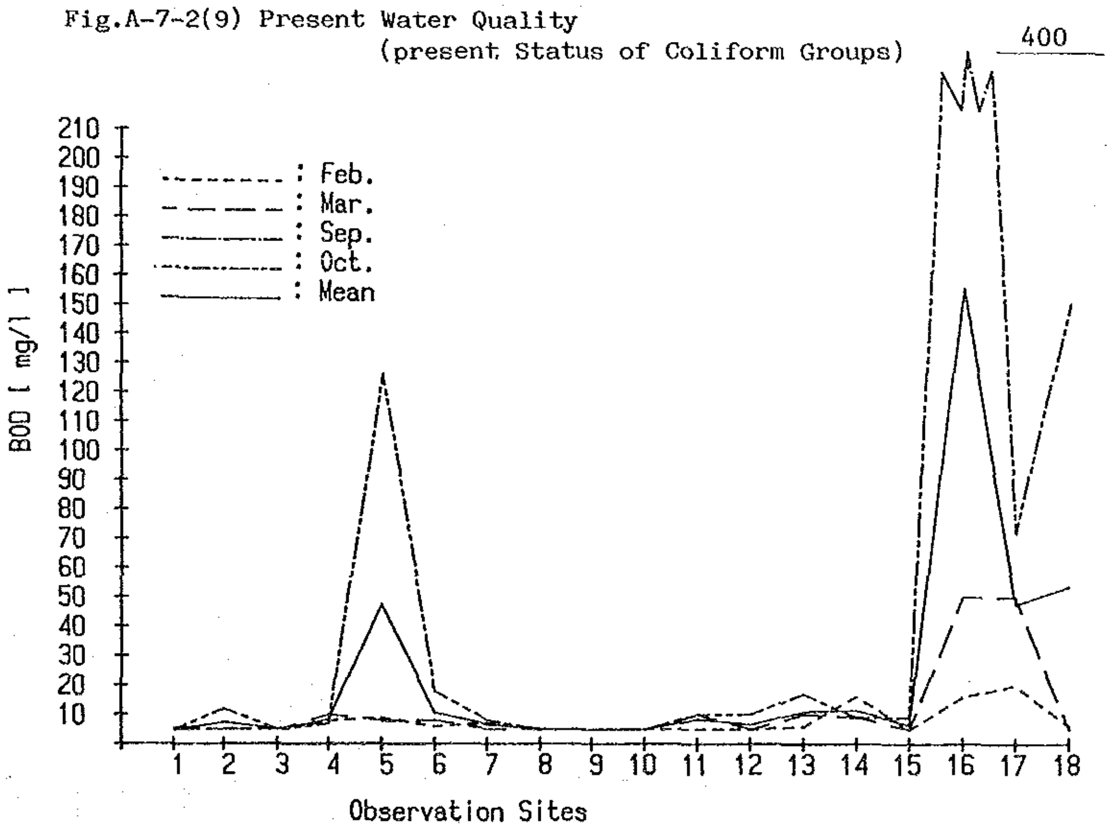


Fig.A-7-2(10) Present Water Quality (Present Status of BOD)

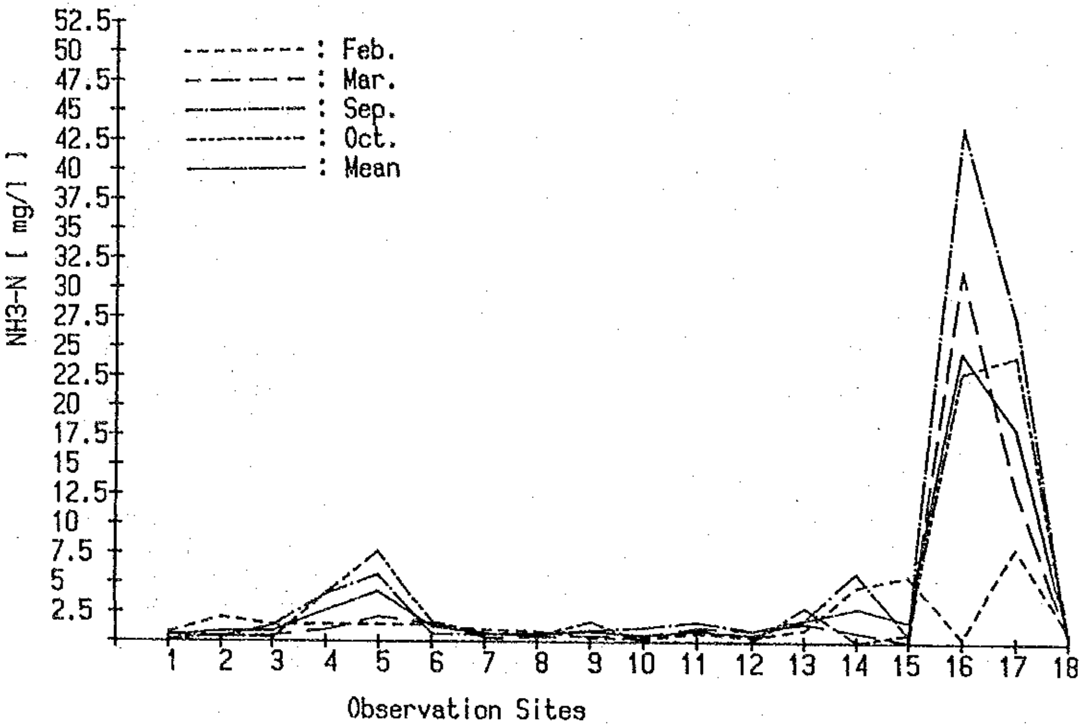


Fig.A-7-2(11) Present Water Quality (Present Status of NH_3 -N)

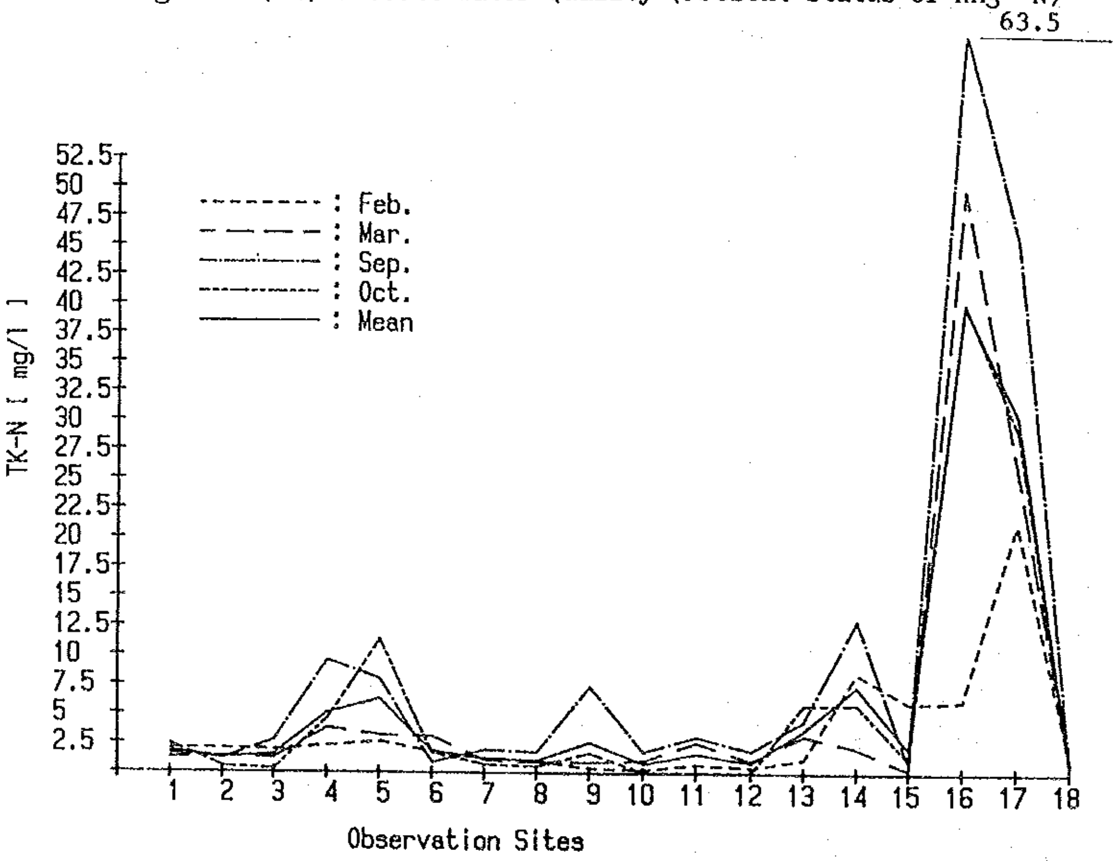


Fig.A-7-2(12) Present Water Quality (Present Status of Kjeldal-N)

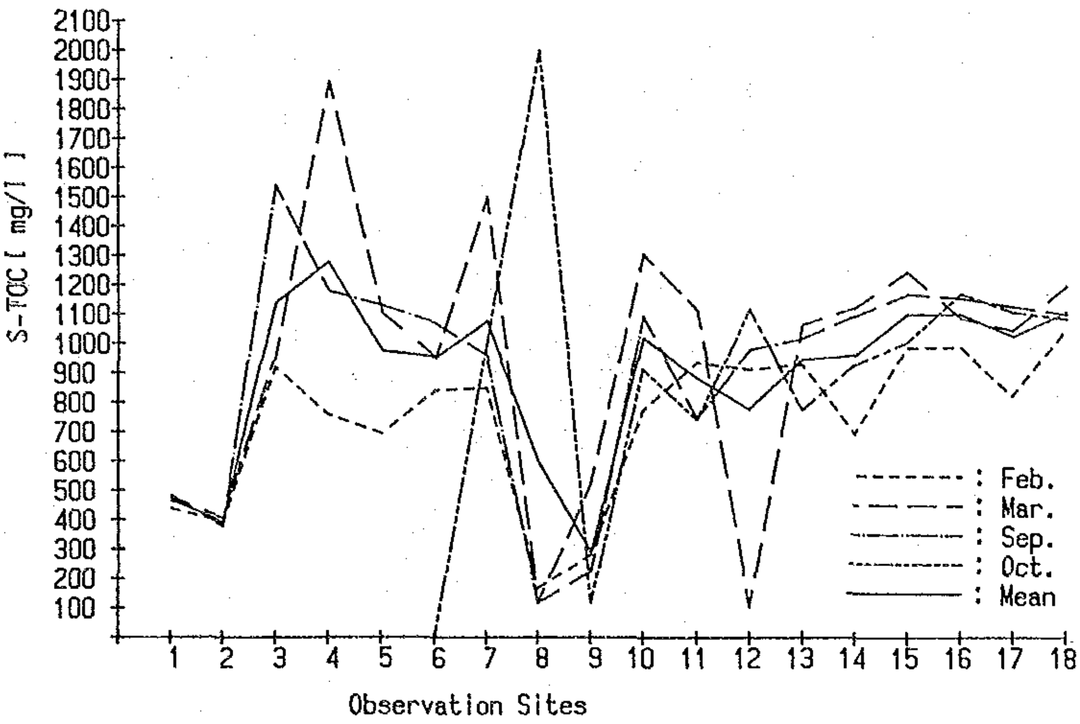


Fig.A-7-2(13) Present Water Quality (Present Status of Soluble TOC)

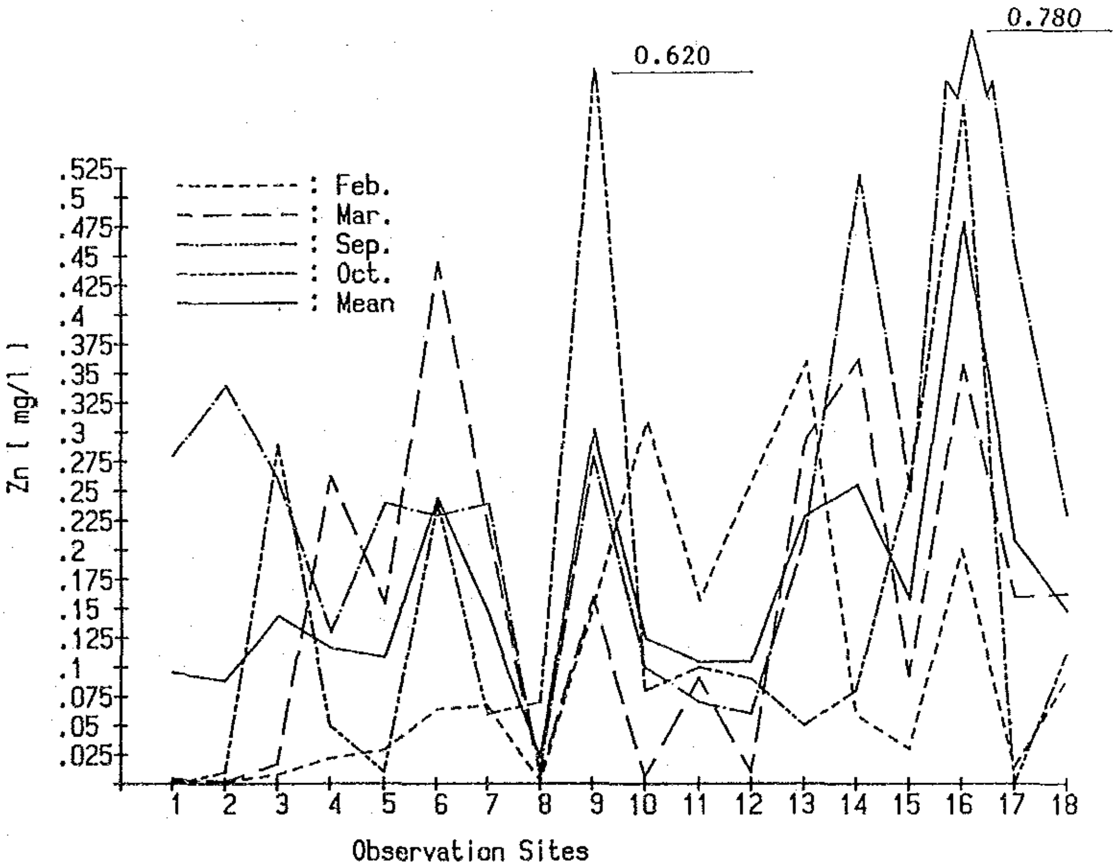
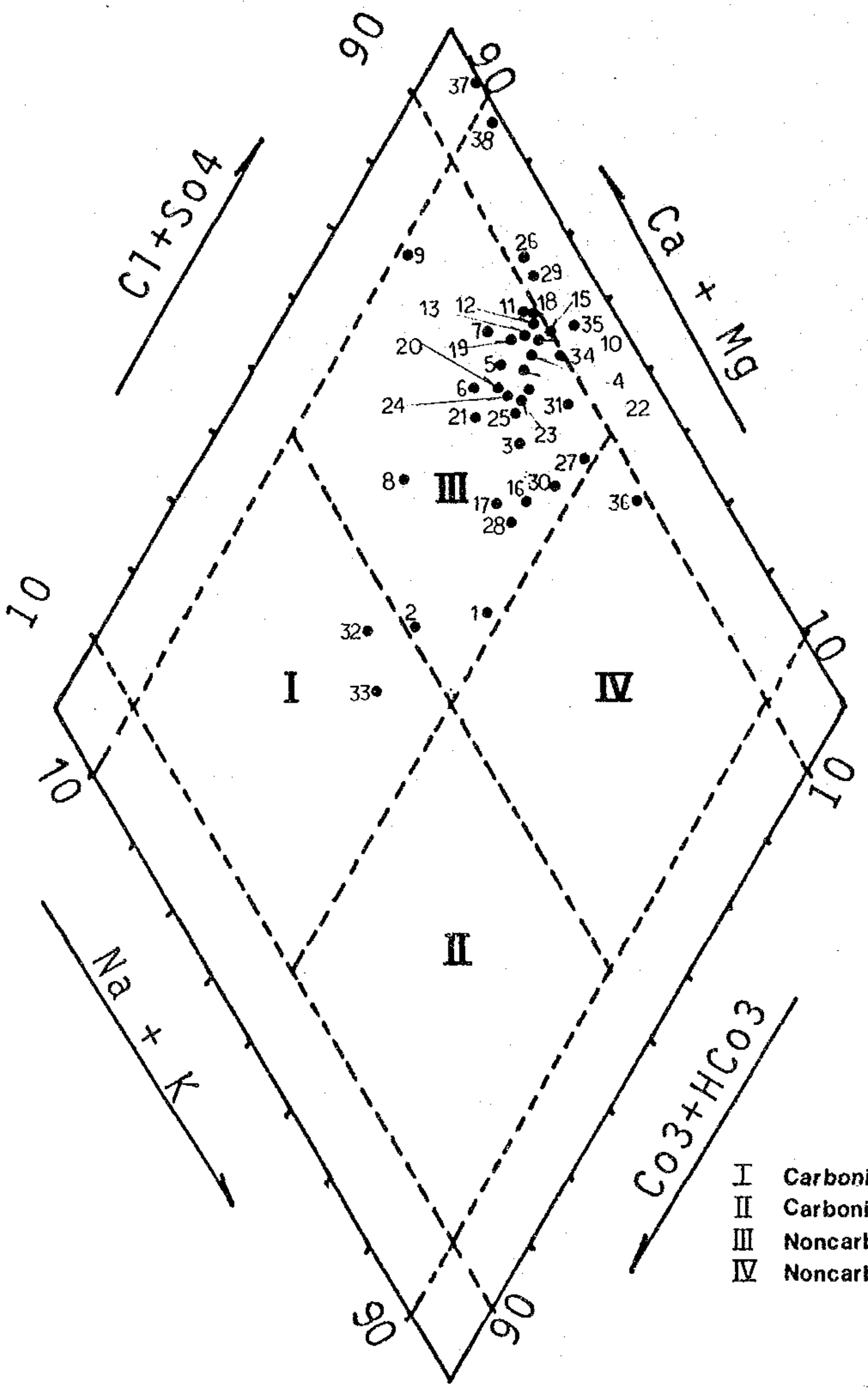


Fig.A-7-2(14) Present Water Quality (present Status of Zn)



I	Carbonic – Calcium Type
II	Carbonic – Sodium Type
III	Noncarbonic – Calcium Type
IV	Noncarbonic – Sodium Type

Fig. A-7-3 Key - Diagram

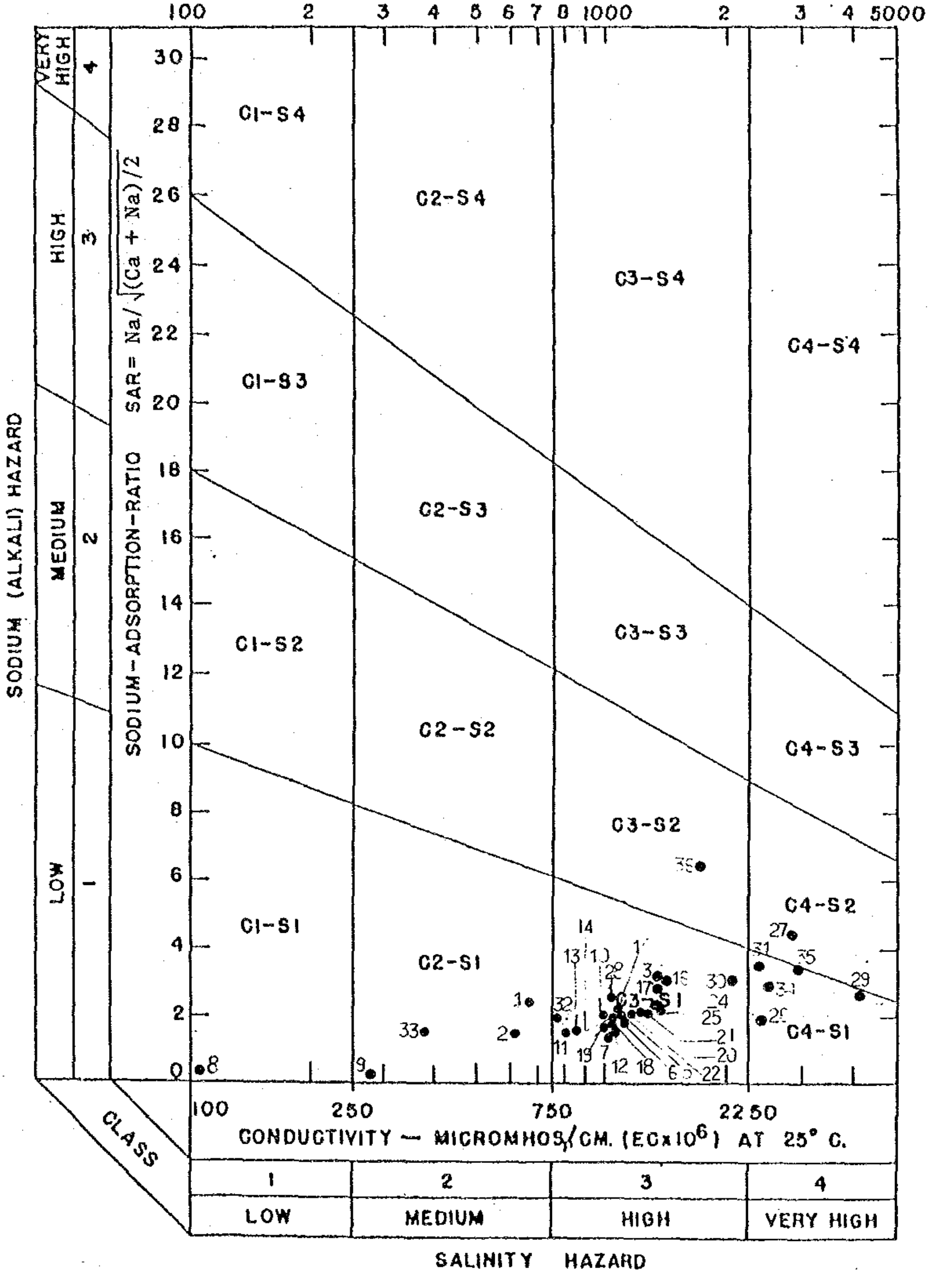


Fig A-7-4 Classification for Irrigation Water

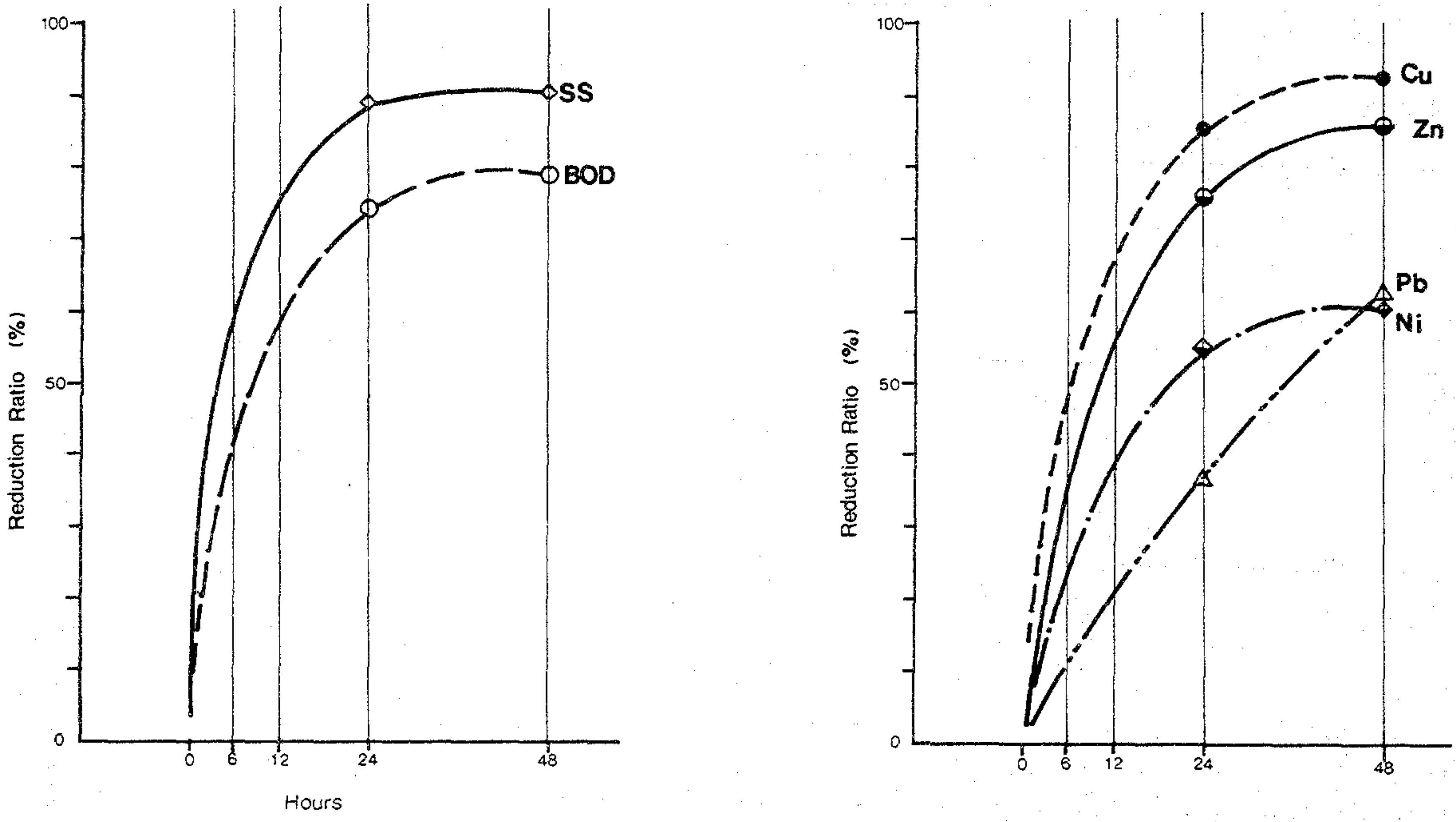


Fig. A-7-5 Reduction Curves

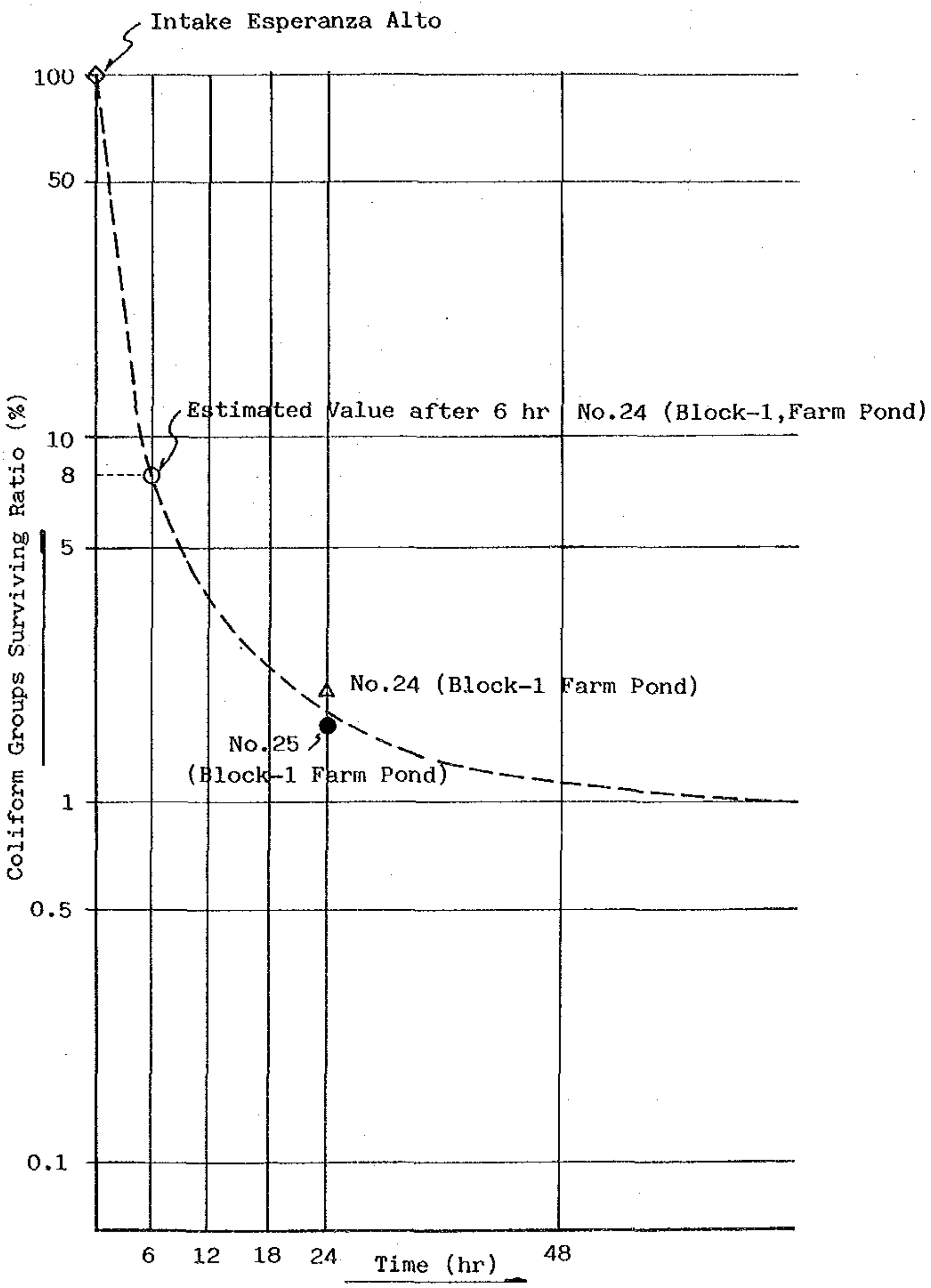


Fig.A-7- 6 Coliform Groups Reduction Curve (Based on the Laboratory Test Conducted by the Study Team, Table A-7-11)

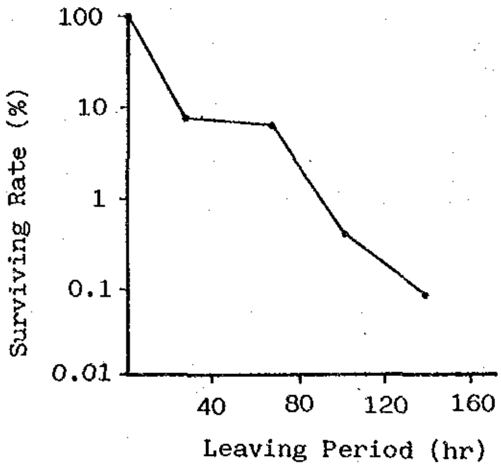


Fig.A-7-7 Relationship between Surviving Rate of Virus/Bacteria and Leaving Period a Pond

Source: Ralph Mitchell : Water Pollution Microbiology,1978

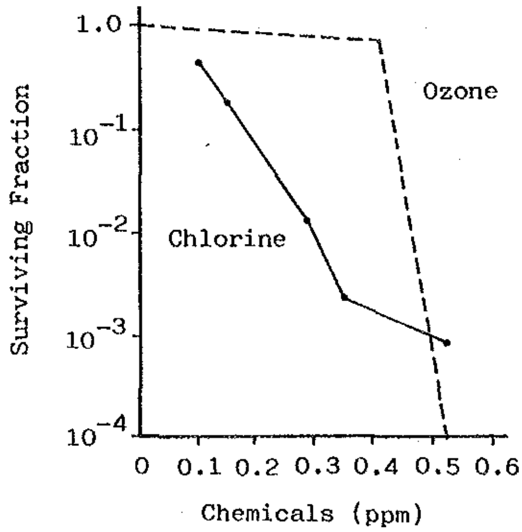


Fig.A-7-8 Relationship between Surviving Rate of Coliform Groups and Content of Chemicals

Source : R.S Ingols and R.H.Fetner : Water Treatment Exam,1957

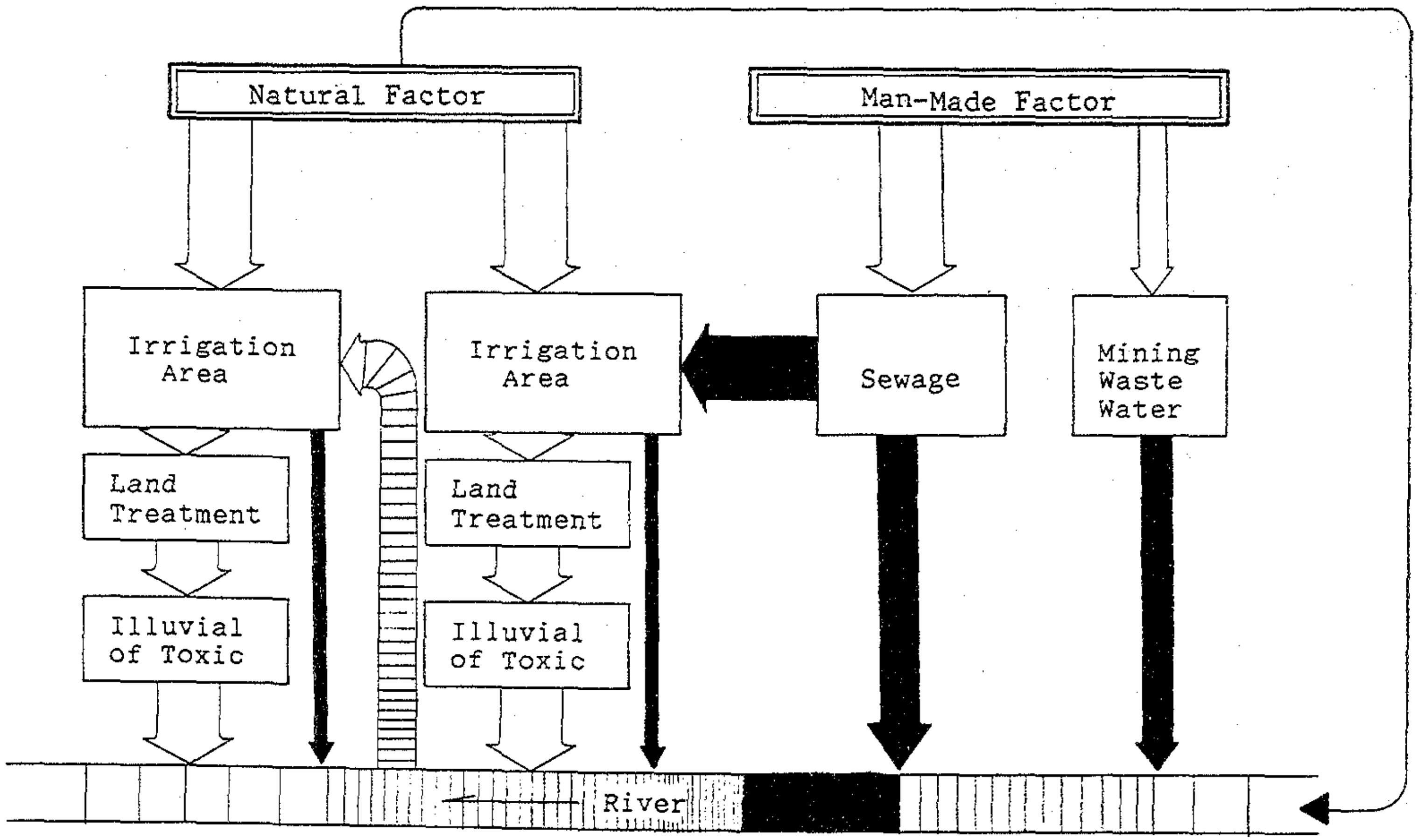
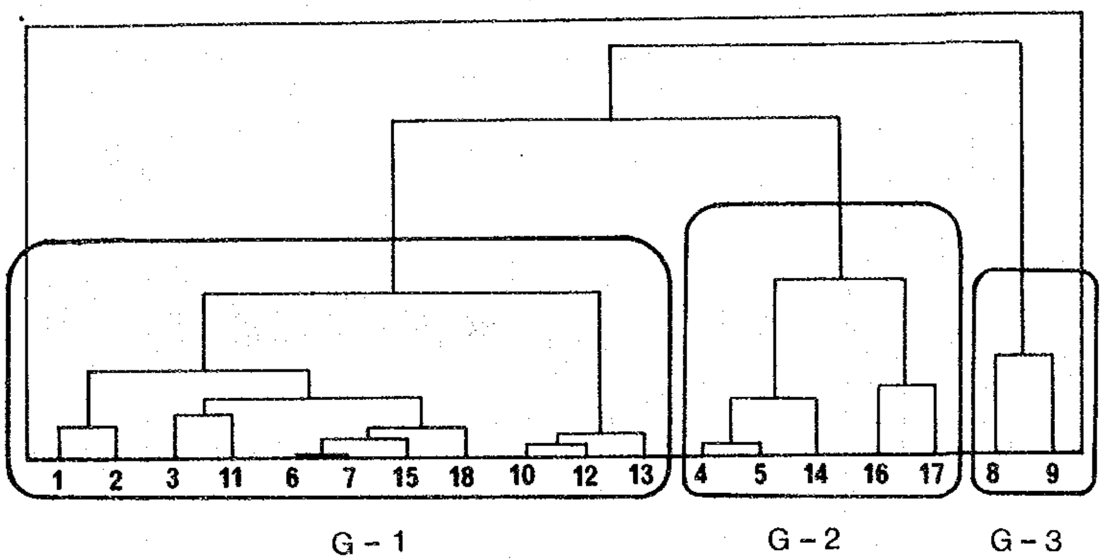


Fig A-7-9 Mechanism of Water Pollution



Note : No. shows observation site.

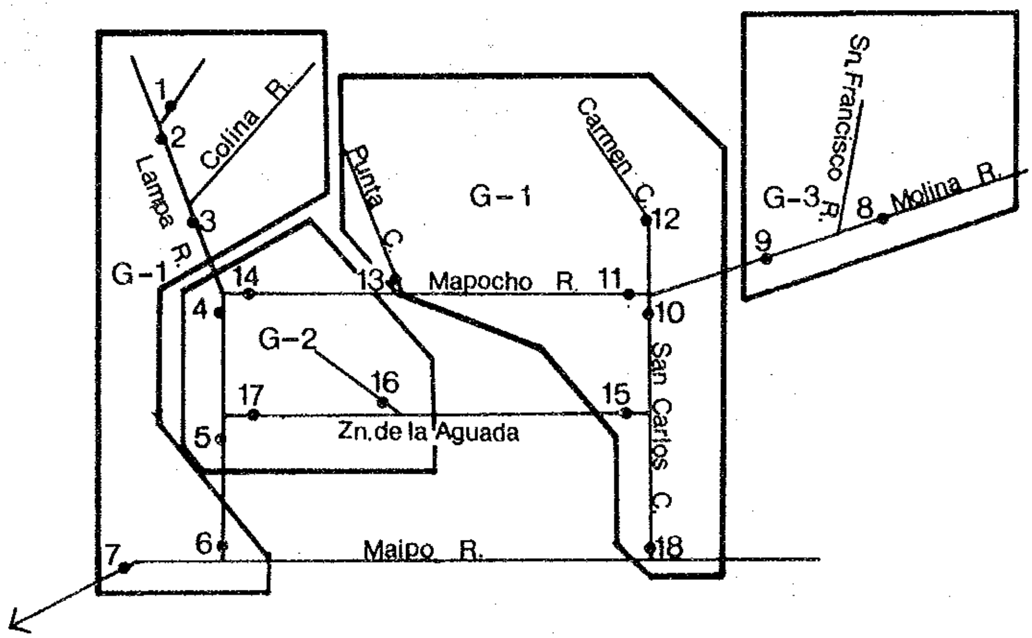


Fig.A-7-10 Dendrogram of Present Water Flow System

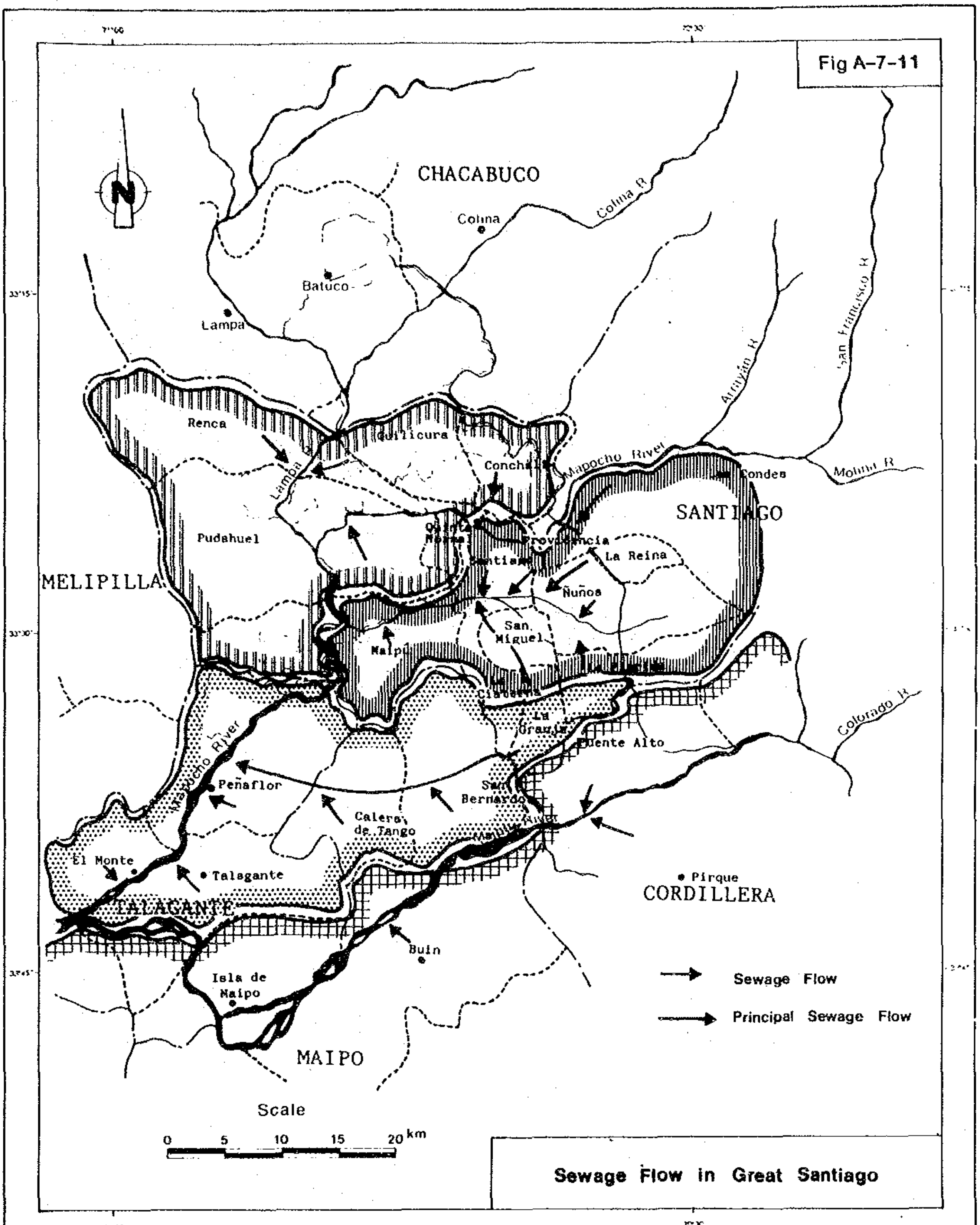


Fig A-7-11
CHACABUCO
Colina
Colina R.
Batuco
Lampa
San Francisco R.
Arrayán R.
Renca
Quilicura
Conchalí
Mapocho River
Condes
Molina R.
SANTIAGO
Pudahuel
Quinta Normal
Providencia
La Reina
MELIPILLA
Ñuñoa
San Miguel
Maipú
La Granja
Puente Alto
Colorado R.
Mapocho River
Peñaflor
San Bernardo
Calera de Tango
El Monte
Talagante
Pirque
CORDILLERA
TALAGANTE
Buin
Isla de Maipo
MAIPO
Sewage Flow
Principal Sewage Flow
Scale
0 5 10 15 20 km
Sewage Flow in Great Santiago

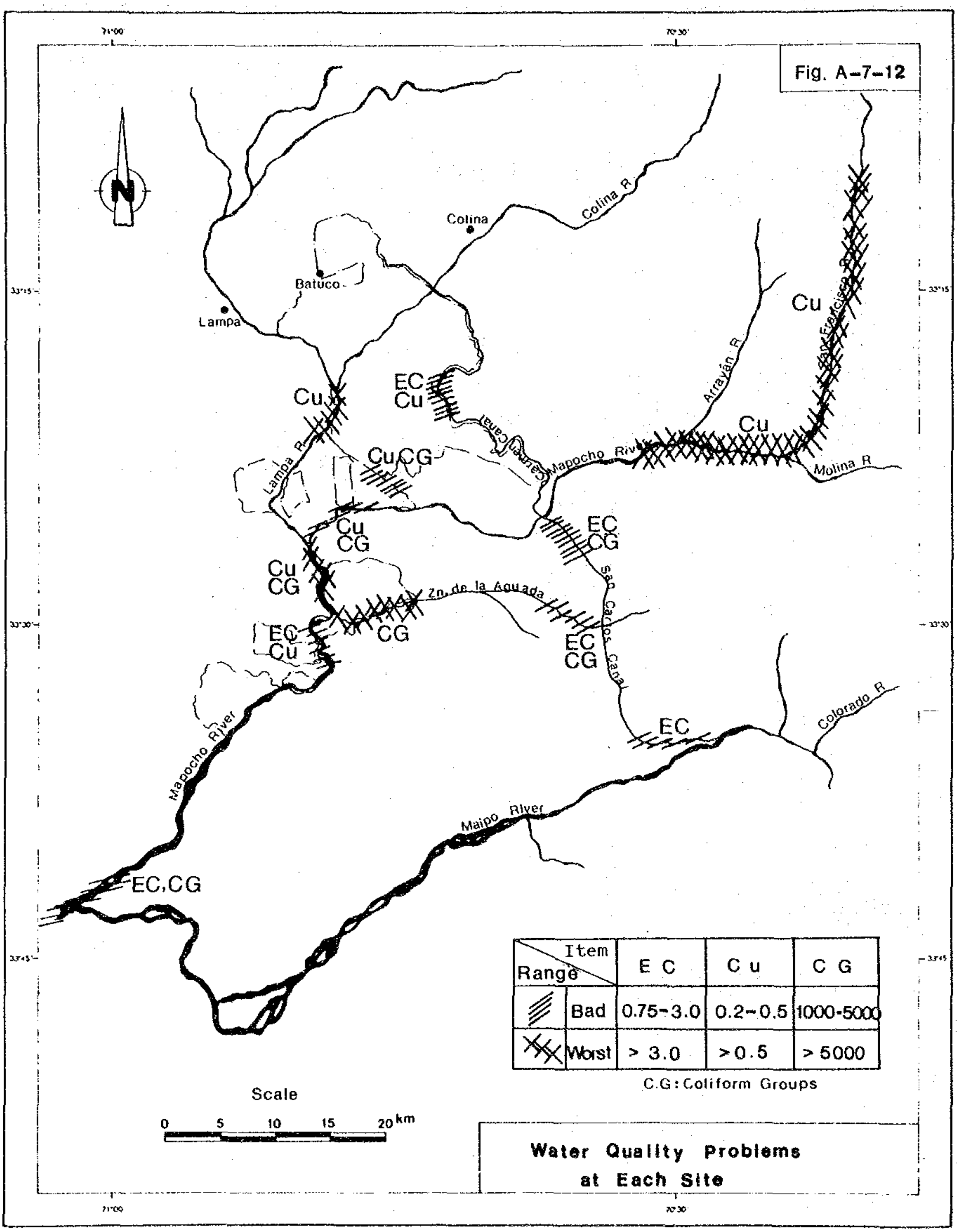
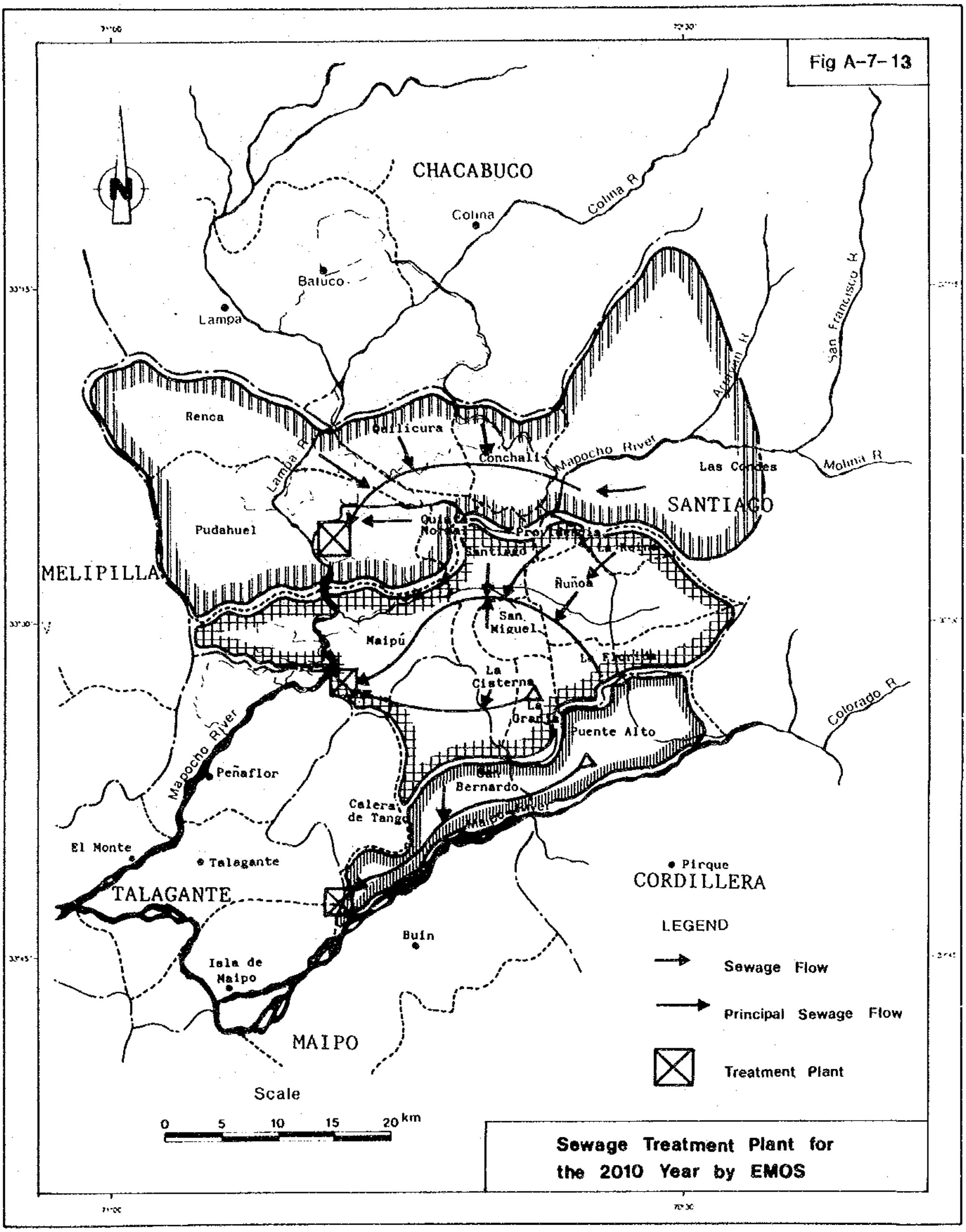


Fig. A-7-12
Colina R.
Colina
Batuco
Lampa
Lampa R.
Arrayán R.
San Francisco R.
Molina R.
Mapocho River
Carmen Canal
Zn. de la Aguada
San Carlos Canal
Colorado R.
Maipo River
Cu
EC
CG
EC,CG
Item
Range
E C
C u
C G
Bad
0.75~3.0
0.2~0.5
1000-5000
Worst
> 3.0
> 0.5
> 5000
C.G: Coliform Groups
Scale
0 5 10 15 20 km
Water Quality Problems
at Each Site



Sewage Treatment Plant for the 2010 Year by EMOS

7.2 Water Quality Improvement Scheme

(1) Selection of the Objective Area

- Block-1:
  The main canals are the Esperanza Alto and Esperanza Bajo canals. Both canals draw directly their irrigation waters from the Mapocho river. In addition, intake facilities of these canals are located just below the junction where Zanjón de la Aguada flows into the Mapocho river. Therefore, the water quality of this block is influenced by the sewage from Santiago city. The water quality should be improved so that the water can be used for irrigation. Items to be improved will be EC, SS, Cu and Coliform groups.

- Block-2:
  All canals in this block directly draw their irrigation waters from Zanjón de la Aguada. Consequently, in view of irrigation water, it is most necessary to improve the water quality of this block. Items to be improved will be EC, SS, Na%, Cu, N, BOD and Coliform groups.

- Block-3:
  The main canal is the Punta canal. It draws its water through the Mapocho river. Therefore, this water is contaminated with the sewage from Santiago city. The water quality should be improved so that the water can be used for irrigation. Items to be improved will be SS, Cu and Coliform groups.

- Block-4:
  The main canal is the Carmen canal. Originally, the water quality of this canal is the same as of the Maipo river. But it is contaminated with the sewage from Santiago city. The works for separating the irrigation water from the sewer water will be carried out by the Government of Chile in the near future. If this works is completed, there will be no future problem in the water quality.

In view of the above, the water quality improvement is necessary for the areas of Blocks-1, 2 and 3.

(2) Method of Water Quality Improvement

The following three methods were studied for the improvement of the water quality:

a. Separation of irrigation water from sewer water
b. Change of water resources
c. Water treatment

Table A-7-6 Representative Water Quality Standard

Item	Unit	Maximum Limit for Irrigation
pH		Normal Range 5.5 - 9.0
EC	mmhos/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	number/100 ml	1,000
BOD	ppm	(20) 1/
NH_3 -H	ppm	(5) 1/

1/ Proposed by the Study Team

Table A-7-7 Characteristics of Water Quality at Selected Sites

Item	EC	SS	Na	Cu	Cd	BOD	Coliform Groups
Unit	mmhos/cm	mg/l	%	mg/l	mg/l	mg/l	
Max. limit	0.75	500	35	0.2	0.01	20	1000
Range Good (o) Bad (*) Worst(•)	<0.75 0.75-3.0 >3.0	<500 500-1000 >1000	<35 35-80 >80	<0.2 0.2-0.5 >0.5	<0.01 .01-.05 >0.05	<20 20-50 >50	<1000 1000-5000 >5000
Site 1	o	o	*	o	o	o	o
2	o	o	*	o	o	o	*
3	*	o	*	•	o	o	o
4	*	o	o	•	o	o	•
5	*	o	o	*	o	o	•
6	*	o	o	o	o	o	*
7	*	*	o	o	o	o	*
8	o	o	o	o	o	o	o
9	o	*	o	•	*	o	o
10	*	*	o	o	o	o	*
11	o	o	o	o	o	o	*
12	*	o	o	*	o	o	*
13	o	*	o	*	o	o	*
14	*	*	*	*	o	*	•
15	*	•	o	o	o	o	*
16	*	•	*	o	o	•	•
17	*	o	*	o	o	•	•
18	*	*	o	o	o	o	o

Note pH, Pb and Zn : No Problem at any sites.

- Separation of irrigation water from sewer water: when this method is adopted, the problem is how to dispose of the sewer water safely. If it is disposed of carelessly, secondary contamination will happen in the lower parts of the Study Area and the fundamental problems will remain unsolved. In the end the final solution this method will be the construction of a plant of sewage treatment.

- Change of water resources: this method has the following two different alternatives.

  a. Development of surface water resources
  b. Use of groundwater or underflow water

Alternative a. assumes the water resources development of the Maipo river to obtain irrigation water of good quality. This will not be feasible due to the problem of water rights and development costs (refer to Appendix 11).

Alternative b. will also not be feasible from the technical and economic points of view (refer to Appendix 4).

Consequently, "water treatment" is considered to be the most economical method.

In view of the above, the method of water quality improvement for each block is as follows:

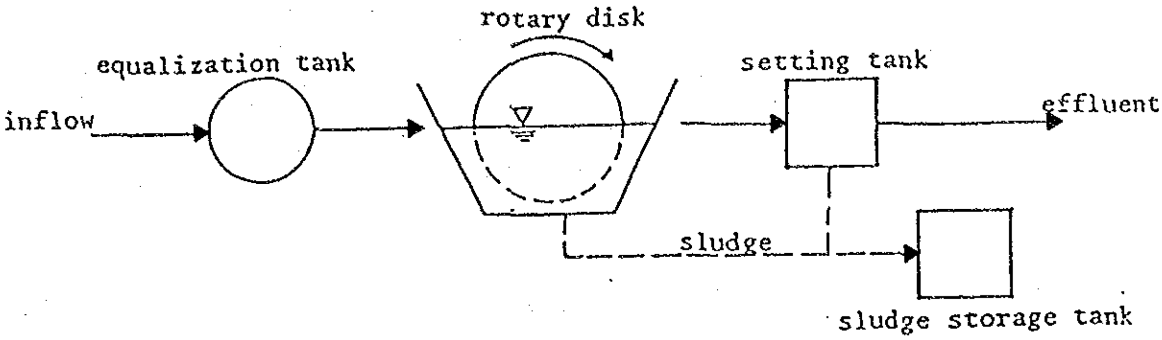
Block-1: Water Treatment
Block-2: Water Treatment
Block-3: Change of Intake Point

(3) Selection of Water Treatment System

1) Brief Description of the System

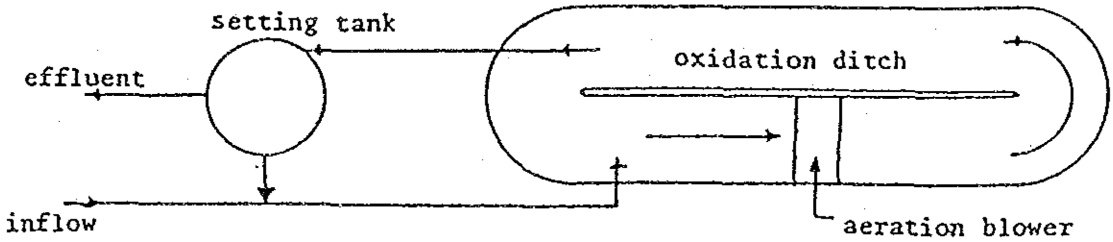
a. Rotary Disk Process

A disk is dipped half into waste water which has been separated through initial sedimentation. The water is subjected to both aerobic and anerobic treatments by rotating the disk and final sedimentary separation is completed.



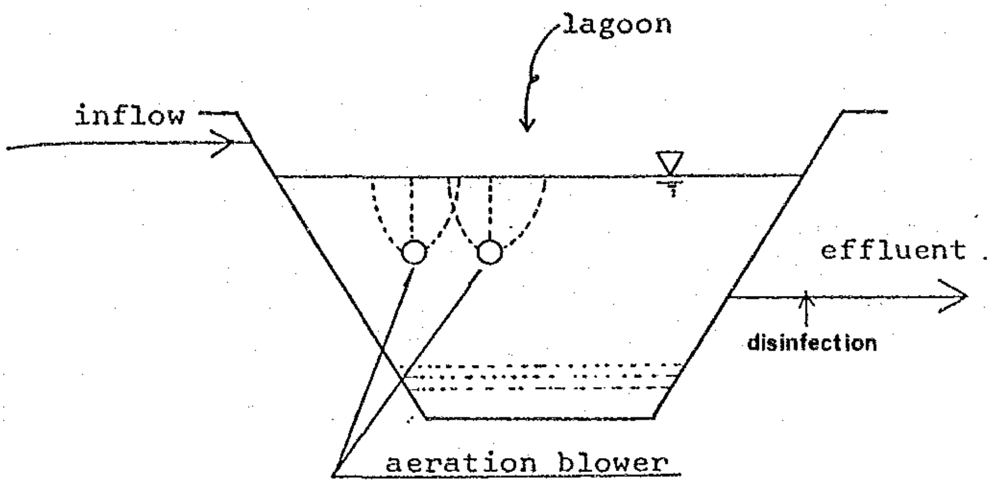
b. Oxidation Ditch System

Waste water is circulated in the linked ditch with aeration. The water is subjected to both aerobic and anerobic treatments by circulating in the ditch. This system is simple one, and is maintained and operated easily, but a large area is necessary.



c. Aerated Lagoon

Aerated lagoon is based on stabilization pond. Stabilization pond is simple earthwork structure open to the sun and air, which constitute its natural resources. Aerated lagoon, in which suspended and dissolved degradable substances are stabilized by aerobic and microbic populations supplied with needed oxygen by algal photosynthesis as well as by gas transfer at lagoon surface, sometimes with support from mechanical or diffused-air aeration.



2) Selection of the System

The Aerated Lagoon System was selected for the water treatment method in the Project in consideration of its merits as shown in Table A-7-8.

(4) Number of Treatment Plants

The comparisons of number of treatment plants for Blocks-1 and 2 are shown in Table A-7-9 respectively. As a result of the comparisons, one treatment plant is proposed for Block-1 and four separate treatment plants for Block-2.

(5) Determination of Detention Time

Detention time has direct effect on the volume of the lagoon of a treatment plant, resulting on its construction cost. Therefore, it is the key point in the planning of a treatment plant to minimize the detention time as much as possible.

The result of 48 hour laboratory tests indicate the following:

a. 6 hour detention is the turning point of the reduction curve; that is, the reduction ratio is steep up to 6 hours and then it tapers off.

b. This means that 6 hour detention is the minimum period for achieving detention effect.

c. The water quality (except for BOD) reaches the acceptable level by 6 hour detention as shown in Fig A-7-28.

However, BOD will be dissolved to the acceptable level by mechanical aeration, judging from the past experience.

By mechanical aeration, treated water becomes aerobic with the acceleration of bacterial dissolution. The aerobic conditions are effective for the reduction of coliform groups contained in the water and bad odor. The growth of insects will also be reduced in the aerobic conditions. To secure the safe reduction of coliform groups, chlorination facilities are installed on a treatment plant. Consequently, the detention time of 6 hours for contaminated water was adopted.

(6) Operation and Maintenance

1) Aeration

Annual electric power consumption required for each treatment plant is estimated as shown in Table A-7-10. In the estimation, twelve hour operation per day (one hour alternate operation) is proposed.

2) Disinfection

Judging from the result of the laboratory tests of the waters collected from farm ponds in the Project Area, 92% removal of coliform groups will be expected by the proposed Aerated Lagoon system (Fig A-7-29).

The relationship between surviving rate of virus/bacteria and leaving period in a pond tested by Ralph Mitchell (Water Pollution Microbiology, (978) is shown in Fig A-7-30 for reference.

Standard allowable limit of coliform groups, 1,000 pcs/100^{ml}, requires 99.9% removal of them from the water. In order to increase the removal ratio of coliform groups from 92% to 99.9%, chemical disinfection is necessary. Disinfection using chlorine shows the most effective result.

Required volume of chlorine is determined in consideration of the nature of the waters (pH, temperature, contact time of chlorine, etc) as well as the content of coliform groups. Chlorine of 0.5 mg/ℓ is sufficient for removing coliform groups up to 99.9% at pH7.0 - 8.0, temperature 20^{o} C and contact time 15 min as shown in Fig A-9-31.

Table A-7-12 shows the estimated required volume of chlorine for respective treatment plants. However, actual volume of chlorine should be determined through tests with use of respective water samples at the sites.

3) Sludge Removal

The sludge volume in an aerated lagoon will be about 10% of the removed BOD. The sludge removal for proposed aerated lagoons will shall be made every year by using bulldozer and dump trucks procured for operation and maintenance of the Project. Estimated sludge volumes and sludge disposal time for respective lagoons are shown in Table A-7-13.

Proposed sludge disposal procedures are as follows:

a. To stop the inflow of irrigation water into the lagoon and to drain the water ponded in the lagoon some time during rainy season.

b. To dry up the sludge remained in the lagoon until it becomes dry enough for excavating it with a bulldozer (a few days may be required).

c. To haul the sludge by dump trucks to designated disposal areas shown below:

- Esperanza and Rinconada: An area to be designated inside the Rinconada plant area (3.0 km, 200 m)
- Ortuzano: Existing ganbage disposal area near Zanjon de la Aguada (2.6 Km)
- Loma Blanca and Encanado : the Encanado plant area (2.6 km, 200 m) An area to be designated inside

d. To burn the disposed sludge to ashes after completely drying it up.

e. To cover the remaining sludge with earth by 50 cm to promote the resolution by bacteria ,after burning it.

Table A-7-8 Comparative Chart for Different Treatment Formula

Item	Rotary Disk	Oxidation Ditch	Aerated Lagoon
Removal ratio BOD	90% or more	90% or more	90% or more
Amount of sludge produced	40% of BOD	40% of BOD	20% of BOD
Detention time	one hour	24 hours	6 hours
Maintenance	once a week	once a week	once two months
Power consumption	small	small	small
Sludge return	none	Possible	none
Recovery from accident	1 or 2 week	2 or 3 days	no problem
Load regulating capacity	large	large	large
Foul odor	little	little	little
Noise	small	small	small
Plot for works	small	large	large
Cost	medium	high	low
Assessment	better	good	best

Table A-7-9 Numerical Comparison of Number of Treatment Plants

(Aerated Lagoon Type)

Block	1		2			
Number of Plants	2	1	4	3	2	1
Volume of Lagoon and Related Works	V1 = 30,000 m^3 V2 = 38,000 Headworks = 2	V 1 = 68,000 m^3 Headworks = 1	V1 =30,000 m^3 V 2 = 11,000 V 3 = 11,000 V 4 = 41,000	V1 = 30,000 m^3 V2 = 11,000 V3 = 52,000	V1 = 30,000 m^3 V2 = 63,000 Pump : 1 Bridge : 1 Canal : 2 km	V1 = 93,000 m^3 Pump : 1 Bridge : 1 Canal : 7 km
1. Volume of Water	2	3	2	3	3	4
2. Construction Cost	4	2	3	3	3	2
3. Required Area	5	4	3	3	4	4
4. Difficulty of Works	2	2	1	2	5	5
5. Operation and Maintenance	5	3	5	5	4	3
6. Suretyness of Intake	3	2	3	3	2	2
7. Ancillary Works	3	3	1	1	4	4
8. Water Quality	3	3	3	3	3	3
9. Durability of Facilities	1	1	1	1	3	3
10. Sludge Disposal	2	3	2	3	4	5
11. Easeness of Operation	4	2	4	4	3	2
Total	34	28	28	31	38	37
Evaluation		Best	Best			

Note: 1 (best) - 3 (medium) - 5 (worst)

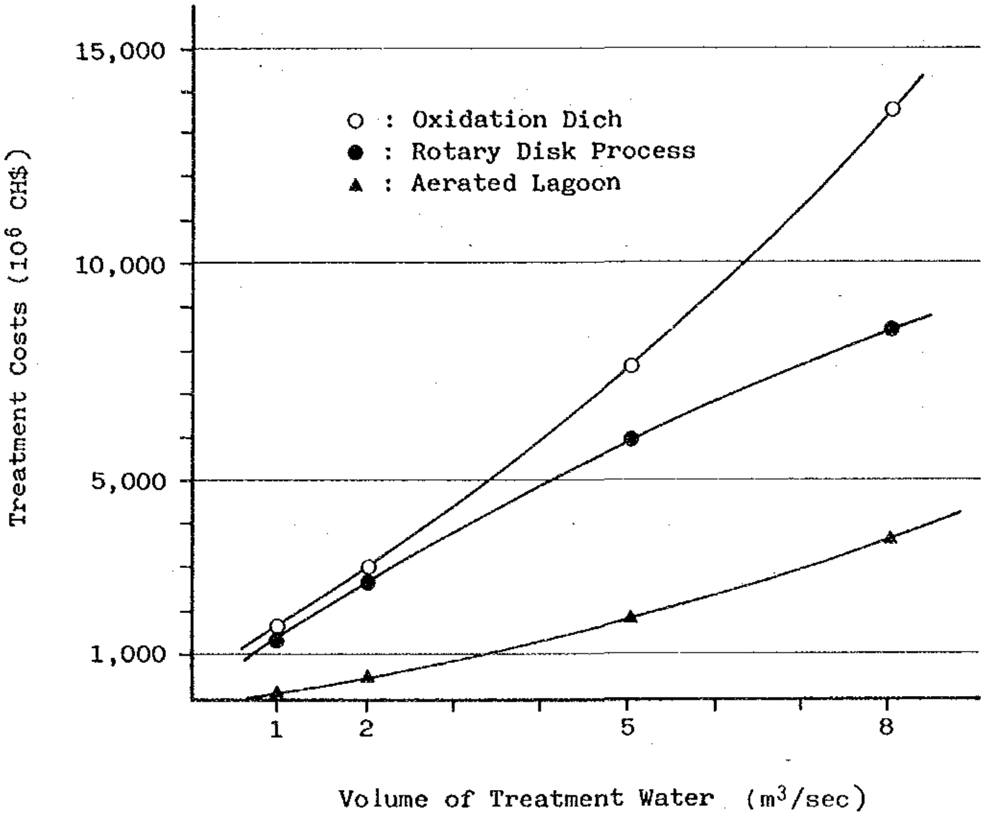


Fig. A・7・14 Comparison of Treatment Costs

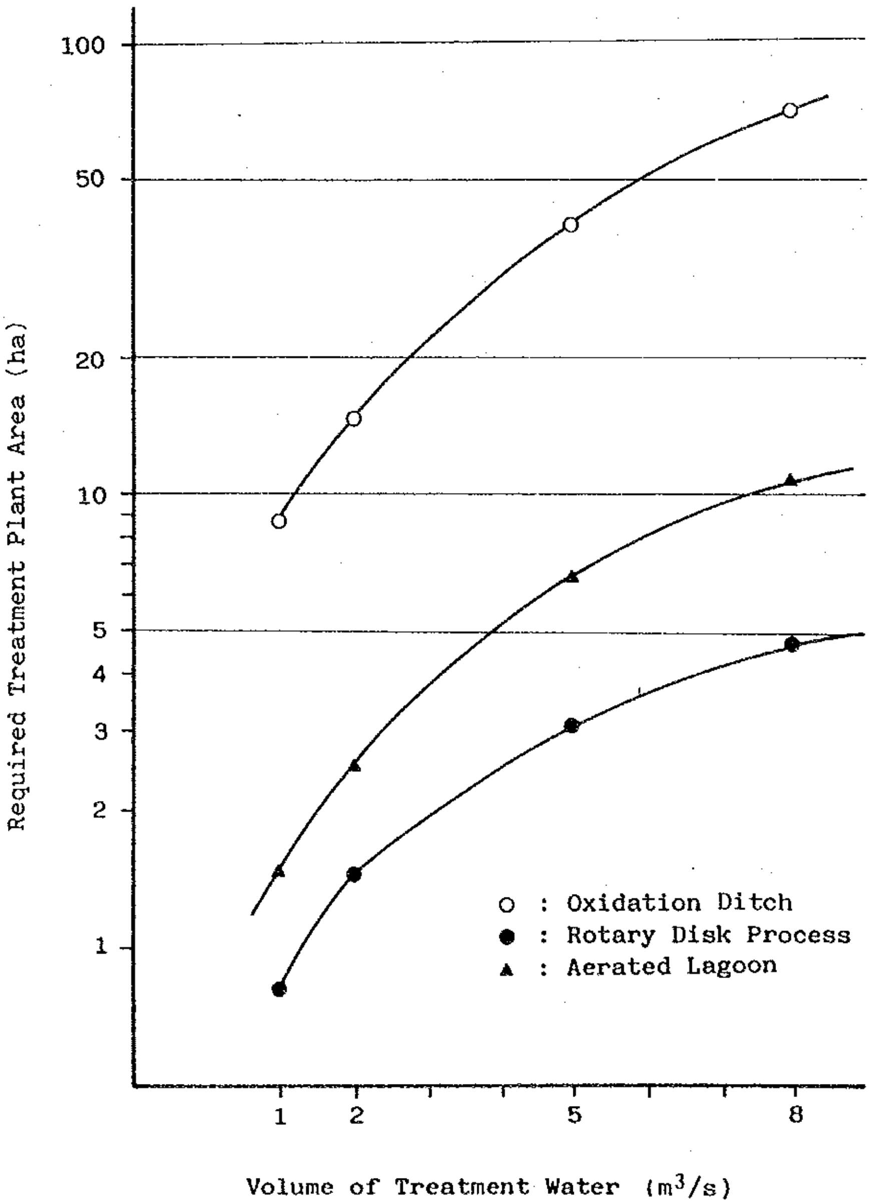


Fig A－7－15 Comparison of Required Plant Area

Table A-7-10 Estimation of Operation Time Required for Sludge Disposal

Item	Unit	(1) Esperanza	(2)Ortuzano	(3) Loma Blanca	(4) Encañado	(5) Rinconada
Ave. Water Volume	m /s	1.36	0.62	0.22	0.22	0.83
BOD Density	mg/l	50	100	100	100	100
Removal Ratio	%	60	80	80	80	80
Sludge Birth Ratio	%	10	10	10	10	10
Gross Sludge Amount	g/m^3	50x0.6x0.1=3	100x0.8x0.1=8	8	8	8
Water Content	%	95	95	95	95	95
Net Sludge Amount	g/m^3	3x0.05=0.15	8x0.05=0.4	0.4	0.4	0.4
Net Sludge Amount per Year	Kg	6,433 1/	7,821	2,775	2,775	10,470
Unit Weight	Kg/m^3	5	5	5	5	5
Sludge Volume per Year	m^3	1,300	1,600	600	600	2,100
Bulldozer (15t)						
Travel Distance	m	10	10	10	10	10
Cycle Time	min	0.59	0.59	0.59	0.59	0.59
Efficiency	--	10	10	10	10	10
Unit Handling Volume	m^3/hr	127.99 2/	127.99	127.99	127.99	127.99
Total Required Time	hr	10	13	5	5	17
No. of Unit Used	unit	1	1	1	1	1
Net Operation Time	hr	10	13	5	5	17
Dump Truck (8t)						
Travel Distance	m	3,000	2,600	2,600	200	200
Cycle Time	min	25.50	23.50	23.50	11.50	11.50
Unit Handling Volume	m^3/hr	11.07 2/	12.02	12.02	24.55	24.55
Total Required Time	hr	118	133	50	25	86
No of Unit Used	unit	6	6	4	2	6
Net Operation Time	hr	20	22	13	13	14

1/ $0.15 \times 10^{-3} \times 1.36 \times 86,400 \times 365 = 6,433$ (units: g/m^3, Kg/g, m^3/s, s/day, day/year, Kg/year)

2/ Table A-17-14

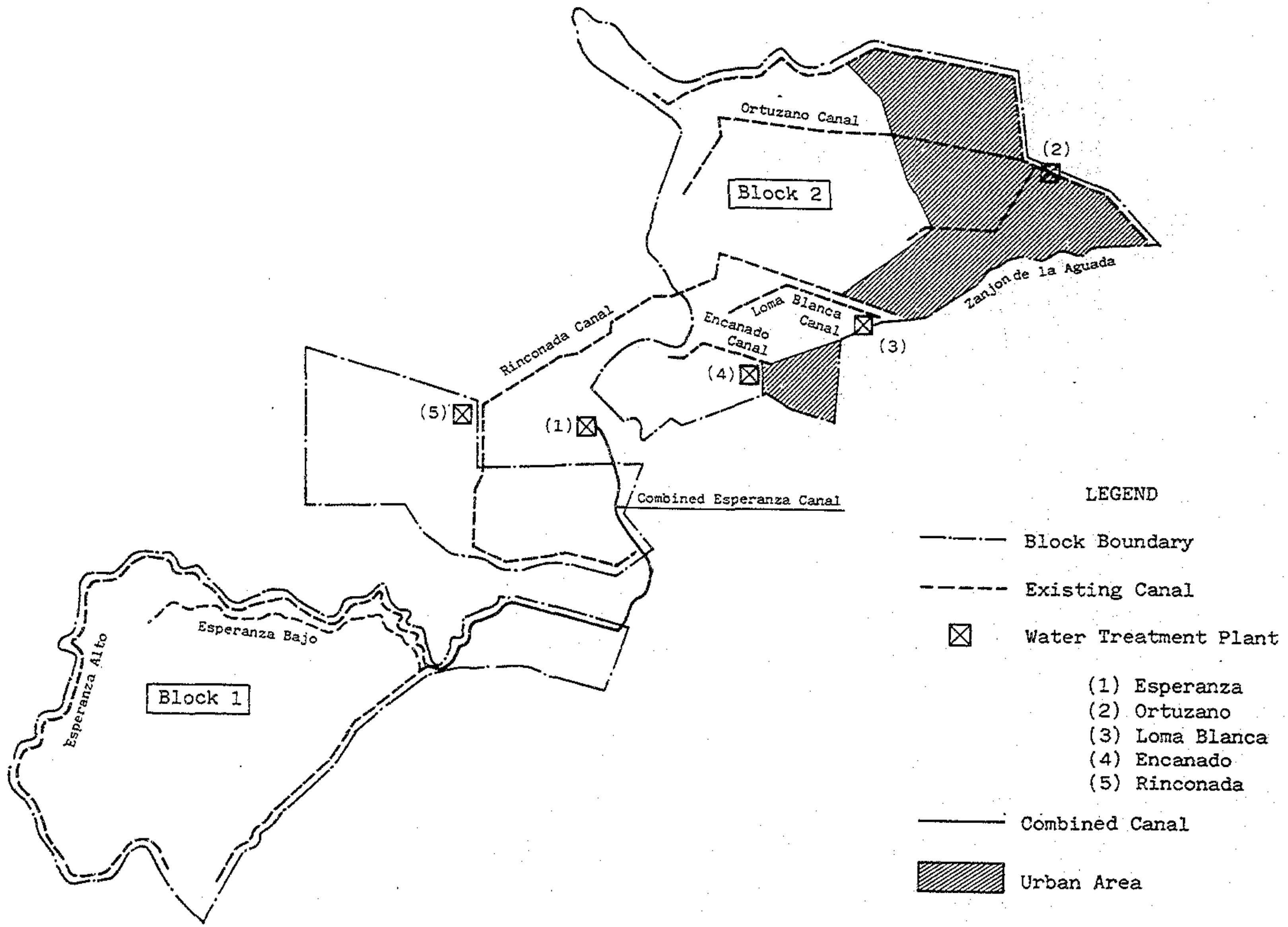


Fig.A-7-16 Location Map of Proposed Water Treatment Plant

Table A-7- 11 Removal Ratio of Coliform Groups

Observation Point	Coliform Groups (No/100ml)	Removal Ratio (%)	Remarks
20	16 x 10^6	0	at Intake of Esperanza Alto
24	33 x 10^4	97.9	at Farm Pond in Block-1
25	26 x 10^4	98.4	"

Result of Laboratry Test

Table A-7- 12 Required Chlorine Volume

Name of Treatment Plant	Annual Ave. Discharge Q (m^3/s)	Chrorine Ratio (mg/l)	Daily Chlorine Volume (g/day)	Annual Chrorine Volume (Kg/year)
Esperanza	1.36	0.5	58,752	21,444
Ortuzano	0.62	0.5	26,784	9,777
Loma Blanca	0.22	0.5	9,504	3,469
Encañado	0.22	0.5	9,504	3,469
Rinconada	0.83	0.5	35,856	13,087

Table A-7- 13 Electric Demands for Aeration Blower
(Result Laboratory Test in Sept.1985)

Name of Treatment Plant	Required Equipment (Unit)	Unit Con- sumption (kW)	Daily Operation Time (hr)	Daily Power Con- sumption (KWH/day)	Annual Power Con- sumption (KWH/year)
Esperanza	4	15	12	720	262,800
Ortuzano	8	15	12	1,440	525,600
Loma Blanca	3	15	12	540	197,100
Encañado	3	15	12	540	197,100
Rinconada	11	15	12	1,980	722,700

Table A-7-14 Efficiency of Equipment

(a) Dump Truck (8t) f = 1.0 E=1.0 (m^3/hr)

L (m)	Cm \ Kind / Sq	Sand	Silt	Clay	Gravel	Crushed Stone
		4.71	5.00	4.44	4.21	3.20
100	11.00	25.67	27.27	24.24	22.97	17.45
200	11.50	**24.55**	26.09	23.19	21.97	16.70
300	12.00	23.53	25.00	22.22	21.05	16.00
400	12.50	22.59	24.00	21.33	20.21	15.36
500	13.00	21.72	23.08	20.51	19.43	14.77
600	13.50	20.92	22.22	19.75	18.71	14.22
700	14.00	20.17	21.43	19.05	18.05	13.71
800	14.50	19.47	20.69	18.39	17.42	13.24
900	15.00	18.82	20.00	17.78	16.84	12.80
1,000	15.50	18.22	19.35	17.20	16.30	12.39
1,200	16.50	17.11	18.18	16.16	15.31	11.64
1,400	17.50	16.13	17.14	15.24	14.44	10.97
1,600	18.50	15.26	16.22	14.41	13.66	10.38
1,800	19.50	14.48	15.38	13.68	12.96	9.85
2,000	20.50	13.77	14.63	13.01	12.32	9.37
2,200	21.50	13.13	13.95	12.40	11.75	8.93
2,400	22.50	12.55	13.33	11.85	11.23	8.53
2,600	23.50	**12.02**	12.77	11.35	10.75	8.17
2,800	24.50	11.52	12.24	10.88	10.31	7.84
3,000	25.50	**11.07**	11.76	10.46	9.91	7.53
3,200	26.50	10.65	11.32	10.06	9.53	7.25
3,400	27.50	10.27	10.91	9.70	9.19	6.98
3,600	28.50	9.91	10.53	9.36	8.86	6.74
3,800	29.50	9.57	10.17	9.04	8.56	6.51
4,000	30.50	9.26	9.84	8.74	8.28	6.30
4,200	31.50	8.96	9.52	8.47	8.02	6.10
4,400	32.50	8.69	9.23	8.21	7.77	5.91
4,600	33.50	8.43	8.96	7.96	7.54	5.73

(B) Bulldozer (15t) f = 1.0 (m^3/hr)

E \ L	10	15	20	25	30	35	40	45	50
CM	0.59	0.76	0.93	1.10	1.27	1.44	1.51	1.78	1.95
Q	182.85	141.95	116.00	98.07	84.94	74.92	67.01	60.61	55.32
0.20	36.57	28.39	23.20	19.61	16.99	14.98	13.40	12.12	11.06
0.25	45.71	35.49	29.00	24.52	21.24	18.73	16.75	15.15	13.83
0.30	54.85	42.58	34.80	29.42	25.48	22.48	20.10	18.18	16.60
0.35	64.00	49.68	40.60	34.33	29.73	26.22	23.45	21.21	19.36
0.40	73.14	56.78	46.40	39.23	33.98	29.97	26.80	24.24	22.13
0.45	82.28	63.88	52.20	44.13	38.23	33.71	30.15	27.27	24.90
0.50	91.42	70.97	58.00	49.04	42.47	37.46	33.50	30.30	27.66
0.55	100.57	78.07	63.80	53.94	46.72	41.20	36.85	33.33	30.43
0.60	109.71	85.17	69.60	58.84	50.97	44.95	40.20	36.36	33.19
0.65	118.85	92.27	75.40	63.75	55.21	48.70	43.55	39.39	35.96
0.70	**127.99**	99.36	81.20	68.65	59.46	52.44	46.90	42.42	38.73
0.75	137.14	106.46	87.00	73.55	63.71	56.19	50.25	45.46	41.49
0.80	146.28	113.56	92.80	78.46	67.96	59.93	53.60	48.49	44.26
0.85	155.42	120.66	98.60	83.36	72.20	63.68	56.96	51.52	47.02

7.3 Problem caused by Trihalomethan

(1) General

Trihalomethan (THM), which is considered to be catcinogenic substance, is formed by the reaction of chlorine and organic maters in wastewater. THM has a chemical constitutional formula of CHX_3, substituting halogen for hydrogen of methan.

In tap water, chloroform ($CHCℓ_3$), bromodichloromethan($CHBr\ Cℓ_2$), dibromochloromethan ($CHBr_2\ Cℓ$) and bromoform ($CHBr_3$) mainly constitute the THM. Maximum allowance of the total THM is regulated to be 0.10 mg/ℓ by Environment Protect Department of America (EPA) of the USA.

In Japan, it is enacted provisionally in March 1983 that the annual mean value of the total THM in the drinking water should be less than 0.10 mg/ℓ.

(2) Characteristics of the THM formation

1) Ability of THM formation

The form reaction of the THM has relation with many factors such as amount of chlorine, contact time, water temperature, pH value, organic concentration and ion concentration of Br.

Water with the COD value more than 3 mg/ℓ is generally considered to contain the THM exceeding the regulated value of 0.10 mg/ℓ. Table A-7-15 shows the ability of THM formation with respect to various type of wastewater.

Table A-7-15 Characteristics to Form THM in Various Type of Wastewater

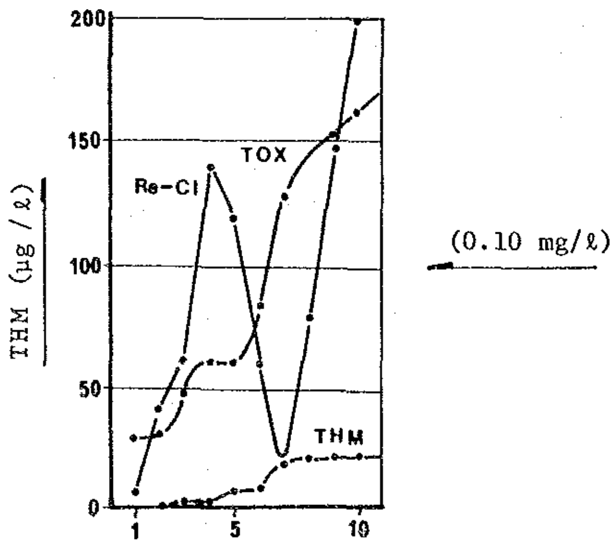
Type of wastewater	THM (μg/ℓ)	THM (μg THM/ g TOC)
SP Wastewater	590	25
KP Wastewater	1,125	30
WPP Wastewater	2,250 - 2,260	1.5-1.7 (μg THM/mg pv)
Primarily Settled Sewage	480-770	-
Primarily Settled Sewage	1,271	27
Biologically Treated Sewage	460	33
Biologically Treated Sewage	74.8	11.0
Human Excreta	44,500	9.0
Biologically Treated Human Excreta	1,500	38.5
Biologically Treated Human Excreta	1,300	28.0
Natural Colored Water	1,440	48.0
Humic Acids	-	36.9
Phenol	-	37.1

Note TOC : Total Organic Carbon

The table indicates that primarily settled sewage is likely to form the THM in the range of 27 - 33 ug per 1 mg of TOC.

2) Relation between chlorine injection amount and THM

The amount of THM formation is generally dependent on the chlorine injection amount within wastewater.



Injection Amount of Chlorine (mg/ℓ)

The above figure implies that with the chlorine injection amounts less than 2 mg/ℓ, the THM formation in the wastewater becomes as low as nil.

(3) <u>Consideration on the Protected Chlorine Injection Amount into Sewage within the Proposed Water Treatment Scheme</u>

The chlorine injection amount in this water treatment scheme is set forth as 0.5 mg/ℓ for respective treatment plants. As previously suggested, with the said amount of the chlorine injection, the amount of THM formation becomes vary small, which concludes that there will be no fear of carcinogenesis within the proposed treatment plants.

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Table A-8-3 Various Aspects of Population in the Rural Area (Metropolitan Region)

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Table A-8-1 Population and Growth Rate

Region and Province	Comuna	Area (Km²)	Block N°	Population 30 June 1985 Population	Density (Population /Km²)	Short Term Growth Rate Annual Average (%)
Metropolitan Region		15,419.80	-	4,772,854	310	1.74
Santiago Province		2,001.48	-	4,090,736	2,044	1.61
	Huechu-raba	44.45	4	72,740	1,637	3.23
	Quili-cura	56.75	3	27,119	478	3.83
	Renca	23.17	3	113,256	4,881	2.32
	Puda-huel	197.00	2,3	116,494	592	2.97
	Cerri-llos	37.20	2	77,066	2,072	3.24
	Maipú	131.00	2	143,555	1,096	2.72
Chacabuco Province			-	61,840		2.14
	Colina	985.00	4	31,651	33	2.13
	Lampa	430.00	4	19,507	46	2.13
Talagante Province			-	142,748		2.66
	Peñaflor	160.00	1	70.330	440	3.80

Source: Chile 85, INE

Table A-8-2 Annual Average Population Growth Rate (Metropolitan Region)

(Unit : %)

Item	Ration		Annual Average Population Growth		
	1985	200	Male	Female	Total
Urban Area	96.9	98.3	1.92	1.87	1.90
Rural Area	3.1	1.7	-2.44	-2.38	-2.42
Average			1.81	1.78	1.80

Source : Proyecciones de Población 1970 - 2000, INE

Table A-8-3 Various Aspects of Population in the Rural Area (Metropolitan Region)

Item / Age Group	Population (June 30, 1985)	Male: 53.3%(1985) - 53.1%(2000)		Female: 46.7%(1985) - 46.9%(2000)	
		Distribution (June 30, 1985)	Annual Average Growth Rate(%)	Distribution (June 30, 1985)	Annual Average Growth Rate(%)
0 - 14 years	52,502	32.9	-3.1	38.5	-29
15 - 64 years	88,059	62.3	-2.2	56.3	-2.2
65 - years	7,375	4.8	-1.2	5.2	-1.3
Total	147,136	100.0	-2.4	100.0	-2.4

Source: Proyecciones de Población 1970 - 2000, INE

Table A-8-4 Distribution of Farm Size

Block	Farm Size (ha)	- 5	5 - 10	10 - 20	20 - 50	50 - 100	100 - 500	500 -	Total
1	Number of Farm	19	38	22	17	6	4		106
	(%)	18	36	21	16	5	4		100
2	Number of Farm	109	64	44	21	10	6		254
	(%)	43	25	17	8	4	3		100
3	Number of Farm	31	52	68	36	7	7		201
	(%)	15	26	34	18	3.5	3.5		100
4	Number of Farm	262	348	223	82	37	25	2	979
	(%)	27	35.5	23	8	4	2.5	0	100
Total	Number of Farm	421	502	357	156	60	42	2	1,540
	(%)	27	33	23	10	4	3	0	100

Source : Actualizado Propiedades 1797, CIREN

Table A-8-5 Assessment of Price of Agricultural Land

I. Irrigated 1/ (Unit: Ch$/ha as of the second semester, 1985)

Land Classification / Comuna	Ir(< 1.5%)	IIr(1.5%-3%) (Irx 85%)	IIIr(3%-5%) (Irx 60%)	IVr(5% <) 2/ (Irx 30%)
Maipú	580,500	493,500	348,500	174,500
Pudahuel, Quilicura	496,000	422,000	298,000	149,000
Colina, Peñaflor	446,500	380,000	268,000	134,000
Lampa	434,000	369,000	260,500	130,500
Conchalí	410,000	348,000	245,500	123,000

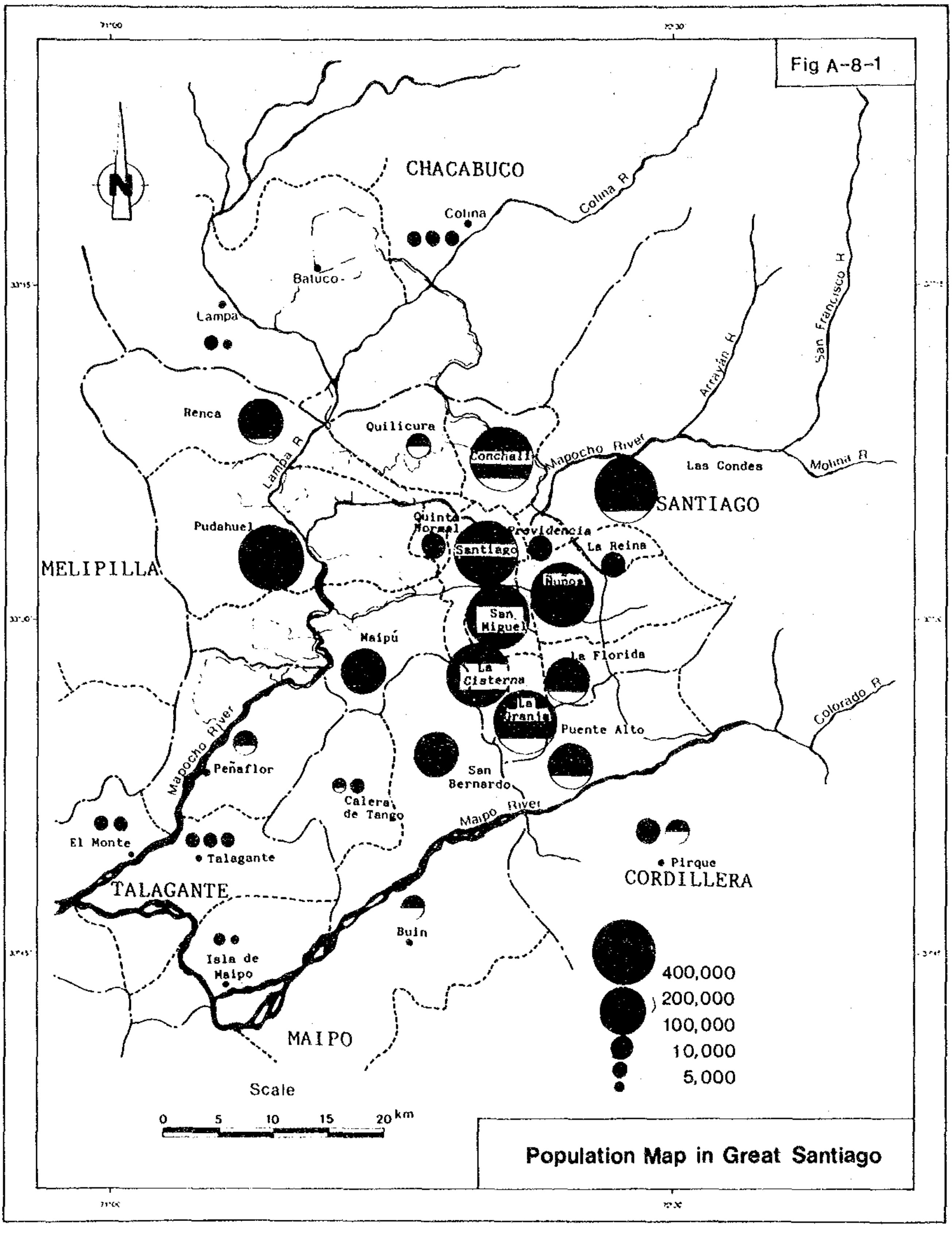
II. Non-Irrigated 1/ (Unit: Ch$/ha)

Land Classification / Region	Is	IIs (Isx80%)	IIIs (Isx60%)	IVs (Isx30%)	Vs (Isx20%)	VIs (Isx10%)	VIIs (Isx 5%)	VIIIs
Metropolitan	37,500	30,000	22,500	11,500	7,500	4,000	2,000	90

III. Projected Urban Area 3/

Comuna	4/ UF/m^2	Million Ch$/ha, (Sep. '85 Prices)
Maipú	0.19 - 1.06	5.13 - 28.62
Pudahuel	0.4	10.80
Quilicura	0.25 - 0.50	6.75 - 13.50
Conchalí	0.82	22.14

Note: 1/ Based on the standard of assessment provided by the Tax Office
2/ The gradient of land
3/ Based on the survey carried out by MINVIU
4/ "Unidad de Fomento"



Population Map in Great Santiago

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Table A-9-1 Change of Urban Area

(Unit : ha)

Block \ Year	1985	1991	Increase
1	30	30	0
2	240	1,410	1,170
3	410	1,040	630
4	1,530	3,710	2,180
Total	2,210	6,190	3,980 1/

Source: Ordenanza Plan Intercomunal de Santiago, MINVIU, 1985
Normas Técnicas por Subsectores Geográficos, MINVIU, 1982
Crecimiento Estimado de 1980 a 2010 por Uso del Suelo, EMOS

Note : 1/ Agricultural land 3,870 ha and agricultural infrastractures area 110 ha

Appendix 10: Agriculture

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Fig. A-10-5 Outline of Livestock Meat Marketing Channel in Santiago

10.1 General Condition

(1) General Statements on Chilean Agriculture

The agricultural activity plays an important role from the point of view of its use, due to the fact that approximately 16% (1984) of all the economically active workers are agriculture workers. With respect to gross domestic product, this field comprises about 9% (1983) of the overall production. The agricultural annual variation is lower than the average domestic product. As from the 1982 recession, a negative growth is found.

Depression in agriculture sector is due to the priority strategy in industrial development by the successive governments, failure of agrarian reform, large land owner, etc.

The present Government has carried out various measures in this field, for instance, devolution of unjustly occupied land to farm owners, land distribution to settlers and legal cancellation of prohibition of agriculture land holding by private enterprise.

In consequence, there is an increase in cultivated area, production and number of highly profitable crops (for instance table grapes, apples, vegetables, etc.), after the landuse change. Fresh fruits are specially thought of as export product.

On the other hand, the cultivated area of such traditional crops as wheat, barley and maize has decreased and their production has remained inactive, since the free price was established, due to competition with import product. Specially basic cereals depend on import, for instance self-sufficiency ratio of wheat is less than 40%. The food import, including raw sugar and raw oil, has consumed a bigger part of foreign earnings. The Government recently used the strategy to promote basic cereal production, and cropping area and production increased from the agriculture year 1983/84.

The self sufficiency ratio of wheat returned to 50% in the year 83/84, and at present it follows that trend.

(2) Agricultural Description by Block

1) Block-1

Small Farmers with holding of several hectares are distributed in Los Aromos, El Sauce and Santa Teresa. In El Quillay large-scale farmers of about 300 ha are found. The rest is occupied by the medium-size farmers with the holding of 20 - 30 ha. The large-scale farmers raise cattle, using most of his land either for meadow or pasture. Ordinary fields are found mainly in the rest of the area. Some orchards are found in Santa Monica, vineyards in Las Brisas and El Nogal. Pasture is found in both eastern and western tips of El Torebal. Lemon trees grow in its central part, which is poorly managed.

2) Block-2

a. The right margin of the Mapocho river

Most of the Rinconada Lo Cerda belong to the agricultural experiment station affiliated to the University of Chile. Pasture is found in most of the station. El Divisadero is occupied by three large-scale farmers who grow wheat in part and raise cattle on the pasture in the rest. In the south orchards are found. Ordinary fields are found along the river.

b. The left margin of the Mapocho river

Ordinary fields are distributed in most of the area, except the centrally located hilly area, which is used extensively for grazing by a large-scale farmer. Small-scale raw eating vegetables growers are distributed in Loma Blanca. Large-scale vineyards are found in El Maiten Eastern part of the block is being encroached by using plots.

3) Block-3

a. East of Arturo Merino Benitez airport

Ordinary fields are found in most of the area. Vineyards for producing export table grapes are found in this area. Urbanization is conspicuous in the eastern part.

b. West of the airport

- The left margin of the Lampa river

  Southern half, Lomas de Pudahuel is covered by natural pasture. A part is occupied by the military, the other by large-scale farmers. In the northern half, ordinary fields of small farmers are found in Peralillo and Campo Alegre. Small-scale vineyards are found in Aguas Claras. Large-scale fodder crops are distributed along the river. The rest is covered by natural pasture.

- The right margin of the Lampa river

  Medium-scale farmers are scattered in El Noviciado. They grow annual crops and raize cattles. Along the western hill area lies a large scale orchard of prickly pears.

4) Block-4

a. Huechuraba comuna

The agricultural land has rapidly been decreasing by urbanization. Small farmers are distributed in the area adjacent to the housing plot, a few large-scale farmers at the piedmont. Ordinary fields are mostly found except some vineyards.

b. Quilicura comuna

Agricultural lands are quickly disappearing because of urbanization. Both small farmers and medium-size farmers, who cultivate on ordinary fields, are found here.

c. Colina comuna (east side of Panamerican way) and Lampa comuna (between Panamerican way and the railway)

Both small farmers and medium-size farmers are relatively densely distributed, and cultivate on ordinary fields. Besides, the latter has pastures. Some large-scale orchards and vineyards are also found. Grazing land is found both in southern part, which is adjacent to Quilicura comuna, and in northern part, i.e., Batuco area.

d. Lampa comuna (east side of the railway)

Apart from the marshes, most of the area are used as grazing areas by large-scale cattle raisers. Ordinary fields which are cultivated by medium size farmers are found in a part of the area. Orchards of prickly pears are distributed near Lampa town along the hill area.

10.2 Agricultural Production

(1) National Agriculture

Table A-10-1 Main Agricultural Products (1)

Crop \ Year		1980/1981	1981/1982	1982/1983	1983/1984	1984/1985
Wheat						
Sow Land	(10^3ha)	432	374	359	471	506
Harvest	(10^3t)	686.0	650.5	586.0	988.3	1,164.7
Yield	(t/ha)	1.59	1.74	1.63	2.10	2.30
Oats						
Sow Land	(10^3ha)	80	68	85	96	85
Harvest	(10^3t)	130.7	117.6	146.3	163.0	170.4
Yield	(t/ha)	1.63	1.72	1.72	1.69	2.01
Barley						
Sow Land	(10^3ha)	46	58	38	33	35
Harvest	(10^3t)	91.4	117.9	73.2	73.5	85.0
Yield	(t/ha)	1.99	2.05	1.92	2.22	2.43
Rye						
Sow Land	(10^3ha)	9	6	5	4	5
Harvest	(10^3t)	9.2	6.1	4.5	4.4	11.5
Yield	(t/ha)	1.05	1.10	0.91	1.29	2.28
Rice						
Sow Land	(10^3ha)	31	37	30	40	39
Harvest	(10^3t)	99.7	131.2	115.6	165.0	156.6
Yield	(t/ha)	3.18	3.55	3.80	4.14	4.08
Maize						
Sow Land	(10^3ha)	126	107	118	138	131
Harvest	(10^3t)	518.2	484.1	511.6	721.4	771.8
Yield	(t/ha)	4.13	4.52	4.34	5.21	5.91

Table A-10-2 Main Agricultural Products (2)

Crop \ Year		1980/1981	1981/1982	1982/1983	1983/1984	1984/1985
Dried Beans						
Sow Land	(10^3ha)	118	122	86	85	83
Harvest	(10^3t)	138.2	162.5	84.4	94.1	100.7
Yield	(t/ha)	1.17	1.34	0.98	1.11	1.21
Lentils						
Sow Land	(10^3ha)	48	39	23	24	36
Harvest	(10^3t)	17.7	15.8	13.8	16.0	24.7
Yield	(t/ha)	0.37	0.41	0.60	0.68	0.68
Peas						
Sow Land	(10^3ha)	18	12	10	10	6
Harvest	(10^3t)	11.0	7.4	5.7	6.3	6.3
Yield	(t/ha)	0.63	0.61	0.59	0.65	0.98
Chickpeas						
Sow Land	(10^3ha)	16	10	8	12	11
Harvest	(10^3t)	6.4	4.1	3.2	6.9	9.2
Yield	(t/ha)	0.40	0.40	0.41	0.58	0.81
Potatoes						
Sow Land	(10^3ha)	90	77	67	81	63
Harvest	(10^3t)	1,007.3	841.6	6,836	1,036.2	908.6
Yield	(t/ha)	11.20	10.87	10.18	12.73	14.45
Sugarbeet						
Sow Land	(10^3ha)	37	22	36	48	44
Harvest	(10^3t)	1,460.5	963.0	1,642.8	2,194.0	2,124.4
Yield	(t/ha)	39.74	43.87	46.13	45.87	48.15
Sunflower						
Sow Land	(10^3ha)	5	3	3	5	20
Harvest	(10^3t)	7.4	5.4	4.6	7.4	32.5
Yield	(t/ha)	1.45	1.58	1.60	1.51	1.63
Rape						
Sow Land	(10^3ha)	24	10	3	4	19
Harvest	(10^3t)	26.9	13.2	2.9	4.1	31.9
Yield	(t/ha)	1.13	1.28	1.08	0.97	1.67

Source: Boletin Mensual No. 692, Banco Central de Chile

Table A-10-3 Fruit Tree and Vineyard Products

Crop \ Year	1980/1981	1981/1982	1982/1983	1983/1984	1984/1985
Plums					
Planted Area (ha)	3,210	3,720	4,451	4,849	5,150
Production (10^3t)	17.2	18.4	20.8	22.5	25.0
Apricots					
Planted Area (ha)	1,385	1,275	1,288	1,290	1,310
Production (10^3t)	13.0	13.2	12.9	13.3	14.0
Peaches					
Planted Area (ha)	6,361	6,192	5,994	6,037	6,040
Production (10^3t)	81.0	82.6	83.5	85.0	90.0
Lemons					
Planted Area (ha)	5,954	5,655	5,276	5,399	5,450
Production (10^3t)	70.7	71.6	69.6	58.0	70.0
Apples					
Planted Area (ha)	15,768	16,652	17,562	17,797	18,000
Production (10^3t)	298.4	345.0	365.0	410.0	470.0
Oranges					
Planted Area (ha)	5,166	5,339	5,682	5,796	5,900
Production (10^3t)	58.8	65.4	66.5	68.6	70.0
Avocados					
Planted Area (ha)	6,678	7,143	7,315	7,583	7,680
Production (10^3t)	25.0	27.7	29.6	31.5	28.0
Pears					
Planted Area (ha)	3,309	3,691	3,921	4,190	4,200
Production (10^3t)	45.5	50.6	47.6	52.3	55.0
Table Grapes					
Planted Area (ha)	14,480	15,958	17,363	18,824	20,800
Production (10^3t)	121.7	162.7	196.4	225.0	250.0

Source: Boletin Mensual No. 691, Banco Central de Chile

(2) Regional Agriculture

1) Annual Crops

Wheat crop is found in more than half of the cropped area of total annual crops, and sunflower is increasing remarkably. This rise is mainly due to price increase. Especially minimum incomes is secured for the wheat growers.

Unit yields of wheat and maize in the Region are over those of national average. In addition, expected yields for the agriculture year 1984/85 are estimated to be quite high, because of good seed use, adequate crop management and price incentive.

Table A-10-4 Crop Yield (1983/84 Agricultural Year)

(Unit: t/ha)

Crop	Nation	Metropolitana Region	
		1983/84	1984/85 1/
Wheat	2.10	3.54	3.37
Oats	1.69	1.50	-
Barley	2.22	2.46	3.26
Maize	5.21	5.85	6.34
Dried Beans	1.11	1.09	1.43
Potatos	12.73	13.76	14.52

Source: Encuesta Nacional Agropecuaria Año Agrícola 1983-1984, INE

1/ Survey data by INE

2) Vegetables

The cropped area for vegetables is decreasing because of countless and constant difficulties in commercialization, measures taken by the Ministry of Health and over production.

The annual production of raw eating vegetable crops is about 47,000 ton (1975/76). The production shows a high variation depending on climate conditions, disease and plague damage, and product price. Most of the products are consumed in the Metropolitan Region.

With respect to contamination of raw eating vegetable crops, the Ministry of Health announced Resolution N° 350 in January 1983, by means of which 10 vegetable crops were prohibited. An area of about 5.000 ha has been affected after this Resolution, but this order has not yet been followed by some farmers. The vegetable species prohibited to grow in the area that use sewage or contaminated waters are the following:

1. Lettuces
2. Chicories
3. Coriander
4. Parsley
5. Big raddishes
6. Little raddishes
7. Carrots
8. Berries
9. Strawberries
10. Chilean strawberries

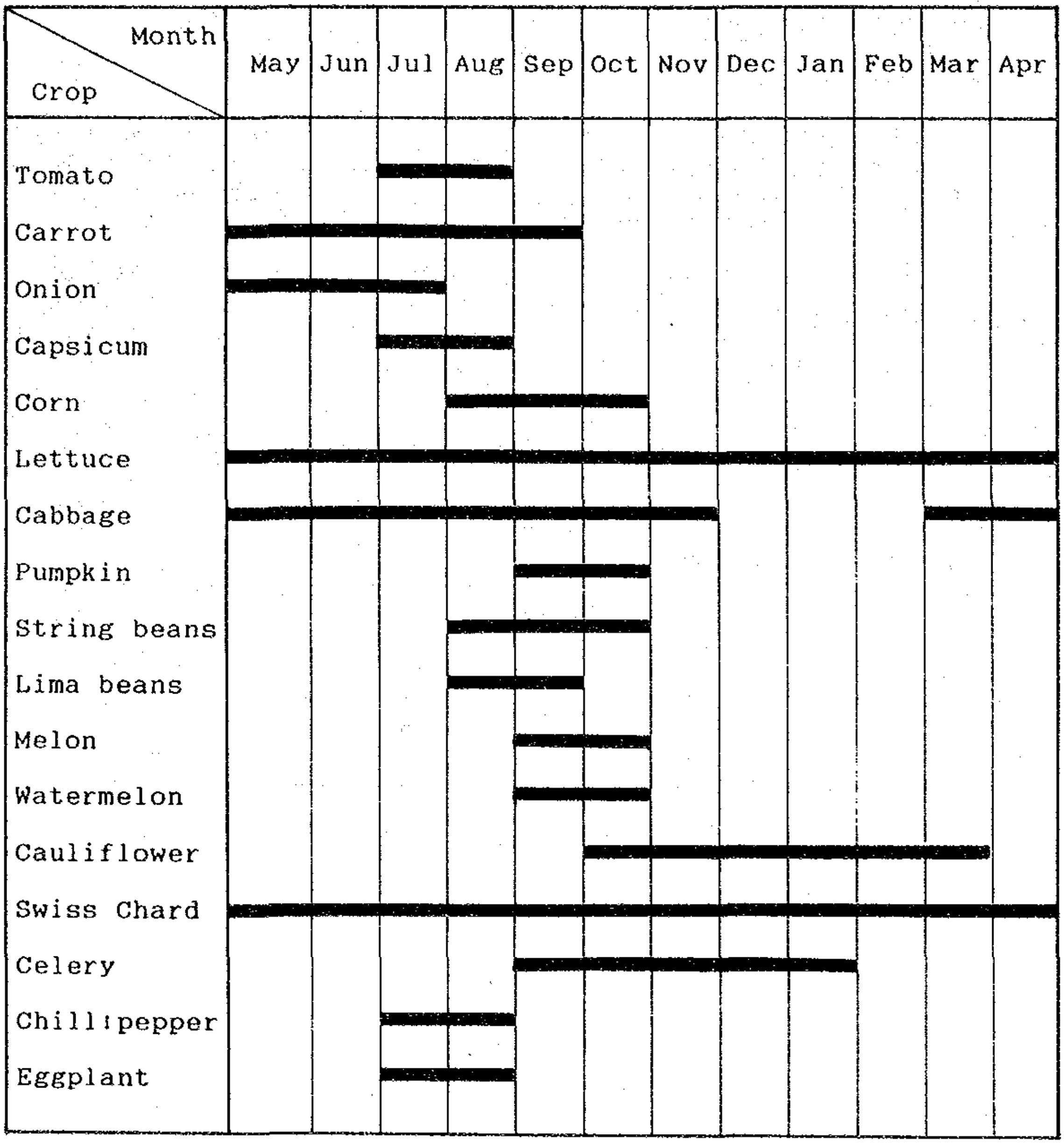

Fig A-10-1 Seeding Season of Vegetables

3) Fruits

An increase in cropped area and in volume of production in this field during recent years is due to high revenues from export. Some producers devote themselves mainly to fruit production for export.

In the whole country the cropped area of main fruits is 100,645 ha, and in the Metropolitan Region it is 18,631 ha (1984). The cropped area of lemons, pears, walnuts in the Metropolitan Region represents more than 30% of the total cropped area of the country, and the cropped area of table grapes, plums and nectarines also represents more than 25%.

10.3 Agricultural Foreign Trade

(1) Imports

Table A-10-5 Import of Wheat

Item \ Year	1980	1981	1982	1983	1984
Amount of import (millions of US$)	175.7	211.0	175.8	198.3	154.5
Quantity of import (t)	869,802	1,029,268	992,034	1,158,283	958,866
National Production (t)	966,000	685,970	650,450	585,950	988,283
Self-Sufficient rate (%)	52.6	40.0	39.6	33.6	50.8

Source: Indicadores de Comercio Exterior, Banco Central de Chile, Dic.,1984

(2) Exports of Fresh Fruits

The export values of agriculture, livestock and forest products (including sea food) amounts to US$428.1 million (1984) and account for about 12% of the total exports. The export value of agricultural products aline is US$345.6 million and the export value of fresh fruits account for about 85% of it.

Among fresh fruits, table grapes account for more than 50 % of the export values, followed by apples, nectarines, pears and plums. The export value of table grapes account for 48% of the total export values of agricultural products. The export volume of apples and table grapes presents a large part of the export volume of fresh fruits.

In recent years, the total export values has been rather stable, meanwhile exports of fresh fruits have increased substantially, especially the increase of exports of table grapes have been remarkable.

Export prices of fresh fruits vary between 0.3 - 1.3 US$/kg, and the prices of plums, peachs and table grapes are high. Recently the export prices have tended downwards, but last year the prices of many commodities recovered to the former levels. Nevertheless, the prices of pears and apples are still tending downwards.

As for major import countries of fresh vegetables, the U.S.A imports about 80% of table grapes, and five countries, Saudi Arabia, Netherlands, the United Arab Emirates, the U.S.A and West Germany import some 70% of apples.

Table A-10-6 Exports of Agricultural Products

(Unit: 10^3 US$)

Product \ Year	1980	1981	1982	1983	1984	(%)
Cereals	2,318	271	2,319	1,374	10,528	3.0
Pulses	48,147	50,281	16,015	16,119	13,171	3.8
Fresh Fruits	168,749	198,536	232,788	220,451	293,615	85.0
Vegetables	5,922	2,764	9,023	-2,080 1/	7,059	2.0
Seeds, Fibers	3,582	3,800	4,371	5,205	5,870	1.7
Others	15,632	12,352	13,551	12,646	15,372	4.5
Total	244,350	268,004	278,067	253,713	345,615	100.0

Source: Indicadores de Comercio Exterior, Banco Central de Chile, Dic.1984

1/ Este valor negativo se explica por la presentación de liquidaciones finales con menores valores por exportaciones de cebollas enviadas en libre consignación efectuadas durante la temporada 1982/1983.

Table A-10-7 Export Value and Quantity of Fresh Fruits (1984)

Crop	Export Value (Million 10^6 US$)	Export Quantity (10^3 of Ton)
Table Grapes	164.7	178.4
Apples	74.5	208.4
Nectarines	14.1	18.3
Pears	11.4	27.9
Plums	9.1	8.8
Peaches	4.8	5.0
Others	15.0	1.2
Total	293.6	448.0

Source: Indicadores de Comercio Exterior, Banco Central de Chile, Dic.1984

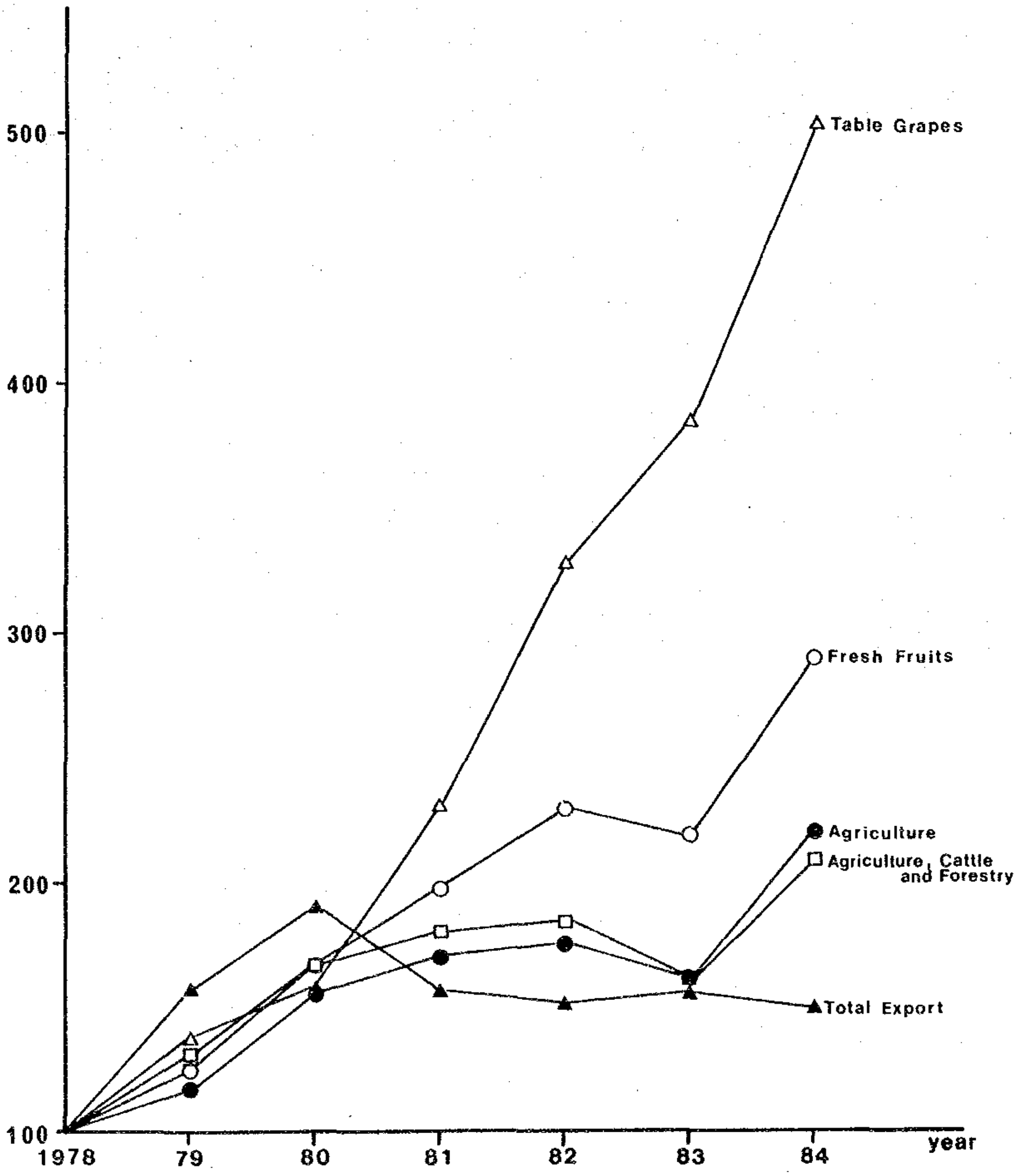

Fig A-10-2 Variation of Export Values (1978 = 100)

Source: Indicadores de Comercio Exterior, Banco Central de Chile, Dic. 1984

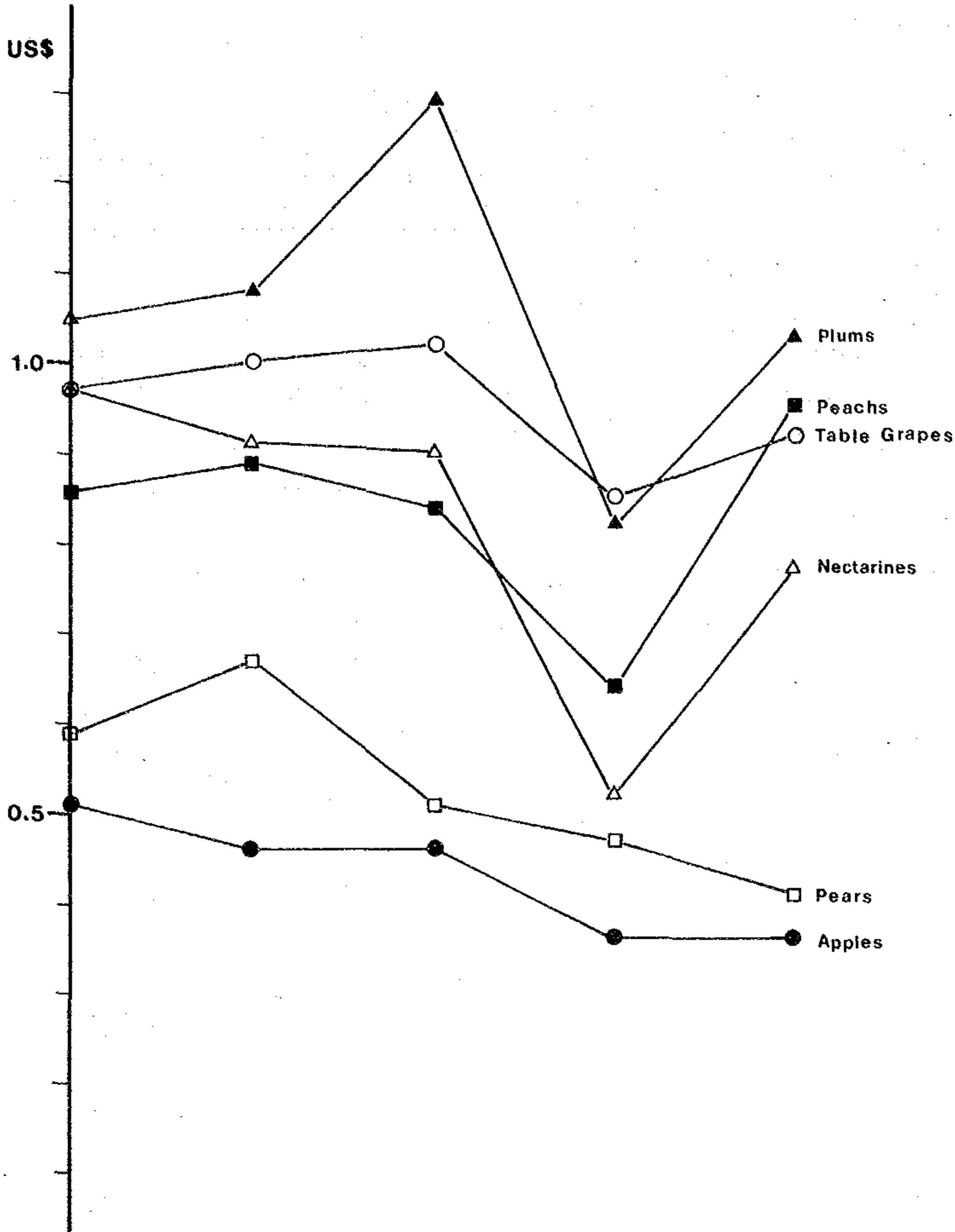

Fig A-10-3 Export Prices of Fresh Fruits (US$/kg)

Source: Indicadores de Comercio Exterior, Banco Central de Chile Dic.1984

10.4 Production Cost

Table A-10-8 Production Costs - 1

(Unit: Ch$)

Crop (Production)	Wheat 1	Wheat 2	Wheat 3
1. Works			
Labor	6,400	6,400	3,200
Machinery	13,200	19,200	23,000
Animal	2,400		
Sub-Total	22,000	25,600	26,200
2. Input Supplies			
Seed or Seedling	9,400	10,800	10,800
Fertilizer	15,500	21,800	28,000
Insecticide	1,300	2,900	4,700
Fungicide			3,700
Herbicide	900	1,100	4,400
Other			
Sub-Total	27,100	36,600	51,600
3. Credit Interest			
Sub-Total	2,200	2,800	3,500
Total	51,300	65,000	81,300

Source of Table A-10-8 to 15 :

Programa de Mejoramiento de las Estadisticas Agropecuarias 1984/85, INE
Programa Trienal 1985-1987, MA, 1985
Necesidades de Insumos por Cultivo, Agro-Colina, 1985
Separata de Antecedentes Estadisticos, MA, 1985
Boletin Economico y de Mercado, SNA, 1985
Informativo Agro-economico, Fundación Chile, 1985
Información de Estandares de Insumo y Jornadas, CIREN, 1985
Catastro Fruticola ReGión Metropolitana, CIREN, 1983
La Platina No.30, INIA, 1985
Farm Survey, 1985

Table A-10-9 Production Costs - 2

(Unit: Ch$)

Crop (Production)	Maize 1	Maize 2	Maize 3
1. Works			
Labor	20,000	18,000	12,000
Machinery	4,000	13,200	18,800
Animal	9,600	7,200	3,600
Sub-Total	33,600	38,400	34,400
2. Inpur Supplies			
Seed or Seedling	11,400	12,600	12,600
Fertilizer	20,100	22,800	33,200
Insecticide	3,700	3,700	6,000
Fungicide			
Herbicide		1,100	3,100
Other	1,100	2,300	2,600
Sub-Total	36,300	42,500	57,500
3. Credit Interest			
	3,100	3,600	4,100
Total	73,000	84,500	96,000

Table A-10-10 Production Costs - 3

(Unit: Ch$)

Crop (Production)	Onion	Corn	Pumpkin	Tomato	Watermelon
1. Works					
Labor	73,200	17,800	20,400	59,400	30,200
Machinery	7,200	10,000	14,000	20,000	16,000
Animal		3,000	3,600	1,500	16,500
Sub-Total	80,400	30,800	38,000	80,900	62,700
2. Input Supplies					
Seed or Seedling	10,200	4,500	2,800	6,100	10,900
Fertilizer	15,000	19,100	26,300	40,100	16,000
Insecticide	5,900	17,400	6,700	16,800	2,900
Fungicide	7,000		9,300	8,500	6,400
Herbicide					
Other					
Sub-Total	38,100	41,000	45,100	71,500	36,200
3. Credit Interest					
	5,300	3,200	3,700	6,900	4,500
Total	123,800	75,000	86,800	159,300	103,400

Table A-10-11 Production Costs - 4

(Unit: Ch$)

Crop (Production)	Melon	String Beans	Lettuce	Lima Beans	Carrot
1. Works					
Labor	28,600	54,200	19,200	53,200	74,600
Machinery	16,000	10,000	10,000	10,000	10,000
Animal	12,300	3,600		3,600	600
Sub-Total	56,900	67,800	29,200	66,800	85,200
2. Input Supplies					
Seed or Seedling	8,500	18,000	13,400	23,000	30,200
Fertilizer	17,800	4,200	17,800	6,000	10,800
Insecticide	13,000	15,200	15,100	15,200	7,100
Fungicide	10,300	2,500	1,200	1,500	
Herbicide			27,100		7,100
Other		9,000		6,000	
Sub-Total	49,600	48,900	74,600	51,700	55,200
3. Credit Interest					
	4,800	5,300	4,700	5,300	6,300
Total	111,300	122,000	108,500	123,800	146,700

Table A-10-12 Production Costs - 5

(Unit: Ch$)

Crop (Productio)	Peaches	Lemos	Nectarines	Plums	Pears	Table Grapes
1. Works						
Labor	34,200	35,800	36,600	37,800	31,000	64,000
Machinery	9,000	14,000	10,000	10,000	14,000	17,000
Animal				600		300
Sub-Total	43,200	49,800	46,600	48,400	45,000	81,300
2. Input Supplies						
Seed or Seedling						
Fertilizer	65,200	36,600	45,700	26,200	18,400	57,500
Insecticide	8,300	7,900	10,800	10,100	13,300	8,600
Fungicide	6,700	7,800	14,000	7,300	15,700	20,200
Herbicide						
Other	15,000	15,000	15,000	15,000	15,000	18,000
Sub-Total	95,200	67,300	85,500	58,600	62,400	104,300
3. Credit Interest						
	12,500	10,500	11,900	9,600	9,700	16,000
Total	150,900	127,600	144,000	116,600	117,100	202,000

Table A-10-13 Production Costs - 6

(Unit: Ch$)

Crop (Planting)	Peaches	Nectarines	Plums	Pears	Table Grapes
1. Works					
Labor	14,600	15,800	14,200	13,800	54,300
Machinery	6,000	6,000	7,000	7,000	11,200
Animal					300
Sub-Total	20,600	21,800	21,200	20,800	65,800
2. Input Supplies					
Seed or Seedling	57,000	52,500	49,500	49,500	57,200
Fertilizer	27,800	26,200	24,400	24,500	63,300
Insecticide	7,200	6,100	8,300	8,300	7,600
Fungicide					18,500
Herbicide					
Other					268,100
Sub-Total	92,000	84,800	82,200	82,300	414,700
3. Credit Interest					
	10,100	9,600	9,300	9,300	43,200
Total	122,700	116,200	112,700	112,400	523,700

Table A-10-14 Production Costs - 7

(Unit: Ch$)

Crop (Formation)	Peaches	Nectarines	Plums	Pears	Table Grapes
1. Works					
Labor	12,200	13,200	7,600	14,000	21,400
Machinery	7,000	7,000	5,000	8,000	5,000
Animal					300
Sub-Total	19,200	20,200	12,600	22,000	26,700
2. Input Supplies					
Seed or Seedling					
Fertilizer	44,900	51,000	17,800	18,900	63,300
Insecticide	9,700	9,400	10,800	18,000	7,600
Fungicide	11,200	16,800	12,900	5,600	18,500
Herbicide					
Other					
Sub-Total	65,800	77,200	41,500	42,500	89,400
3. Credit Interest					
	7,700	8,800	4,900	5,800	10,400
Total	92,700	106,200	59,000	70,300	126,500

10.5 Production Values

Table A-10-15 Present Production Costs, Yields and Producer's Prices

Crop		Production Cost (Ch$/ha)	Yield (per ha)		Producer's Price (ch$)
Wheat	Block - 1	65,000	4.2	t	37.8/kg
	Blocks - 2·3	65,000	4.3	t	"
	Block - 4	51,300	3.2	t	"
Maize	Block - 1	84,500	6.7	t	21.3/kg
	Blocks - 2·3	84,500	6.2	t	"
	Block - 4	73,000	4.8	t	"
Onion		123,800	30	t	7.0/kg
Corn		75,000	$25x10^3$	units	8.0/unit
Pumpkin		86,800	18	t	7.0/kg
Tomato		159,300	40	t	7.0/kg
Watermelon		103,400	$4.2x10^3$	units	40.0/unit
Melon		111,300	$10x10^3$	units	15.0/unit
String Beans		122,000	300	bags	600/baks
Lettuce		108,500	$60x10^3$	units	3.0/unit
Lima Beans		123,800	200	bags	850/baks
Carrot		146,700	$180x10^3$	units	1.0/unit
Peaches	for export	150,900	10.5	t	80/kg
	for domestic	"	"		25/kg
Lemons	for export	127,600	16.7	t	30/kg
	for domestic	"	"		18/kg
Nectarines	for export	144,000	10.1	t	62/kg
	for domestic	"	"		28/kg
Plums	for export	116,600	7.3	t	76/kg
	for domestic	"	"		33/kg
Pears	for export	117,100	13.6	t	36/kg
	for domestic	"	"		25/kg
Table Grapes	for export	202,000	18.1	t	74/kg
	for domestic	"	"		40/kg

Table A-10-16 Present Gross and Net Production Values

(Unit: Ch$/ha)

Crop		Gross Production Value	Net Production Value
Wheat	Block - 1	158,800	93,800
	Blocks - 2·3	162,500	97,500
	Block - 4	121,000	69,700
Maize	Block - 1	142,700	58,200
	Blocks - 2·3	132,100	47,600
	Block - 4	102,200	29,200
Onion		210,000	86,200
Corn		200,000	125,000
Pumpkin		126,000	39,200
Tomato		280,000	120,700
Watermelon		168,000	38,700
Melon		150,000	64,600
String Beans		180,000	58,000
Lettuce		180,000	71,500
Lima Beans		170,000	46,200
Carrot		180,000	33,300
Peaches	for export	840,000	689,100
	for domestic	262,500	111,600
Lemons	for export	501,000	373,400
	for domestic	300,600	173,000
Nectarines	for export	626,200	482,200
	for domestic	282,800	138,800
Plums	for export	554,800	479,200
	for domestic	240,900	165,300
Pears	for export	489,600	372,500
	for domestic	340,000	222,900
Table Grapes	for export	1,339,400	1,137,400
	for domestic	724,000	522,000

Source : Table A-10-8 to 12 and Table A-10-15

Table A-10-17 Proposed Number of Small Farmers

Block	Present	Project
1	68	68
2	184	128
3	105	85
4	693	549
Total	1,050	830

Source : Actualizado Propiedades 1979,CIREN

Table A-10-18 Proposed Yields of Introduced Fruits and Table Grapes

(Unit: t/ha)

Year \ Crop	Peaches	Nectarines	Plums	Pears	Table Grapes
3	—	—	—	—	4.0
5	8.5	10.5	5.0	2.5	11.5
10	15.0	16.5	10.0	18.0	16.5
15	14.0	15.5	11.0	25.0	13.4
20	10.0	11.0	11.0	25.0	8.2

Source: Informativo Agro-economic, Fundación Chile, 1985

Table A-10-19 Proposed Direct Production Costs (Planting and Formation)

(Unit: Ch$/ha)

Crop	Planting	Formation
Peaches	122,700	92,700
Nectarines	116,200	106,200
Plums	112,700	59,000
Pears	112,400	70,300
Table Grapes	523,700	126,500

Source : Tables A-10-13 and 14

Table A-10-20 Crop Budgets

(Unit: Ch$)

Crop	Cropped Area (%)	Gross Production Value	Production Cost	Net Production Value
Onion	17	210,000	123,800	86,200
Corn	17	200,000	75,000	125,000
Pumpkin	13	126,000	86,800	39,200
Tomato	10	280,000	159,300	120,700
Watermelon	9	168,000	103,400	64,600
Melon	9	150,000	111,300	38,700
String Beans	8	180,000	122,000	58,000
Lettuce	6	180,000	108,500	71,500
Lima Beans	6	170,000	123,800	46,200
Carrot	5	180,000	146,700	33,300
Vegetables Weighted Mean	100	187,100	111,300	75,800
For Export				
Peaches	27	808,500	150,900	657,600
Lemons	26	501,000	127,600	373,400
Nectarines	20	626,200	144,000	482,200
Plums	18	554,800	116,600	438,200
Pears	9	462,400	117,100	345,300
Fruits Weighted Mean	100	615,200	134,200	481,000
Table Grapes		1,248,900	202,000	1,046,900
Mean of Fruits and Table Grapes		868,700	161,300	707,400
For Domestic				
Peaches	27	241,500	150,900	90,600
Lemons	26	300,600	127,600	173,000
Nectarines	20	282,800	144,000	138,800
Plums	18	240,900	116,600	124,300
Pears	9	312,800	117,100	195,700
Fruits Weighted Mean	100	271,400	134,200	137,200
Table Grapes		669,700	202,000	467,700
Mean of Fruits and Table Grapes		430,700	161,300	269,400
Fruits and Table Grapes Without Project		518,300	161,300	357,000
Fruits and Table Grapes With Project		781,100	161,300	619,800

Source : Table A-10-16

Table A-10-21 Production Value Budgets per Farmer

(Unit: Ch$)

Block and Item	Without Project	With Project
1		
Cultivated Area (ha)	4.4	5.3
Cropped Area (ha)	4.4	9.5
Gross Production Value	922,600	2,406,100
Direct Production Cost	483,200	1,011,300
Net Production Value	439,400	1,394,800
N.P.V/Cultivated Area	99,900	263,200
2		
Cultivated Area (ha)	3.4	4.9
Cropped Area (ha)	3.4	8.8
Gross Production Value	710,300	2,212,100
Direct Production Cost	374,200	936,000
Net Production Value	336,100	1,276,100
N.P.V/Cultivated Area	98,900	260,400
3		
Cultivated Area (ha)	4.6	6.7
Cropped Area (ha)	4.6	12.1
Gross Production Value	990,900	2,997,300
Direct Production Cost	510,500	1,282,100
Net Production Value	480,400	1,715,200
N.P.V/Cultivated Area	104,400	256,000
4		
Cultivated Area (ha)	4.0	5.8
Cropped Area (ha)	4.0	10.4
Gross Production Value	830,500	2,418,800
Direct Production Cost	433,500	1,039,600
Net Production Value	397,000	1,379,200
N.P.V/Cultivated Area	99,300	237,800

Source : Table 4-3-3 and Tables A-10-16 and 20

10.6 Farm Household Economy

Table A-10-22 Cropping Labor Forces

(Unit: man·day/ha)

		Labor Force	
		Without Project	With Project
Wheat	blocks - 1, 2, 3 block - 4	16 16	8 16
Maize	blocks - 1, 2, 3 block - 4	45 50	30 45
Onion Corn Pumpkin Tomato Watermelon Melon String Beans Lettuce Lima Beans Carrot		159.5 44.5 51 148.5 75.5 71.5 135.5 48 133 186.5	
Vegetables Weighted Mean		100.4	
Peaches Limons Nectarines Plums Pears		85.5 89.5 91.5 94.5 77.5	
Fruits Weighted Mean		88.6	
Table Grapes		160	
Mean of Fruits and Table Grapes		117.2	

Source : Tables A-10-8 to 12 , and 20

Table A-10-23 Required Labor Forces per Farmers

(Unit: man·day/year)

Block and Item	Without Project	With Project
1		
Total Required Labor	398	622
Family Labor	375	375
Employment Labor	23	247
Surplus Labor	0	0
2		
Total Required Labor	310	575
Family Labor	310 1/	375
Employment Labor	0	200
Surplus Labor	65	0
3		
Total Required Labor	420	786
Family Labor	375	375
Employment Labor	45	411
Surplus Labor	0	0
4		
Total Required Labor	365	728
Family Labor	365 1/	375
Employment Labor	0	353
Surplus Labor	10	0

Source : Tables 4-3-3 and A-10-23

1/ Maximum Family Labor Force is 375 man.day/year

Table A-10-24 Indirect Production Costs

(Unit: Ch$)

Block and Item	Farm Size (ha)	Cultivated Area (ha)	Admini-stration Cost 1/	Tax	Water Charge	Cleaning Cost of Canal and Field	Commercial Cost 2/	Technical Assistance Cost	Total
1 Without Project	6.6	4.4	35,200	13,200	31,700	42,200	22,000	-	144,300
With Project	6.6	5.3	42,400	13,200	38,200	25,400	26,500	5,600	151,300
2 Without Project	5.1	3.4	27,200	10,200	24,500	32,600	17,000	-	111,500
With Project	5.1	4.9	39,200	10,200	35,300	23,500	24,500	5,600	138,300
3 Without Project	6.9	4.6	36,800	13,800	33,100	44,200	23,000	-	150,900
With Project	6.9	6.7	53,600	13,800	48,200	32,200	33,500	5,600	186,900
4 Without Project	6.0	4.0	32,000	12,000	28,800	19,200	20,000	5,600	117,600
With Project	6.0	5.8	46,400	12,000	41,800	27,800	29,000	5,600	162,600

Note: 1/ Operation, maintenance and depreciation costs of agricultural infrastructures and equipments, etc.

2/ Transportation cost of input supplies and packing cost of products, etc.

Table A-10-25 Self-employment Wage and Non-agricultural Income

(Unit: Ch$)

Block and Item	Without Project	With Project
1		
Self-employment Wage	150,000	150,000
Non-agricultural Income	0	0
2		
Self-employment Wage	124,000	150,000
Non-agricultural Income	26,000	0
3		
Self-employment Wage	150,000	150,000
Non-agricultural Income	0	0
4		
Self-employment Wage	146,000	150,000
Non-agricultural Income	4,000	0

Source : Table A-10-23

Table A-10-26 Surplus of Farm Household Economy Budgets

(Unit: Ch$)

Block	and Item	Without Project	With Project
1	Net Production Value	439,400	1,394,800
	Indirect Production Cost	144,300	151,300
	Agricultural Net Return	295,100	1,243,500
	Family Wage	150,000	150,000
	Agricultural Income	445,100	1,393,500
	Non-agricultural Income	0	0
	Income of Farm Household	445,100	1,393,500
	Living Cost	267,100	400,700
	Economic Surplus	178,000	992,800
2	Net Production Value	336,100	1,276,100
	Indirect Production Cost	111,500	138,300
	Agricultural Net Return	224,600	1,137,800
	Family Wage	124,000	150,000
	Agricultural Income	348,600	1,287,800
	Non-agricultural Income	26,000	0
	Income of Farm Household	374,600	1,287,800
	Living Cost	224,800	337,200
	Economic Surplus	149,800	950,600
3	Net Production Value	480,400	1,715,200
	Indirect Production Cost	150,900	186,900
	Agricultural Net Return	329,500	1,528,300
	Family Wage	150,000	150,000
	Agricultural Income	479,500	1,678,300
	Non-agricultural Income	0	0
	Income of Farm Household	479,500	1,678,300
	Living Cost	287,700	431,600
	Economic Surplus	191,800	1,246,700
4	Net Production Value	397,000	1,379,200
	Indirect Production Cost	117,600	162,600
	Agricultural Net Return	279,400	1,216,600
	Family Wage	146,000	150,000
	Agricultural Income	425,400	1,366,600
	Non-agricultural Income	4,000	0
	Income of Farm Household	429,400	1,366,600
	Living Cost	257,600	386,400
	Economic Surplus	171,800	980,200

Source : Tables A-10-21,24 and 25

10.7 Livestock

Table A-10-27 Changes of Population and Number of Livestock Animal

Year	Population (1,000 persons)	Number of Livestock Animals (1,000 head) Cattle	Sheep	Swine
1936	4,778(100)	2,537(100)	5,749(100)	518(100)
1955	6,743(141)	2,512(99)	6,440(112)	980(189)
1965	8,510(178)	2,870(113)	6,690(116)	1,022(197)
1976	10,372(217)	3,389(134)	5,674(98)	895(173)
1980	11,682(244)	3,625(143)	6,064(116)	1,068(206)
1984	11,878(249)	3,650(144)	6,000(104)	1,070(207)

Note: Figure enclosed by parenthesis shows an index. (1936 = 100)
Source: INE-ODEPA, and Statistical Synthesis of Chile 1980-1981, Banco Central de Chile

Table A-10-28 Trend of Livestock Numbers During Last 6 Years
(Unit: 1,000 head or pcs)

Kind of Animal	1979	1980	1981	1982	1983	1984
Cattle	3,575	3,575	3,745	3,800	3,865	3,870
Dairy Cattle	706	735	750	715	680	650
Sheep	5,928	6,064	6,135	6,000	6,200	6,300
Goats	600	600	600	600	600	600
Swine	1,036	1,068	1,150	1,150	1,100	1,150
Chickens	22,000	24,000	25,000	21,000	20,000	18,000
Horses	450	450	450	430	450	460

Source: FAO, Production Yearbook, Vol.35,36,37,38.

Table A-10-29 Recent Changes of Livestock Production.
(Units: 1,000 ton-meat, 1,000 liter-milk, 1,000 pcs-egg)

Items		1978	1979	1980	1981	1982	1983	1984
Beef	(10^3ton)	164.9	167.5	162.3	184.6	194.6	208.1	196.8
Mutton	(10^3ton)	15.3	17.7	15.5	15.6	14.9	13.3	11.9
Pork	(10^3ton)	33.9	42.5	49.7	55.8	57.7	50.2	59.2
Chicken Meat	(10^3ton)	58.6	78.9	102.0	125.0	113.0	86.5	70.0
Chicken Egg	(10^3pcs)	1,167.2	1,217.2	1,425.0	1,117.0	1,117.0	1,250.0	1,300.0
Milk	(10^3l)	978.0	953.5	1,080.0	1,200.0	1,114.0	900.0	880.0
Unprocessed Wool	(10^3ton)	19.3	19.6	20.6	21.6	21.6		

Source: Statistical Synthesis of Chile 1978-1982, Banco Central de Chile

Table A-10-30 Annual Consumption Tendency of Livestock Products

	1980	1981	1982	1983	1984
Total per capita meat consumption (kg)	30.1	33.9	34.4	31.6	28.9
Beef supply(1,000 ton)	166.6	189.7	201.8	209.9	201.4
(Domestic production)	(162.3)	(184.6)	(194.5)	(208.1)	(196.8)
(Import)	(4.3)	(5.1)	(7.3)	(1.8)	(4.6)
Per capita consumption(kg)	15.0	16.8	17.9	18.0	17.0
Mutton supply(1,000 ton)	15.5	15.6	14.9	13.3	11.9
Per capita consumption(kg)	1.4	1.4	1.3	1.1	1.0
Pork supply(1,000 ton)	49.7	55.9	57.7	59.2	59.2
Per capita consumption(kg)	4.5	4.9	5.1	5.1	5.0
Chicken meat supply(1,000 ton)	102.0	122.5	114.0	86.5	70.0
Per capita consumption(kg)	9.2	10.8	10.1	7.4	5.9
Milk supply(million ℓ)	1,080.0	1,200.0	1,056.0	900.0	880.0
Per capita consumption(ℓ)	97.3	106.3	93.7	77.0	74.1
Egg supply(1,000 pcs)	1,425.0	1,442.8	1,312.8	1,250.0	1,300.0
Per capita consumption(pcs)	128.0	106.3	116.4	107.0	109.4

Source: Statistical Synthesis of Chile 1980-1984, Banco Central de Chile

Table A-10-31 Changes of Wholesale Prices of Major Livestock Products in Santiago.

Items	1980	1981	1982	1983	1984
Beef(Ch $/kg)	72.45	81.94	78.74	97.47	138.10
Pork(Ch $/kg)	73.01	81.12	76.14	100.14	130.63
Mutton(Ch $/kg)	86.43	89.43	81.27	106.47	141.89
Chicken Meat(Ch $/kg)	59.33	58.27	55.09	81.71	113.57
Chicken Egg(Ch $/pc)	2.13	2.17	2.55	3.87	4.80
Processed Milk(Ch $/l)	13.78	15.92	17.40	23.61	29.99

Source: Boletin Pecuario, Abril, 1985. Ministrio de Agricultura.

Table A-10-32 International Comparision of Beef Price
(Unit: US cent/kg liveweight)

	Chile	Argentine	Uruguay	Brasil	U.S.A.	Canada	Australia	New Zealand
1978	89	45	36	68	115	118	45	42
1979	117	91	80	93	149	142	89	70
1980	136	101	69	83	148	142	100	65

Source: Desarrollo del subsector Carnes Rojas en Chile, FAO, Aug. 1981

Table A-10-33 Physical Swine Production Data in Chile.

FARROW TO FINISH OPERATION	Average
Sow Production	
Conception-first service	80 %
No. of Litters per Sow per Year	2.2
No. of Pigs Born Alive.	10.0
No. of Pigs Weaned per Litter	9.0
Percent Death Loss (Farrow to Wean)	10 %
No. of Pigs Weaned per Sow per Year	19.8
Percent Death Loss (Wean to Finish)	5 - 10 %
No. of Hogs Sold per Sow per Year	18 or more
Age at Weaning	3 - 4
Nutrition	
Total Feed Conversion Efficiency (includes Boars, Sows and Replacement Stocks)	3.5
Average Liveweight of Hog Sold	95-100 kg
Average Age of Hog Sold	180 days
Management	
Labor Hours per Hog (Farrow to Finish, including Breeding Stocks)	1.5-2.5 hours

Table A-10-34 Hog Production Costs (Based on 150 Sow Herd Farrow to Finish Operation)

	18Pigs/Sow/Year (Ch.$)
A: OPERATING COSTS	
FEED COSTS	
Sow Gestation	543
Sow Lactation	353
Boar Ration	51
Market Hog	6,820
TOTAL FEED COSTS	7,767
VET. MEDICINE AND SUPPLIES	300
MAINTENANCE AND REPAIRS	200
UTILITIES	52
REPLACEMENT BREEDING STOCK COSTS	95
MISCELLANEOUS	200
DEATH LOSS	172
INTEREST ON OPERATION	395
TOTAL OPERATION COSTS	9,181
B: FIXED COSTS	
DEPRECIATION	
Building (5%)	250
Equipment 15%)	321
TOTAL FIXED COSTS	571
C: LABOR COSTS	
2 hours per Market Hog	100
TOTAL LABOR COSTS	100
TOTAL PRODUCTION COSTS PER 100 KG MARKET HOG	9,852
MARKET HOG PRICE AT 95 KG LIVEWEIGHT (@135Ch.$/kg)	12,825
BENEFIT PER MARKET HOG	2,973

Table A-10-35 FEED REQUIREMENT AND COSTS (Breakdown of the Production Costs)

	KG	UNIT PRICE (Ch.$/kg)	COST (Ch.$)
Creep Feed Ration-C.P.19%			
Birth--10kg	5	41.56	207.8
Starter Ration-C.P.18%			
10-25kg			
Conversion Rate 2.0	30	25.32	759.6
Grower Ration-C.P.16%			
25-50kg			
Conversion Rate 3.0	75	21.82	1,636.5
Finishing Ration-C.P.14%			
50- 95kg			
Conversion Rate 4.0	200	21.08	4,216.0
SUB TOTAL FOR MARKETING HOG	280		6,819.9
Sow Gestation-C.P.13%			
288 days, @ 2kg/day	576	16.98	9,780.5
Sow Lactation-C.P.15%			
77 days, @ 5kg/day	385	20.61	7,935.0
Boar Ration-C.P.13%			
365 days, @ 2.3kg/day	804	16.98	13,652.0

Note : Feed requirements and feed unit prices were obtained from survey data.

Table A-10-36 FEED COSTS (Breakdown of the Production Costs)

MAIN FEEDSTUFFS	COSTS(CH.$/KG)
Corn	20.0
Fishmeal	35.0
Soybean meal	32.0
Wheat bran	11.0
Rice bran	13.5
SUPPLEMENTS	
Vitamine pre mix	405.0
Mineral pre mix	60.0
Antibiotics	2,200.0
Salt	5.0
HOME PREPARED RATION	
Creep Feed- CP.19%	41.56
Starter-C.P.18%	25.32
Grower- CP.16%	21.82
Finisher- CP.14%	21.08
Sow Gestation and Boars-C.P.13%	16.98
Sow Lactation-C.P.15%	20.61

Costs for feedstuffs and home prepared rations were obtained from producer records in the study and survey area.

Table A-10-37 OPERATING COSTS (Breakdown of the Production Costs)

(Estimated based on a 150 sow herd farrow to finish operation. Costs were estimated and obtained from producer records.)

VET. MEDICINE AND SUPPLIES

Vaccination, Iron, Vitamines and others.
(Penicillin, Antiparasitic agents, etc.) 300 Ch.$/Market hog

MAINTENANCE AND REPAIRS

200 Ch.$/Market hog

DEATH LOSS

Death loss was assumed to be a 4 % of 1/2 of the operating costs.
172 Ch.$/Market hog

UTILITIES

Utility costs were arrived at by a field survey data among a select group of hog producers. It was estimated at 140,000 Ch.$/year for this size operation.
52 Ch.$/Market hog

INTEREST ON OPERATION

Applied to 1/2 of the operating costs, with interest rate of 9 % for 6 month.
395 Ch.$/Market hog

REPLACMENT COSTS

Sow and Boar prices were obtained from field survey data.

SOW REPLACEMENT (Price of gilt 30,000 Ch.$ at 95 kg)

① 25% culling rate per year. ② Cull sow weighing approximately 200 kg.
③ Price of cull sow 120 Ch.$ per kg(liveweight).

Purchase of replacement per sow:	7,500 Ch.$
Sale of cull sow:	6,000 Ch.$
Replacement cost per sow:	1,500 Ch.$

BOAR REPLACEMENT (Price of boar 40,000 Ch.$ at 100 kg)

① 15 sows and gilts per boar. ② 33.3% culling rate per year. ③ Cull boar weighing approximately 250 kg, price of cull boar 120 Ch.$ per kg(liveweight)

Purchase of replacement per boar:	13,200 Ch.$
Sale of cull boar:	9,900 Ch.$
Replacement costs per boar:	3,300 Ch.$

TAble A-10-38 FIXED COSTS (Breakdown of the Production Costs)

DEPRECIATION

20 years (5 %) straight line on building.

7 years (15 %) straight line on equipment.

Salvage value= 10 % of original costs.

Building costs- 1,412 m²

-Farrowing Pen, Weanling Pen, Growing Pen, Sow stalls.

-Feeder barn

-Office-Feed-Utility

100,000 Ch.$/Sow

Equipment

-Water supply

-Electrical Service

-Feed Mill (5.6 kw/7.5 H.P.)

-Liquid Manure System

45,000 Ch.$/Sow

LABOUR COSTS (Breakdown of the Production Costs)

Labour hours vary with the amount of mechanization. Labour requirement used were obtained from field survey data.

2.0 hours per market hog.

Labour wage were obtained from survey data 400 Ch.$ per man per day in some livestock farms near Santiago.

100 Ch.$/Market hog

10.8 Agricultural Supporting Services

The technology transfer programs under the Ministry of Agriculture are grouped into two lines, that is, "Programa de Transferencia tecnológica" by INDAP and "Programa de Grupos de Transferencia tecnológica" by INIA. The former applies to the small farmer whose land is less than 12 ha and intends to improve the standard of living and the increase of productivity. The principal sub-programs are the following:

a) Offer of informations on technology
b) Overall transfer of technology
c) Direct technical support

On the other hand, the subject of the latter is the medium-size producer. In this program groups of 15 - 20 persons form units of activity. Its objective is the improvement of capacity of medium-size producers. At present, 9 groups are in a state of action in the Metropolitan Region, 3 of which are located in the Mapocho River Basin.

Colina	Production of fruits trees	2,318 ha
Colina	Production of vegetables and other farm products	1,550 ha
Maipú	Production of vegetables and other farm products	600 ha

Each of these groups consists of 15 - 18 persons.

10.9 Marketing

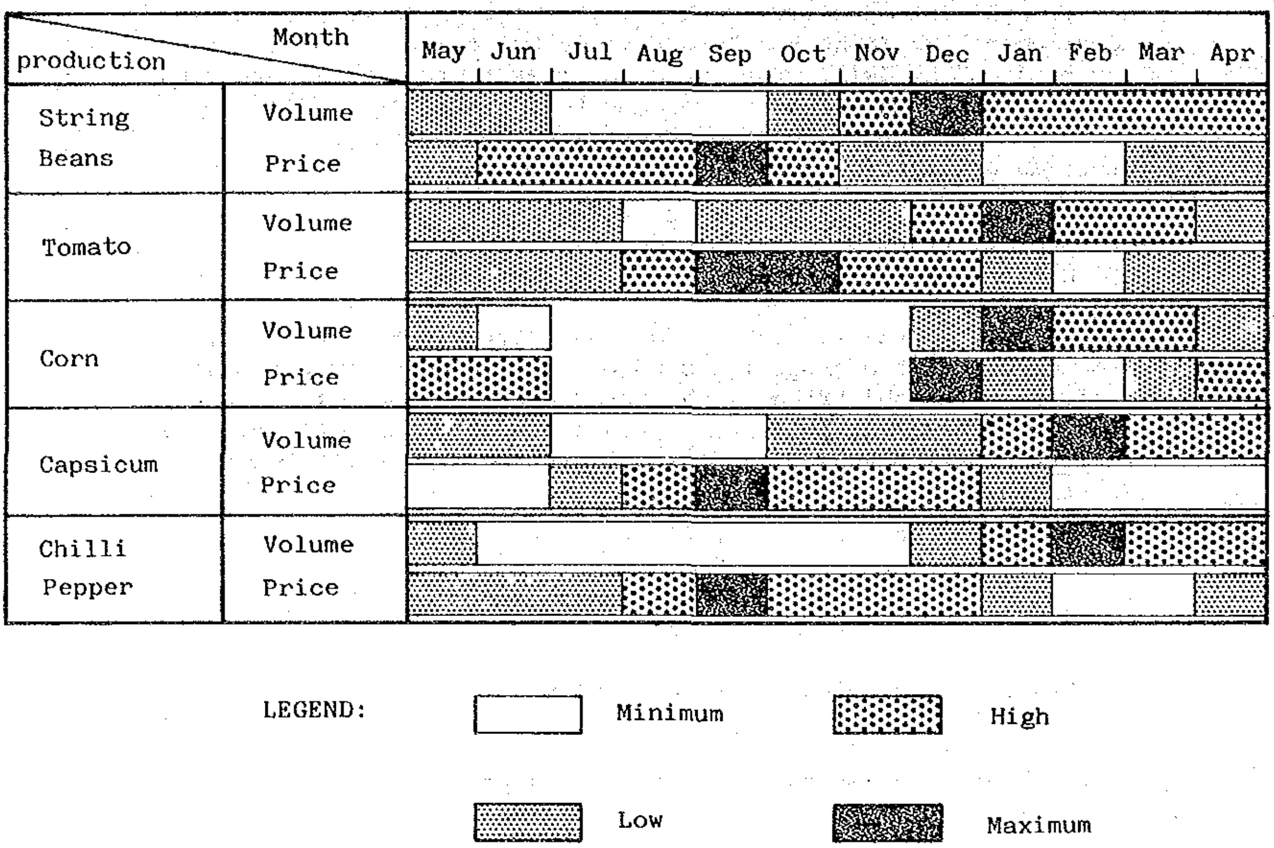

Fig. A-10-4 Seasonal Variations of Vegetables in Santiago Markets.

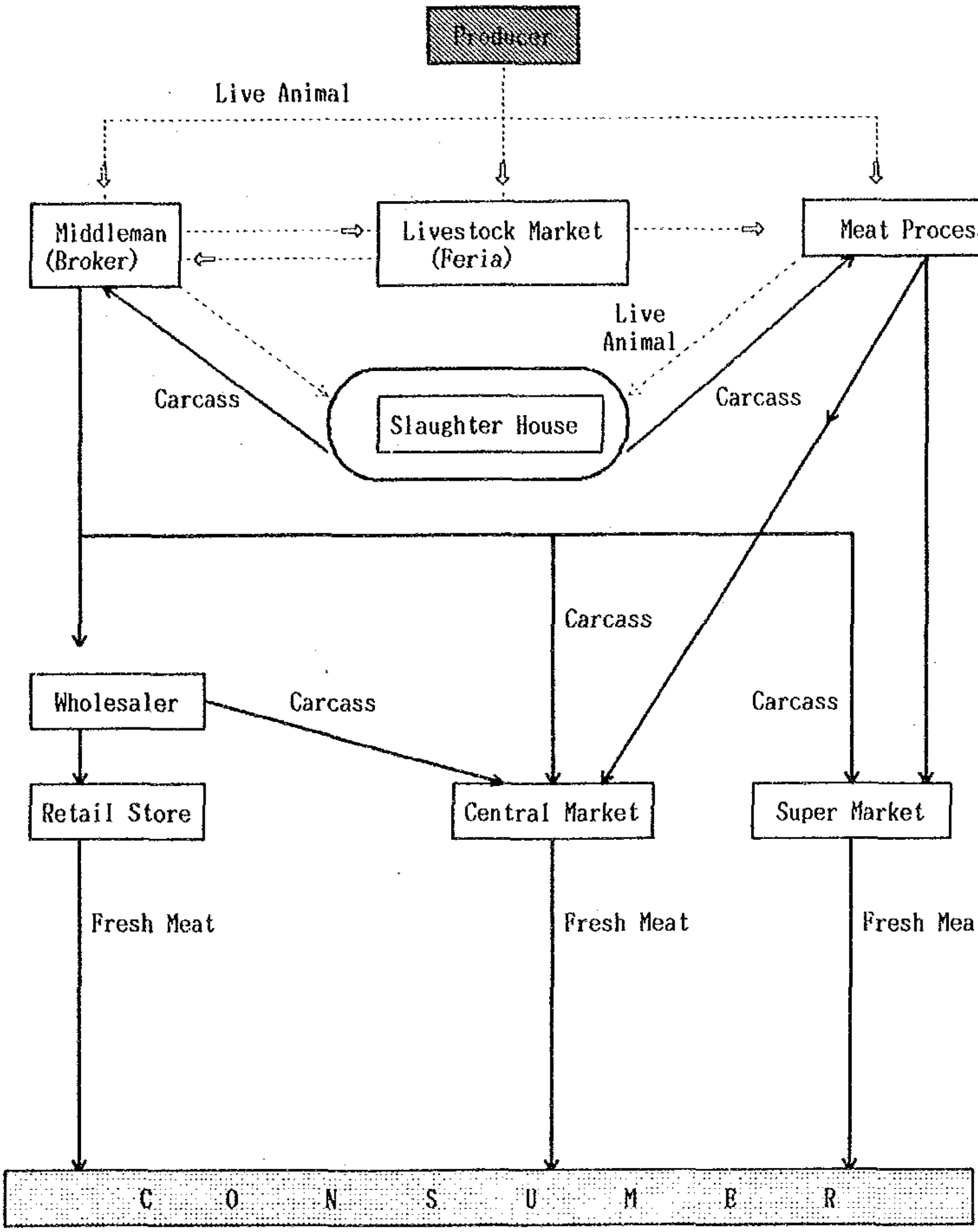

Fig A-10-5 Outline of Livestock Meat Marketing Channel in Santiago.

Appendix 11: Irrigation

11.1 Water Balance in Existing Conditions

11.2 Computation of ETcrop

11.3 Gross Duty of Water in Proposed Double Cropping Conditions

11.4 Irrigation Plan

11.5 Dam Plan

11.6 Proposed Irrigation Facilities

11.7 Esperanza Headworks

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11.9 Observation about Water Rights

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Fig A-11-16 Boring Log at Esperanza Headworks

Fig A-11-17 Centralized Control System

Fig A-11-18 Block Diagram of Local Control System

11.1 Water Balance in Existing Conditions

(1) Gross Duty of Water

The gross duty of irrigation water (Qd) is obtained from the following formula in accordance with FAO Mannual:1/

$$Qd = \frac{A \times (ET\ crop - Re)}{8,640 \times Ep} \quad (m^3/s)$$

where:
- A : irrigation area (ha)
- ETcrop : crop evapotranspiration (mm/day)
- Re : effective rainfall (mm/day)
- Ep : irrigation efficiency

1/ Crop Water Requirements, Irrigation and Drainage Paper 24, revised 1977, FAO

1) Irrigation Area (A)

As the irrigation area (A), the present upland field determined through the landuse survey in this study is adopted. For Block-2, the upland field of 300 ha located beside the Project Area within the University of Chile is added, because the area is included in the same irrigation network.

2) Crop Evapotranspiration (ETcrop)

ETcrop is obtained on the basis of the Pan Evaporation Method adopted by CNR in the irrigation planning as shown below:

$$ETcrop = Kc \times ETo$$
$$ETo = Kp \times Epan$$

where:
- ETcrop : crop evapotranspiration (mm/day)
- Kc : crop coefficient
- ETo : reference crop evapotranspiration (mm/day)
- Kp : pan coefficient
- Epan : pan evaporation (mm/day)

As the values of Epan, the records of 1974/75 in Station Santiago (No.24) are adopted, because they correspond to the 6.7 year return period values, judging from the analysis based on the records of 1963 to 1981.

ETcrop for both single and double cropping patterns were determined for the analysis of the irrigation water balance in consideration of the present cropping conditions and proposed cropping pattern, respectively. The adopted combination of crops is as follows:

Single Cropping

Wheat	: 36%,	Maize	: 24%
Fruit	: 10%,	Winter vegetable:	12%
Summer vegetable	: 18%		

Double Cropping

Wheat + vegetable	: 45%
Maize + vegetable	: 30%
Fruit	: 25%

3) Effective Rainfall (Re)

Sixty (60)% of the rainfall with more than 5 mm/day is considered as the effective rainfall in the analysis. The rainfall records of the following stations are used:

Station Santiago (No 24) for Blocks-1 and 2
Station Fundo Valle Hermoso (No 12) for Blocks-3 and 4

4) Irrigation Efficiency (Ep)

As the present irrigation efficiency (Ep), the value 0.4 is adopted in consideration of the present field conditions and FAO manual (Table A-11-3) as follows:

$$Ep = Ec \times Eb \times Ea = 0.7 \times 0.8 \times 0.7 = 0.4$$

where: Ec : intake and conveyance efficiency 0.7
Eb : field canal efficiency 0.8
Ea : field application efficiency 0.7

5) Gross Duty of Water

The maximum values of the gross duty of irrigation water in the present conditions (Qdmax) are shown in Table A-11-4.

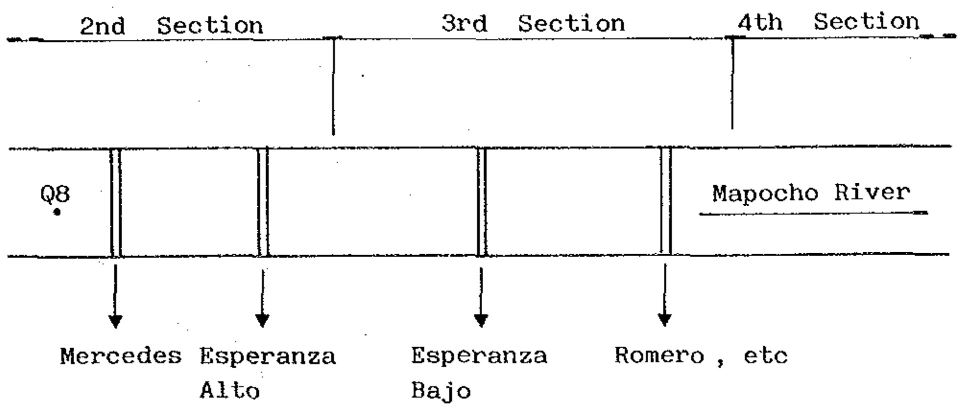
(2) Available Irrigation Water

The value of the irrigation waters in the present condition (Qa) is obtained on the basis of the observed river discharge records and in consideration of the existing water rights in the downstream areas.

1) Block-1

20% of the Mapocho river discharge at Station Rinconada de Maipú, Q8(No 8) was adopted as Qa for Block-1 in consideration of the maximum intake volumes calculated as follows:

$$Qa = \frac{2.5 \times Q8}{9.0 + 2.5 + 0.5} = 0.2 \times Q8$$



The maximum intake volume in each point is:

Mercedes : 9.0 m^3/s

Esperanza (Alto + Bajo) : 2.5 m^3/s (A=2,660 ha 1/, ETcrop = 3.3 mm/day, Ep = 0.4)

Romero, etc : 0.5 m^3/s (A= 480 ha , ETcrop = 3.3 mm/day, Ep = 0.4)

2) Block-2

All the sewage to Zanjón de la Aguada, 6.6 m^3/s is taken as Qa.

$$Qa = \frac{230 \text{ l/capita/day} \times 2,480,000 \text{ capita}}{86,400} = 6.6 \text{ m}^3/\text{s}$$

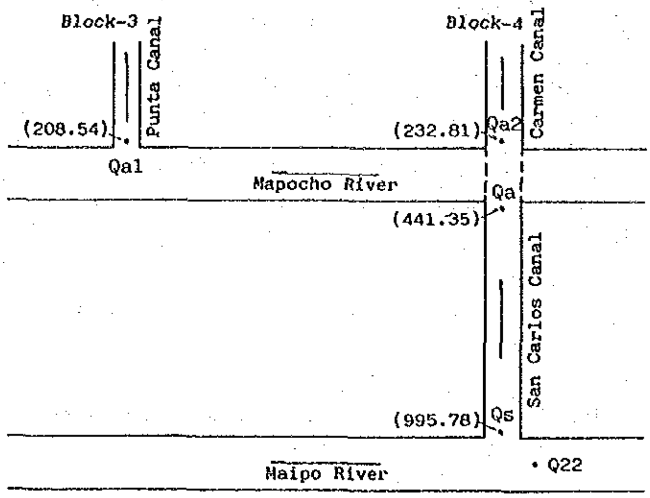
where:

230 l/capita/day : average water consumption per capita per day

2,480,000 : population whose used water drained to Zanjón de la Aguada (1984)

1/ As the objective field, both upland field and pature are considered.

3) Blocks-3 and 4



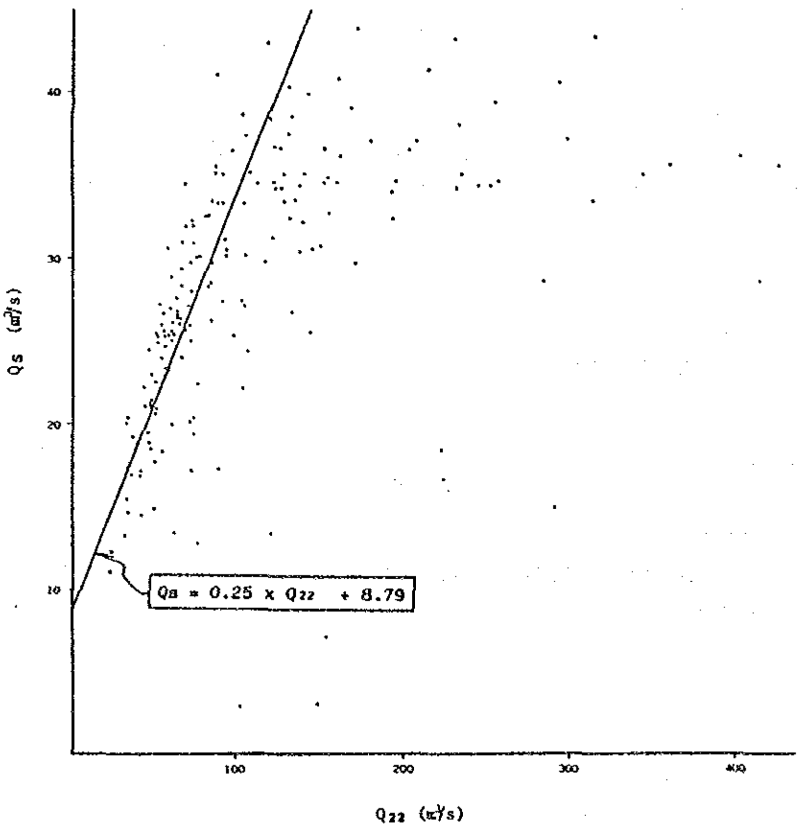
where: Q22 : river discharge at Station La Obra (No 22)

Qs : intake volume to San Carlos canal

(441.35) : water right (regadores)

The relationship between Q22 and Qs is obtained on the basis of the observed records from 1970 to 1984 as follows:

$$Qs = 0.25 \times Q22 + 8.79$$



The available irrigation water for each block is obtained with the ratio of water right as follows:

Block -3 and 4 : $Qa = \frac{441.35}{995.78} \times Qs$

$= 0.1108 \times Q22 + 3.896$

Block-3 : $Qa1 = \frac{208.54}{995.78} \times Qs$

$= 0.0520 \times Q22 + 1.841$

Block-4 : $Qa2 = \frac{232.81}{995.78} \times Qs$

$= 0.0585 \times Q22 + 2.055$

(3) Balance of Irrigation Water

The balance of irrigation waters in existing condition was calculated based on the hydrological records of forty (40) years from 1940/41 to 1980/81 using following formula :

$Qs = Qa - Qd$

where :

Qs : Shortage of irrigation water (m^3/s)

Qa : Available water (m^3/S)

Note : Computed based on monthly discharge records of stations No 8 and No 22,1940/41 - 1980/81, for Block-1 and 2 and Block-3 and 4,respectively

Qd : Gross duty of irrigation water in existing conditions (m^3/s)

Note : Computed based on monthly rainfall records of stations No 24 and No 12,1940/41 - 1980/81, for Block-1 and 2 and Block-3 and 4,respectively

The results of the analysis are shown in Table A-11-5.

11.2 Computation of ETcrop

(1) Determination of Cropping Pattern and Crop Coefficient Curve

The proposed cropping patterns are determined in consideration of the present cropping conditions in the Project Area and crop coefficient curve for each crop obtained based on the FAO manual.

(2) Calculation of ETo

Reference crop evapotranspiration (ETo) is calculated with the Pan Evaporation method adopted presently by CNR by adopting the observation values in 1974/75 which correspond to the 6.7 return period (85% probability) ones (Table A-11-8):

ETo = Kp x Epan (mm/day)

when: Kp : pan coefficient

Epan : pan evaporation (mm/day)

(3) Calculation of ETcrop

Tables A-11-7(1) to 7(3) show the result of calculation of ETcrop for the proposed cropping patterns.

(4) Calculation of ETcrop Combined

Table A-11-6 shows the estimated ETcrop values for the existing single cropping and the double cropping based on the proposed cropping combination.

11.3 Gross Duty of Water in Proposed Double Cropping Conditions

(1) Objective Irrigation Area (A)

The objective irrigation area (A) is obtained by reducing the following areas from the existing agricultural land.

"a" Area which will be urbanized by 1991
"b" Area which contains high saline/alkaline soils
"c" Area which will not get water by gravity due to its high altitude

It is proposed that the areas "b" and "c" are utilized as pastures without changing them to the lands of other purposes.

Objective Irrigation Area

(Unit: ha)

Block	Agricultural Land			Proposed non-irrigation Area				Object Irrigat
	Upland Field	Pasture	Sub-Total ①	Area "a"	Area "b"	Area "c"	Sub-Total ②	Area ①
1	1,760	900	2,660	0	0	0	0	2,66
2	3,730	660	4,390	1,120	0	350	1,470	2,92
3	2,300	2,760	5,060	620	540	750	1,910	3,15
4	8,600	11,020	19,620	2,130	6,040	0	8,170	11,45
Total	16,390 1/	15,340	31,730	3,870	6,580	1,100	11,550	20,18

(2) Crop Evapotranspiration (ETcrop)

The following values of ETcrop for double cropping pattern are used.

Month	4	5	6	7	8	9	10	11	12	1	2	3
ETcrop (mm/day)	1.4	0.7	0.4	0.4	1.4	1.7	2.4	2.8	3.8	5.1	4.4	2.3

(3) Irrigation Efficiency (Ep)

In consideration of the improvement of main canals and better water management because of the Project, an irrigation efficiency value of 0.5 is adopted on the basis of the FAO manual.

$Ep = Ec \times Eb \times Ea$

$= 0.9 \times 0.8 \times 0.7$

$= 0.5$

where: Ec : intake and conveyance efficiency 0.9
Eb : field canal efficiency 0.8
Ea : field application efficiency 0.7

(4) Effective Rainfall (Re)

The same as the present conditions (Refer to (1) 11.1).

(5) Gross Duty of Irrigation Water

The maximum values of the gross duty of irrigation water in the proposed conditions (Qd max) are shown below:

Block	A (ha)	ETcrop (mm/day)	Re (mm/day)	EP	Qdmax (m^3/s)
1	2,660	5.1	0	0.5	3.1
2	3,220 1/	5.1	0	0.4 2/	4.7
3	3,150	5.1	0	0.5	3.7
4	11,450	5.1	0	0.5	13.5
Total	20,480 1/	-	-	-	25.0

1/ includes the upland field of 300 ha owned by the University of Chile

2/ EP value in present conditions (0.4) is used because of no improvement of existing canals.

(6) Balance of Irrigation Water

The balance of irrigation waters in the proposed condition was calculated based on the same hydrological records as those used for the calculation in existing condition.

11.4 Irrigation Plan

(1) Block-1

1) 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 a strict water management.

Item	ETcrop (mm/day)	EP	Gd= ETcrop/EP	Qa 1/ (m/s)	Ai 2/ (ha)
Present condition	5.1	0.4	12.75	1.4	950
Improved condition	5.1	0.5	10.20	1.4	1,190

1/ Available water (refer to (2) of 3.5.1)
2/ Ai = Qa x 8,640/Gd

2) Water Resources Development

The shortage of irrigation water even after the improvement of facilities is 1.7 m^3/s 1/ for an objective irrigation area of 2,660 ha and 0.7 m^3/s 2/ for the existing upland field of 1,760 ha. In order to lessen water shortage, the following measures were studied:

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

a. 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 obtained as follows:

$$Vs = \frac{\overline{ETcrop} \times 3,650}{Ep} \times As$$

1/ Qsmax = Qdmax - Qa = 3.1 - 1.4 = 1.7 m^3/s
2/ Qs = Q'dmax - Qa = (5.1/0.5 x 1,760)/8,640 - 1.4 = 0.7 m^3/s

where: $\overline{ET}$crop: annual mean ETcrop 2.2 mm/day
As: area where irrigation water is lacking 1,470 ha (=2,660-1,190)

$$Vs = \frac{2.2}{0.5} \times 3,650 \times 1,470$$

$$= 24 \times 10^6 \ m^3$$

The fact that the volume of surplus water is bigger than that of shortage means that a recovery of irrigation water will be possible from an hydrological point of view.

However, the area of the pond for storing the surplus will be 600 ha in the case of a 4 m deep pond (practical limit). In consideration of the present upland field of 750 ha (1,760 -1,190) as the objective area, the required pond area will become 230 ha.

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 necessory for the facilities.

b. 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 the other uses by EMOS.

c. Development of Groundwater
It will not be feasible. Refer to Appendix 4.

d. Development of Surface Water by Construction of Dam.
It will not be feasible. Refer to Section 11.3.

(2) Block-2

The population number whose used water drained to Zanjón de la Aguada that will increase with the expansion of Santiago city is estimated to be 2,780,000[1/] in 1990.

Qa = 230 l/capita/day x 2,780,000
= 7.4 m^3/s

Therefore, the sewage volume will become 7.4 m^3/s. It will be adopted as the available water (Qa) in the future.

1/ Source: Tratamiento (Descontaminación) de río Mapocho, ODEPLAN - Instituto de Economia.

On the other hand, the total volume of the required irrigation water is obtained as follows:

A (ha)	ETcrop (mm/day)	Re (mm/day)	EP	Qdmax (m/s)	Qa (m/s)
3,220 1/	5.1	0	0.4	4.8	7.4

1/ includes the upland field of 300 ha owned by UCh

Comparing the water requirements and available water in the future, it will be possible to introduce double cropping agriculture in Block-2 without development of new water resources.

(3) Block-3

1) Improvement of Facilities

The water of Punta canal is contaminated because it is taken from the Mapocho river, even though its water source is the Maipo river. To solve this problem, the change of the intake point and the construction of a new canal, resulting in the increase of the conveyance efficiency of the canal, is proposed.

2) Water Balance

In Block-3, there will be a water surplus of 3.7 m^3/s due to abundant available water of Qa=7.4 m^3/s, compared to the maximum gross duty of water of Qdmax=3.7 m^3/s.

(4) Block-4

1) Water Right 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.

2) Improvement of Facilities

The present flow capacity of the Carmen canal 7.0 m^3 is small compared with the gross duty of water of 13.5 m^3/s.

The following improvement works 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 a flood.

- Enlargement and improvement of the Carmen canal for 24 km from the intake to the junction to the Batuco canal

- Enlargement and improvement of the San Carlos canal for 17.0 km from the junction with the Florida canal to the outlet to the Mapocho siphon.

3) Water Resources Development

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

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

a. Utilization of Surplus Water

The total volume of surplus irrigation water for the period from April to September is obtained 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 area of the pond to store the surplus will be 700 ha in the case of a 4 m deep pond. It will be possible to increase the irrigable area by 1,780 ha (8,720 - 6,940) with the utilization of surplus water.

However, it will not be practicable to utilize the surplus water for irrigation as the main water source, because of the reasons mentioned in section (1), a.

b. Utilization of the Surplus Water of Yeso Dam
Refer to Section (1).

c. Development of Groundwater
Refer to Section (1).

d. Development of Surface Water by constructing a Dam
Refer to Section (1)

Measures	Available Water Qa (m^3/s)			Total	Irrigable Area Ai (ha) 1/
	① Improvement of canals	② Transferring of water right	③ Utilization of surplus water		
Present condition	7.0	-	-	7.0	4,740
Present canal+ ③	7.0	-	2.1	9.1	6,160
①	8.2	-	-	8.2	6,940
①+③	8.2	-	2.1	10.3	8,720
①+②	8.2	3.7	-	11.9	10,080
①+②+③	8.2	3.7	1.6	13.5	11,450 (max.)

1/ Ai = 8,640 x Qa / Gd
Gd : Present 12.75 mm/day (5.1 / 0.4)
Plan 10.20 mm/day (5.1 / 0.5)

11.5 Dam Plan

(1) Objectives

The objectives of the study in this section were to examine the possibility of the development of water resources by constructing a dam from the technical and economic view point.

(2) Selected Dam Site

1) Mapocho Dam

The following two sites were selected in consideration of the topographical, geological and hydrological characteristics.

- Site 1 for Mapocho dam (1): Immediately upstream (watershed = 280 km^2) of the confluence with the San Francisco river
- Site 2 for Mapocho dam (2): Immediately downstream (watershed = 600 km^2) of the confluence with the San Francisco river

2) Maipo Dam

Sub-Station, Las Lajas, watershed of which is 4,990 km^2, was selected as the site for the Maipo dam, in consideration of the topographical, geological and hydrological characteristics, bed-load discharge conditions, damage and loss of existing houses and villages, etc.

(3) Objective Water Quantity to be Developed

The following two values were taken into account as the objective water quantity (Q) to be developed by a dam:

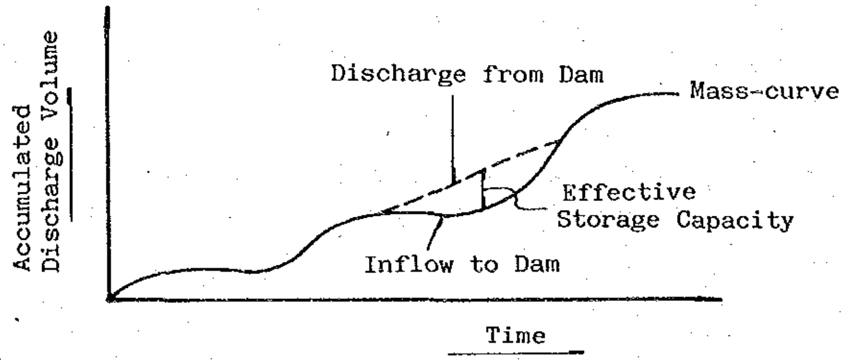
Case 1: Q = 3.3 m^3/s (1.7 m^3/s for Block-1 and 1.6 m^3/s for Block-4) corresponding to the shortage of irrigation waters even after the improvement of existing facilities in the irrigation scheme.

Case 2: Q = 8.5 m^3/s (3.1 m^3/s for Block-1, 3.8 m^3/s for Block-2 and 1.6 m^3/s for Block-4) as a new resource, in consideration of the supply of good irrigation waters to Blocks-1 and 2 in stead of the contaminated waters as well as the recovery of shortage of waters aimed at in Case 1.

(4) Estimation of Effective Storage Capacity

1) Method

The developable water amount and storage capacity of dam were obtained based on the discharge mass-curve of the objective rivers for the period of 1942 to 1980.



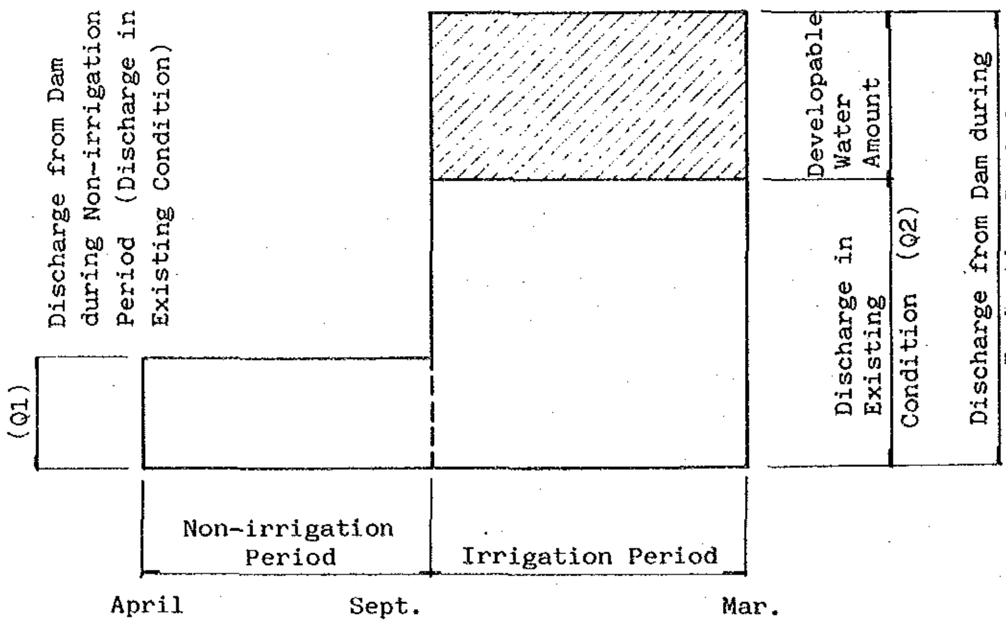
2) Inflow to Dam

Discharge data for the objective rivers used in the analysis were obtained from "Proyecto Maipo Estudio Hidrolôgico e Hidrogeolôgico, Volumen IV Escorrentia Superficial" prepared by CNR, as follows:

Maipo river : El Manzano (No. 16)
Mapocho river : Los Almendros (No. 5)

3) Developable Water

Developable water was computed based on the assumption shown in the following figure.



where: 1. Irrigation period: 6 month (Oct. - Mar. of next year)

2. Discharge from dam during non-irrigation period: The monthly minimum discharge of 6.7 year return period

3. Discharge from dam irrigation period: The monthly minimum discharge of 2, 5 and 6.7 year return period

The probable obligated discharges (Q1 and Q2) in existing conditions are as follows:

Dam	Q1 (m^3/s)	Q2 (m^3/s)		
	6.7 (85%)	2 (50%)	5 (80%)	6.7 (85%)
Maipo	34.0	75.0	56.0	53.0
Mapocho (1)	0.58	1.3	0.9	0.8
Mapocho (2)	1.24	2.8	1.8	1.6

4) Result of Analysis

The relationship between the developable water amount and effective dam capacity for each probability year is shown in Fig A-11-3(1) to 3(3).

(5) Sedimentation

The volume of sediment was estimated based on the following assumption:

a. Unit sediment volume : 100 m^3/km^2/year
b. Objective period : 100 years

(6) Determination of Dam Capacity

The dam capacities were obtained by adding the sediment volumes to the effective dam capacities as follows:

Dam	Catchment Area (km²)	Developable Water 1/ (m³/s)	Effective Storage Capacity (m³)	Sediment Volume (m³)	Required Reservoir Volume (m³)
Mapocho Dam (1)	280	2.0	25.8×10^6	2.8×10^6	28.6×10^6
Mapocho Dam (2)	600	3.3	25.3×10^6	6.0×10^6	31.3×10^6
Maipo Dam	4,990	8.5	18.5×10^6	8.5×10^6	27.0×10^6

1/ Since the development of 8.5 m³/s water resources from a Mapocho dam is hydrologically impossible, a Mapocho dam and a Maipo dam were studied for Case 1 and 2, respectively. However, the development of 2.0 m³/s water resources was the hydrological limit for Mapocho dam (1).

(7) Dimension of Dams

The dimensions of each dam are summarized below:

Dam	Type	Height (m)	Length (m)	Dam Body (m³)	Side Slope	
					uptream	downstream
Mapocho Dam (1)	Rock-fill	105	550	4.7×10^6	1:2.5	1:2
Mapocho Dam (2)	"	110	380	3.7×10^6	1:2.5	1:2
Maipo Dam	"	70	620	2.0×10^6	1:2.5	1:2

(8) Construction Cost

The construction cost of each dam was roughly estimated as shown below. Details are shown in Table A-11-11.

Dam	Available Water (m³/s)	Construction Cost (10⁶Ch$)	Construction Cost (per1m³/s)
Mapocho Dam (1)	2.0	9,941	4,971
Mapocho Dam (2)	3.3	9,123	2,765
Mapocho Dam	8.5	11,845	1,394

(9) Topography and Geology of Dam Site

1) Mapocho dam (1) site

a. Topography

The terraces in the left margin can be divided into three ones, low, middle and high, according to their relative height. The low terrace is located about 2 m above the water surface of the Mapocho river. On the lower terrace, there are some eucalyptus and willow trees. The facies components are mainly unconsolidated gravels with much amount of clayey and sandy materials (Fig A-11-10). The middle terrace is located about 18 m above the lower terrace with terrace cliff of approximately 30° of slope. The facies components are poorly-classificated clastic materials such as sub-angular boulder gravels. This terrace is correlated with the terrace in upsteam section of the right margin. The terrace surface is an erosional plain with approximately 5° to south. The high terrace has almost eroded surface with 10° to south. The origin of middle and high terraces seem to be fluvio-glacial deposit due to glacial striae of boulder gravels.

b. Geology

There are outcrops in the right margin of the Mapocho river around of the confluence with San Francisco river, which corresponde to Abanico Formation. The rock facies of this site is composed of coarse or fine-grained andestic lavas. The fine grained one includes the coarse grained one in the form of xenolith or interfinger. The fine grained one is intruded by many chert veins.

This rock facies is suffered from slight weathering and many fractures, shears and faults with NW-SE and NE-SW are recognized in directions especially in the fine grained andestic lavas (Fig. A-11-11). Fine fractured rock fragments are observed along shear zones. Fault clays distribute along fault planes with maximum width of 5 cm. Some rocks show glacial striae. The boring log of left margin is shown in Fig A-11-12.

2) Mapocho dam (2) Site

a. Topography

The topography of this site shows a deep gouge with gradient 24° - 28°. The both slopes are principally covered with scattered shrub. The rock facies of this site is composed of Late-Cretaceous-Oligocene Abanico Formation. Judging from the geological structure, the andestic breccias of right margin correspond to upper horizon and that of left margin coincides to lower horizon.

b. Geology

The distribution of rock facies can be observed in boring log (Fig. A-11-13). In the lower horizon, the outcrop consists of principally alternation of dark green andestic lavas (max. 3 m thick) and similar composition of breccias. The later is predominant in the lower horizon. Among the breccias, there are interfingured andestic lava intrution and dark gray hard sandstones with maximum 1 m thick containing some fragments of shell fosils. In general, the weathering would not have ocurred. Some yellow orange fractured planes distribute in the direction N-S and E-W. But, major structural movement would not have occured. It can be concluded that the geology of this site will be comparatively suitable for construction of a dam.

3) Maipo dam Site

The Maipo river flows erode the rocks of the right margin and sediment clastic materials in the left margin. The fresh afanitic andesites crop out in the right margin. There are moderate joints with N-S and E-W of strike and steep dip, containing parcially clorites or calcites veins. Flow structure is recognized to N $20^oE/53^oE$.

In the left margin, there are three terraces. The low terrace is located 20 m above the water surface of the Maipo river. The columnar section of cliff of the terrace and grading curve of detrial material are shown in Figs A-11-14 and 15, respectively. The middle terrace is distributed 25 m above the water surface with 8^o of dip to north. The cliff of the high terrace is composed of many boulder gravels. The terrace surface shows 7^o to north at the north edge of the terrace and $2\text{-}3^o$ to north in the surroundings of the contact with outcrop of fluidal welded tuff. This terrace is utilized for upland field. These terraces are formed by fluvio-glaciation.

(10) Consideration

It is very expensive to develop irrigation waters by constructing a dam; that is, Ch$4,971 x 10^6 for developping available water of $1 m^3/s$ in the case of Mapocho dam (1), Ch$2,765 x 10^6 for Mapocho dam (2) and Ch$1,394 x 10^6 for Maipo dam. This shows that the construction of a dam for developping irrigation waters is unfeasible.

However, it will be advisable that a Mapocho dam be further studied in consideration of the effect against flood discharges of larger return period as well as the water resources development.

In this case, Mapocho Dam Site 2 will be more attractive because of the following reasons:

a. It will be practically impossible to develop the required amount of water by the Mapocho dam (1) (the development of 2.0 m^3/s will be the maximum).

b. The bigger watershed of Site 2 will be more effective not only for water resources development but also for flood control.

c. The geological condition of Site 2 will be better than that of Site 1 judging from the conducted boring investigation and geological survey.

d. The efficiency of a dam in Site 2 will be bigger than that of Site 1.

11.6 Proposed Irrigation Facilities

Based on the basic irrigation concepts, studies on the irrigation and related facilities which are to be improved and/or newly proposed were made blockwise. As a result, the following facilities are proposed for each block.

1) Block-1

Two alternatives were studied, i.e., a) Improvement of the existing intakes of Esperanza Alto and Esperanza Bajo canals (to be executed independently), and b) Integration of the existing two intakes mentioned above. Each case is briefly described in the following.

a. Independent improvement of the existing intakes of Esperanza Alto and Esperanza Bajo canals (Case-A).

i. Improvement of the Intake of Esperanza Alto Canal

- Design parameters:

Required capacity of Esperanza Alto canal:

$Qi=1.7\ m^3/s$

Design high-water discharge of the Mapocho river:

$Qr = 1,100\ m^3/s$

- Construction of an Intake:

Location	:	Same place where the existing intake is
Type	:	Floating type
Length	:	L = 30 m
Height	:	H = 1.0 m
Gate	:	1 set (steel gate)
Training levee	:	L = 100 m (concrete)

- Improvement of Esperanza Alto Canal:

Length to be improved: L = 2.7 km

Type of canal : Earth canal

Dimensions of the canal	:	Top width	B = 5.1 m
	:	Bottom width	b = 1.4 m
	:	Height	H = 0.93 m
	:	Side Slope	S = 1 : 1.5
	:	Longitudinal Slope	I = 1/600
	:	Freeboard	Fb = 0.30 m

- Construction of Protection Dike

Location	:	Along the Mapocho river
Length	:	L = 2.4 km (for both banks of the river)
Type	:	Embankment
Dimensions	:	Top width B = 5.0 m
		Height H = 2.5 m
		Slope S = 1 : 1.5

ii. Improvement of the Intake of Esperanza Bajo Canal

- Design parameters

Required capacity of Esperanza Bajo canal:
Qi=1.4 m^3/s
Design high-water discharge of the Mapocho river:
Qr = 1,100 m^3/s

- Construction of an Intake

Locaiton	:	Same place where the existing intake is
Type	:	Floating type
Length	:	L = 25.0 m
Height	:	H = 1.0 m
Gate	:	1 set (steel gate)

- Construction of Protection Dike

Location	:	Along the Mapocho river
Length	:	L = 8.0 km (for both banks of the river)
Type	:	Embankment
Dimensions	:	Top width B=5.0 m
	:	Height H = 2.5 m
	:	Slope S = 1: 1.5

b. Integration of the existing intakes of Esperanza Alto and Esperanza Bajo canals (Case-B)

- Design parameters:

Required capacity at the integrated intake : Qi = 3.1 m^3/s
Design high-water discharge of the Mapocho river:
Qr = 1,100 m^3/s

To integrate the existing two intakes, the following works are required:

- Construction of a Headworks:

Location	:	Near the existing intake of Esperanza Alto canal
Type	:	Floating type
Length	:	L = 200 m
Height	:	H = 1.5 m
Gate	:	2 sets (steel gate)
Training levee	:	L = 40 m (concrete)

- Construction of a new Esperanza canal:

Length	:	L = 2.7 km
Type	:	Earth canal
Dimensions of the canal	:	Top width B = 6.0 m
	:	Bottom width b = 1.5 m
	:	Height H = 1.5 m
	:	Side slope S = 1 : 1.5
	:	Longitudinal Slope I = 1/1,400
	:	Freeboard Fb = 0.30 m

- Construction of a Protection Dike:

Location	:	Along the Mapocho river
Length	:	L = 2.4 km (for both banks of the river)
Type	:	Enbankment
Dimenisions	:	Top width B = 5.0 m
	:	Height H = 2.5 m
	:	Slope S = 1 : 1.5

- Construction of a Chute:

Location	:	Immediately after the division of Esperanza Alto and Bajo Canals
Total fall	:	F = 20.0 m
Width	:	B = 1.35 m
Length	:	L = 40.0 m

c. Geology at Construction Site

Boring site was selected on the low recent fluvial terrace of right margin of the Mapocho river near of present headworks of Esperanza Alto canal approx. 30 m from the edge of river to the west. Sedimentary facies are mainly unconsolidated gravels and sands (Fig A-11-16). The artesian clean water appears at the point 13 m deep from ground surface under a inpermeable layer (max. 10 ℓ/min). N-values are generally high.

d. Results of the Comparison

From the comparison study on the two alternatives, it is resulsted that Case-B is more feasible from the following economical and technical point of view:

During dry season, the average water level of the Mapocho river is 3.0 m lower than that of Esperanza Bajo canal. Accordingly, to draw the water from the Mapocho river, it is necessary to raise water level of the Mapocho river by providing a weir crossing the Mapocho river, which causes a backwater effect on the river of about 3.0 km. It requires the construction of an embankment of 8.0 km long along the Mapocho river, which is not feasible compared with Case-B.

2) Block-2

The existing irrigation systems are well-developed and are maintained in good condition. Therefore, improvement of the existing irrigation facilities as well as construction of new irrigation facilities will not be necessary.

3) Block-3

The following two alternatives were taken up:

a. Construction of a conduit along the Mapocho river (Case-A)

Location	:	Along the right bank of the Mapocho river (from the end of San Carlos canal to the intake of the Punta canal)
Type	:	Concrete pipe (ø = 1,200 mm x 2)
Length	:	L = 6.45 km (including 250 m of siphon crossing the Mapocho river)

b. Improvement of Carmen canal and Construction of new Punta canal (Case-B)

Case-B includes the following:

- Lining of Carmen canal

Length of lining: L = 14.2 km (from outlet of Siphon to junction with Punta canal)

Required Capacity: $Qi = 17.2\ m^3/s$

Dimensions of canal after widening : Width (top and bottom) B = 3.2 m

: Height H = 2.4 m

: Longitudinal slope: I=1/500

: Freeboard Fb = 0.4

- Construction of Punta canal

Type : Earth canal

Length : L = 14.7 km (from Conchalí to the north of the airport)

Dimensions of canal : Top Width B = 6.1 m

: Bottom width: b = 2.5 m

: Height H = 1.3 m

: Side Slope 1:1.5

: Longitudinal slope 1 = 1/800

: Freeboard Fb = 0.3 m

- Construction of a Chute

Total fall : F = 68.8 m

Width : B = 2.5 m

Length : L = 630 m

Slope of chute : I = 1/9

c. Results of the Comparison

From the comparison study on the two alternatives, it is resulted that Case B is more practicable with the following:

Item	Case A	Case B
Roughly Estimated Construction Cost (Ch$)	1.7×10^9	1.2×10^9
Difficultiness of Construction Works	more difficult	easier

The breakdown of Construction Cost for Case A is shown in Table A-11-12

4) Block-4

a. It is proposed that the existing Carmen canal should be improved to carry the maximum required water of 13.5 m^3/s. The improvement of Carmen canal includes the following:

- Improvement from the junction with the Punta canal to the junction with Batuco canal (L = 13.2 km)

- The improvement will be done by lining the canal so that it has the required capacity of 13.5 m^3/s.

- The dimensions of the canal after the improvement are as follows:

Width (top and bottom)		B = 3.0 m
Height	:	H = 2.2 m
Longitudinal slope	:	I = 1/500
Freeboard	:	Fb = 0.4 m

b. It is also proposed that the San Carlos canal be improved from the junction with Florida canal to the junction with the Mapocho river. The total improvement length will be 17.0 km.

In consideration of the following basic concepts for the improvement works, a rectangular-type concrete canal is proposed.

- To minimize the land acquisition, the improvement should be done utilizing the existing San Carlos canal to the maximum extent.
- To minimize the earth work required for the improvement
- To reduce maintenance costs of the canal
- To reduce conveyance loss in the canal

11.7 Esperanza Headworks

(1) General

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 of the facilities.

b. Design Intake Requirement

The design intake requirement was determined to be 3.1 m^3/s, which covers the maximum gross duty of irrigation water for Block-1.

c. Foundation Type

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

d. Specific Features

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

Item	Dimension
Fixed Weir	187 $m^{(L)}$ x 1.5 $m^{(H)}$
Scouring Sluice Gate	5.0 $m^{(W)}$ x 1.5 $m^{(H)}$ - 2 sets
Intake Gate	2.0 $m^{(W)}$ x 1.2 $m^{(H)}$ - 2 sets

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

(2) Design of Fixed Weir

1) Design parameter

a. Elevation of river bed at construction point : EL + 436.7 m

b. Width of river at construction point : 200 m

c. Intake water level : EL + 438.5 m

d.	Flood discharge	:	1,100 m^3/s
e.	Width of weir incl. gate	:	B = 200 m
f.	Hight of fixed weir	:	Df = 3.00 m
g.	Depth from weir crest	:	D_1 = 1.50 m
h.	Depth of over flow water	:	h_1 = 1.44 m
i.	Design high water level	:	HWL = EL + 439.64 m
j.	Velocity head of over flow	:	hv = 0.74 m
k.	Unit weight of weir	:	γ = 2.35 t/m^3
l.	Condition of foundation	:	gravel and sand

2) Shape of weir

In order to determine the foundamental trapezoid of weir, formulas of Bligh and Etheverr were adopted as follows;

a. Crest width of weir (B)

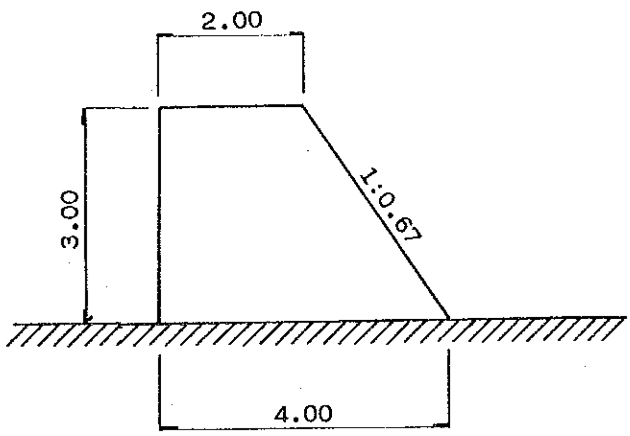
Blight: $$B = \frac{h_1 + hv}{\sqrt{\gamma}} = \frac{1.44 + 0.74}{2.35} = 1.42 \text{ m}$$

Ethverr: $$B = 0.552(\sqrt{Df} + \sqrt{h_1 + hv}) = 0.552x(\sqrt{3.0} + \sqrt{1.44 + 0.74}) = 1.77 \text{ m}$$

b. Bottom width of weir (L)

Bligh: $$L = \frac{Df + h_1 + hv}{\sqrt{\gamma}} = \frac{3.0 + 1.44 + 0.74}{\sqrt{2.35}} = 3.38 \text{ m}$$

Considering these results and the allowance for safety, the foundamental trapezoid was determined as shown below:



3) Length of rear apron

The length of a rear apron is determined using the Bligh Formula as follows,

$$L = 0.6\ C\sqrt{D_1} = 0.6 \times 9 \times \sqrt{1.50} = 6.61\ \text{m}$$

where: C : coefficient for the Bligh Formura (9 for gravel and sand)

D_1: difference between the water surface of rear apron and the crest of weir

Considering this result and the allowance for safety, the length of rear apron was determined to be 8.60 m.

4) Thickness of rear apron

The thickness of rear apron can be obtained at tow points as follows:

Point A:

$$hf_A = \frac{1.50 + 3.00}{14.1} \times 1.5 = 0.48\ \text{m}$$

$$t_A = \frac{4}{3} \times \frac{1.50 - 0.48}{2.35 - 1} = 1.03 = 1.50\ \text{m}$$

Point B:

$$hf_B = \frac{1.50 + 11.1}{14.1} \times 1.5 = 1.34\ \text{m}$$

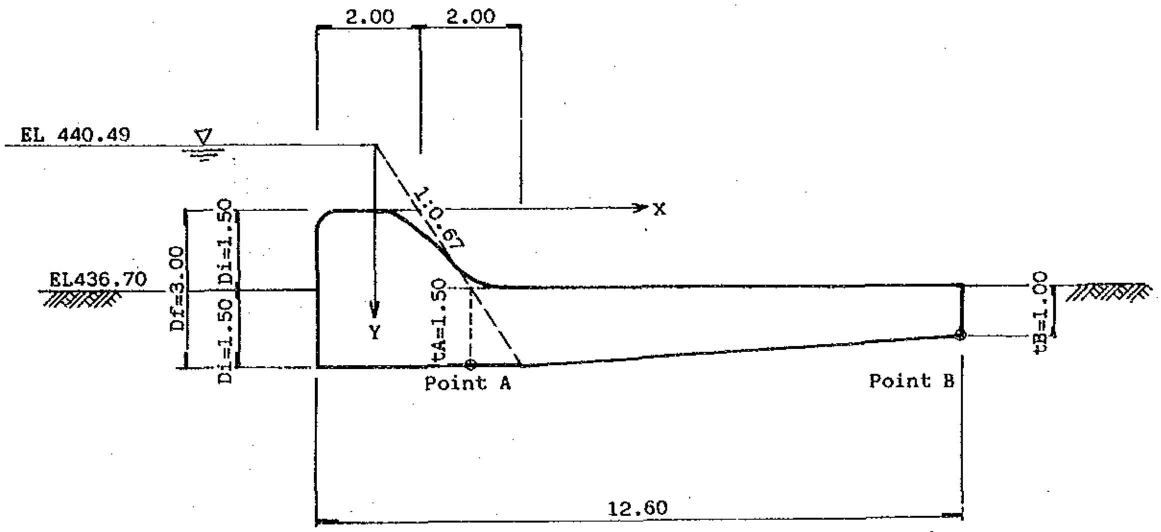
$$t_B = \frac{4}{3} \times \frac{1.50 - 1.34}{2.35 - 1} = 0.16\ \text{m}$$

Considering the safety for water flow and friction caused by gravel and sand, thicknesses of ta and tb are determined to be 1.5 m and 1.0 m, respectively.

5) Modification of weir crest shape

The profile of weir crest shall be designed carefully to get the smooth flow and to avoid the negative pressure that will cause damages on the crest.

Modified weir crest profile and the arranged section of weir are shown as below:



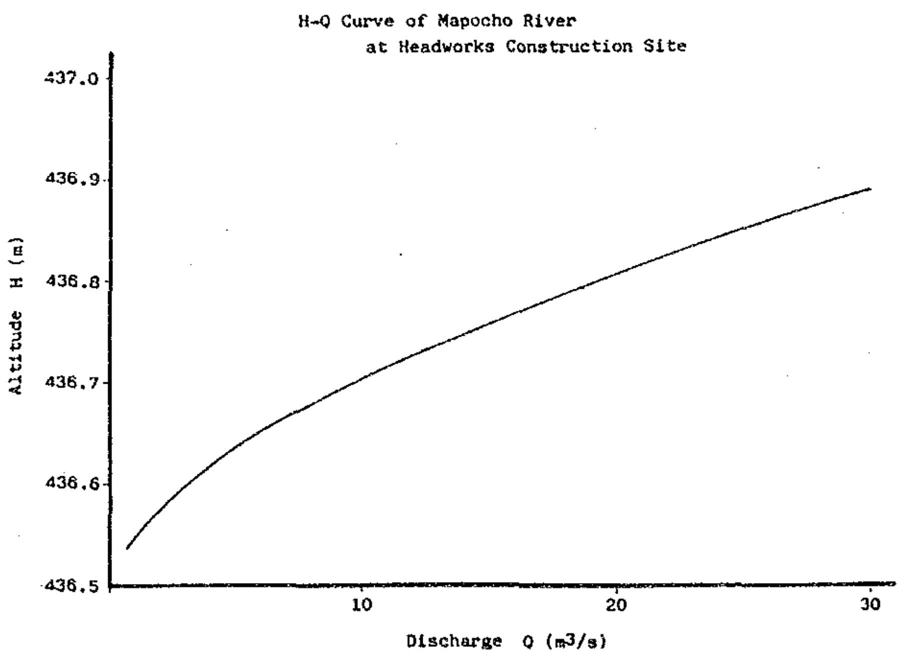
(3) Design of Scouring Sluice

1) Design parameter

a.	Flood discharge	:	Q_{max} = 1,100 m^3/s
b.	Average discharge during irrigation period	:	Q_m = 20 m^3/s
c.	Elevation of Scouring Sluice at point A	:	EL_1 = 436.9 m
d.	Elevation of scouring sluice at point C	:	EL_3 = 436.5 m
e.	Width of scouring sluice	:	Bm = 9.5 m
f.	Width of pier	:	P = 1.0 x 3 = 3 m
g.	Length of scouring sluice	:	ℓ = 40 m
h.	Coefficient of roughness	:	n = 0.017
i.	Froude number	:	F_2 = 1.75

2) Calculation of water level

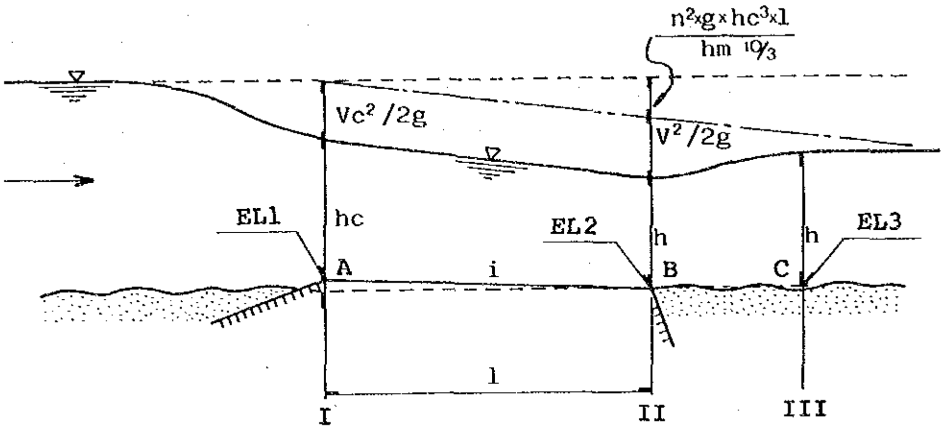
Given the discharge of the Mapocho river to be 20 m^3/s, the water level was determined to be EL + 436.84 m from the H-Q curve of Mapocho river as shown below.



3) Calculation of slope of scouring sluice

If the extent of flow through the scouring sluice is designed under sub-critical flow condition, it takes more time to score sluice and permits vain discharge. Therefore, the extent of flow has to be established under jet flow condition. The slope to meet the jet flow condition can be obtained in the following manner:

LONGITUDINAL SECTION OF SCOURING SLUICE



$$i = \frac{1}{\ell}\left(h_2 + \frac{qc^2}{2gh_2} - 1.5\ hc\right) + \frac{n^2 \cdot qc^2}{\{(hc + h_2)/2\ ^{10/3}\}}$$

$$= \frac{1}{40}\left(0.528 + \frac{2.1^2}{2 \times 9.8 \times 0.528^2} - 1.5 \times 0.766\right) + \frac{0.017^2 \times 2.1^2}{\{(0.766+0.528)/2\ ^{10/3}\}}$$

$= 0.00465 + 0.005438$

$= 0.01008$

where: i : slope of scouring sluice

qc : *unit discharge at scouring sluice*
$qc \leq \frac{Qm}{Bm} = 2.1\ m^3/s/m$

hc : critical depth
$= (qc^2/g)^{1/3} = (2.1^2/9.8)^{1/3} = 0.766\ m$

h_2 : water depth at II - II section
$= \{qc^2/(F_2^2 \cdot g)\}^{1/3} = \{2.1^2/(1.75^2 \times 9.8)\}^{1/3}$
$= 0.528$ m

h_3 : water depth at III - III section

$$= \frac{h_2}{2} (\sqrt{8F_2^2 + 1} - 1)$$

$$= \frac{0.528}{2} \times (\sqrt{8 \times 1.75^2 + 1} - 1)$$

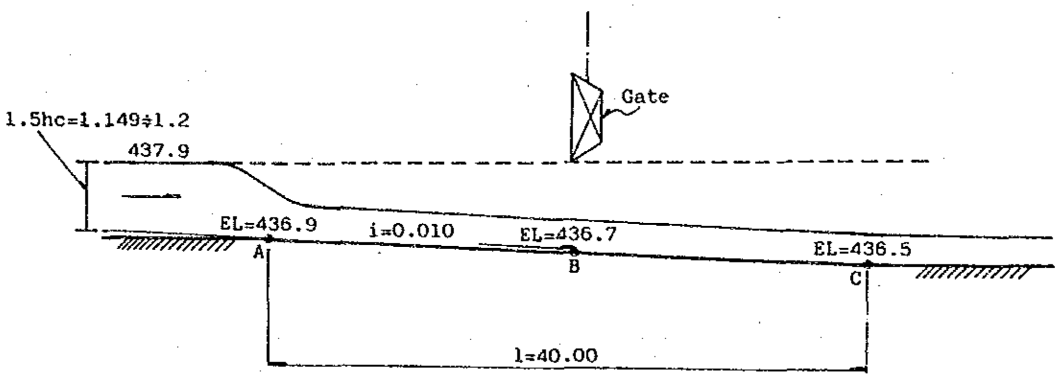
$$= 0.264 \times 4.051 = 1.069 \text{ m}$$

$EL_2 = EL_3 + i \cdot \ell_2 = 436.5 + 0.01008 \times 20 = 436.7016 \quad 436.9$

$El_1 = EL_3 + i \cdot \ell = 436.5 + 0.01008 \times 40 = 436.9032 = 436.9$

$WLr = 436.84 < WL_3$ ($= EL_3 + h_3 = 436.5 + 1.069 = 437.569$)

Considering these results, the longitudinal section of scouring section is determined as shown below:



(4) Design of Intake

1) Elevation of Intake Invert

The elevation of intake invert was calculated to comply with the following conditions:

- that is should be higher by more than 1 m than that of scouring sluice invert; and

- that the difference between the elevations of intake invert and scouring sluice invert should be larger than one-sixth of flood water depth.

Considering these results, the elevation of intake invert was determined to be EL 437.7 m.

2) Cross Section of Intake

The cross section of intake has been proposed, given that the intake water depth to be 0.80 m and the velocity of flow to be around 1.00 m/s.

The width of intake (B) is determined as follows:

$B = Q/hv = 3.1/(0.8 \times 1.0) = 3.88$ m

The intake is designed to have two spans with one pier (0.6 m width).

$B' = 2.0 \times 2 = 4.0$ m > 3.88 m

Therefore, total width of intake is determined to be 4.6 m ($B = 4.0 + 0.6$)

11.8 Centralized Control System

(1) General

It is recommended that a centralized control system of irrigation water for all blocks (Block-1, 2 and 3+4) be considered in the future in case the farmers in a block agree to introduce a controlled agricultural production after the targeted development level of the Project is obtained.

(2) Proposed Control System

The proposed control system of irrigation water with the effective operation of a headworks and division works is shown in Figs A-11-17 and 18. In its preparation, the following matters were considered:

a. Adjustment of volume of irrigation waters taken from the rivers in compliance with the actual monthly water requirements;

b. Quantity control with the partial intake gate operation;

c. Control both at the site and from the control center;

d. Automatic recording of irrigation waters used; and

e. Minimization of the costs required for operation and maintenance of the proposed system.

(3) Required Cost

The cost required for the establishment of proposed control system varies greatly depending on detailed local requirements. The general range is from US$100,000 to $150,000 per system.