Table B-13 Analyses of Surface Water

Date Sampled	Field Description: Plot No.	Leachate Sample No.	Depth cm.	pH	EC x10³ at 25°C	TDS ppm	SSP	SAR	RSC meq/l	Milliequivalent per litre meq/l: Na	Ca+Mg	Ca	K	CO_3	HCO_3	SO_4	Cl
Leachate collected from samplers installed at 20, 40, 60 and 100 cm depths in the plots During the test.																	
	1	1	-	7.02	0.79	550	50	3.0	0	4 3	4.1	2 6	0 25	0	1 3	2.4	3.5
		2	-	7.96	0.61	360	43	2.1	0	2 9	3 7	2 0	0 18	0	1 3	1 7	2.7
Jul.13/ 1981																	
	2	3	-	6.52	1.16	680	64	5.4	0	7.6	4 0	1 9	0.23	0	0 68	1.5	7.9
		4	-	6.45	1.09	680	63	5 0	0	7 0	3.9	2.1	0.16	0	0.59	1.2	7 3
	3	5	-	7.26	0.92	610	70	6.1	0	7 0	2.6	1.4	0 43	0	0.45	1.9	5.3
		6	-	6 10	0 89	600	68	5.6	0	6 6	2.8	1 4	0 34	0	0 22	0.51	5.1
	4	7	-	6.06	1 48	1040	76	8.9	0	11 1	3 1	1.7	0 37	0	0 09	2 7	9 6
		8	-	6 22	1.45	1060	79	9 8	0	11 2	2 6	1 7	0 38	0	0 22	2.6	9 4
Jul.15/ 1981	5	9	-	6.64	1.18	630	64	5 2	0	7.1	3.7	1 7	0 30	0	0 99	3.1	6.3
		10	-	6.54	1.25	740	65	5.5	0	7 5	3 7	2 3	0 32	0	0 58	4.8	7 3
	6	11	-	7.22	0.44	300	32	1.2	0	1 4	2 8	2,0	0.16	0	1,80	0,34	1.2
		12	-	7.01	0.41	250	27	0 96	0	1 2	3 1	1,7	0 13	0	1,80	2.6	1.2
	7	13	-	6 49	0,83	780	60	4.0	0	4 8	2.8	1.1	0 24	0	1 13	2.4	4.5
		14	-	6 56	1.06	520	65	5 1	0	6 0	2 8	1 7	0 37	0	0 90	0 69	5 8
	8	15	-	6.62	1.08	490	59	4.5	0	5 9	3.4	1.7	0 64	0	1.38	1.1	4.7
		16	-	6.58	0 89	460	71	5.5	0	5 5	2 0	1 4	0.27	0	1.35	1.2	4.6
	Rain water		-	7.31	0.06	40	15	0 19	0	0 01	0 57	0 28	0 01	0	0 45	0 86	0 02
Jul.22/ 1981	1	1	-	7.51	0.80	510	49	2 7	0	3.7	3.7	2 8	0.16	0	3.38	2.2	3 2
		2	-	7.62	0.76	490	47	2.5	0	3 4	3.7	3 4	0 13	0	3.15	3.1	2.9
	2	3	-	7.21	1.08	690	69	5.5	0	6 5	2 8	2 3	0 16	0	1.35	1.9	5.9
		4	-	7.06	0.98	650	67	4.9	0	5 6	2 6	1.4	0.13	0	1.35	4.4	5.4
	3	5	-	7.11	1.14	600	56	4.7	0	6 6	4 0	2 0	1.2	0	2 93	1.1	6.1
		6	-	7.14	1.13	630	57	4 7	0	6 2	3 4	2 3	1.2	0	2.93	1.4	6 0
	4	7	-	6.92	1.92	1160	73	8.2	0	12	4 3	2 6	0 19	0	1.57	2.2	12
		8	-	6.84	1.71	1010	78	8.8	0	11	3.1	2.6	0 18	0	1.12	4.8	11
Jul.24/ 1981	5	9	-	7.52	1.66	990	62	5.8	0	9 6	5.4	2 8	0 35	0	5.18	2.9	8.0
		10	-	7.21	1.42	810	67	6.3	0	9 2	4.3	2 0	0 24	0	2 70	2.2	7.3
	6	11	-	7,75	0.65	390	29	1.4	0	2.2	5.1	2.6	0.21	0	4 28	1.7	1.5
		12	-	7.57	0.61	330	33	1 5	0	2 2	4.3	2.6	0 20	0	3.92	1 6	1.4
	7	13	-	7.33	1.35	610	68	5.6	0.57	8 3	4.3	2 8	0 29	0	4.87	1.4	6.1
		14	-	7.64	1.50	850	59	5.1	0	8 4	5.4	3.7	0.31	0	4.96	2.6	7.0
	8	15	-	7.18	1.12	670	60	4.6	0.88	6.7	4.3	2.8	0 22	0	5.18	3.4	4 5
		16	-	7.34	1.14	580	64	5 1	1 03	7 0	3.7	2.8	0.20	0	4 73	3.4	4.8

Table B-14 Progress of Test

		BLOCK A		BLOCK B		BLOCK C	
		Cylinder No.1	Cylinder No. 2	Cylinder No. 3	Cylinder No. 4	Cylinder No. 5	Cylinder No. 6
L-I	1st day	150 mm	150 mm	150 mm	150 mm	150 mm	150 mm
	2nd day	Soil Sampling	Soil Sampling	150 mm	150 mm	150 mm	150 mm
	3rd day			Soil Sampling	Soil Sampling	150 mm	150 mm
	4th day					Soil Sampling	Soil Sampling
	Total depth	150 mm	150 mm	300 mm	300 mm	450 mm	450 mm
L-II	1st day	150 mm	150 mm	150 mm	150 mm	150 mm	150 mm
	2nd day	Soil Sampling	Soil Sampling	150 mm	150 mm	150 mm	150 mm
	3rd day			Soil Sampling	Soil Sampling	150 mm	-
	4th day					Soil Sampling	Soil Sampling (20 mm stayed)
	Total depth	150 mm	150 mm	300 mm	300 mm	450 mm	280 mm
L-III	1st day	150 mm	150 mm	150 mm	150 mm	150 mm	150 mm
	2nd day	Soil Sampling	Soil Sampling	-	-	-	-
	3rd day	(80 mm stayed)	(50 mm stayed)	(40 mm stayed)	(115 mm stayed)	Soil Sampling	Soil Sampling
	4th day			(discontinued the test)		(10 mm stayed)	
	Total depth	70 mm	100 mm	-	-	140 mm	150 mm
L-IV	1st day	150 mm	150 mm	150 mm	150 mm	150 mm	150 mm
	2nd day	Soil Sampling	Soil Sampling	150 mm	150 mm	150 mm	150 mm
	3rd day			Soil Sampling	Soil Sampling	150 mm	150 mm
	4th day					Soil Sampling	Soil Sampling
	Total depth	150 mm	150 mm	300 mm	300 mm	450 mm	450 mm

Table B-15 Results of Soil Analyses of Plot C_1[1] and B_6[2]

Location No.	Depth (cm)	pH		Sat. % SP	Elect Cond. ECx10^3	Saturation Extract (meq./l)								SAR	C.E.C.	ESP
						Soluble Cations				Soluble Anions						
		Past	1:5			Na	Ca+Mg	Ca	K	CO_3	HCO_3	SO_4	Cl			
C_1																
1	30	4.6	5.3	52.9	5.8	42	21	12	0.45	0	0.22	1.9	50	13	9.1	25
2	30	5.4	5.6	50.6	2.6	16	11	5.8	0.22	0	0.45	4.6	18	6.8	16	10
3	30	6.2	6.3	53.8	1.9	-	-	-	-	-	-	-	-	-	-	-
4	30	5.7	5.9	50.9	3.9	22	20	11	0.54	0	0.68	2.6	31	6.9	17	4.6
B_6																
5	30	5.8	6.4	47.4	3.8	29	9.5	4.6	0.26	0	0.68	3.4	30	13	20	8.4
6	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
7	30	6.7	6.9	50.6	2.8	19	7.6	4.5	0.33	0	2.5	2.1	21	9.7	18	7.8
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
17	30	5.8	6.4	49.3	4.9	37	12	7.6	0.35	0	1.3	2.6	40	15	13	13

NOTE: 1) Leaching test field (paddy field)

2) Initial leaching test field (upland field)

DATA SOURCE: Salinity Survey Report of Water Use Experimental Station, Phetchaburi, March 1979

Table B-16 Water Quality of Irrigation Water

	PH	Ec x 10^3 at 25 c	TDS PPM	SSP	SAR	RSC Meq/1	Boron PPM	Cations & Anions (meq.1) Na	Ca + Mg	Ca	K	Co3	HCo3	So4	CL
Sample 1	7.6	0.18	136	15	0.3	-	-	0.30	1.67	0.96	0.05	-	1.31	0.31	0.28
Sample 2	9.8	0.16	112	20	0.4	-	-	0.38	1,47	0.81	0.04	-	1.26	0.26	0.33

Note : Sample 1 --- Water from irrigation canal 2R-1

Sample 2 --- Water from irrigation canal 6R-1L-3

Figure B-1 Location of Water Sampler

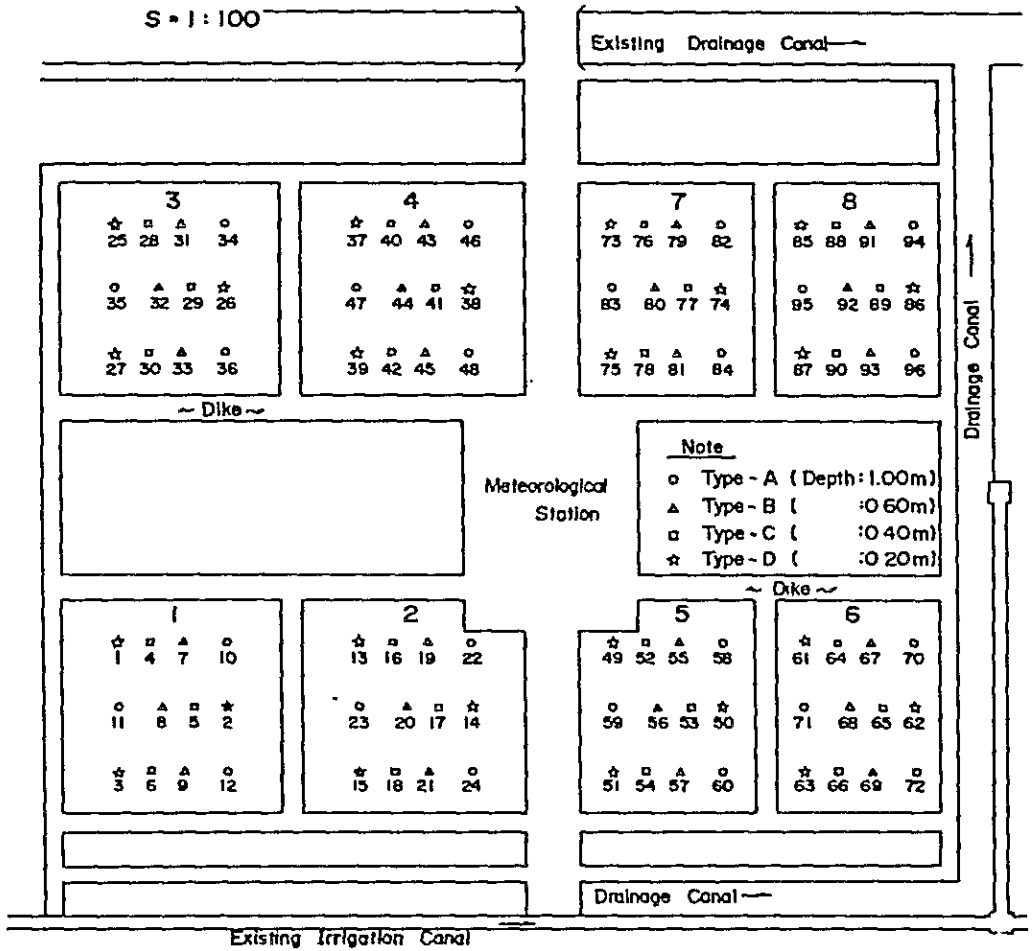


Figure B-2-1 Sampling Location and Land Use

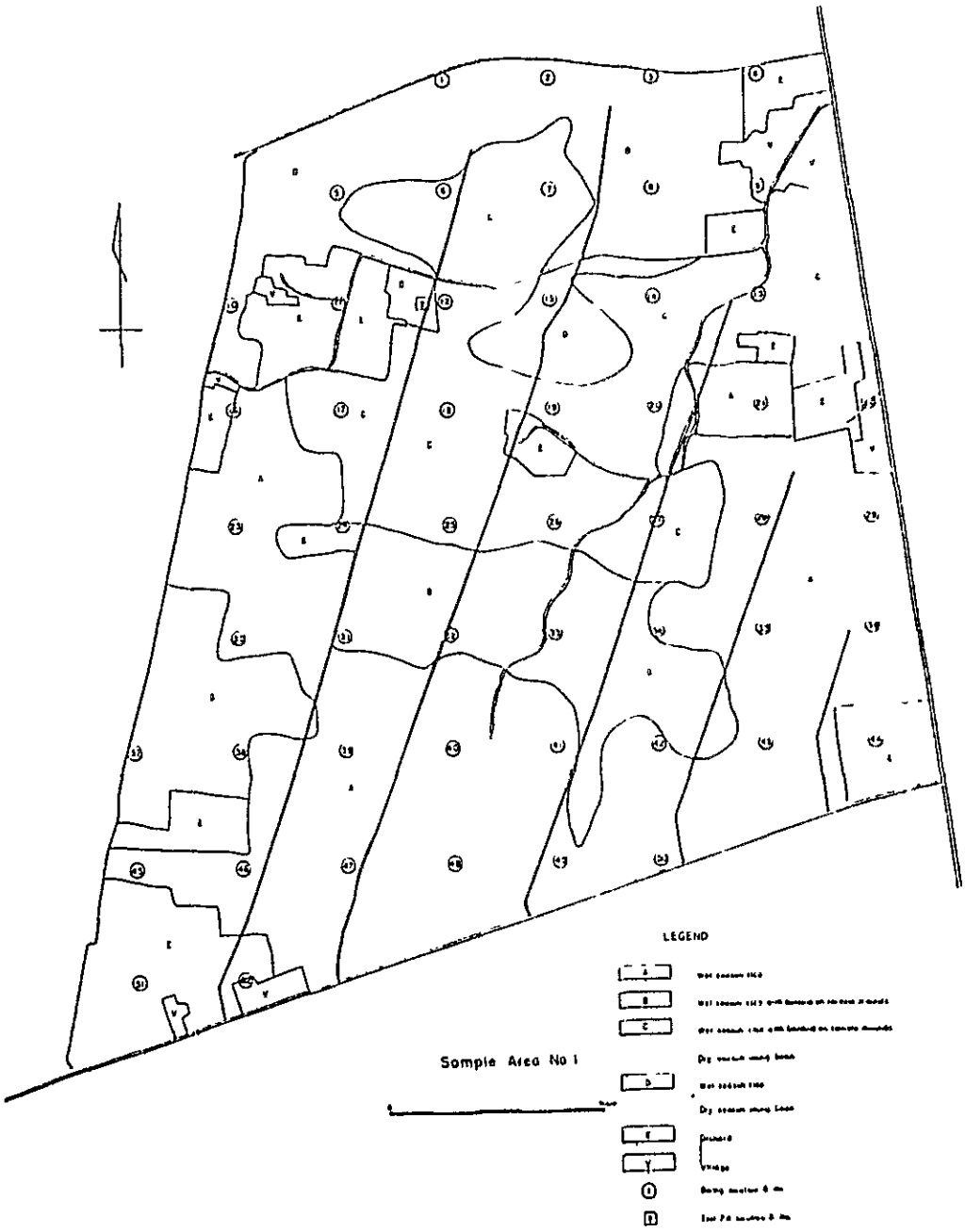
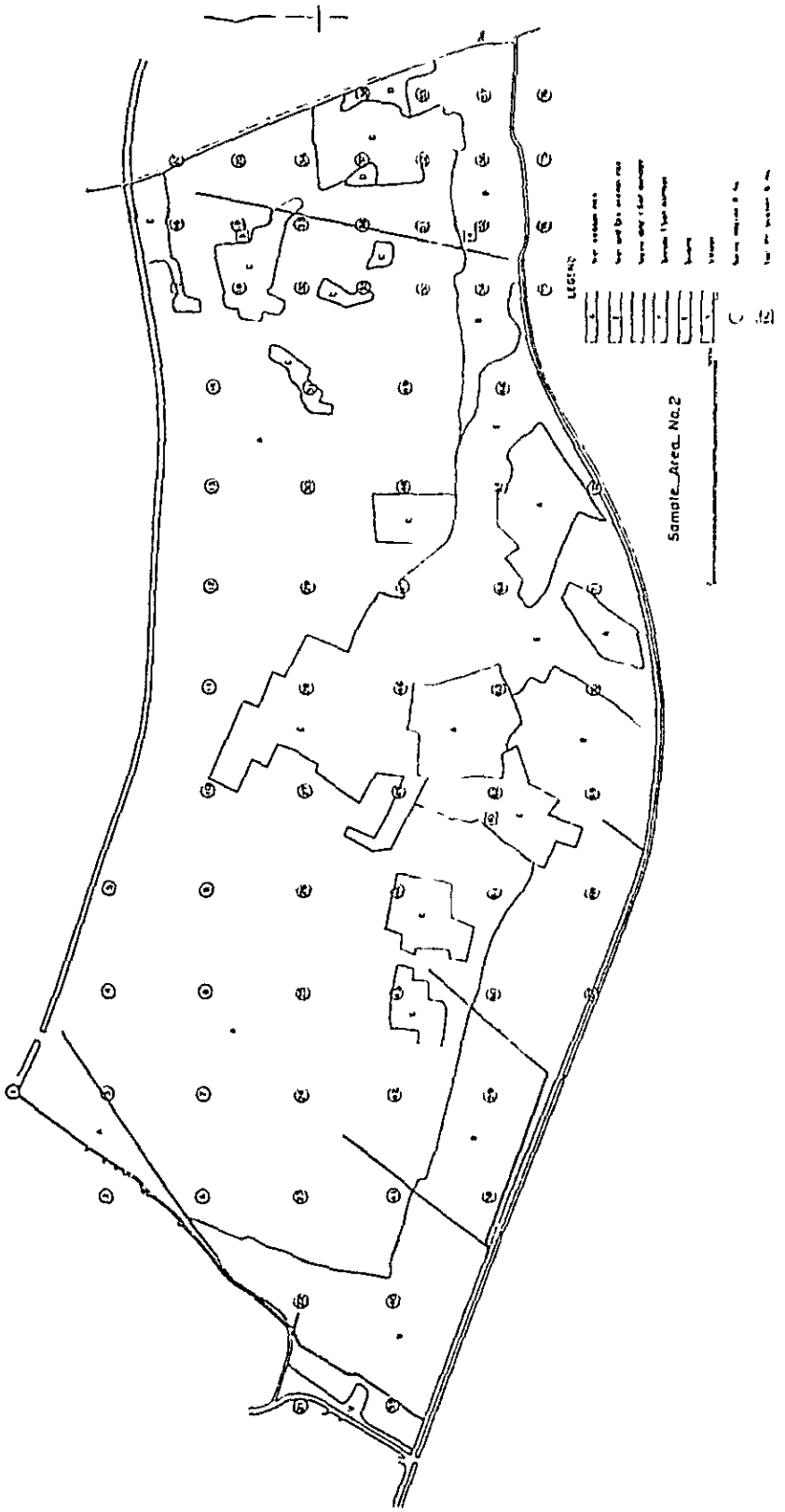


Figure B-2-2 Sampling Location and Land Use



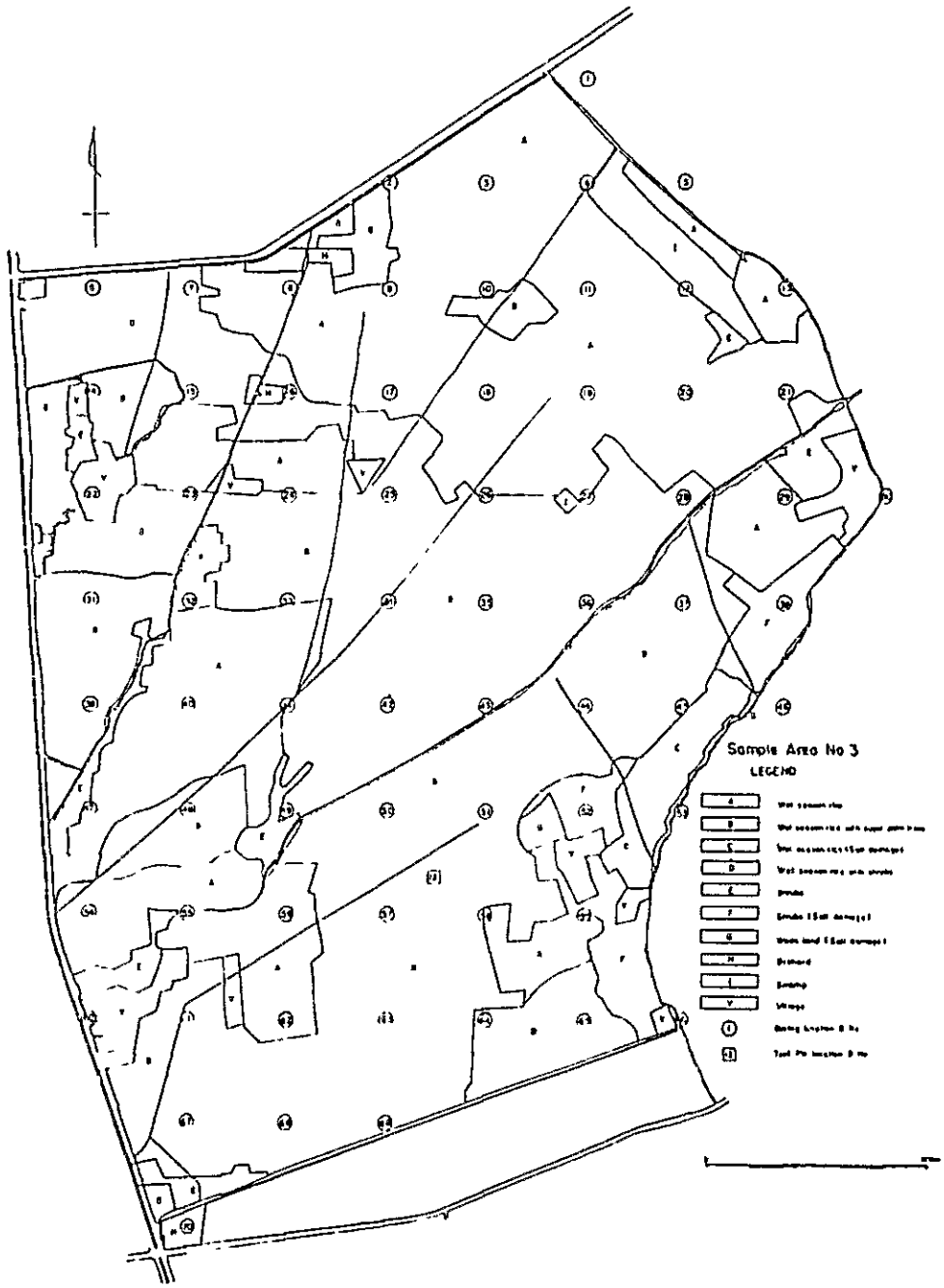
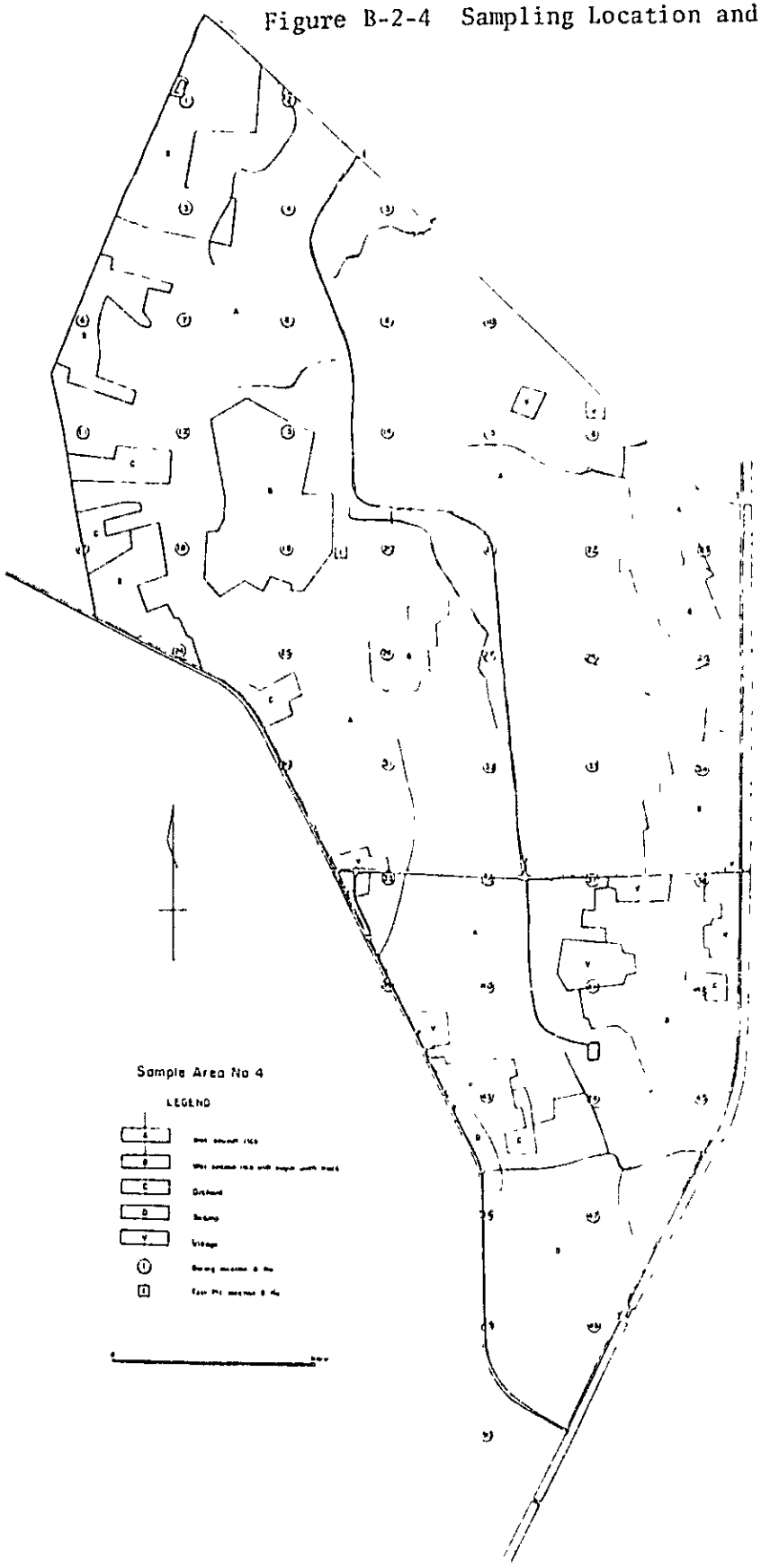


Figure B-2-3 Sampling Location and Land Use

Figure B-2-4 Sampling Location and Land Use



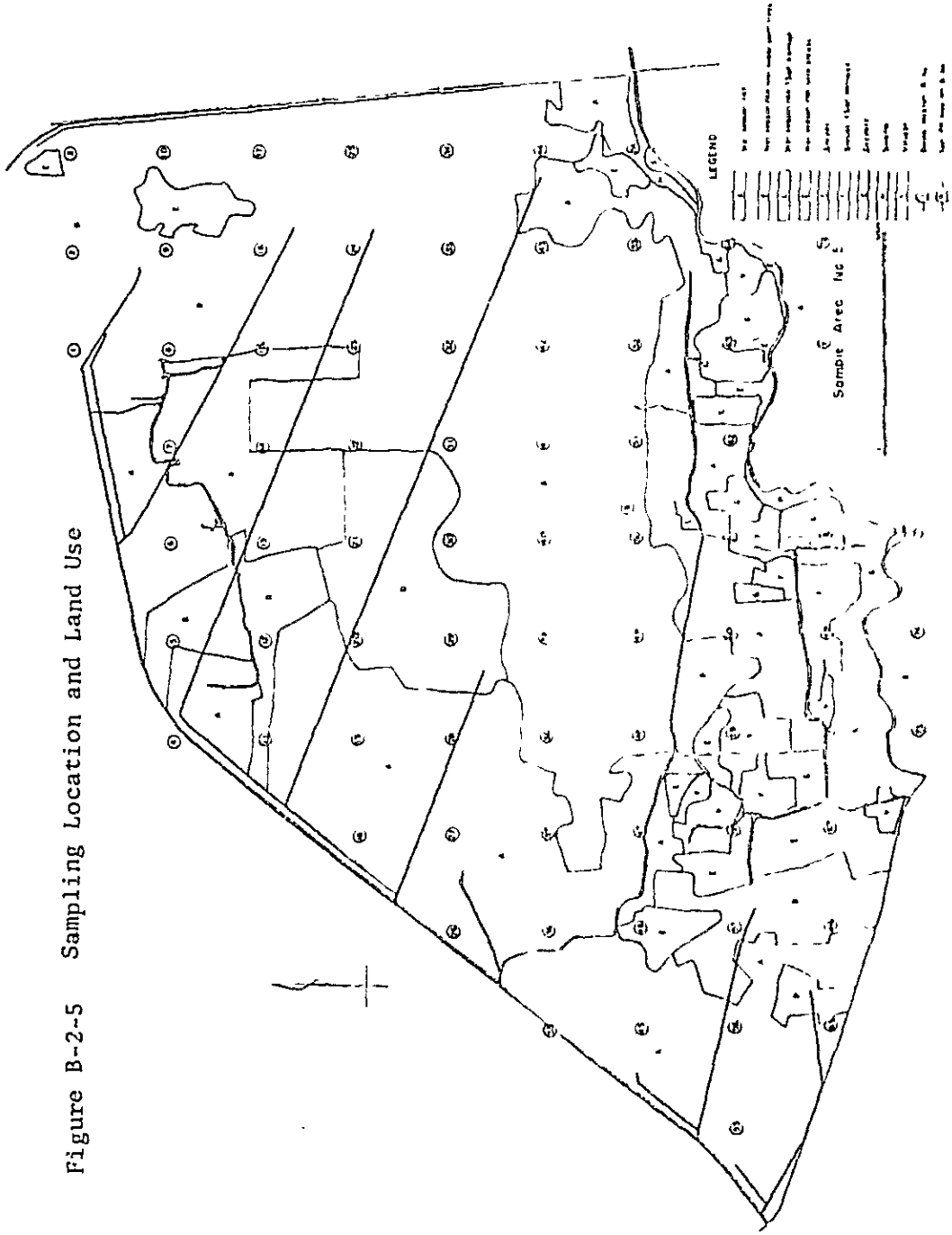
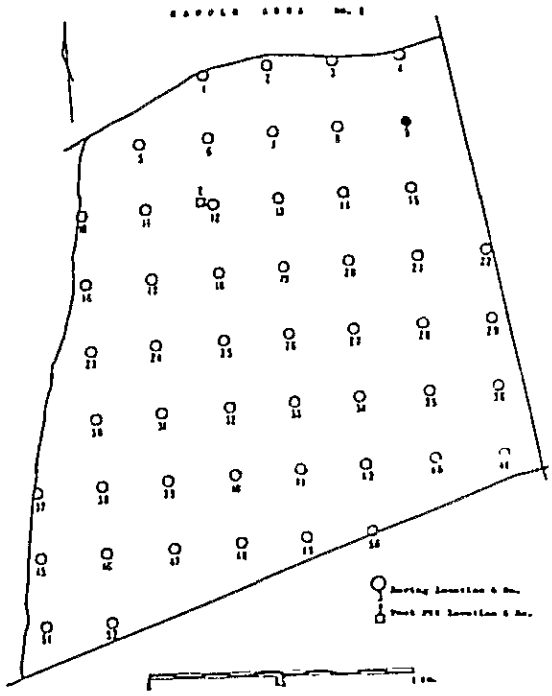


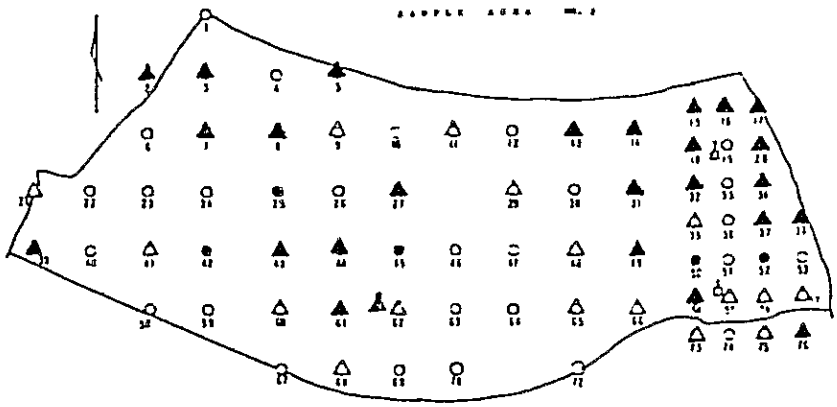
Figure B-2-5 Sampling Location and Land Use

Figure B-3-1 Situation of Soil Salinity and pH in the Sample Area



LEGEND

Soil	Salinity	Soil pH
○	<4 m mhos/cm	<5.5
●	4-6 m mhos/cm	5.6-6.5
△	6-8 m mhos/cm	6.6-7.3
▲	>8 m mhos/cm	>7.4



SOIL SALINITY

Figure B-3-2 Situation of Soil Salinity and pH in the Sample Area

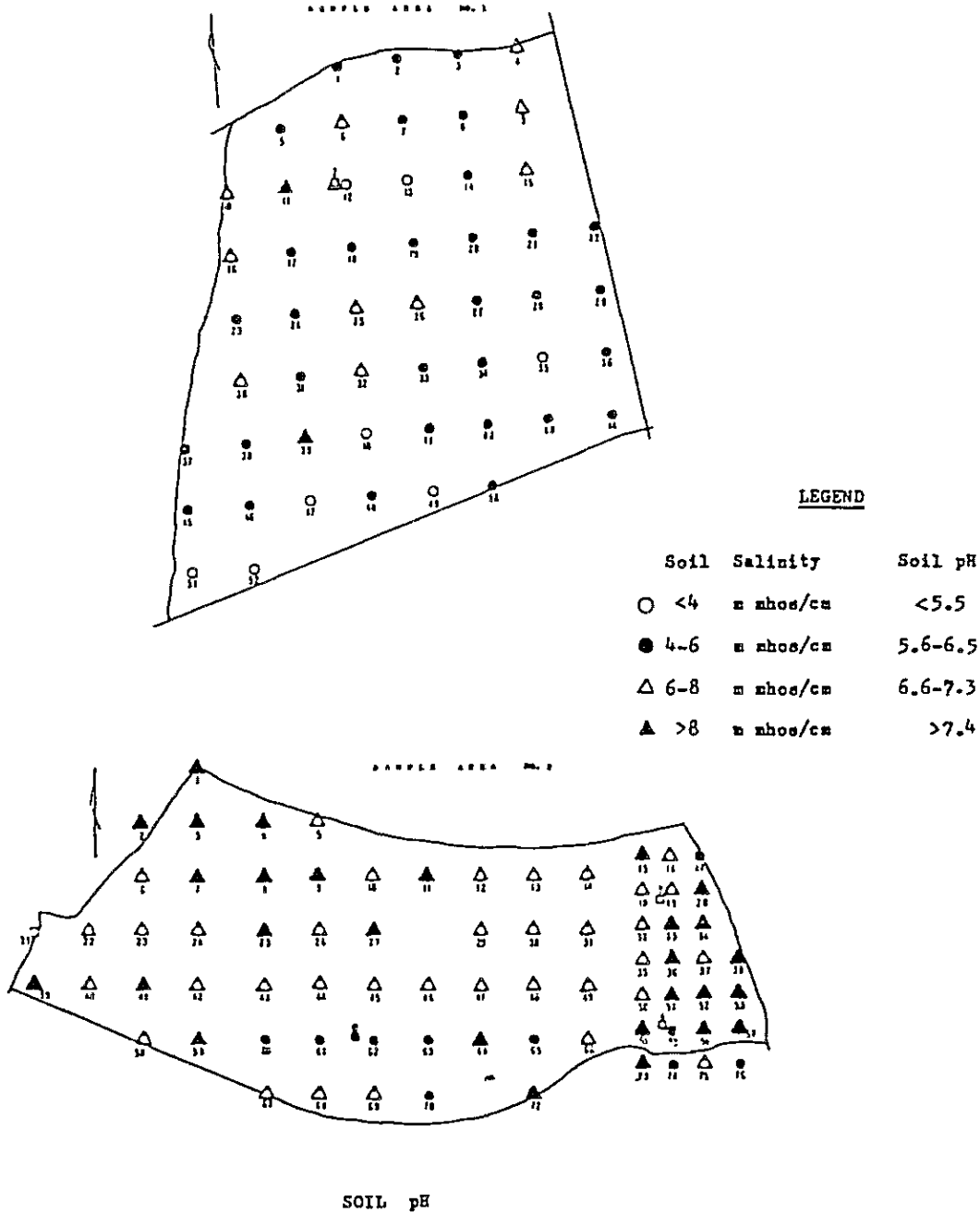


Figure B-3-3 Situation of Soil Salinity and pH in the Sample Area

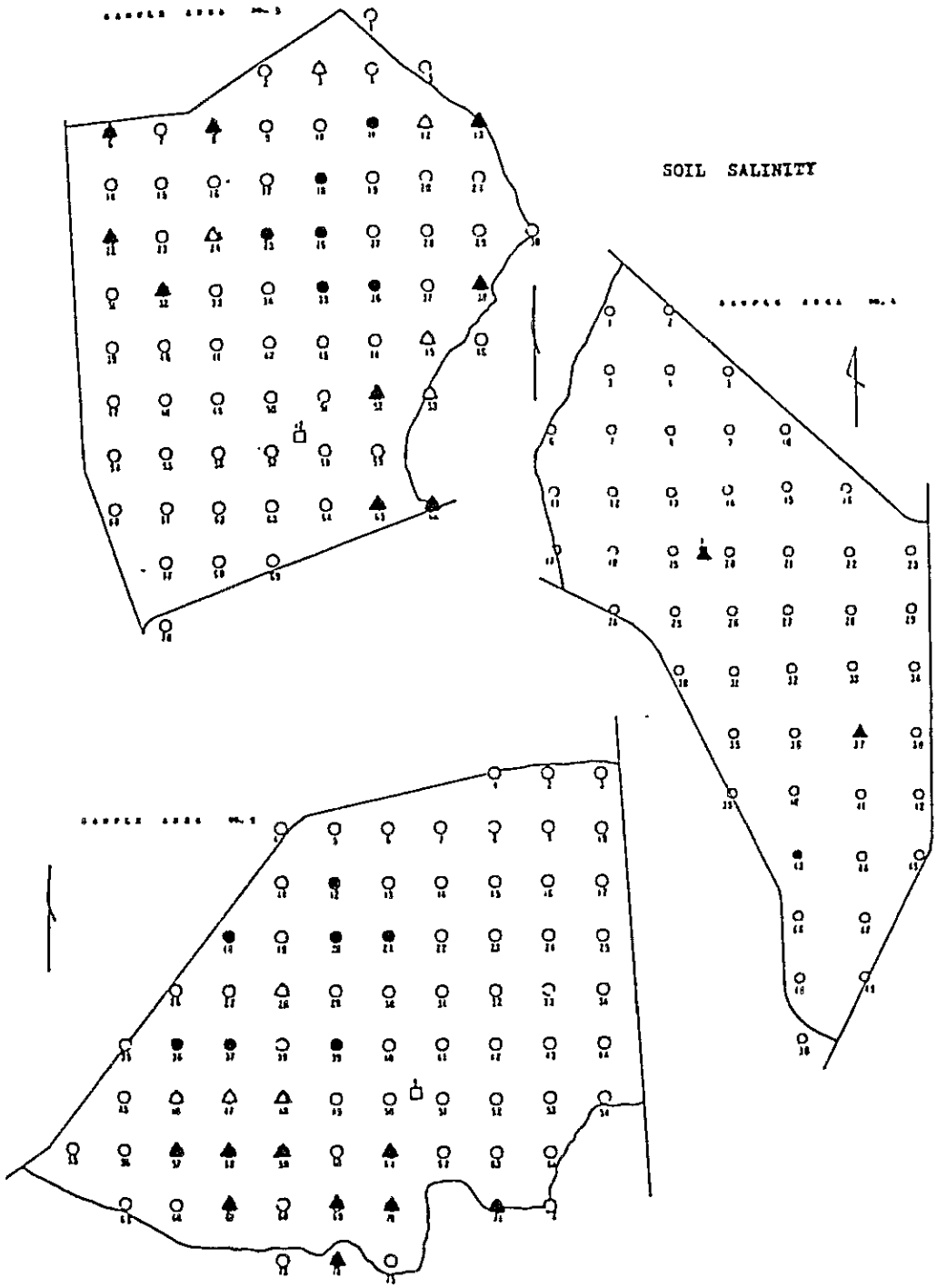


Figure B-3-4 Situation of Soil Salinity and pH in the Sample Area

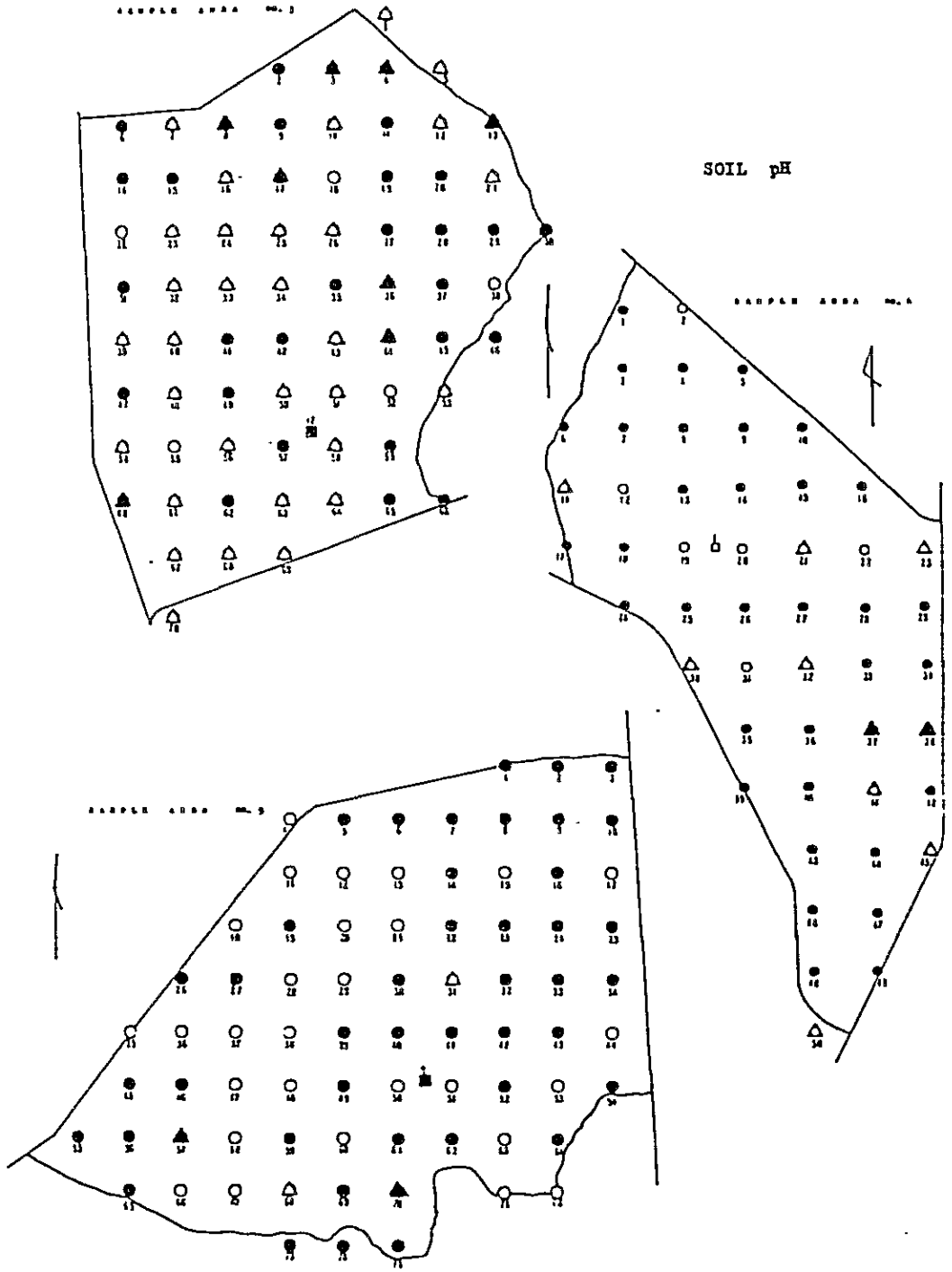


Figure B-4 Proportion of Particle Size of Test Pits

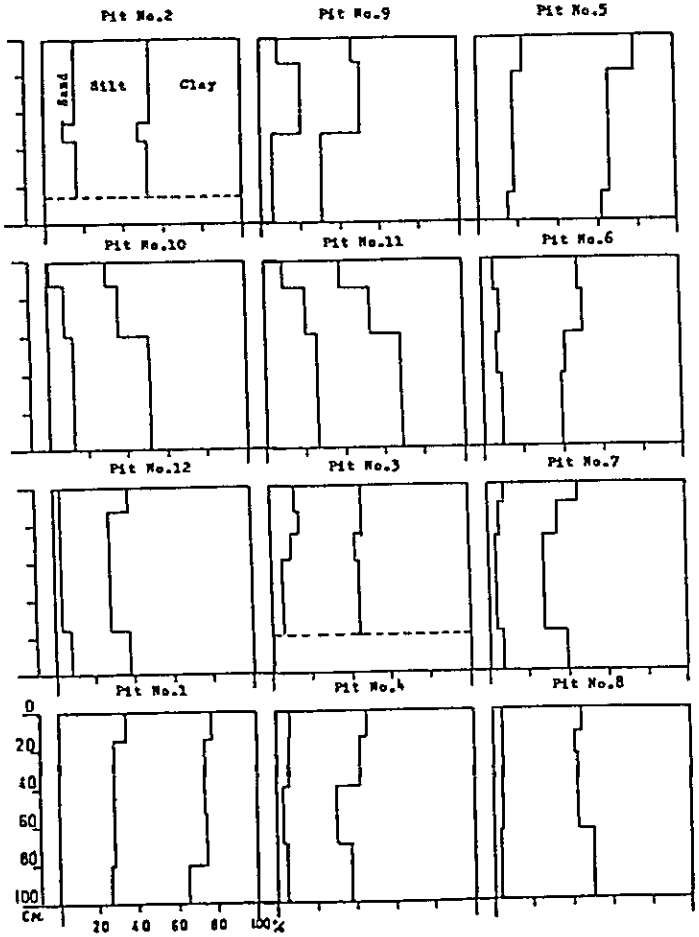


Figure B-5 Profile Pore-space Relationships

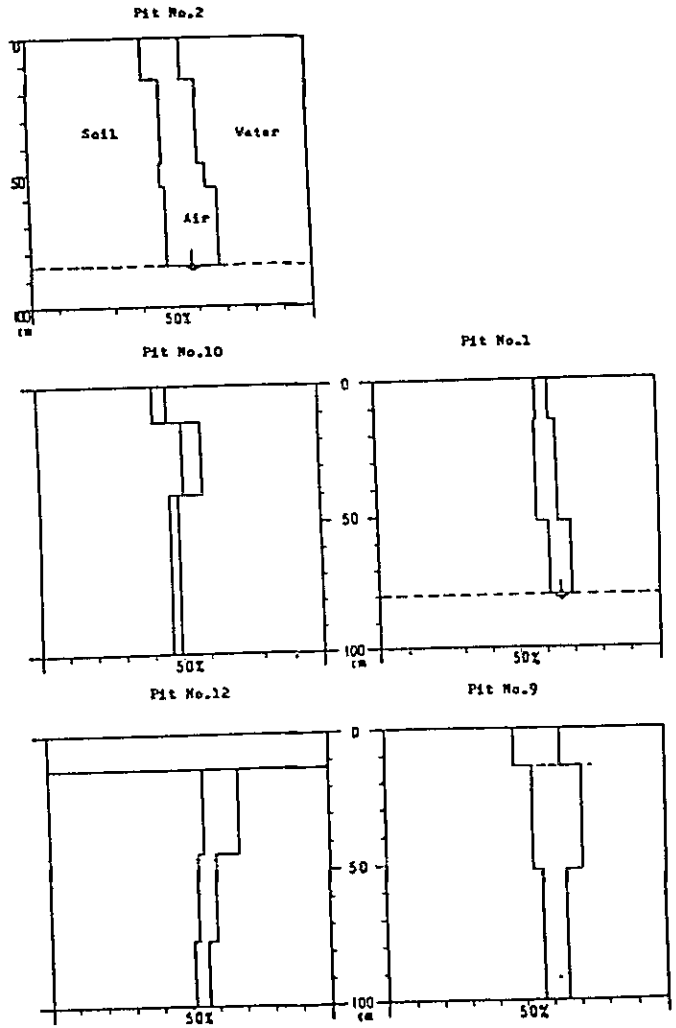
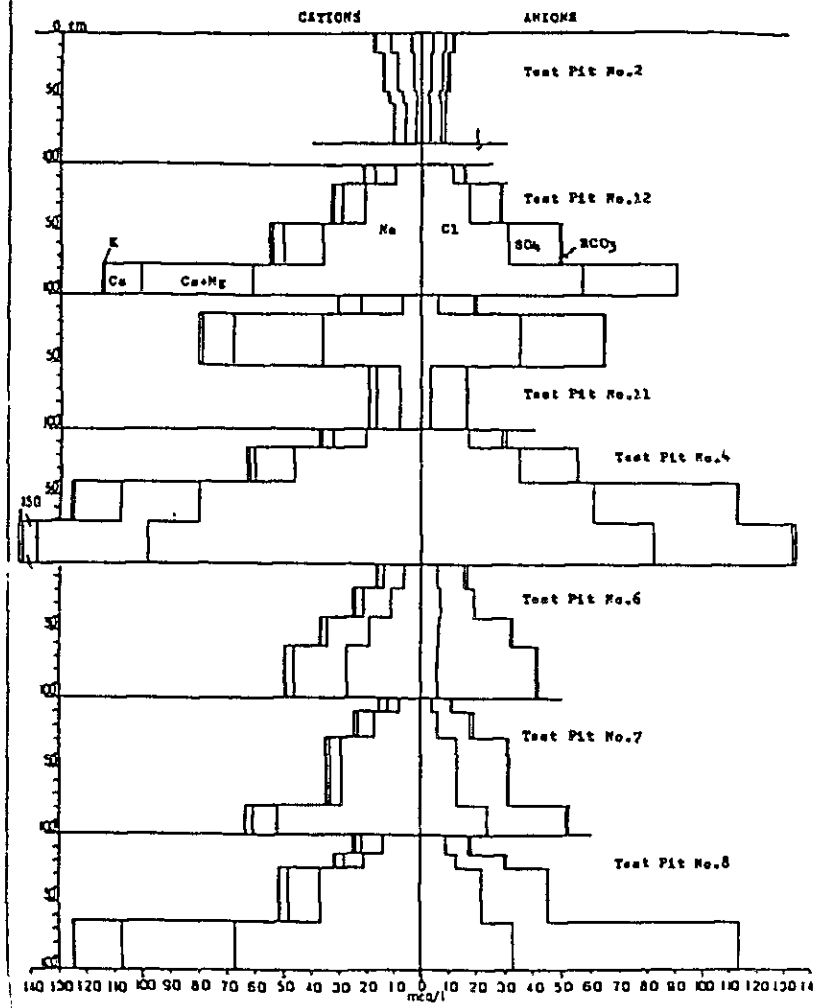


Figure B-6 Composition of Salts in Saturation Extracts of Soil



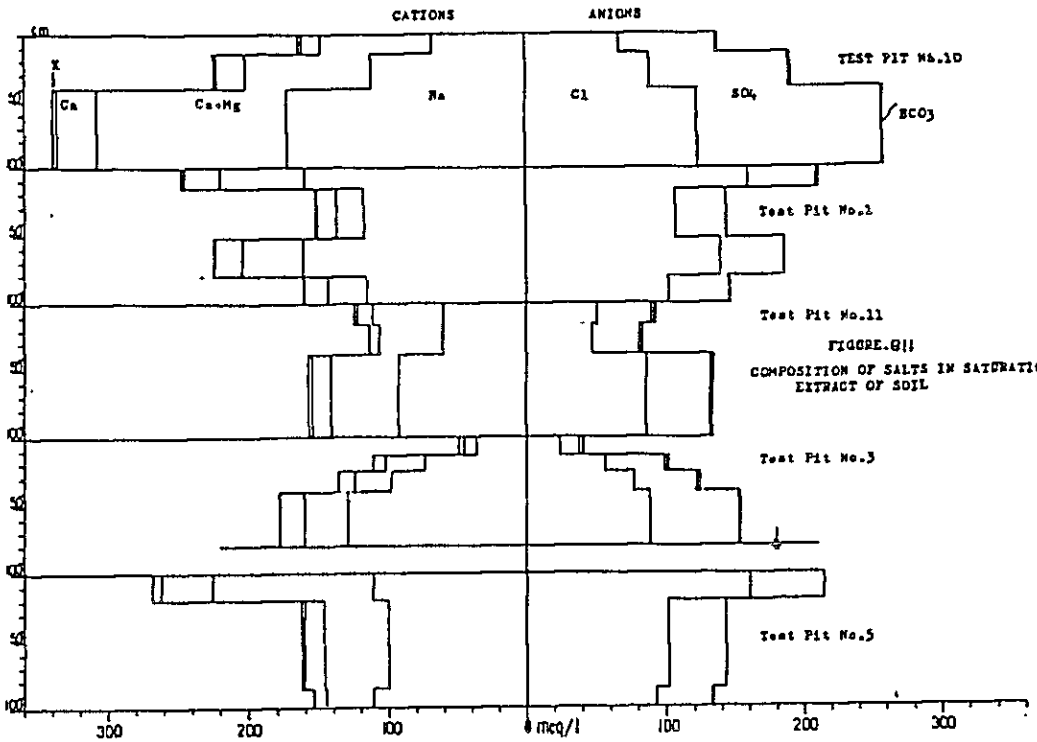
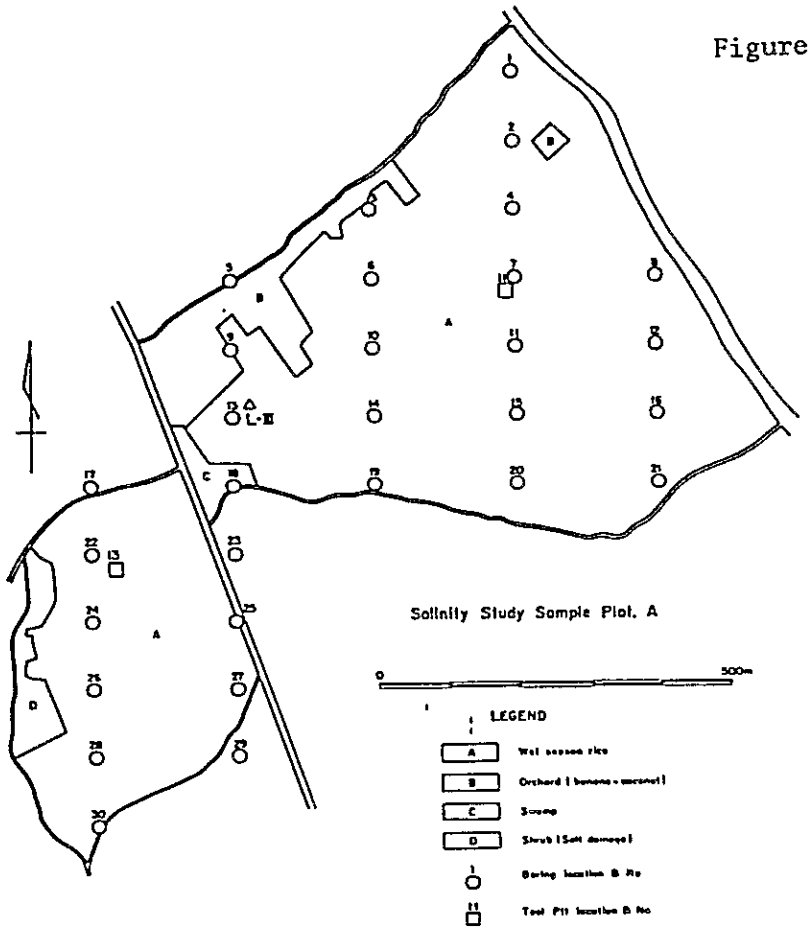


FIGURE.B11
COMPOSITION OF SALTS IN SATURATION EXTRACT OF SOIL

Figure B-7-1 Salinity Study Sample Plot



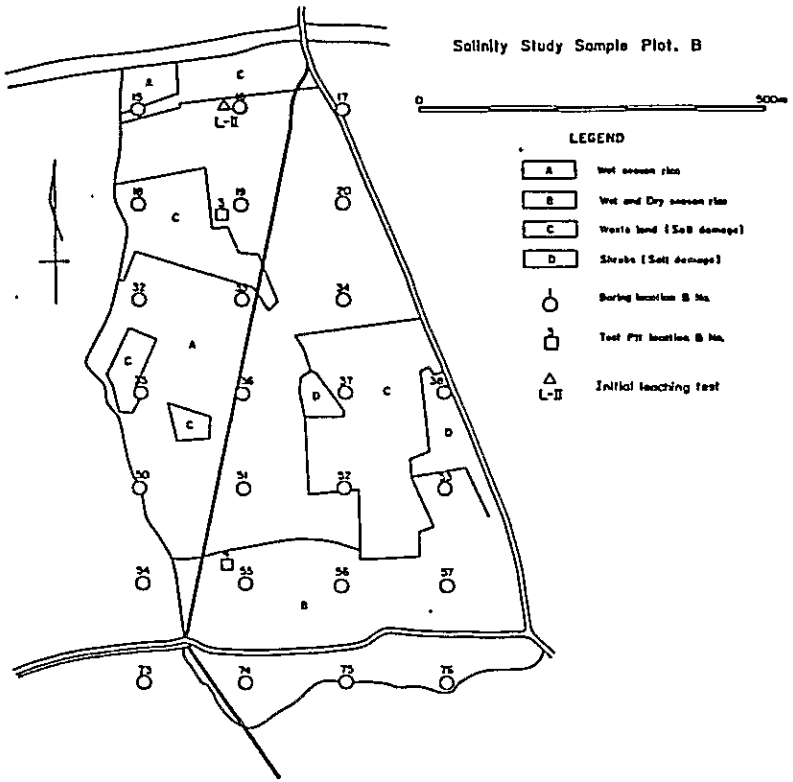
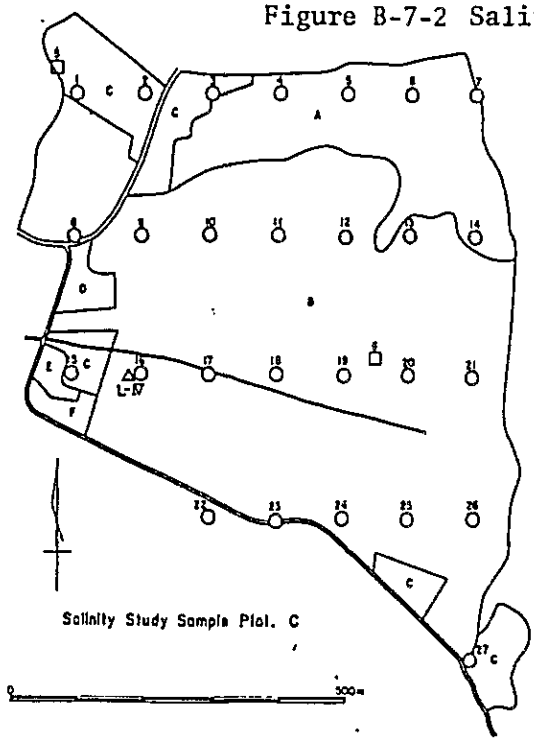
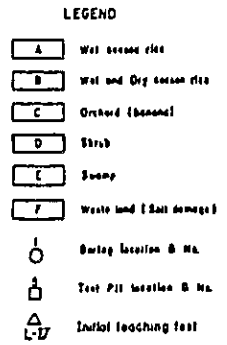
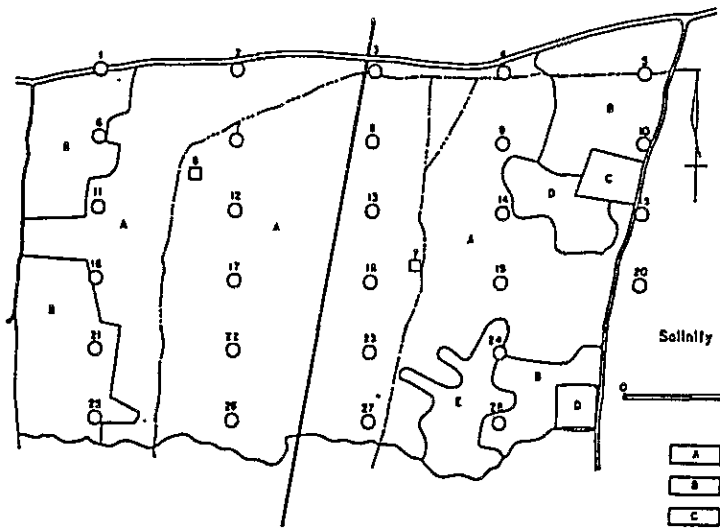


Figure B-7-2 Salinity Study Sample Plot







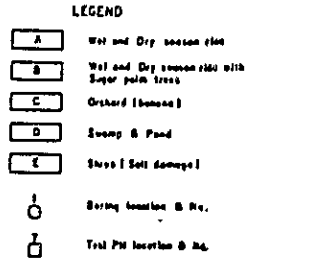


Figure B-8 Variation of Ground Water Salinity between Dry Season and Rainy Season

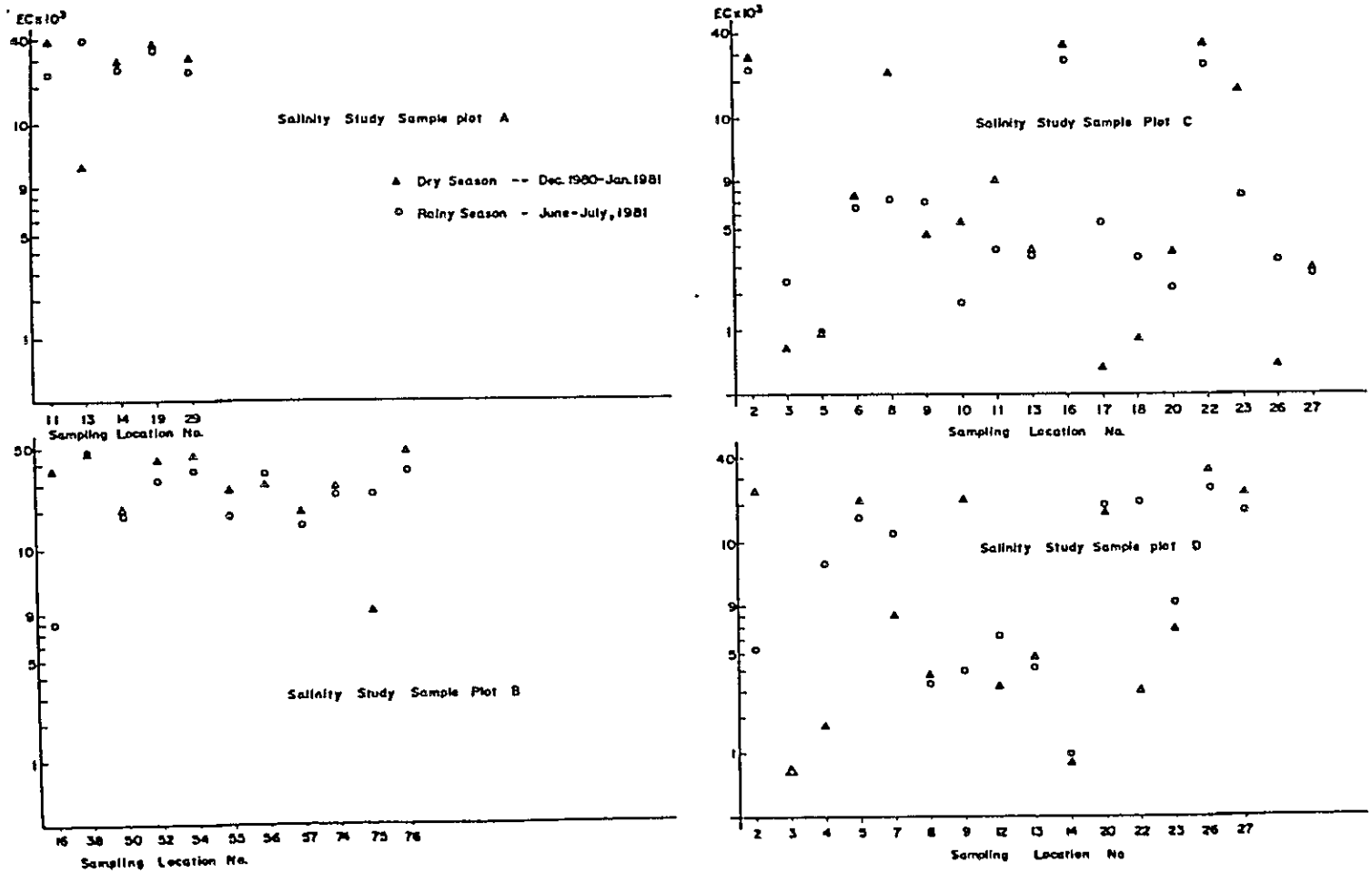


Figure B-9-1 Relation between Salinity of Surface Soil and Subsoil
(Salinity Study Sample Plot)

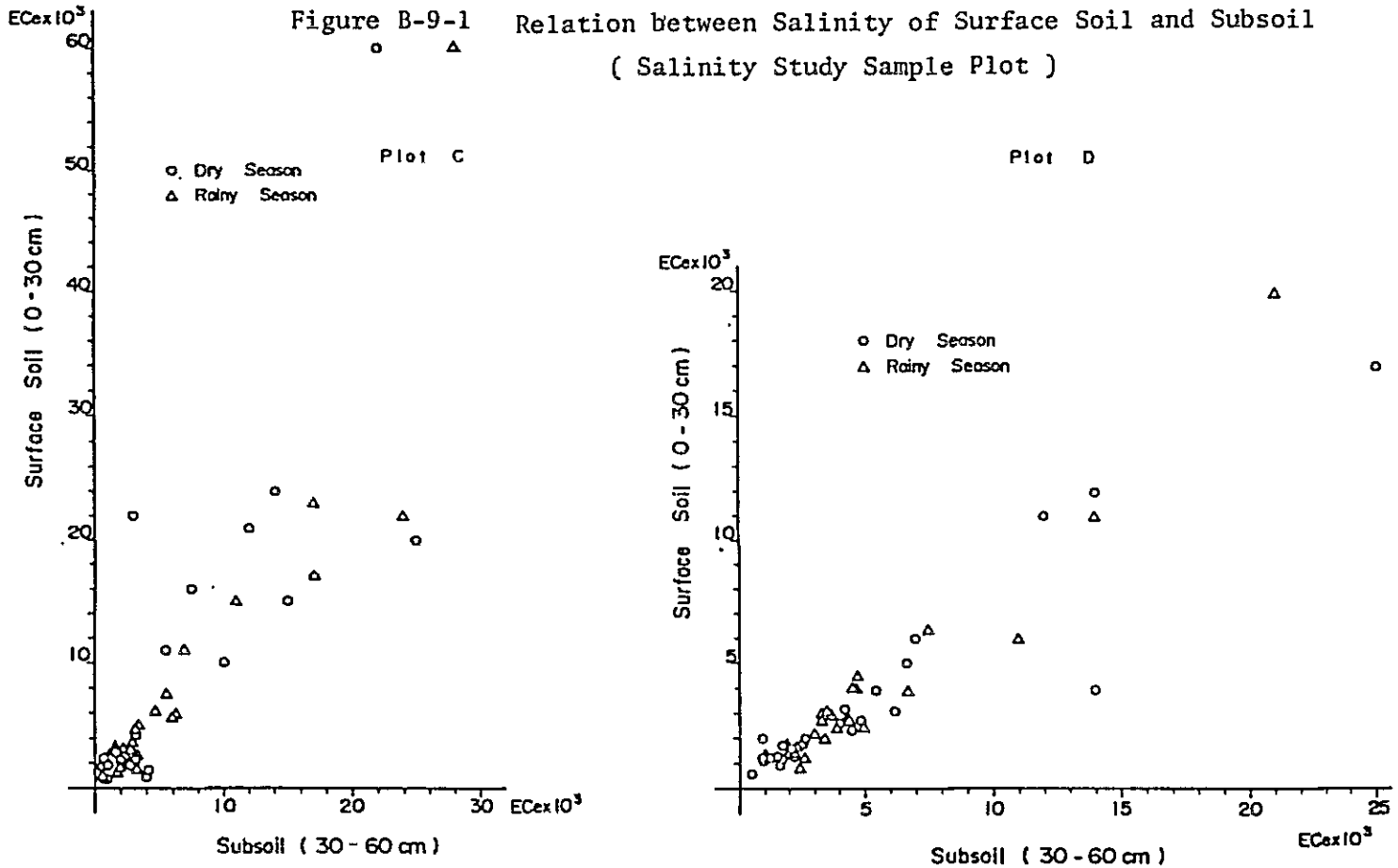


Figure B-9-2 Relation between Salinity of Surface Soil and Subsoil
(Salinity Study Sample Plot)

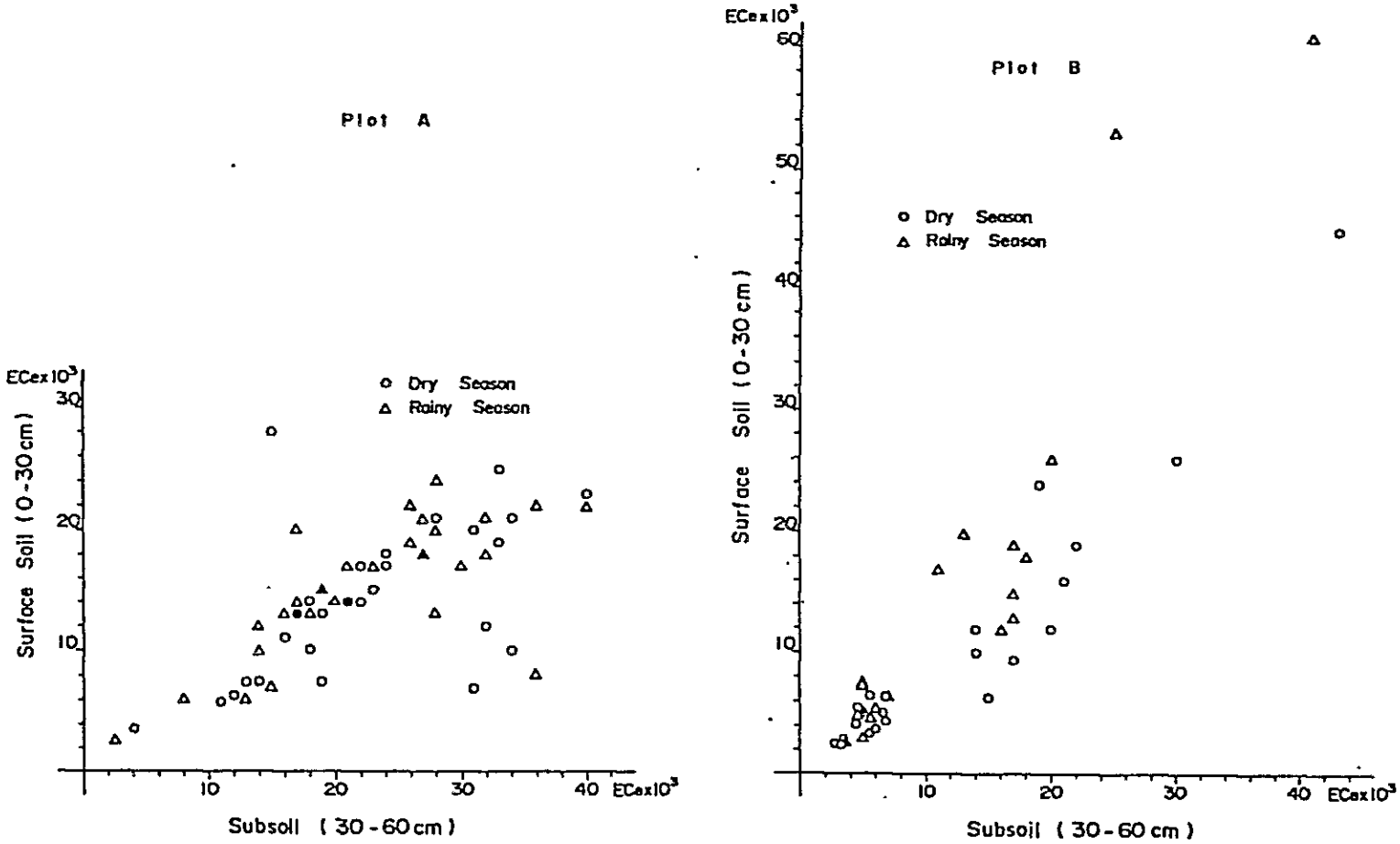


Figure B-10-1 Daily Change of Leachate Salinity by Plot

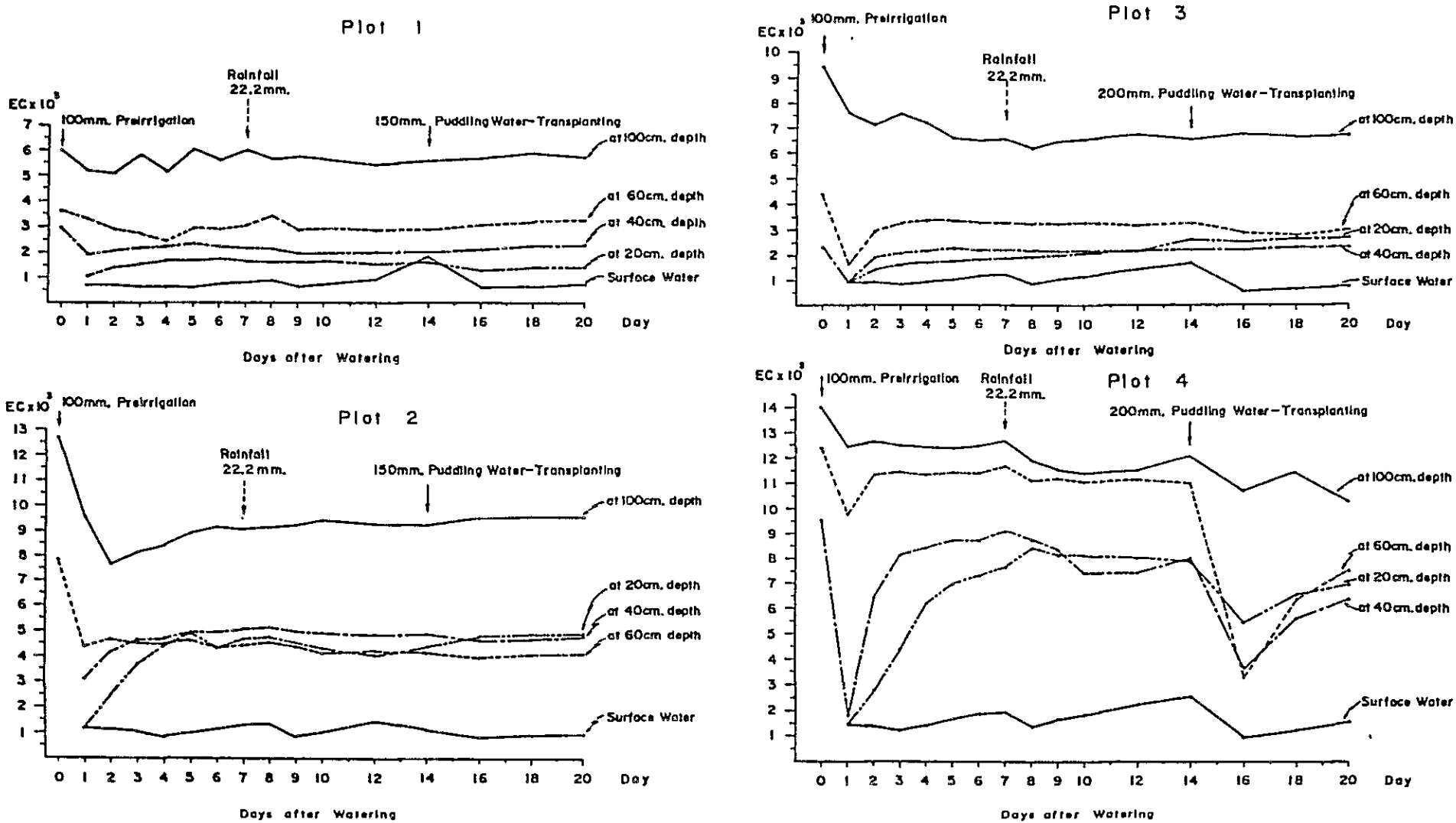


Figure B-10-2 Daily Change of Leachate Salinity by Plot

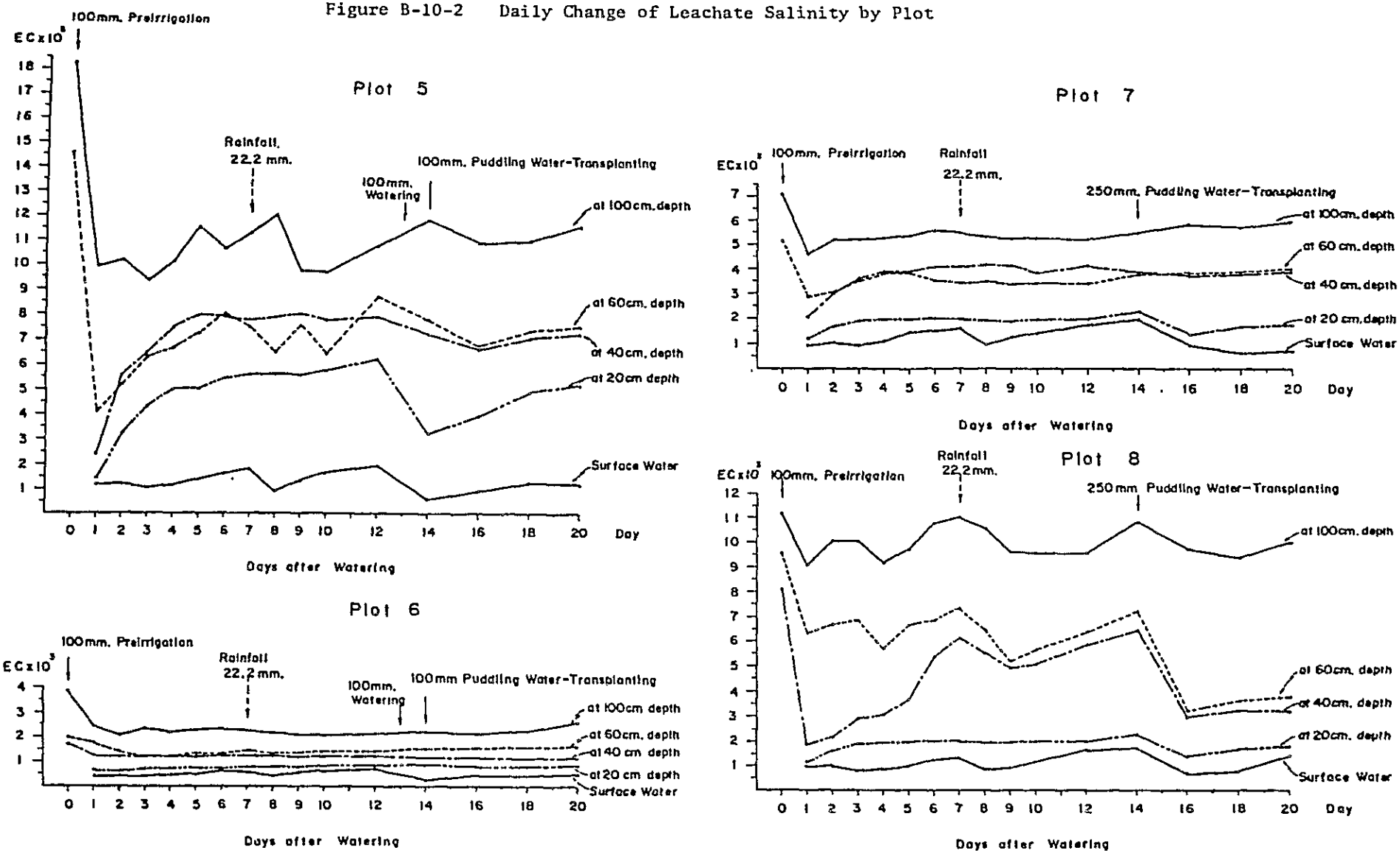
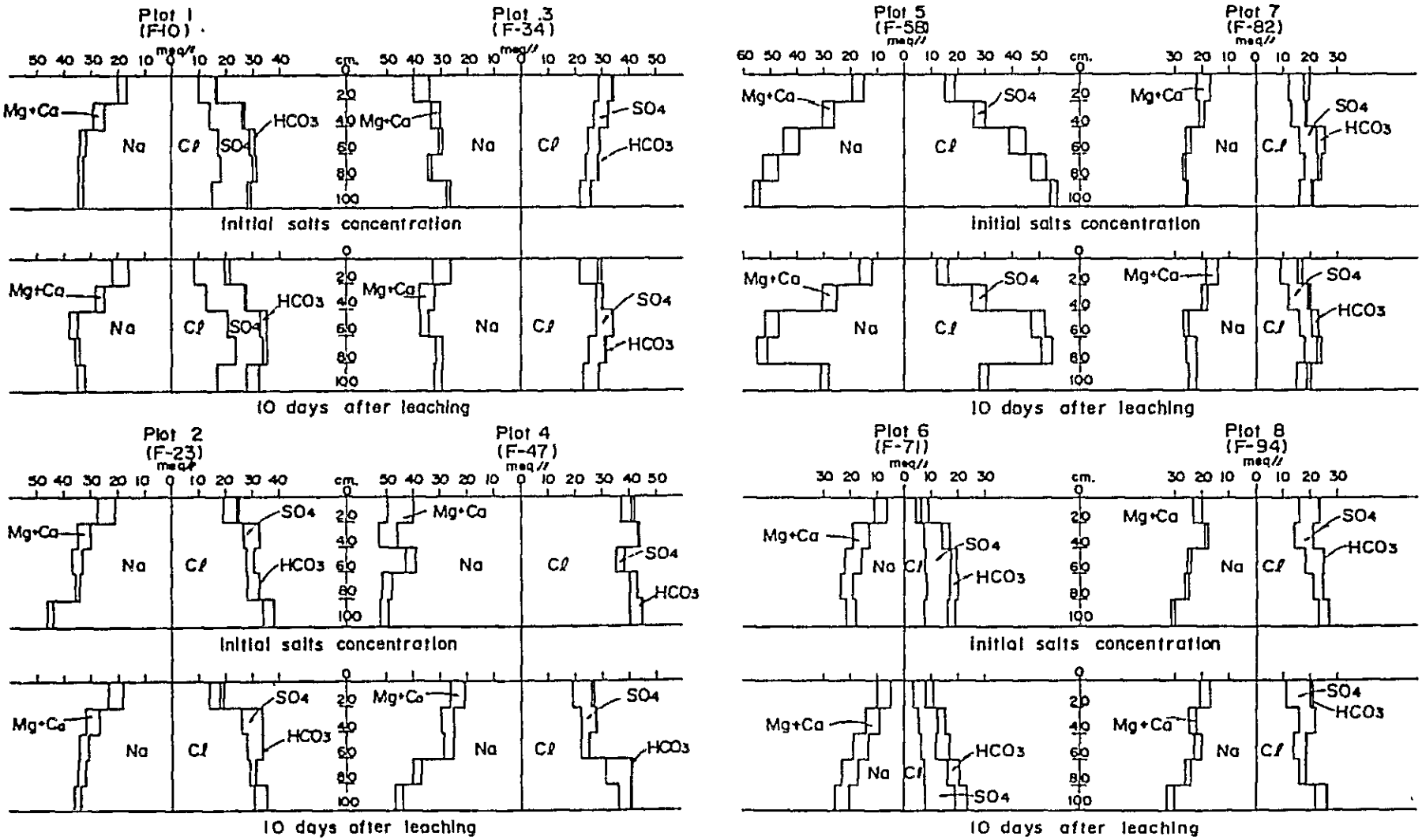


Figure B-11 Composition of Initial and Leached Soluble Salts



Remark: K and CO3 are excluded because of negligible concentration in this figure

Figure B-12-1 Change of Leachate Salinity by Soil Depth

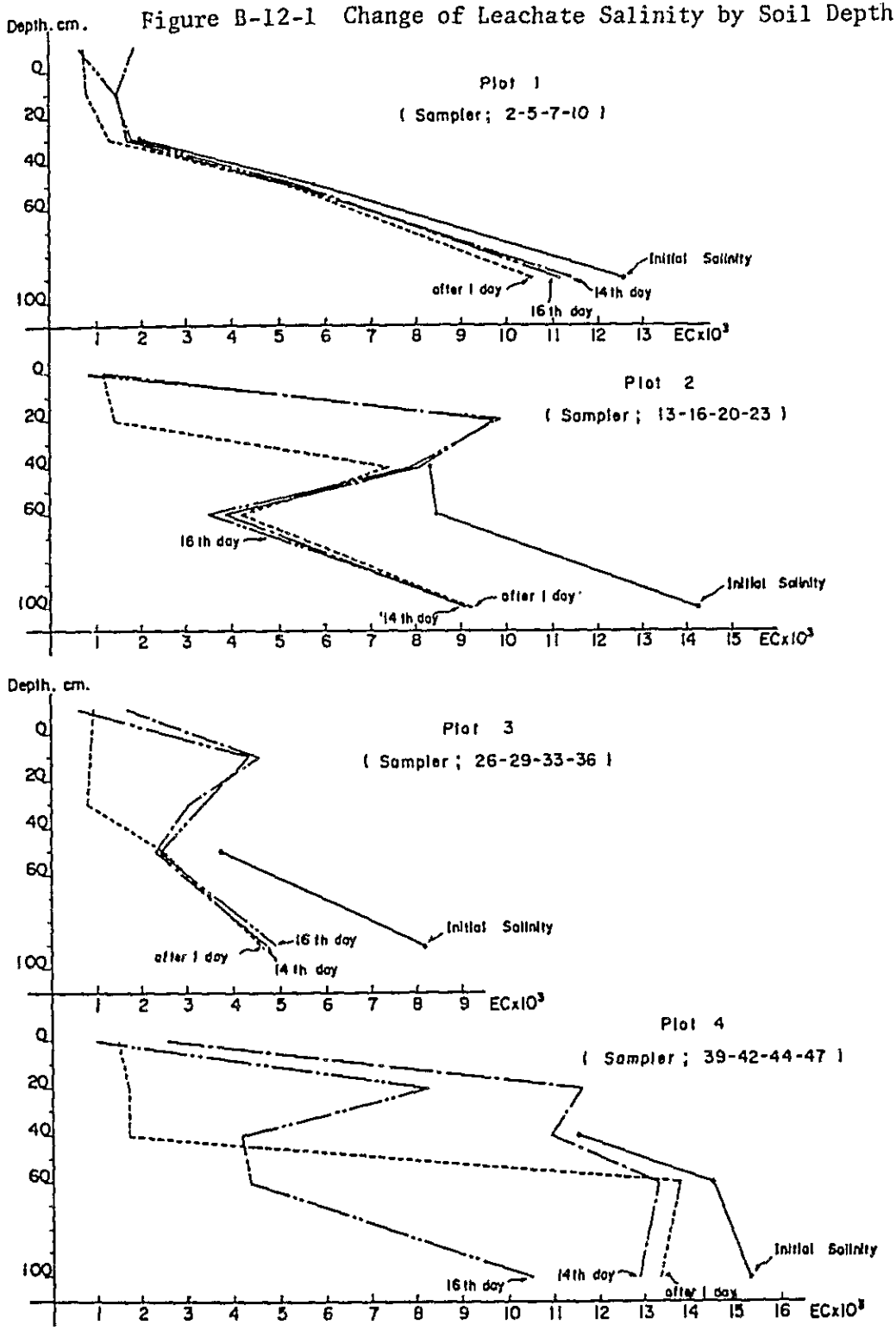


Figure B-12-2 Change of Leachate Salinity by Soil Depth

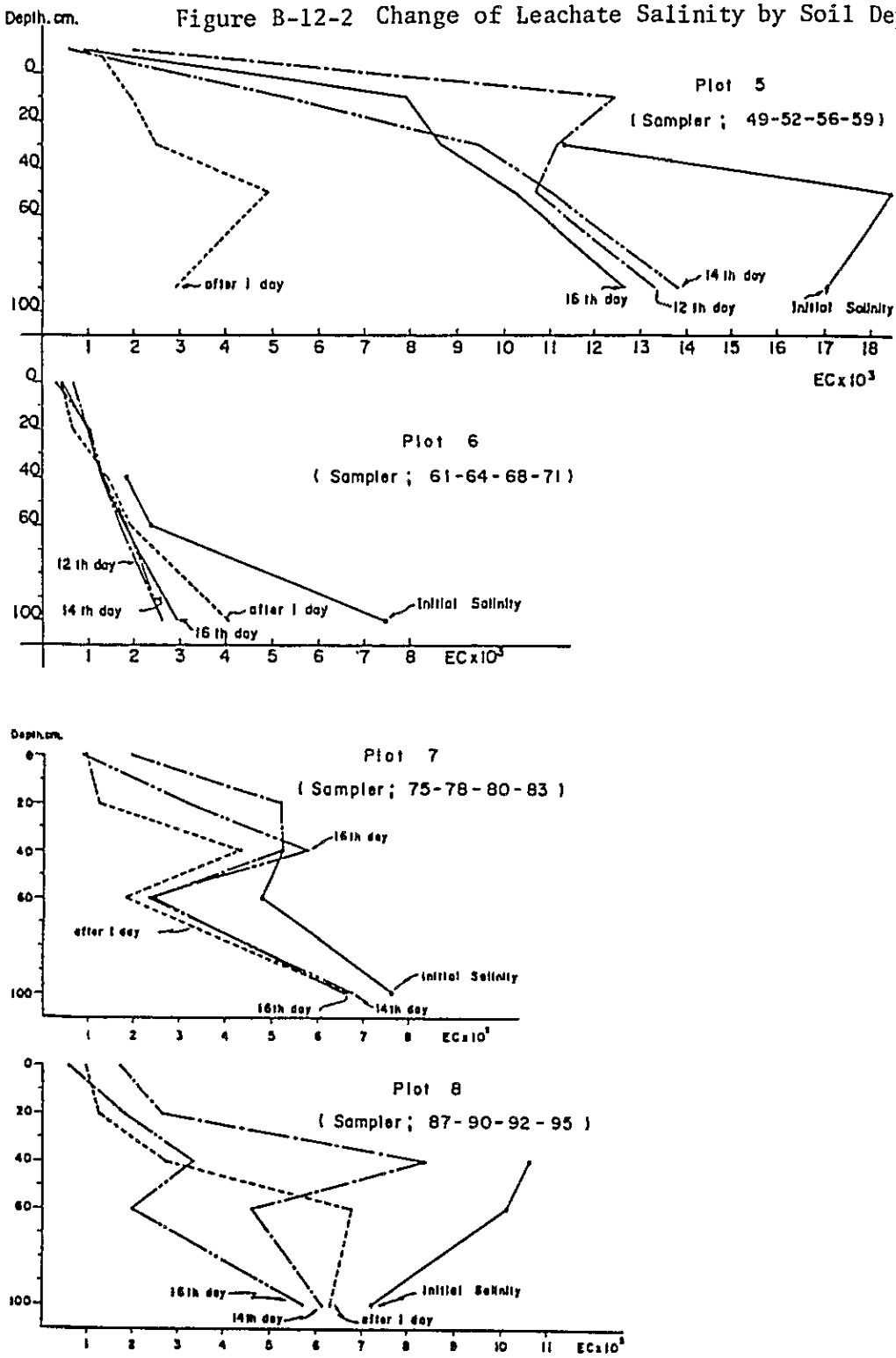
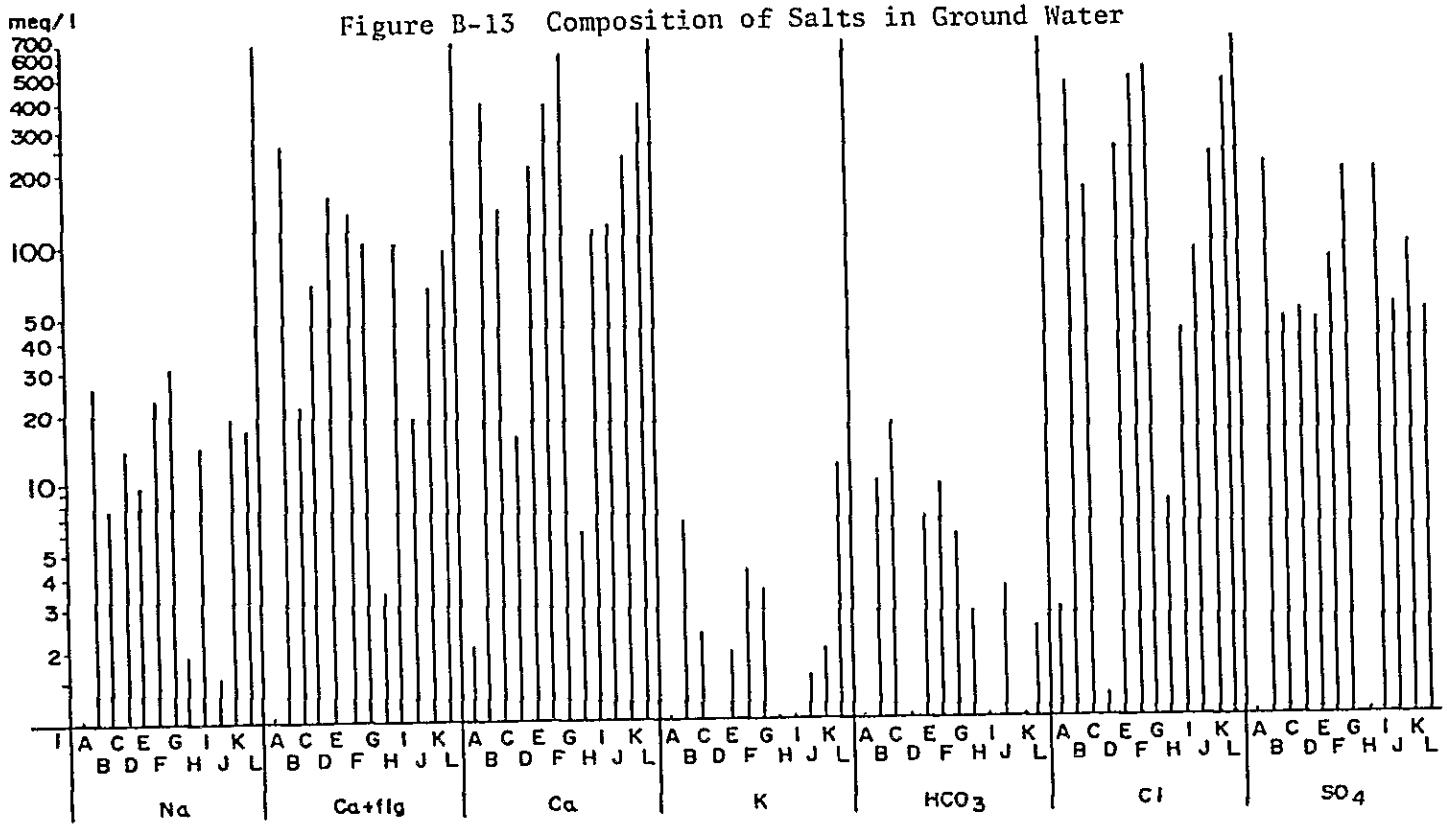
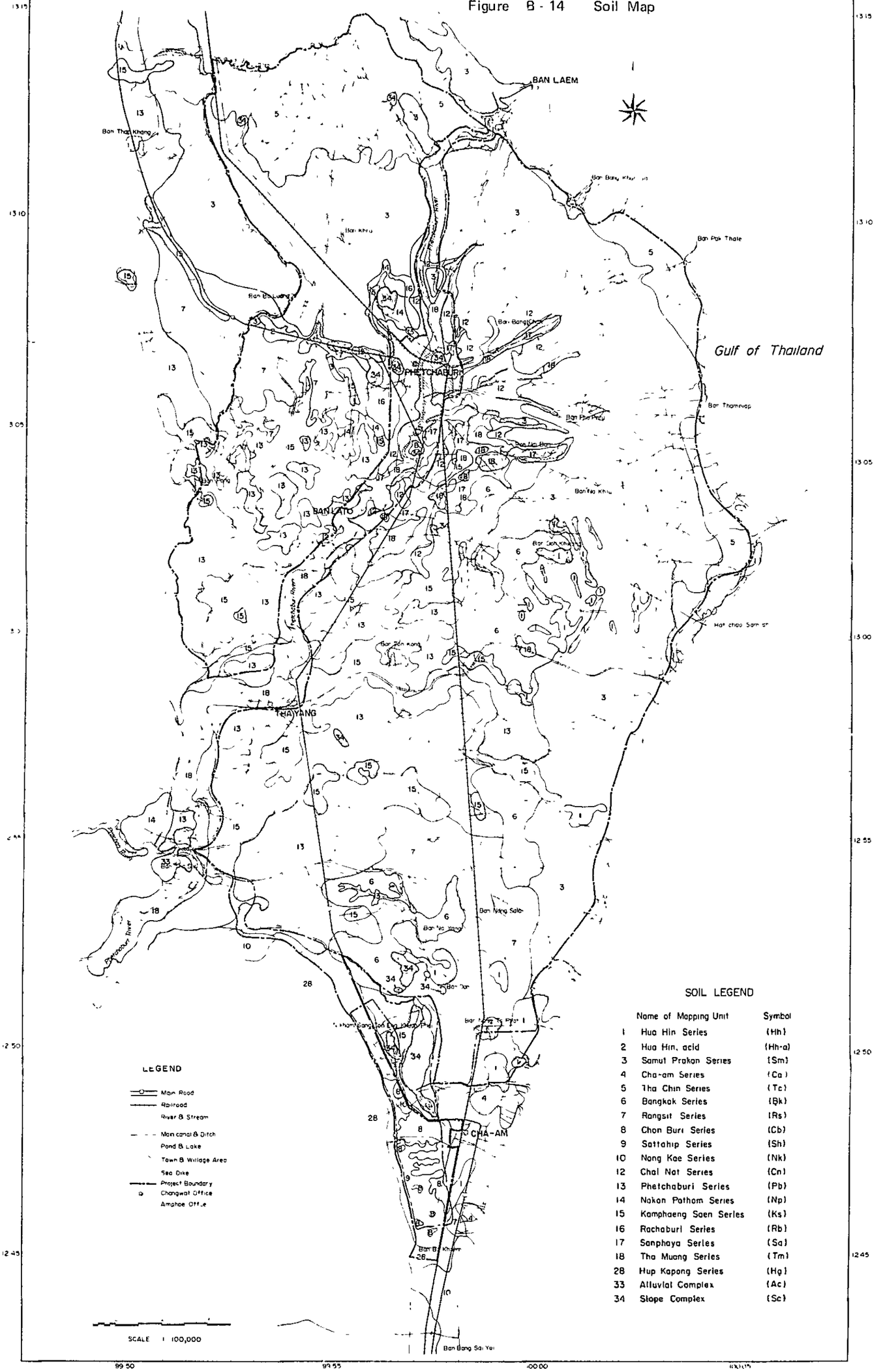


Figure B-13 Composition of Salts in Ground Water



NOTE: A--Pit No. 2 (Area No.1) E--Pit No 3 (Plot.B) I--Pit No.6 (Plot.C)
B--Pit No.10 (Area No2) F--Pit No. 4 (Plot.B) J--Pit No. 7 (Plot D)
C--Pit No.12 (Area No 3) G--Pit No. 5 (Plot.C) K--Pit No. 8 (Plot. D)
D--Pit No. 9 (Area No 5) H--Irrg.water (Plot.C) L--Sea.water

Figure B - 14 Soil Map



NOTE This soil map was provided for the feasibility study of Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project according to Detailed Recconnaissance Soil Map of Phetchaburi Province Soil Survey Division, Department of Land Development, MOAC 1977

Figure B-15 Soil Sample Location Map

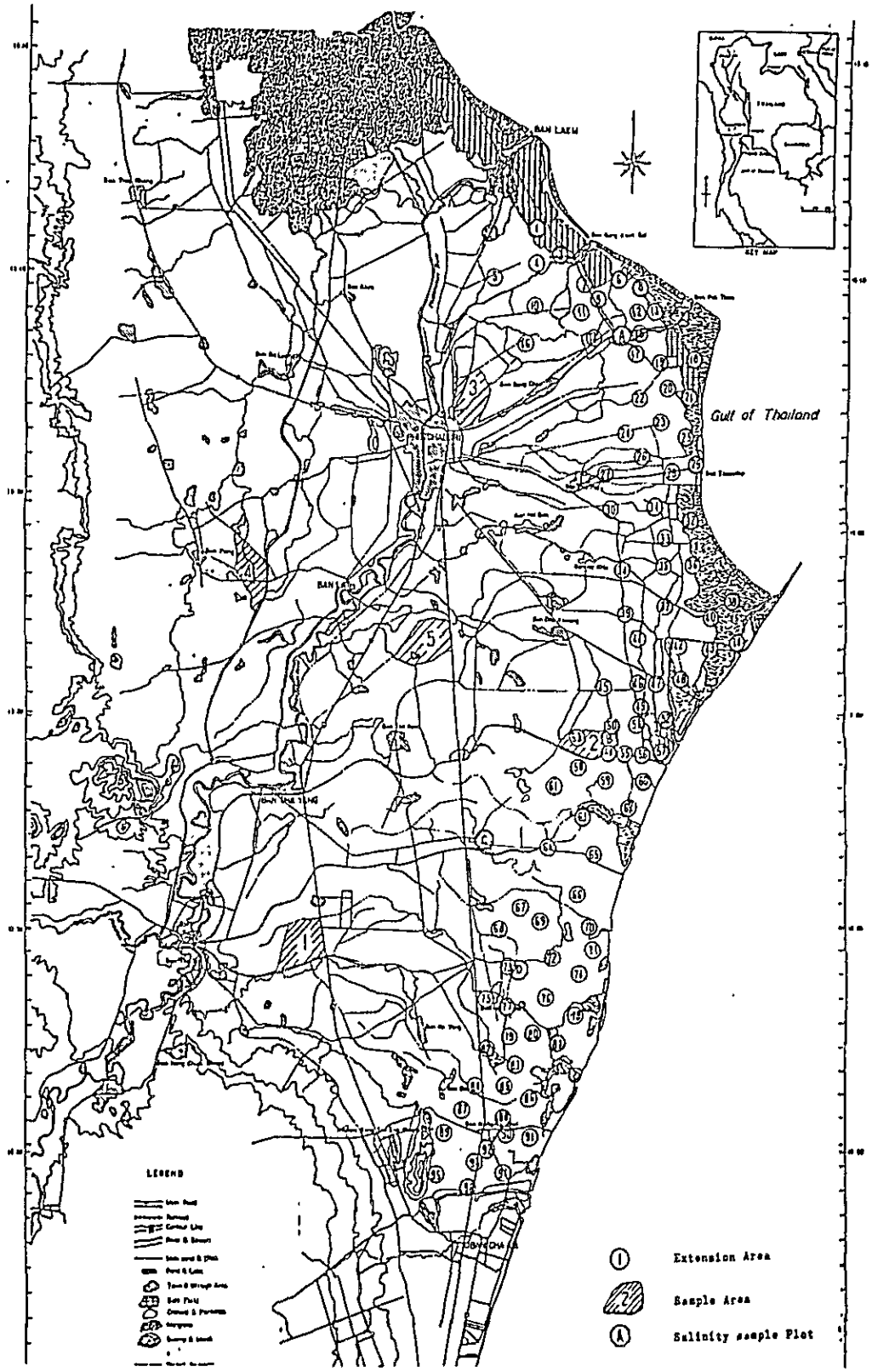


Figure B - 16 Extension Area

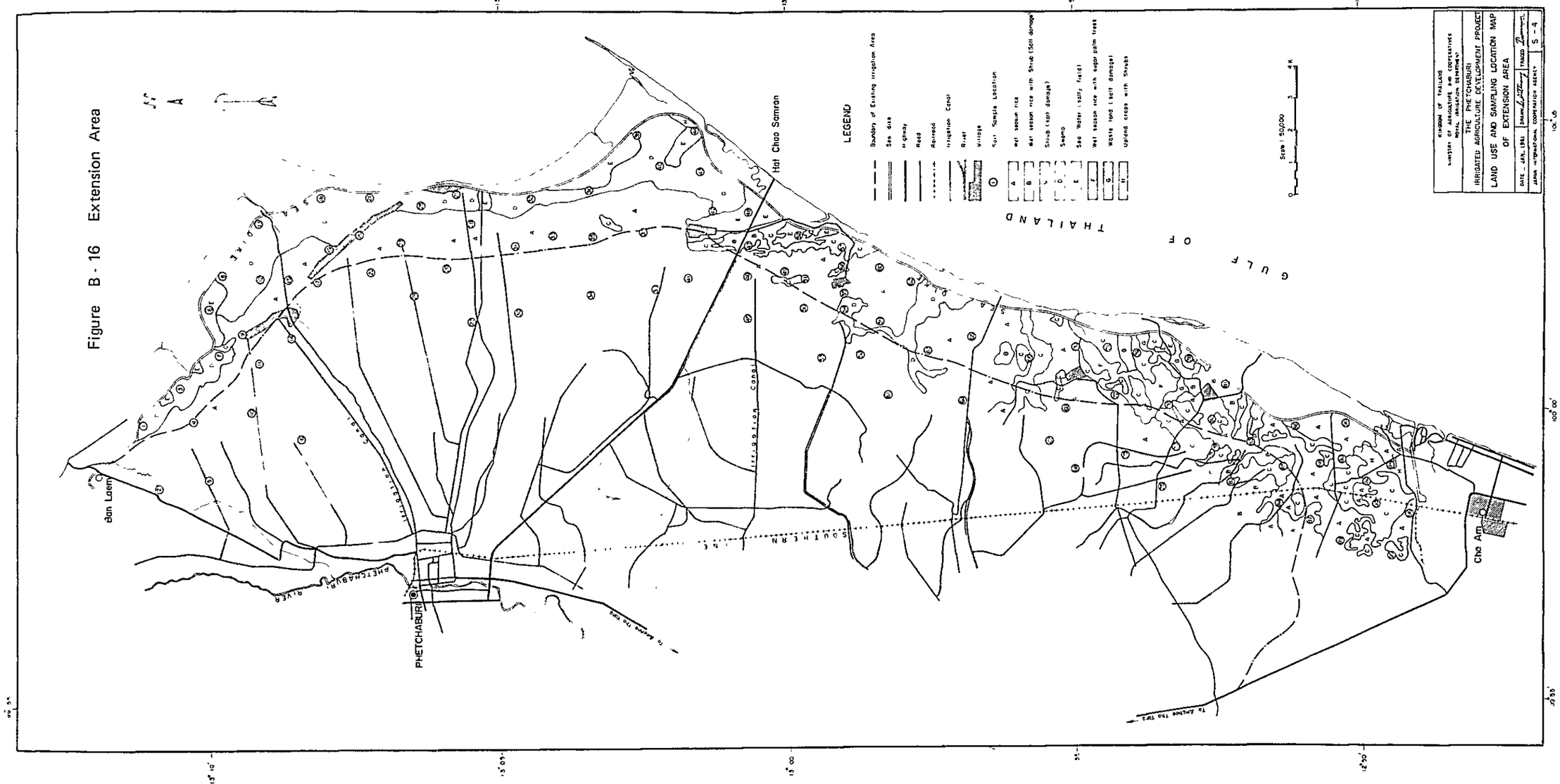
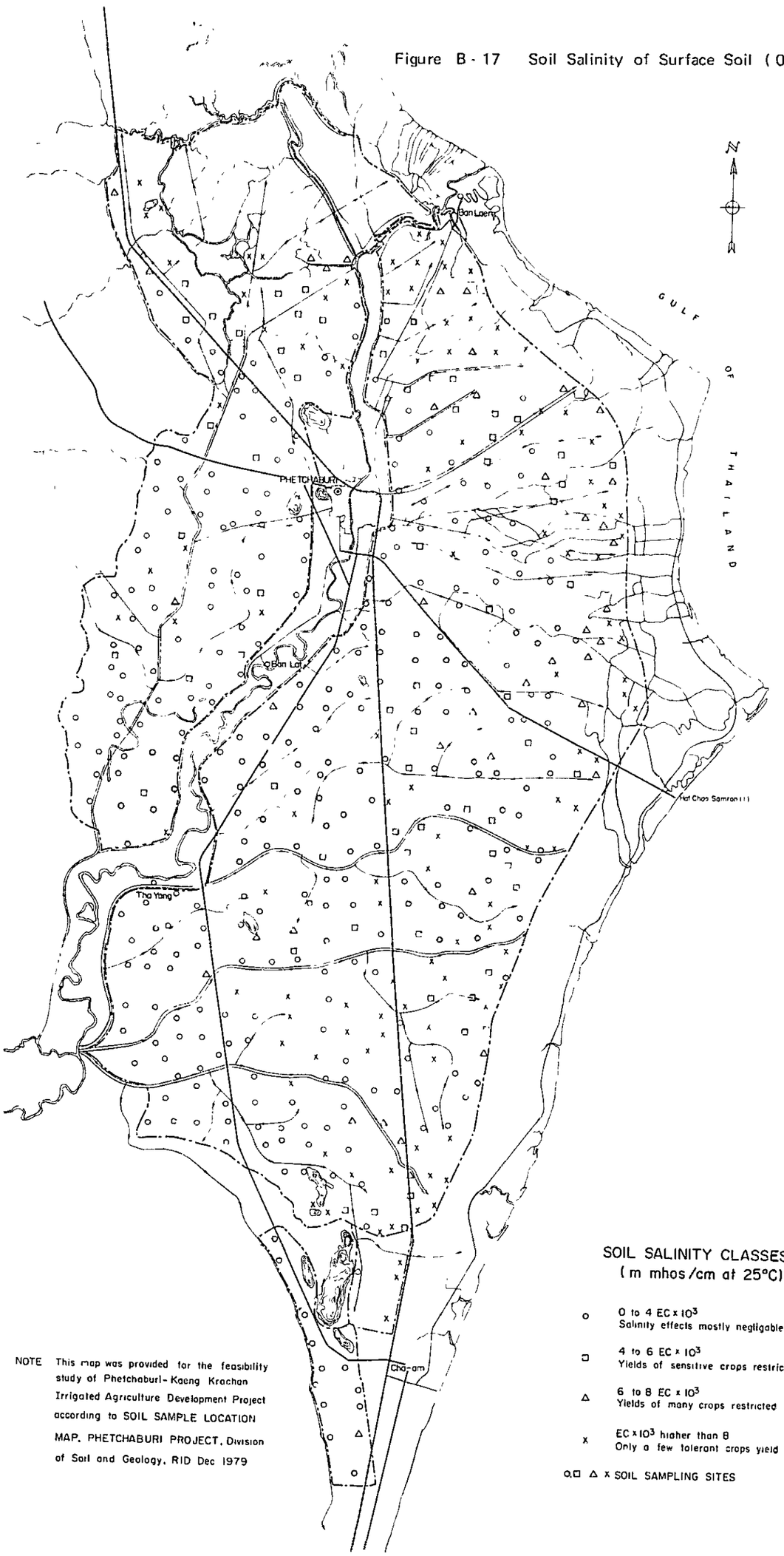


Figure B - 17 Soil Salinity of Surface Soil (0 - 30cm.)



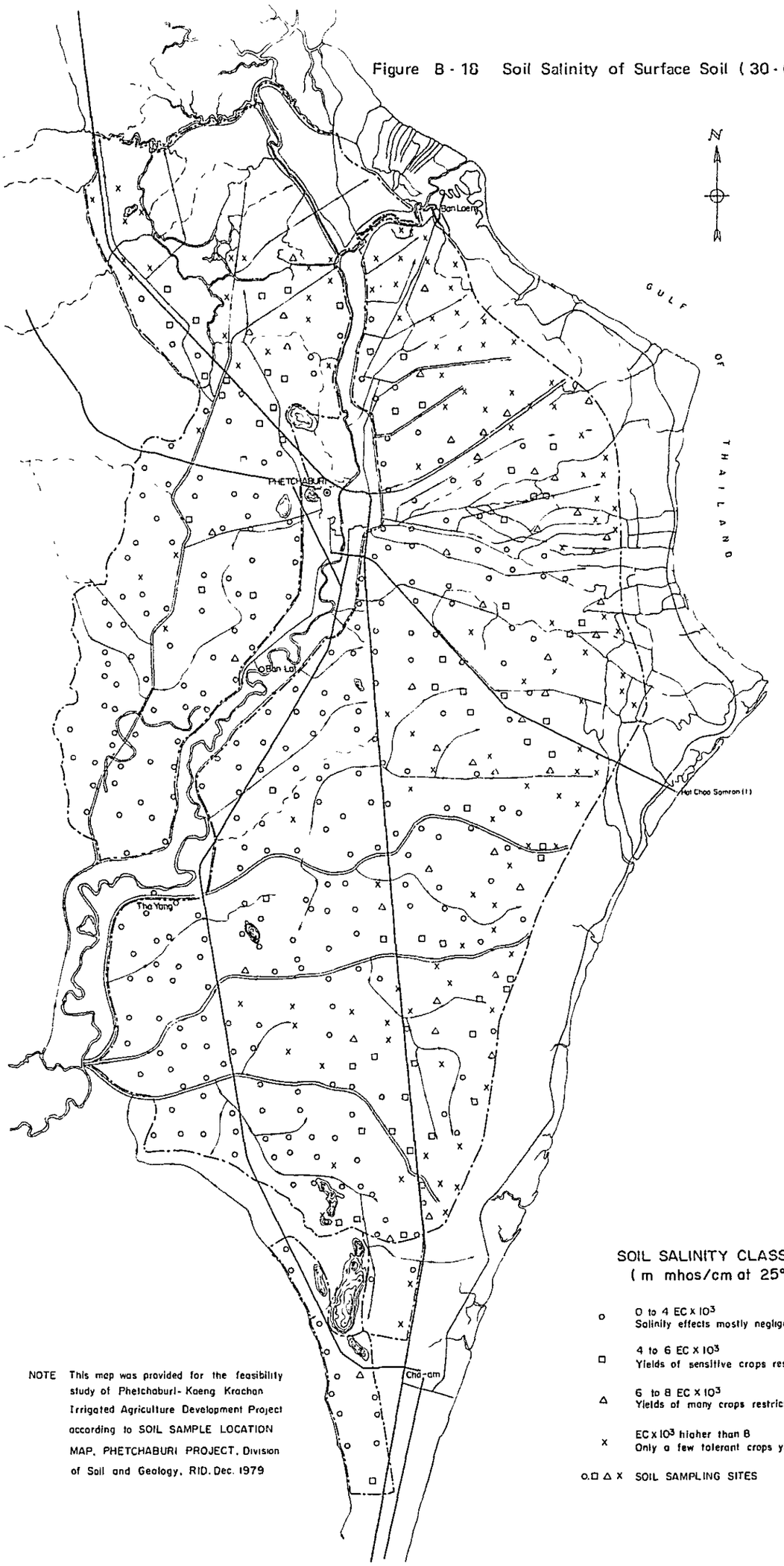
NOTE This map was provided for the feasibility study of Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project according to SOIL SAMPLE LOCATION MAP, PHETCHABURI PROJECT, Division of Soil and Geology, RID Dec 1979

SOIL SALINITY CLASSES
(m mhos/cm at 25°C)

- o 0 to 4 EC x 10^3 Salinity effects mostly negligable
- □ 4 to 6 EC x 10^3 Yields of sensitive crops restricted
- △ 6 to 8 EC x 10^3 Yields of many crops restricted
- x EC x 10^3 higher than 8 Only a few tolerant crops yield satisfactorily

o,□ △ x SOIL SAMPLING SITES

Figure B - 18 Soil Salinity of Surface Soil (30 - 60cm.)



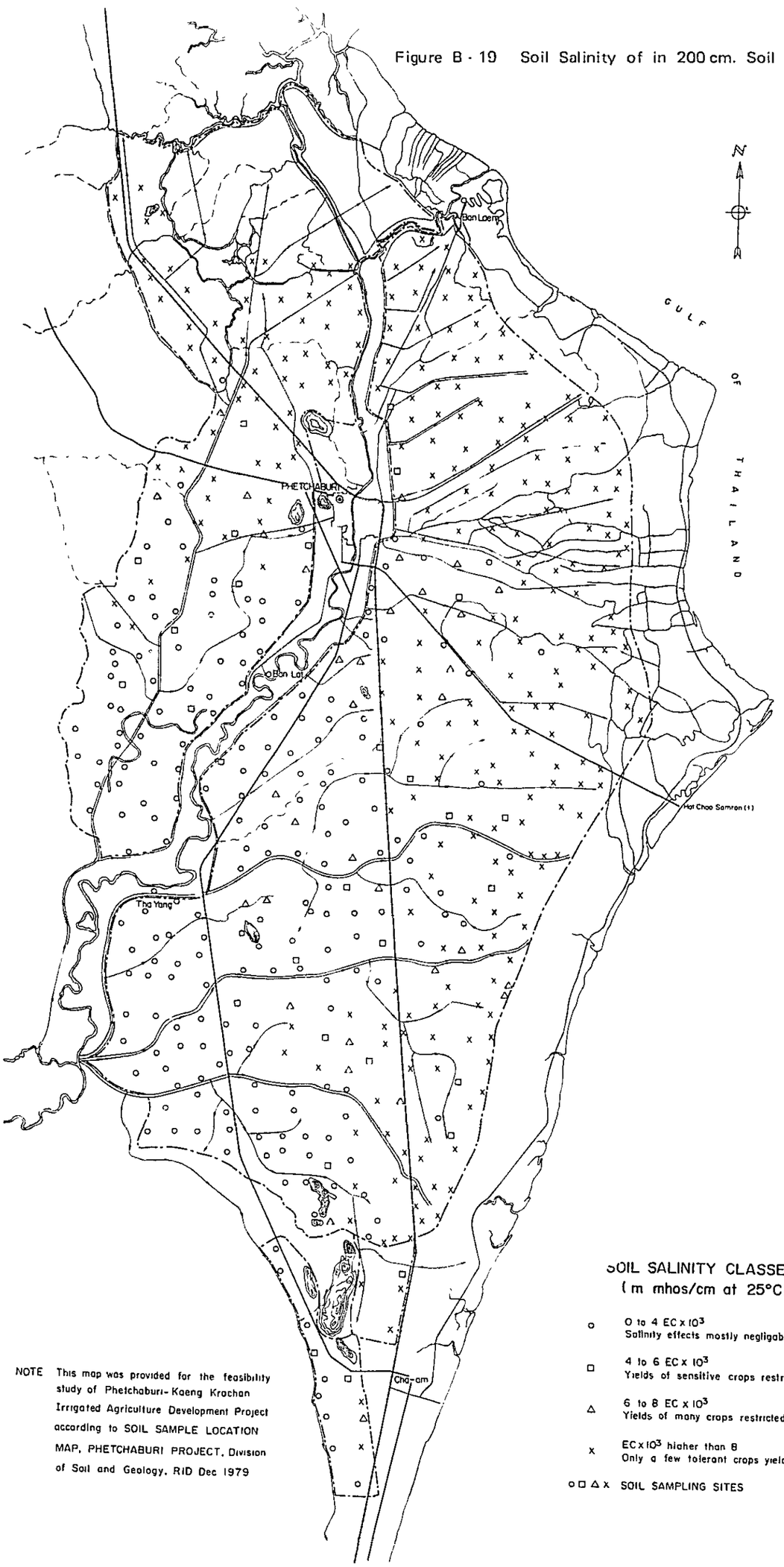
NOTE This map was provided for the feasibility study of Phetchaburi- Kaeng Krachan Irrigated Agriculture Development Project according to SOIL SAMPLE LOCATION MAP, PHETCHABURI PROJECT, Division of Soil and Geology, RID. Dec. 1979

SOIL SALINITY CLASSES
(m mhos/cm at 25°C)

- o — 0 to 4 EC x 10^3 Salinity effects mostly negligable
- □ — 4 to 6 EC x 10^3 Yields of sensitive crops restricted.
- △ — 6 to 8 EC x 10^3 Yields of many crops restricted.
- x — EC x 10^3 higher than 8 Only a few tolerant crops yield satisfactorily

o.□ △ x SOIL SAMPLING SITES

Figure B - 19 Soil Salinity of in 200 cm. Soil Depth



NOTE This map was provided for the feasibility study of Phetchaburi-Kaeng Krachan Irrigated Agriculture Development Project according to SOIL SAMPLE LOCATION MAP, PHETCHABURI PROJECT, Division of Soil and Geology, RID Dec 1979

SOIL SALINITY CLASSES
(m mhos/cm at 25°C)

- o — 0 to 4 EC x 10^3 Salinity effects mostly negligable
- □ — 4 to 6 EC x 10^3 Yields of sensitive crops restricted
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- x — EC x 10^3 higher than 8 Only a few tolerant crops yield satisfactorily

o □ △ x SOIL SAMPLING SITES

APPENDIX C AGRICULTURE

APPENDIX C AGRICULTURE

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APPENDIX C. AGRICULTURE

C-1. Present Land Use

C-1-1. Acreage of the Survey Area

The Project Boundaries were defined according to the newly prepared topo-map at the scale of 1/10,000 by the left bank main canal and the drainage canal for the west, the Klong Ban Noi and the Klong Ban Parak for the north, the existing sea dike for the east and the Hua Hin canal for the east. The objective area for the survey was determined by quadrature on the map as about 74,000 ha conbined by the above boundaries, including the irrigable area along the Hua Hin canal up to 20 km point.

The brekdown of the present land use is tabulated in Table C-1 as a result of estimation by areas commanded by the respective lateral canal systems.

C-1-2. General Descriptions of the Present Land Use

i) Completion of the Kaeng Krachan dam and the related irrigation facilities in 1968 has permitted the irrigated agriculture to be practised for the dry season cropping as well as for the wet season cropping in the Project Area, where the agricultural development has been promoted gradually since then.

ii) The existing farm lands and those available for farming in the Area were estimated at 56,450 ha, equivalent to 76.3 percent of the total land area of 74,000 ha. The wet season cropping covers 95.3 percent of the total farm lands, while the dry season cropping 22.0 percent. For references, the above estimation is based on the presumption that the uplands and the orchards can be utilized in the both seasons, the dry and the rainy.

Recently, however, the consecutive drought years have prevented

the dry season paddy cropping, and in 1981, the dry season paddy cropping has been practised in only 90 ha of the ill-drained fields, which is equivalent to 3.8 percent of the total.

iii) The paddy growing is dominant in the Area, and the rainy season paddy occupies 88.0 percent of the total cropped area, while the dry season paddy does 10.3 percent, and the orchards (4.2 percent), upland crops (3.0 percent) and the second cropping of the paddy growing, respectively. The cropping intensity for these crops has become about 110 percent.

The major tree-crops grown in the orchards are banana, coconut, lemon (manan) and mango. The second crops for the paddy fields are mungo beans, vegetables, etc.

Vegetables grown in the Area are mainly cucumber, shallot, pumpkin, melon, long bean, sugar corn, and some others including groundnut, soybean and sugar cane, which occupy a very small shore of about one percent.

iv) Approximately 90 percent of the rainy season paddy is cropped with the LV, whereas the HYV are found mostly around the naional highway No.3177 in the upstream portions of the main and lateral canals.

v) The dry season paddy has been grown in the same fields that provide a favourable irrigation conditions every year, covering about 10 percent. Such dry season paddy cropping recorded highest for about 8,000 ha in 1979, whereas in 1980 decreased to 5,800 ha and in 1981 sharply dropped to 90 ha due to water shortage by drought.

vi) The fruit-crops like banana, lemon (manan), and mango and upland crops are found mostly in high-lying lands where no gravity irrigation water is available but pumping irrigation.

vii) Coconuts are grown in the plantation scattered in the downstream of the left bank of the main canal, while some are found sporadically around the villages.

viii) Sugar canes are grown in high-lying lands of about 100 ha in Tha Yang and Cha-am in the southern part of the Project Area; however, the said cropping acreage has been prone to decrease recently.

The present land use in the Project Area is illustrated in Figure C-1.

C-1-3. Problems and Countermeasures for Land Use

i) At present, the HYV have been cropped by about 10 percent for the both seasons of the dry and the rainy, respectively. Such a low rate of the HYV diffusion has resulted from not only critical water shortage but poor field conditions that have restricted the timely and adequate irrigation water supply to the fields.

ii) On the other hand, the land use ratio in the downstream areas is remarkably low in resulting in the unfavourable farm management of the local farmers. The major reason of such an inactive farming is the critical water shortage and salt damage.

iii) The cropping in the Project Area, as a whole, is malpractised to a large extent in the dry season due to water shortage, and the fallow lands in the dry season have caused the capirally-rise of the salt which results in the partial salt damage by the secondary

salt accumulation on the ground surface.

The single cropping paddy yields should be drained immediately after harvesting the rainy season cropping and be plowed to interrupt the capillary-rize of the salt for preventing the secondary accumulation of the salt on the ground surface.

iv) The staged improvement of the yield conditions as countermeasures for the aforesaid items i) and ii) will be the prerequisites to the Project.

The first stage of the improvement will aim at eliminating the difficulties in irrigation by means of rehabilitation of the canals. The rehabilitation should be carried out so that the water level in the terminal point of the farm ditch can hold at least 20 cm higher than the paddy field surface to be irrigated.

Next comes the improvement of the drainage facilities. The water over allowable inundation depth gives harm to the paddy plants in their growing, in particular, flooding over the plants immediately after transplantation will severely damage the plants. Furthermore, unnecessary standing water in the fields will promote the secondary soil salinization of the fields. The drainage improvement is essetial to prevent such damages to the plants as well as the irrigation improvement.

The drainage improvement should be planned based not only on the prevention of inundation but on the principle of soil management and effective farming practices along with the growth stage of the plants.

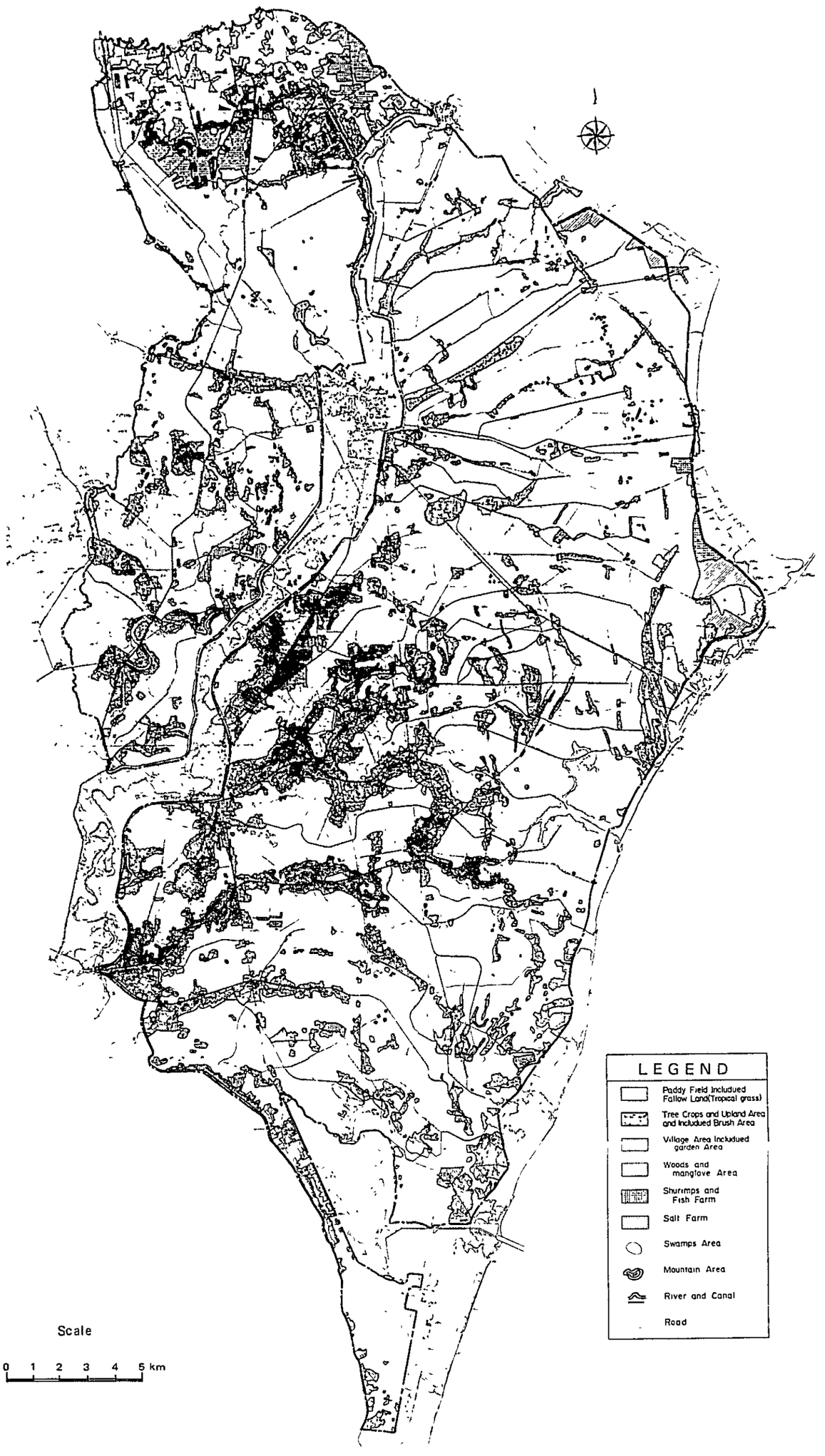
Especially, the Project Area, suffering from critical water shortage, should be developed with prudence for recycling use of the drained water as return flow to the fields.

Table C-1 Present Land Use

- Unit: ha -

Item / Area	Gross Area (1)	Arable Area								Non Arable Area					
		Paddy				Upland Crops (6)	Tree Crops (7)	Fallow Land (8)	Sub-total (9)	Road, Canal & River (10)	Salt Farm (11)	Shrimp and Fishpond (12)	Village (13)	Others (14)	Sub-total (15)
		Wet Season (2)	Dry Season												
			Paddy (3)	Upland Crops (4)	Fallow (5)										
Left Bank Area	19,800	11,400	1,220	880	9,300	150	580	1,860	13,990	1,040	-	320	1,220	3,230	5,810
Right Bank Area	44,100	30,970	4,600	1,640	24,730	1,550	1,820	520	34,860	3,790	-	-	2,850	2,600	9,240
Sea Dike Area	10,100	7,300	-	-	7,300	-	-	300	7,600	90	430	100	400	1,480	2,500
Total (ha)	74,000	49,670	5,820	2,520	41,330	1,700	2,400	2,680	56,450	4,920	430	420	4,470	7,310	17,550
(Rai)	(462,500)	(310,438)	(36,375)	(15,750)	(258,312)	(10,625)	(15,000)	(16,750)	(352,813)	(30,750)	(2,688)	(2,625)	(27,937)	(45,687)	(109,688)
%	100.0	67.2	7.9	3.4	55.9	2.3	3.2	3.6	76.3	6.6	0.6	0.6	6.0	9.9	23.7

Figure C - 1 Present Land Use Map



C-2. Present Field Husbandry and Cropping Pattern

C-2-1. Outline of Present Field Husbandry

The present field husbandry in the Project Area is outlined on the existing major crops and promising crops in future according to the results of farm economic survey and interviews with representatives of the extension agents.

(1) The rainy season paddy: The rainy season paddy (transplanting in single cropping is most popular in the Area, and the LV are mainly grown (90 percent), while the HYV (10 percent) grown in the fields where the irrigation water is sufficient and other field conditions are favourable.

The rapid diffusion of the HYV can not be anticipated in the Area due to critical water shortage, poor field conditions and lack of farming machines, although every possible effort has been made for extension.

Nursery: The nursery periods for the LV and HYV are 30 days and 25 days, respectively, and the nursery bedding has been carried out in June for the former and in July for the latter. The nursery works are carried out individually in the sufficiently irrigable fields of the farmers' own, through plowing, irrigating, fertilizing, levelling and seeding which is made for the total nursery fields. The seeds required for nursery are 70 kg/ha (11.2 kg/rai) for the LV and 60 kg/ha (9.6 kg/rai) for the HYV. Such seeds are sown after strict selecting, soaking in the water for three to five days, and germination.

Field works for the nursery beds include irrigation, fertilization and weeding. The fertilizer applied in this stage is ammophose, uria.

Preparation of transplanting: Land preparation of the transplanting is practised through one plowing, land soaking, and puddling, and then the transplanting is carried out. Plowing is done about one month before transplanting. The single paddy cropping fields are sometimes plowed two to three months before transplanting (50 percent).

The power tillers or buffaloes are used for plowing and puddling practised one month before transplanting, although the first plowing is sometimes made by large-sized tractor.

Intervals between plowing and puddling take one to two weeks on an average, and the basal fertilizers are dosed before puddling, and irrigation, puddling and land leveling preceed to transplanting.

Transplanting: Young seedlings are picked up after flooding in the nursery beds, and the seedlings are bound into bundles with about five cm diameter. The seedlings, hauled in bundles to the fields, are transplanted.

Transplanting spaces are as follows;

LV : 30 cm x 25 cm 13.3 hills/m^2

HYV : 25 cm x 25 cm 16 hills/m^2

(Transplanting at random)

One hill includes 3-5 seedlings.

Transplanting is practised usually under mutual help of farmers (so-called "Long Kag" in Thai). Poorly irrigated fields tend to delay in transplanting and over-grown seedlings are transplanted with their leaf tops cut. Poor land leveling has forced the farmers to transplant in deep water or contrarily in shallow. For some poorly irrigated fields by gravity, irrigation is made by portable pump for transplanting.

Commonly, 3.7 farmers are engaged in transplanting for one rai including seedling pick-up, and the transplanting period is ordinarily July for the LV and August to September for the HYV.

Irrigation and drainage: The paddy plant growth takes 130 days for the LV and 110 days for the HYV, and the stage-wise days and the irrigation days required are shown as follows:

Stage	HYV	LV
Nursery period	25 days	30 days
Total growing period	110 days	130 days
Maturling period	20 days	20 days
Intermittent drainage	10 days	10 days
Irrigation period	80 days	100 days

- Fertilization/Pest control: For the LV, little fertilization is carried out, and ammophose (16-20-0) is applied by 60 kg/ha, when fertilized. For the HYV, ammophose is applied by 200 kg/ha, but no routine pest control is practised, unless otherwise pest takes place in large scale.
- Weed control: No herbicides are applied for weed control and manual weeding is carried once or twice for the plant growing period by labourers of five to six per ha.

Reaping and harvesting: About 10 days before reaping, all paddy plants in the fields are made to be manually lodged[1/] toward

1/ This work will prevent paddy grains from shattering and facilitate the reaping works.

one direction with bamboo poles. The works can be exercised more effectively when the morning dews are lying on the plants. One or two weeks later, the lodged paddy plants are reaped in the middle of stems manually and then bound into bundles in 20-30 cm diameter. After being dried up for four to five days in the fields, the bundles of paddy are piled up on the footpaths and/or well-dryed fields. All of these works are practised under mutual help - "Long Kag". Threshing and winnowing are carried out in the spatial working lots around the farm houses or specifically provided working lots. The bundles of paddy carried by power tillers or tractors are spread thinly over the working lots so that power tillers or threshing carts drawn by animals can tread to thresh. After threshing, winnowing is practised by wind or winnowing equipment. The winnowed paddy grains are packed up and barned. Some farmers, who have no storage facilities, sell the paddy harvested to the merchants or ricemill owners in the fields immediately after harvesting.

Reaping and harvesting works have been done mostly under "Long Kag", which offers labor without any wage payment but meal services.

Direct sowing of wet season paddy: Direct sowing of the RD strains has been encouraged recently and practised in the Central Plain, especially in Kamphaen Saeng where the method has been applied in a large scale with the dry season paddy. In 1980, the Chao Phya Pilot Farm took up the direct sowing in its experimental cultivation in full scale. The direct sowing, which can save labors of 25 persons/ha for transplanting and four persons/ha for the nursing works, has been employed in the case where the transplanting is prone to be delayed due to delayed irrigation water supply. In the Project Area, HYV for the rainy season cropping has been directly sown in the fields along the national highway No.3177.

Preparation of sowing: The land preparation for direct sowing, similar to that for transplanting, has been carried out through plowing, flooding and leveling. The leveling works are required to be made with considerably high precision that can keep water depth about one centimeter evenly over the fields; otherwise, the deep water, if happens, will delay in germination, resulting in poor harvest. The basal fertilizers are applied in the second land leveling.

Sowing: After levelling and flooding in the fields, the seeds are broadcasted in the fields with water one to two cm in the depth. The seeds, selected and soaked, are broadcasted by 70-80 kg/ha, which will be spread over the field at the rate of about 140 grains/sq.m. In the case, taking the germination ratio by 70 percent, there will grow about 100 seedlings and can secure the necessary number of plants in total for the average harvesting.

Drainage: For germination and rooting of the plants, the irrigation water should be kept in the fields in comparatively deep water, and from seven to 10 days after sowing, the drainage should be so carried out as to dry up the fields resulting in cracks. And the further processes are the same as the way taken for the transplanting paddy cropping.

Harvesting: When the harvesting is carried out, the RD strains should be sown by 20th August, at the latest.

Yield: The target yield can be set up at four tons/ha with considerable labor savings.

(2) Dry season paddy: The low photosensitivity HYV are employed for the dry season paddy cropping. The farming practices for the dry season cropping are almost the same as those for the rainy season, although some exceptions exist as follows:

	Dry	LV (Rainy)	HYV (Rainy)
Nursery period	20 days	30 days	25 days
Transplanting period	Feb.-Mar.	Jul.-Aug.	August
Fertilization (ammophose)	200 kg/ha	Almost nil	200 kg/ha
Harvesting	Jun.-Jul.	December	Nov.-Dec.

(3) Mungbeans: Mungbean is grown by about four percent for the paddy fields as dry season crop, being a major cash income source of the farmers. In January, paddy fields are plowed twice by power tillers or tractors and sown with bean seeds at 30 kg/ha. Furrow irrigation is carried out on necessity and some pest controls may be practised on onece or twice for aphid control. April to May, matured beans in shell are plucked by hands in two harvesting, and plucked shells are dried and threshed. The pluckers required for one ha harvesting are about 30-40 persons.

Soybean cropping is carried out almost in the same way as mungbean cropping, and harvesting is practised by pulling out the total plants to be dried and threshed. Groundnut is commonly grown in paddy fields as dry season crop, sometimes in upland fields, and the harvested nuts are sold in shell. Sorghum is cropped as edible cereals (boiled).

(4) Vegetable: Vegetables are cropped in paddy fields as dry season crops as well as in upland fields. In the upland fields, tree crops are also grown. Vegetables cropped include

melon, cabbage, horse ruddish, chinese cabbage, shallot, etc.

Irrigation for the vegetable growing is carried out from time to time in the dry season.

(5) Fruit-trees and other tree crops: Banana, mango, lime, coconut, sugar plam, etc. are major fruit-and tree-crops in the Project Area.

Banana is grown for about 10 years by ratooning system, after planted, and in the dry season, irrigation is carried out by hose watering at the 10 - 15 day intervals. For poorly irrigated lands, water is supplied by pumps from the canals or whereas weighing is made in a small bunch. The price in the market are quoted on the small bunch basis.

Coconut and sugar palm are mostly grown in plantations in the left bank downstream, excepting some found in the paddy fields or around the farm houses in bush. Taking about 10 years to grow in full, they can bear fruits for about 50 years.

Mango takes about five years to reach the matured tree and can bear fruits for about 30 years.

Lime, growing in full about three years after planting, can bear fruits for about 20 years.

The yields of the respective tree-crops and productive tree ages are surveyed through interviews with extension agents.

Tree Crops	Yield t/ha	Productive Tree Age years
Coconut	5 - 6	20
Sugar Palm	-	-
Lime	50	10
Mango	50	10
Banana	3 - 4	-
Pineapple	20 - 30	-
Other Crops		
Groundnut	3 - 4	(therophyte, in shell)
Cotton	1.4 -1.5	"
Cassava	18 - 20	"
Sweet Potato	15 - 20	"
Caire	5 - 10	

C-2-2. Problems in Present Field Husbandry and Countermeasures

This paragraph covers the problems pointed out on the present field husbandry and their countermeasures to be taken.

1) The diffusion ratio of the LV and the HYV in the rainy season paddy cropping is 90 to 10, and the low diffusion rate of the improved varieties might result from that the field conditions would not be favourably provided to introduce the water evenly in the fields as prerequisite of the HYV cropping of the paddy growing would have been restricted centering around rainy season LV due to absolute shortage in water, in spite of 10 years elapsion after completion of the Project. In general, however, harvest of the HYV is poorer than that of the LV.

2) The field investigation found that the harvesting of the HYV is relatively low compared with that of the LV. For the both varieties, heading and ripening are very poor resulting in recovering growth of heads with many abortive grains. Such poor harvests would be caused from damages in the early growth stage which suggest water shortage, unfavourable inundation, poor land leveling, etc. In particular, the HYV, being vulnerable to these poor conditions, severely suffer from the damages with many abortion plants.

3) The farming machines for land preparation are misused to make land leveling poor (When plowing, the earth is moved at one side). The rotary harrow should be used for land leveling instead of tooth harrow, and a large lump of the earth should be moved by drawing the bars to improve the land preparation techniques.

4) The puddling works made by one power tiller for one ha/day means that the quality in leveling will be low. The farmers, however, are quite indifferent in transplanting for paddy plants wherever the water is deep or shallow. A great care should be paid to this respect as well.

5) Nursery should be made in the collective bedding fields for efficient water use, application of advanced techniques, and so forth.

6) The regular transplanting method should be employed for keeping the number of plants on a certain level and the planned paddy cropping available with successful extension services.

C-2-3. Present Cropping Pattern and Cropping Acreage

The present cropping acreage was estimated based on the table of the present land use, the crop-wise cropping acreage table prepared and the table of the relevant productions prepared by the RID field office (see Table C-1), while the present cropping pattern was composed on the basis of the present fields husbandry and the farm economic survey. The said cropping pattern and the cropping calendar are illustrated in Figure C-2.

C-2-4. Present Crop-wise Productions

The present yields as the base of the estimation of the present crop-wise productions are prepared as shown in Table C-2 in referring the following materials.

i) Crop-wise cropping acreages and productions by RID.

ii) Farm economy analysis (Interview with 300 farm households)

iii) Relationship between Salinity concentration in the soils and the yields of the crops by RID.

iv) Interview records with extension offices in Changwat and Amphoe.

v) Results of field surveys on yields.

Figure C-2 Present Cropping Pattern and Calendar

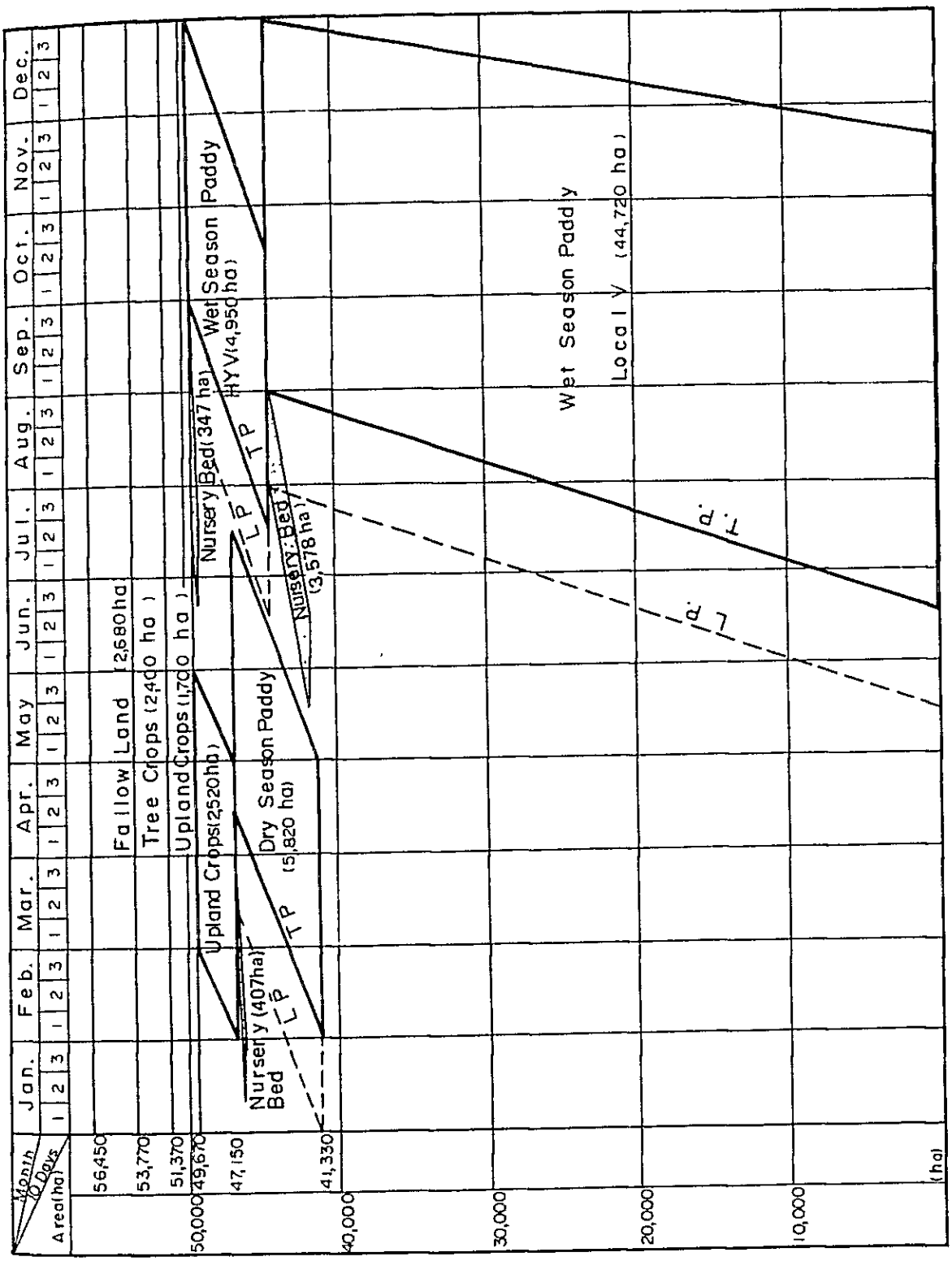


Table C-2 Present Crop Yields and Productions

Crops	Cultivated Area ha (rai)	Yield tons/ha	Production tons	Remarks
1. Paddy Field				
°Paddy, L.V. (Rainy Season)	44,720 (279,500)	2.17	97,042	
°Paddy, H.Y.V. (Rainy Season)	4,950 (30,938)	2.90	14,355	
°Paddy, H.Y.V. (Dry Season)	5,820 (36,375)	3.00	17,460	
Paddy Total	55,490 (346,813)	2.32	128,857	
°Mungbeans, Vegetable	2,520 (15,750)	0.60	1,512	by Mungbeans
2. Upland Field				
°Vegetable and Others	1,700 (10,625)	9.00x2	30,600	by Cucumber
3. Tree Crops Field				
°Banan	1,200 (7,500)	5.00	6,000	
°Coconuts	1,000 (6,250)	4.00	4,000	
°Others	200 (1,250)	5.00	1,000	by Lemon
Total	62,110 (388,188)	-	-	

C-3. Present Input Amounts by Crops

The following table was prepared according to the results of farm economic survey, interviews with local extension agents, and cooperative staff, etc.

Table C-3 Seeds

Paddy	Rainy Season Local	70 kg/ha	12 kg/Rai	Water Nursery
	H.Y.V.	60 "	10 "	
	Dry Season H.Y.V.	60 "	10 "	
Mungbeans		50 "	8 "	Broadcasting
		30 "	5 "	Low Seeding
Vegetable Cucumber		12.5 ℓ	2 ℓ	
		4 "	0.6 "	Seedling
Sugar Cane		20,000 pice	3,200 pice	1.3^m x 0.38^m
Lemon (Manau)		625 "	100 "	4^m x 4^m
Banana		2,500 "	400 "	2^m x 2^m
Coconuts		200 "	32 "	10^m x 5^m

Table C-4 Fertilizer

Paddy	Rainy Season Local	60 kg/ha	9.6 kg/Rai	Ammophose
	H.Y.V.	200 "	32 "	"
	Dry Season H.Y.V.	250 "	40 "	"
Vegetable (1 Crop)		600 "	96 "	"
		10 t/ha	1.6 t/Rai	Compost
Sugar Cane		625 kg/ha	100 kg/Rai	Ammophose
		10 t/ha	1.6 t/Rai	Sugar Cake
Banana		200 kg/ha	32 kg/Rai	Ammophose

Table C-5. Agri-chemical

		Insecticides	Fungicides	Herbicides
Paddy	Rainy Season Local	-	-	-
	H.Y.V.	Malathion Liquid 3 ℓ/ha	Kitagin Powder 10 ℓ	Macette Powder 12.5 ℓ/ha
	Dry Season H.Y.V.	"	"	"
Mungbeans		Malathion Liquid 3 ℓ/ha	-	-
Vagetable		Sumithion 3 ℓ/ha	-	Macette Powder 12.5 ℓ/ha
Lemon (Manan)		"	-	"

Table C-6 Farm Machinery and Building Cost (฿)

Item Machinery and Tools	Holding per Farmer	Holding Per ha	Price	Value per ha	Durable Years	Repayment Cost per ha per year	Remarks
65 H°Class Tractor	0.0055	0.00176	400,000	704	7	154	(0.219117)
Powtiller (8-10 H°)	0.1793	0.0573	25,000	1,432	7	314	"(Domestic)
Small Pump (2-3 H°)	0.224	0.0716	5,000	358	17	50	(0.140456) With Engine
Sprayer	0.450	0.1438	1,000	144	5	29	
Cart (by man power)	0.250	0.0798	1,000	80	9	9	
Sickle	2.860	0.9147	30	27	4	7	
Knife	1.580	0.5048	20	10	4	3	
Hoe	4.720	1.508	50	75	6	13	
Shovel	0.810	0.259	100	26	5	5	
Spade	1.190	0.380	100	38	6	7	
Farrow 1 Set (by Animal)	0.500	0.159	1,000	160	9	18	
Wind	0.442	0.141	500	71	7	10	
Others	-	-	-	100	5	20	
Sub-total						639	
Barn	10,000 ฿	3,195 ฿	-	3,195	40	388	(0.121303)
Other Materials	300	96	-	96	-	96	
Fuel	200	64	-	11	704	704	
Sub-total	15,000	3,355			3,995	1,188	

Cultivated Area Per Farmer: -3.13 ha Interest 12% ( ): - Repayment Ratio

C-4. Present Farm Labor Demand and Farm Mechanization

C-4-1. Total Population and Farming Population in the Project Area

The population of the Project Area, excepting for Phetchaburi city and the area around the river, is shown as follows:

Population	158,666	Persons
No. of Households	26,474	Households
Persons per Household	5.99	Persons
Rate of Male and Female	Male 47.9 Female 52.1	
No. of Farm Households	17,920	Households
Farm Household Ratio	67.7	%
Cultivated Land in the Project Area	56,450	ha
Average Operated Acreage per Farmer	3.15	ha

Source: Rural Community Survey by Ministry of Interior (1978)

Workable Population in Farming

	Grand Total	Male	Female
	Persons	Persons	Persons
Age: 15 - 65	58,944	28,234	30,710

Animals Available for Farming Works

No. of Animals Fed	Buffaloes 1,147 head	Cattle 34,248 head	
Rats of Animals workable	65 %	30 %	
No. of Animals workable	745	10,274	
No. of Workable Animals	745	5,137	Total 5,882 heads

Number of Farming Machines Owned by Farmers

Registered at Changwat Survey	1975/6	6/7	7/8	8/9	9/0	0/1		
Large-sized Tractors (65 H°clall)	112	116	126	130	136	165	20 %	increase
Power tillers (8-10 H°class)	1,896	2,406	2,590	3,461	4,364	5,500	30 %	"

In estimating that about 50 percent of the total number of the farming machins in Changwat is operated in the Project Area, 2,750 power tillers and 83 tractors, are available.

Convertible capacity of farming machines from draft animals

	Plow	Land Preparation	Average
One animal {Drawn by one buffalo	0.16 ha/day	0.16 ha/day	0.16 ha/day
One animal {Drawn by two cattles			
Power tiller 1 unit	0.5 ha/day	0.7 ha/day	0.6 ha/day

For 2.5 months of puddling works (Operative in 67 percent) — 50 day operation

One Animal	4ha(50days x 1/2 x 0.16ha/day)x5,882	=23,528ha 44%
One power tiller	15ha(50days x 1/2 x 0.6ha/day)x2,750x0.75=30,094ha	56%
Total		53,622ha

For 1.5 months of puddling works (Opertive in 80 percent) — 36 day operation

One Animal	2.88ha(36days x 1/2 x 0.16ha/day)x5,882	=16,940ha
One Power Tiller	10.8ha(36days x 1/2 x 0.6ha/day)x2,750x0.75=22,275ha	

Shortage by 21 % for 49,760

C-4-2. Labor Requirement for the Present Crop Growing

The crop-wise labor demands were estimated based on the present field husbandry, farm economic survey, interviews with extension agents, data and information prepared by RID, and the results are tabulated by present cropping calendar and the cropping pattern in Table C-7.

For tabulation of the above, the family labor, being taken by three persons per family, was estimated as input for 150 days for the cropping throughout the year, while 75 days for the cropping a half of the year.

The hired labors should be employed to cover the shortage of the family labor and the farming machines should be used with powertillers for six hours operation/day, while the draft animals were counted by four buffaloes to be equivalent in capacity to one power tiller and eight cattle to one power tiller. One large-sized tractor could cover the total capacity of six power tillers.

According to Table C-7, the crop-wise labor demand by seasons (per ha) were estimated and shown in Table C-8.

Table C-8 was further developed to the total labor demand and farming machine requirements in the Project Area in referring to the proposed cropping pattern, and are illustrated Tables C-9 and C-10 and Figures C-3 and C-4.

C-4-3. Balance of Present Farm Labor and Farming Machines

The following matters can be interpreted from Figures C-3 and C-4.

i) The labor demand comes to its peak twice a year, June to August and November to December, although the latter peak is slightly higher than the former.

ii) The present labor available in the Project Area is estimated at 442,400 persons for 10 days, which exceed the peak demand.

iii) The demand of farming machines comes to its peak in May to July and December, although the former lasts long and is stronger in intensity than the latter.

iv) The farming machines will be employed in the combination of the large-sized tractor, power tiller and draft animals. And eight cattle can be one power tiller in capacity, while four buffaloes do so. And six power tillers can be one large-sized tractor in capacity. The supply in 1981 will be available by 5,880 units in the various conbination, which can sufficiently cover the demand.

As learned comprehensively from the above, the supply of farm labor and the farming machines has sufficiently meet the requirements in the Project Area. Contrarily in the dry season supply of the labor and machines brings about surplus to a certain extent due to restricted cropping by limited water supply.

Table C-7-1 Present Farming Practices and Requirements

Crops(Item)	Nursery Works / Variety	Land Preparation: Plowing	Furrowing	Manure and Fertilizing Puddling	Seeding or Transplanting x Random	Irrigation and Drainage	Weeding and Cultivation	Manureing and Fertilizing 10kg(t/rai)	Chemical Spraying	Harvesting: Cutting Bundling	Threshing 2.3t.yield/ha	Others	Total	Family Labor	Hired Labor
Rainy Season Transplanting															
Local															
Period (month)	Jun.-Jul. 30days	5	6	7	6-8	7-8	7-9	6.8	7.9	12.1	12.1	-	-	-	-
Times	24wa/rai	1	1	1	30cm x 25cm	-	2	1	1	-	kg/rai	-	-	-	-
Manpower	5	3	3	3	23	4	5	2	1	28	7	1	85	59	26
Animal	-	1	1	1	-	-	-	-	-	-	-	1	4	1	3
Machinery	1	2	2	1	-	-	-	-	-	-	2	-	8	5	3
New Variety (HYV)															
Period	7	6	7	8	7-9	8	8-9	8-9	8-10	12	12	-	-	-	-
Times	20wa/rai	1	1	1	25cm x 25cm	-	-	-	-	-	2.5t/ha	-	-	-	-
Manpower	5	3	3	4	26	4	5	2	2	33	9	1	97	68	29
Animal	-	1	1	1	-	-	-	-	-	-	-	1	4	1	3
Machinery	1	2	2	2	-	-	-	-	-	-	2	-	9	6	3
Dry season Transplanting (HYV)															
Period	2	1-2	2	3	2-3	3-5	3-4	3-4	3-5	6	6	6	-	-	-
Times	20wa/rai	1	1	1	25cm x 25cm	-	2	1	2	-	3.0t/ha	-	-	-	-
Manpower	5	3	3	4	29	7	5	2	2	33	9	1	103	57	46
Animal	-	1	1	1	-		-	-	-	-	-	1	4	1	3
Machinery	1	2	2	2	-	2	-	-	-	-	2	-	11	8	3
Sugar Cane (Planting)															
Period	3-4	1-2	2-4	5-6	5-6	-	5-8	6-8	6-8	11-4	-	11-4	-	-	-
Times	wa/rai	-	-	-	40 x 135 18,500piece/ha	-	-	-	-	-	50°t	-	-	-	-
Manpower	4	3	3	3	20	-	37	3	1	32	-	4	110	60	50
Animal	-	-	-	-	2	-	2	1	-	1	-	1	7	1	6
Machinery	-	6hour	5H	5H	-	-	-	-	-	-	-	-	16hour	-	16hour
Sugar Cane (Ratooning)															
Period	-	-	-	-	-	-	3-4	-	-	-	-	-	-	-	-
Times	wa/rai	-	-	-	$(kg)^2$/Rai	-	-	-	-	-	50t/ha	-	-	-	-
Manpower	-	-	-	-	-	-	36	3	1	32	-	4	76	30	46
Animal	-	-	-	-	-	-	2	1	-	1	-	1	5	5	0
Machinery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C-7-2 Present Farming Practices and Requirements

Crops(Item)	Nursery Works Variety	Land Preparation: Plowing	Furrowing	Manure and Fertilizing Puddling t/Rai	Seeding or Transplanting o Row Planting x Random	Irrigation and Drainage	Weeding and Cultivation	Manureing and Fertilizing name t/Rai	Chemical Spraying name t/Rai	Harvesting: Cutting Bundling	Threshing yield t/ha	Others	Total	Family Labor	Hired Labor
Banana															
Period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower	-	10	10	14	13	37	82	40	-	14	-	-	220	97	123
Animal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	1	1	1	-	4	-	-	-	-	-	-	7	-	7
Lime(Lemon)															
Period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower	-	2	-	-	22	30	39	6	35	44	-	7	185	97	88
Animal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	2	-	-	-	20	5	-	-	-	-	-	27	-	27
Cucumber															
Period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower	-	12	12	12	20	80	70	11	2	61	-	4	284	142	142
Animal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	1	-	1	-	1	4	-	1	-	-	-	8	8	-
Mungbeans															
Period	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower	-	3	-	3	-	1	1	1	1	42	7	-	59	39	20
Animal	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery	-	3	-	5	-	-	-	-	-	-	-	-	8	8	-

Table C-8 Present Labor Requirement Per ha

Item			Month / 10days	Jan. 1	Jan. 2	Jan. 3	Feb. 1	Feb. 2	Feb. 3	Mar. 1	Mar. 2	Mar. 3	Apr. 1	Apr. 2	Apr. 3	May 1	May 2	May 3	Jun. 1	Jun. 2	Jun. 3	Jul. 1	Jul. 2	Jul. 3	Aug. 1	Aug. 2	Aug. 3	Sep. 1	Sep. 2	Sep. 3	Oct. 1	Oct. 2	Oct. 3	Nov. 1	Nov. 2	Nov. 3	Dec. 1	Dec. 2	Dec. 3	Total
Paddy	Rainy Season	Local	Manpower		1											1	1	1	1	4	6	6	6	6	6	6	4	2	2	2		2	2	2	2	7	6	6	3	85
			Machine													1	1	1	1	1	1	1	1	1	1	1	1									1	1		11
		HYV	Manpower		1											1	1	2	4	6	6	6	6	6	6	6	2	2	2	2	1	1	3	10	10	10	3	97
			Machine													1	1	1	1	1	1	1	1	1	1										1	1		12
	Dry Season	HYV	Manpower	1	1	4	5	8	8	8	8	8	5	4	4	4	4	5	8	8	8	2																103
			Machine	1	1	1	2	2	1	1	1	1	1						1	1	1																	15
Upland Crops	Mungbeans		Manpower		1	1	2	2	2		1	1	1	1				10	21	10	6																	59
			Machine		1	1	2	2	2										1	1	1																	8
	Vegetalbe		Manpower	5	5	5	5	5	5	10	10	10	10	5	5	5	5	5	10	10	10	5	5	5	5	5	5	8	8	8	10	10	10	15	15	15	10	10	10	284
			Machine							1	1	1						1	1															1	1	1				8
Tree Crops	Banana			2	2	2	4	5	5	8	8	8	5	5	5	10	10	10	10	10	10	10	10	10	9	4	4	5	5	5	4	4	4	4	4	4	5	5	5	220
																1	1	1	1			1	1	1																7
	Coconuts			2	2	1	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2							1	1	1	2	2	2	2	2	2	50
																	1	1																						2
	Lemon			2	2	2	4	5	5	5	5	5	10	10	10	6	6	6	5	5	5	4	4	4	6	6	6	4	4	4	5	5	5	6	6	6	4	4	4	185
							1	1	1	1	1	1	2	2	2	1	1	1	1	1	1				1	1	1				1	1	1	1	1	1				27

Table C-9 Present Labor Requirement

Unit: day/man

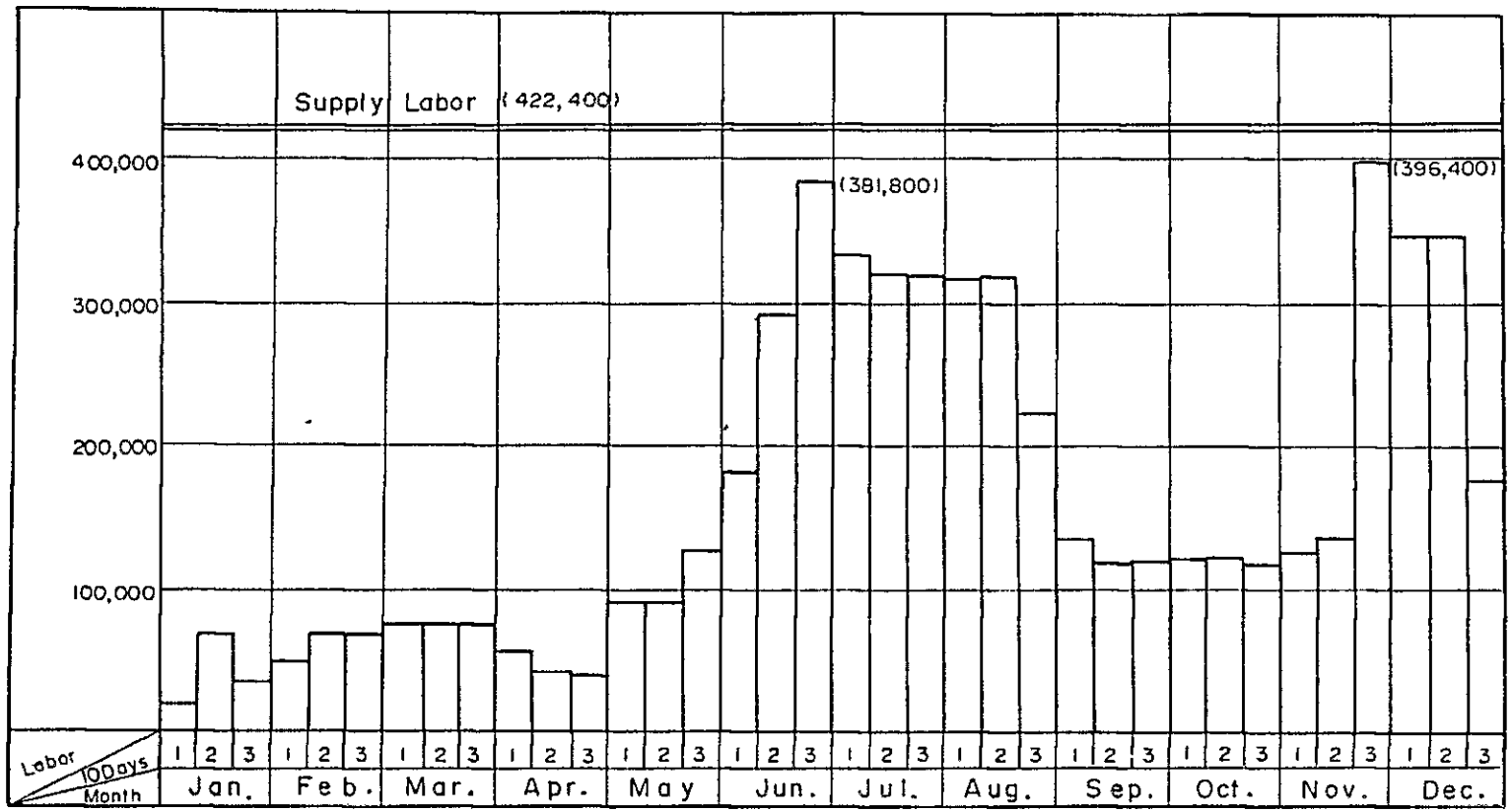
Item	Month / 10days / Area (ha)	Jan. 1	Jan. 2	Jan. 3	Feb. 1	Feb. 2	Feb. 3	Mar. 1	Mar. 2	Mar. 3	Apr. 1	Apr. 2	Apr. 3	May 1	May 2	May 3	Jun. 1	Jun. 2	Jun. 3	Jul. 1	Jul. 2	Jul. 3	Aug. 1	Aug. 2	Aug. 3	Sep. 1	Sep. 2	Sep. 3	Oct. 1	Oct. 2	Oct. 3	Nov. 1	Nov. 2	Nov. 3	Dec. 1	Dec. 2	Dec. 3	Total
Rainy Season Paddy Local	44,720	-	44,720	-	-	-	-	-	-	-	-	-	-	44,720	44,720	44,720	44,720	178,880	268,320	268,320	268,320	178,880	89,440	89,440	89,440	89,440	89,440	89,440	89,440	89,440	268,320	268,320	313,040	134,160	-	-	3,801,200
Rainy Season Paddy HYV	4,950	-	4,950	-	-	-	-	-	-	-	-	-	-	4,950	9,900	4,950	29,700	29,700	29,700	29,700	29,700	29,700	9,900	9,900	9,900	9,900	4,950	14,850	4,950	49,500	49,500	49,500	49,500	14,850	-	-	480,150
Dry Season Paddy HYV	5,820	5,820	5,820	23,280	29,100	46,560	46,560	46,560	46,560	46,560	29,100	23,280	23,280	23,280	46,560	46,560	46,560	46,560	46,560	11,640	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,99,460
Mungbeans	2,520	-	2,520	2,520	5,040	5,040	5,040	-	2,520	2,520	2,520	2,520	-	25,200	25,200	25,200	52,920	15,120	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	148,680
Vegetable	1,700	8,500	8,500	8,500	8,500	8,500	8,500	17,000	17,000	17,000	8,500	8,500	8,500	8,500	8,500	8,500	17,000	17,000	17,000	8,500	8,500	8,500	8,500	8,500	8,500	13,600	17,000	17,000	25,500	25,500	25,500	17,000	17,000	17,000	-	-	482,800
Banana	1,200	2,400	2,400	2,400	4,800	6,000	6,000	9,600	9,600	9,600	6,000	6,000	6,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	10,800	4,800	6,000	4,800	4,800	4,800	4,800	4,800	6,000	6,000	6,000	6,000	-	-	264,000
Coconuts	1,000	2,000	2,000	1,000	1,000	1,000	1,000	2,000	2,000	2,000	1,000	1,000	1,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	2,000	-	-	-	-	1,000	1,000	1,000	2,000	2,000	2,000	2,000	2,000	-	-	50,000
Lemon	200	400	400	400	800	1,000	1,000	1,000	1,000	2,000	2,000	1,200	1,200	1,200	1,000	1,000	1,000	800	800	800	1,200	1,200	1,200	800	800	800	1,000	1,000	1,200	1,200	1,200	800	800	800	-	-	37,000
Total	62,110	19,120	71,310	38,100	49,240	68,100	68,100	76,160	78,680	78,680	57,620	43,300	40,780	91,700	91,700	127,670	181,150	292,540	381,800	332,960	321,320	321,320	223,080	139,540	119,740	118,190	33,700	123,140	396,040	127,890	137,790	174,810	343,620	343,620	-	-	5,863,290

Table C-10 Present Machinery Requirement

Crops	Month / 10days / Area	Jan. 1	2	3	Feb. 1	2	3	Mar 1	2	3	Apr. 1	2	3	May 1	2	3	Jun. 1	2	3	Jul. 1	2	3	Aug. 1	2	3	Sep. 1	2	3	Oct. 1	2	3	Nov. 1	2	3	Dec. 1	2	3	Total
Rainy Season Paddy Local	44,720	-	-	-	-	-	-	-	-	-	-	-	-	44,720	44,720	44,720	44,720	44,720	44,720	44,720	44,720	44,720	-	-	-	-	-	-	-	-	-	-	-	-	44,720	44,720	44,720	491,920
		-	-	-	-	-	-	-	-	-	-	-	-	44,720	44,720	44,720	44,720	44,720	44,720	44,720	44,720	44,720	-	-	-	-	-	-	-	-	-	-	-	-	44,720	44,720	44,720	
Rainy Season Paddy HYV	4,950	-	-	-	-	-	-	-	-	-	-	-	-	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	-	-	-	-	-	-	-	-	-	-	-	-	4,950	4,950	4,950	59,400
		-	-	-	-	-	-	-	-	-	-	-	-	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	4,950	-	-	-	-	-	-	-	-	-	4,950	4,950	4,950	
Dry Season Paddy HYV	5,820	5,820	5,820	11,640	5,820	5,820	5,820	-	-	-	-	-	-	5,820	5,820	5,820	5,820	5,820	5,820	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87,300
		5,820	5,820	11,640	5,820	5,820	5,820	-	-	-	-	-	-	5,820	5,820	5,820	5,820	5,820	5,820	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Dry Season Mungbeans	2,520	-	2,520	5,040	-	2,520	5,040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,160
		-	2,520	5,040	-	2,520	5,040	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Vegetable	1,700	-	-	1,700	-	-	1,700	-	-	-	-	-	-	-	-	-	1,700	1,700	1,700	-	-	-	-	-	-	-	-	-	-	1,700	1,700	1,700	-	-	-	-	13,600
		-	-	1,700	-	-	1,700	-	-	-	-	-	-	1,700	1,700	1,700	-	-	-	-	-	-	-	-	-	-	-	-	-	1,700	1,700	-	-	-	-	-	
Banana	1,200	-	-	-	-	-	-	-	-	-	-	-	-	1,200	1,200	1,200	-	-	-	1,200	1,200	1,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8,400
		-	-	-	-	-	-	-	-	-	-	-	-	1,200	-	-	-	-	-	1,200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Coconuts	1,000	-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,000
		-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Lemon (Manan)	200	-	200	200	200	200	200	400	400	400	200	200	200	200	200	200	200	200	200	-	-	-	200	200	200	-	-	-	200	200	200	200	200	200	-	-	-	5,400
		-	200	200	200	200	200	400	400	400	200	200	200	200	200	200	200	200	200	-	-	-	200	200	200	-	-	-	200	200	200	200	200	200	-	-	-	
Total	62,110	5,820	8,340	16,880	7,720	5,820	7,720	6,220	400	400	46,120	47,120	47,120	58,590	55,690	55,690	50,870	50,870	50,870	5,150	5,150	5,150	-	-	-	-	-	-	200	200	200	1,900	1,900	1,900	49,670	49,670	49,670	688,180
		8,340	8,340	11,060	7,720	7,720	7,720	400	400	400	53,770	53,770	53,770	55,690	55,690	55,690	50,870	50,870	50,870	5,150	5,150	5,150	-	-	-	-	-	-	200	200	200	1,900	1,900	1,900	49,670	49,670	49,670	
		22,500		44,820	23,160			7,020			147,010			169,970			152,610			15,450			-			-			600			5,700			99,340			688,180

Figure C-3 Present Labor Requirement

Unit: man/10day



Present Supply Labor

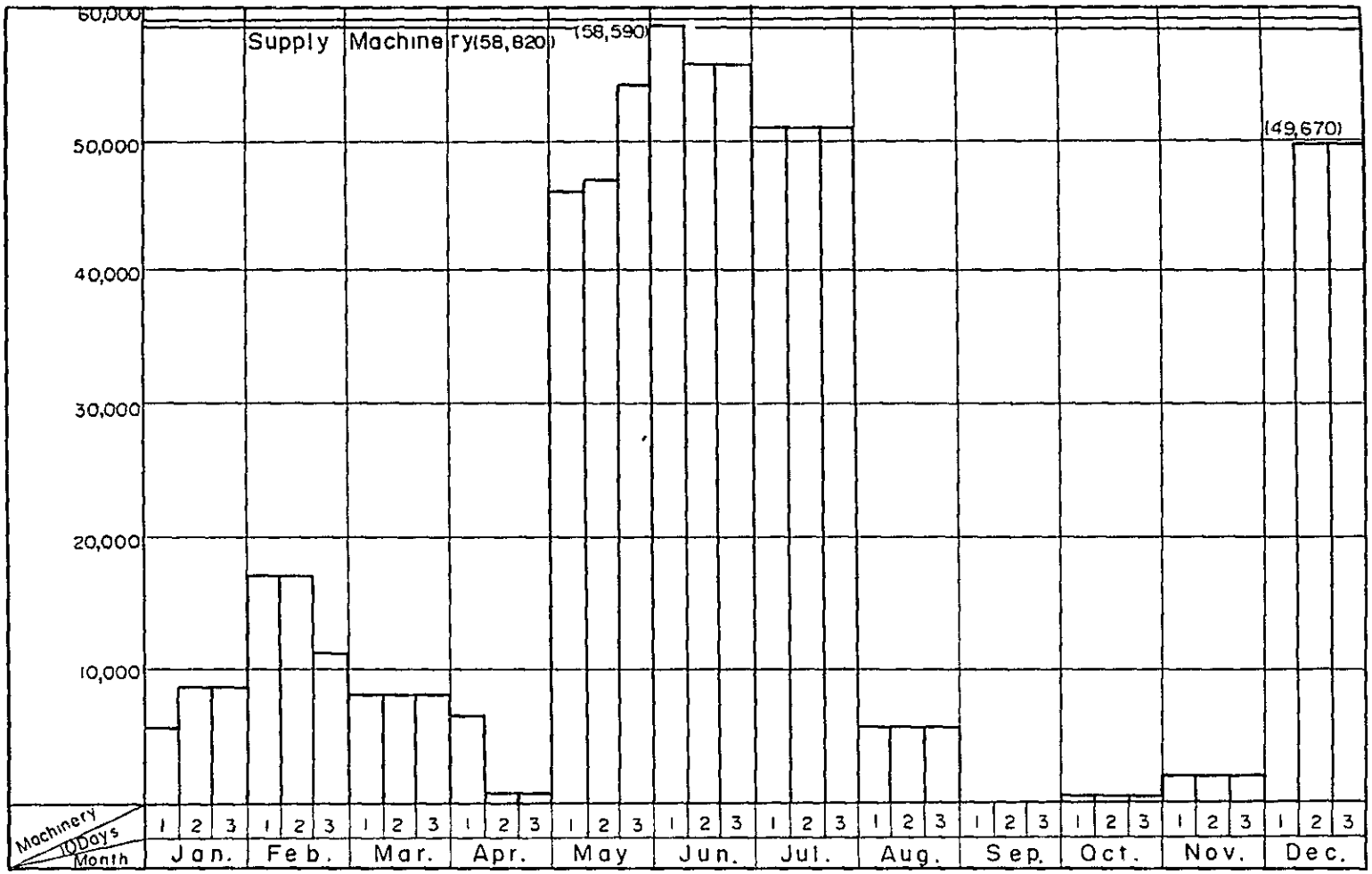
Male 28,234

Female 30,71[illegible] x 0.8 = 24,568

Total 52,802 x 0.8 = 42,241

Figure C-4 Present Machinery Requirement

Unit: set/10day



C-5. Agricultural Development Plan

Improvement of poor irrigation and ill drainage in the existing irrigation area is the major purpose of the Project, which aims at the same time desalinating the saline affected soils and developing the new farm lands of about 7,000 ha along the seadike through desalination and provision of suffecient water sources together with drainage improvement. Eventually, the irrigated agriculture in the Area shall be energetically encouraged under the powerful backup of the agri-supporting services best suited to the local conditions.

C-5-1. Proposed Land Use

i) Amelioration of the field conditions should be planned centering around the provision of the effective irrigation facilities in taking into consideration of the present land use. When planning the land use, the plan for the improvement of the upland and orchards should be incorporated in the proposed land use. The tropical plain specified as fallow lands in the present land use will be so easily converted into farm lands because the ditches and dikes have be already completed for the most of the plain, and the proposed land use takes the plain as the paddy fields (The RID field office also classifies the plain as the paddy fields).

ii) The most urgent problem of the on-farm facilities improvement is to secure the adequate water level in the canals and to increase the cross section of the canals. For accomplishing the said improvement, the rehabilitation of the main and the lateral canals comes the first of all works, and the on-farm improvement follows.

iii) The on-farm development will be made according to the levels, A, B and C, which are designated in the plan of the on-farm

consolidation. The plan should be proceeded mainly with improvement of the irrigation facilities for recycling use of the return flow available by the drainage improvement. The consolidation level of the facilities should be taken by B as a whole, and by A for the areas where the recycling use of the return flow. The staged development, thus, will be promoted.

iv) The land consolidation with type B in the sample areas will result in the consolidated areas as follows:

Existing paddy fields: Deduction six percent (three percent for road, three percent for the facilities)

Fallow lands: Deduction 25 percent (three percent for roads, three percent for the facilities and 19 percent for fallow lands)

Existing uplands: Deduction four - six percent (two percent for roads two percent for facilities)

Existing orchards: Deduction four - six percent (The same rate as above)

v) The existing paddy fields of 7,300 ha and the tropical plain of 300 ha extending between the Project Area and the sea-dike are developed in accordance with the standard mentioned above with water sources secured by return flow. Hence, the development level of the areas shall be of A type.

vi) The development plan excludes those areas of forest lands, waste lands, bogs and swamps dotted in the Project Area.

vii) The consolidated paddy fields, uplands and orchards will be supplied with irrigation water by 100 percent in the rainy season as scheduled while 15 percent of the paddy fields and 15 percent of the mungbean and other vegetable fields will be irrigated based on proposed cropping pattern.

viii) The salt fields scattering in the Area shall be converted into fish ponds, where the brackish water should not be supplied.

ix) The proposed land use is illustrated in Table C-11.

Table C-11 Proposed Land Use

- Unit: ha (Rai) -

Item / Area	Gross Area (1)	Arable Area								Non Arable Area					
		Paddy				Upland Crops (6)	Tree Crops (7)	Fallow Land (8)	Sub-total (9)	Road, Canal & River (10)	Salt Farm (11)	Shrimp and Fishpond (12)	Village (13)	Others (14)	Sub-total (15)
		Rainy Season (2)	Dry Season Paddy (3)	Dry Season Upland Crops (4)	Dry Season Fallow (5)										
Left Bank Area	19,800	12,100	1,700	1,800	8,600	140	550	-	12,790	1,900	-	320	1,220	3,570	7,010
Right Bank Area	44,100	29,500	4,200	4,500	20,800	1,460	1,750	-	32,710	5,840	-	-	2,850	2,700	11,390
Sea Dike Area	10,100	7,100	1,100	1,000	5,000	-	-	-	7,100	550	-	530	400	1,520	3,000
Total (ha)	74,000	48,700	7,000	7,300	34,400	1,600	2,300	-	52,600	8,290	-	850	4,470	7,790	21,400
(Rai)	(462,500)	(304,375)	(43,750)	(45,625)	(215,000)	(10,000)	(14,375)		(328,750)	(51,812)		(5,313)	(37,937)	(48,688)	(133,750)
%	100.0	65.8	9.5	9.9	46.4	2.2	3.1	-	71.1	11.2	-	1.2	6.0	10.5	28.9

Note on the Proposed Land Use - Table C-11 .

(1) The same conditions as the present one.

(2) Existing (2) - [Existing(2) x 0.06] + [Existing(8) x 0.75]

(3) (2) x 0.15

(4) (2) x 0.15

(5) (2) - [(3) + (4)] To be left as fallow lands in the dry season

(6) Existing(6) - [Existing(7) x 0.06]

(7) Existing(7) - [Existing(7) x 0.04]

(8) Existing(8) - [Existing(8) x 0.75] - [Existing(8) x 0.25] = 0

(9) (2) + (6) + (7)

(10) Existing(10) + [Existing(2) x 0.03] + [Exixting(6) x 0.03] + [Existing(7) x 0.02] + [Existing(8) x 0.03]

(11) Existing(11) + [Existing(2) x 0.03] + [Existing(6) x 0.03] + [Existing(7) x 0.02] + [Existing(8) x 0.03]

(12) Existing(13) + Existing(12) To be converted into fishponds.

(14), (15), (16), (17) and (18) remain as the same conditions as the present ones.

(16) Existing(16) + [Existing(8) x (0.25 - 0.06]

(19) The total acreage of the non-farm lands.

C-5-2. Upgrading of the Field Husbandry

(1) Selection of the crops to be adopted in the project

The selection of the crops to be adopted in the Project should be made in the long-term economic prospect. In this study, however, the proposed crops were so selected as to meet the requirements of the land use, present level of the farming techniques prevailing in the Area and demand forecast of the crops, and to keep the general direction of the agricultural development without drastic change in the cropping items.

1 Paddy rice, the staple food in Thailand, is the major export crop, and the production increase in paddy can meet the national policy. Under the situation, the cropping items were selected

so that the rainy season paddy cropping can be successfully realized so far as the irrigation water can be possibly secured and that the maximum water saving in the rainy season can easily carry out the dry season paddy cropping.

2 Mungbean, having resistivity to drying and short maturing period, is most suitable to be grown in the dry season as the second crop of the paddy cultivation and has a considerable domestic demand. Since, furthermore, mungbean is promising as the export-oriented crop with wide range in food use, the plan will introduce this crop as much as possible.

3 The demands of vegetable and fruits are rapidly increasing in the Area as the population concentration has brough a change in diet like of the people in Metropolis Bangkok and other cities and towns in the vicinity thereof. Such a remarkable increase in demands has forced to form a production block of these specific crops. Consequently, the specific production blocks will be formed in the Project Area with advantages in location and transportation near Bangkok, and the vegetable and fruits (melon, etc.) production should be promoted as the second crops of the paddy growing or as an item in the rotational cropping from paddy cropping to upland cropping so far as the irrigation water is available.

4 Tree-crops like coconuts and sugar palm will have no particular change in their cropping. However, those crops of lemon (Manan), banana, mango, etc. should be produced with improved varieties to increase their yields. On the other hand, the collective working system for collecting and forwarding should be established with advanced equipment

for crop sorting, packing, etc. The cropping acreage for tree-crops will remain unchanged in the plan.

(2) Upgrading of the field husbandry

The countermeasures to be taken for field husbandry upgrading are itemized as follows;

1 A powerful campaign should be extended to make the local farmers cooperative staff concerned, extension agents and technical officials in charge of the irrigation services have thorough understanding on the intention of the planned paddy cultivation, and every possible effort should be made to reach the target yield in the whole objective area, which would be set up reasonably.

2 To accomplish the target, the farmers' organization should be firmly established to promote the systematic and contemplated irrigation services, and furthermore, collective paddy growing and the related works in smooth supply of imput materials and funds (by cooperatives) should powerfully support the successfull realization of the plan.

3 At present, the paddy cropping in the Area has troubles in the early stage of the growth stage; more specifically, the problems are nursery, land leveling, transplanting, irrigation and drainage control for about 10 days period of plants' rooting.

To prevent the plants' growing from various troubles, nursery works should be practised collectively, keeping the nursery period strictly and avoiding the transplant of the old seedlings with leaf-cutling by re-sowing for delayed transplanting.

Regular transplanting is essential for holding the definite information of the number of the heads available per unit, and replanting is carried out without fail when any defected plants are found after transplanting.

The land leveling should be practised within the allowable errors of ± 2.0 cm for one unit flooding area (1/4 rai)[1/].

Irrigation should be carried out to keep the water about 5.0 cm deep in the field for 10 days period of plants' rooting; at least, infiltration of puddling water from the other fields should be prevented.

4 The collective works of pest control, irrigation and drainage services are discussed in the paragraph on the Planned Paddy Growing.

5 Plowing, sowing and earth covering for the mungbean cropping have been made by man power, however, mechanized farming for this cropping should be employed as well for increasing in the yield, in the working efficiency, etc., so that labor saving in pest control and harvesting can be realized as well.

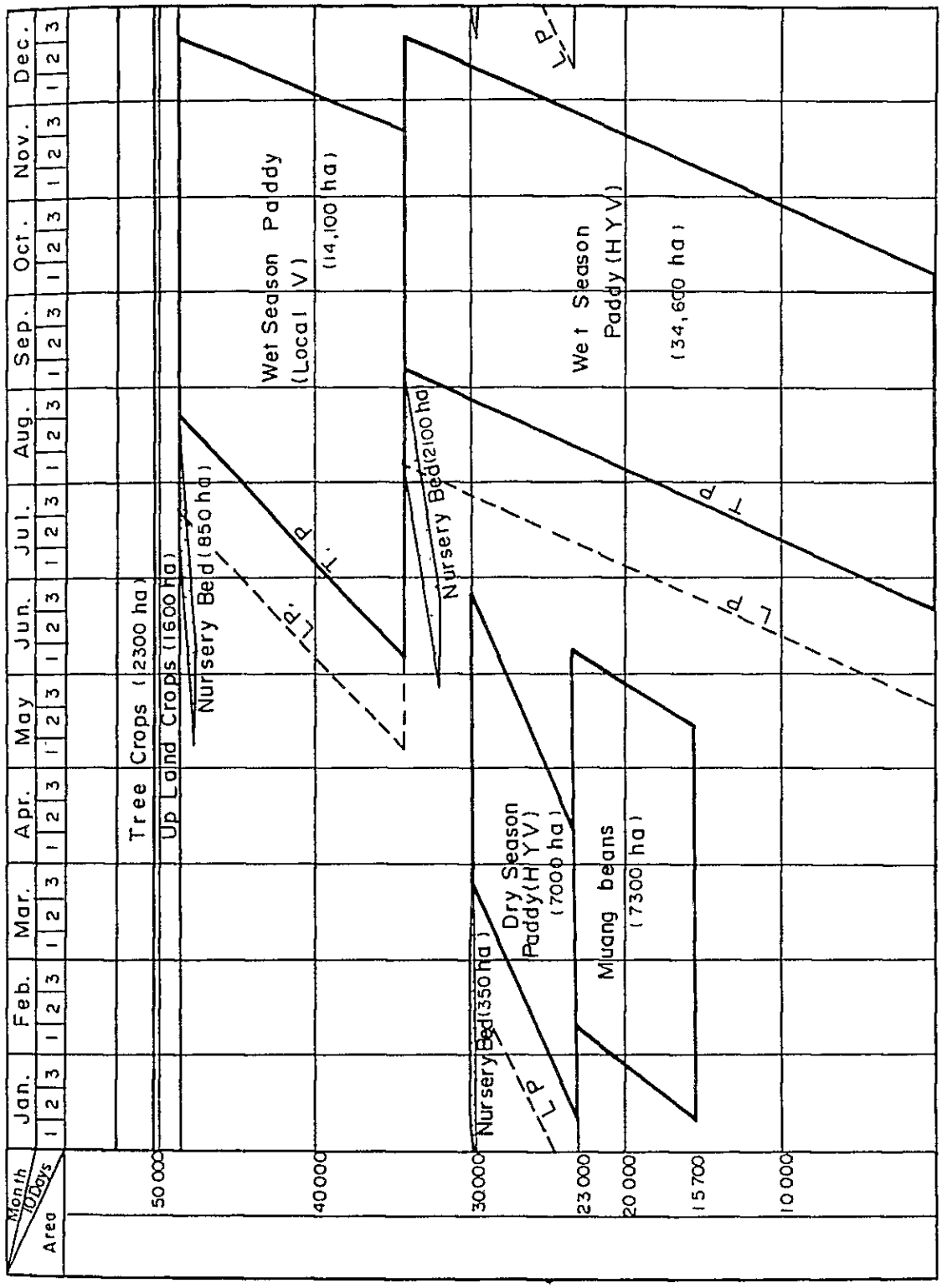
6 Desalination of soils should be carried out with a great care that the fields are to be drained and plowed soonest after harvesting for protecting the soils from capillary-rise of saline water. When the fields are drained, the water should be stored in some ponds or canals so that it can serve in recycling use as the return flow.

1/ One unit flooding area: the field encircled by secondary ridges.

C-5-3. Proposed Cropping Pattern and Calendar

The proposed cropping pattern based on the upgrading plan of field husbandry along with the proposed land use is illustrated in Figure C-5. In this scheme, the puddling period was taken by 2.5 month, although originally 1.5 months (48 days), due to comparatively small canal section to the demand and saving of the rehabilitation cost for these short-capacity canals. A particular attention should be paid to the fact that the end of transplanting of the LV may fall on the last decade of August when the puddling period is taken by 2.5 months. The turn-outs and following ditches should hold the capacity to meet the requirement of the puddling water supply to be made within 45 days in taking into account the collective works and the mechanized farming to be operated.

Figure C-5 Proposed Cropping Pattern and Calendar



C-5-4. Target Yields

The crop-wise target yields and the target yield for the total Project are illustrated in Table C-12, which was derived from the considerations on the present yields of the crops, irrigation/drainage scheme, level of land consolidation, upgrading of field husbandry, organization of local farmers, farm mechanization and related agri-supporting services, advancement of the farming techniques.

(1) The acreages of the HYV, and the LV are allcted as follows:

Acreage of Paddy Field (48,700 ha)

A Type	30 %	14,610 ha
B Type	70 %	34,090 "
Total		48,700 ha

HYV introduction Ratio by Types

A Type	50 %	7,310 ha
B Type	80 %	27,300 "
Total		34,600 ha

Therefor, the 48,700 ha - 34,600 ha = 14,100 ha

(2) Target yield

Rainy Season LV	A Type	7,310 ha	x 3.00 t/ha	= 21,930 t
	B Type	6,790 "	x 3.37 "	= 22,882 t
	Total	14,100 ha	x 3.18 t/ha	= 44,782 t
Rainy Season HYV	A Type	7,300 ha	x 3.67 t/ha	= 26,791 t
	B Type	27,300 "	x 4.30 "	= 117,390 "
	Total	34,600 ha	x 4.17 t/ha	= 144,181 t
Dry Season HYV	A Type	1,100 ha	x 3.85 t/ha	= 4,235 t
	B Type	5,900 "	x 4.53 "	= 26,727 "
	Total	7,000 ha	x 4.42 t/ha	= 30,962 t

Table C-12 Proposed Yield and Production

Crops	Cultivated Area ha	(rai)	Yield tons/ha	Production tons	Remarks
1. Paddy Field					
°Paddy, LV (Rainy Season)	14,100	(88,125)	3.18	44,782	
°Paddy, HYV (Rainy Season)	34,600	(216,250)	4.17	144,181	
°Paddy, HYV (Dry Season)	7,000	(43,750)	4.42	30,962	
Paddy Total	55,700	(348,125)	3.95	219,925	
°Mungbeans, Vegetable (Dry Season)	7,300	(45,625)	1.00	7,300	by Mungbeans
2. Upland Field					
°Vegetable and Others	1,600	(10,000)	15.00x2	48,000	by Cucumber
3. Tree Crops Field					
°Banana	1,000	(6,250)	8.00	8,000	
°Coconuts	1,000	(6,250)	5.00	5,000	
°Others	1,300	(1,875)	8.00	2,400	by Lemon
Total	67,900	(418,125)	-	-	

C-5-5. Input Plan for Respective Crops

The input amounts for the respective crops is planned as follows on the basis upgrading of field husbandry, target yields, farming techniques available, comments by extension agents, and sail conditions.

1) Seeds and seedlings

Table C-13 Seed and Seedling

- Unit: kg/ha -

Item / Crops	Seeds Bed %	Seeds	Seedling	Remark
Paddy, LV Rainy Season	6	60		
Paddy, HYV Rainy Season	6	50		RD. 7, 9, 11, 17, 19, 23
Paddy, HYV Dry Season	6	50		RD. 7, 9, 11
Mungbeans	-	50		Broadcaster Seeding
Cucumber	0.5	4	1.5m x 0.3m 23,000 pieces	or Seeding
Sugar Cane	0.5	400	1.3m x 0.38m 20,000 pieces	
Banana , Tree Crops			Mango 5m x 4m	500 pieces
			Banana 2.5m x 2.5m	1,600 "
			Lime 4m x 4m	625 "

Seeds: Dry 50kg/ha x 7,000ha => 350ton (1 + 0.05) = 368 ton
" x 34,600ha => 1,730ton (1 + 0.05) = 1,817 ton } 3,673 to
Rainy 60kg/ha x 14,100ha => 846ton (1 + 0.05) = 888 ton

2) Fertilizers

The target yields of paddy were set up at 4.5 ∿ 4.8 tons/ha for HYV and 3.8 tons/ha for LV. The following amounts of fertilizers were estimated for enabling to harvest the respective target fields.

Table C-14 Fertilizer

- Unit: kg -

Item / Crops	Seed Bed	Basal Dressing	Side Dressing	Total	N - P - K	Remark
Paddy, HYV (Dry Season)	Urea 6.5 *1/	Ammophos 200	Ammophos 100 Urea 83.5 2 time	Ammophos 300 Urea 90 *1/	89- 60- 0	Transplanting Ammophos 16-20-0
Paddy, LV (Rainy Season)	Urea 6.5 *1/	Ammophos 200	Urea 12.5 1 time	Ammophos 200 Urea 18 *1/	40- 40- 0	"
Paddy, HYV (Rainy Season)	Urea 6.5 *1/	Ammophos 200	Ammophos 75 Urea 28.5 2 time	Ammophos 275 Urea 35 *1/	60- 55- 0	"
Dry Season Mungbeans	-	-	Ammophos 50	Ammophos 50	8- 10- 0	Drilling "
Dry and Wet Season Cucumber or Mellon [Vegetable] (Big)	-	Ammophos 200 *2/ 1,000	Ammophos 200	Ammophos 400 *2/ 1,000	102- 82-134	Ammophos 13-13-21
Sugar Cane	-	Ammophos 300 Sugar Cake 6,250	Ammophos 325 Ammonium Sulphate 65	Ammophos 625 Ammonium Sulphate 65 Sugar Cake 6,250	125-112-112	Ammophose 18-18-18
Banana Other Tree Crops	-	Ammophos 100	Ammophos 100	Ammophos 200	26- 26- 42	Ammophose 13-13-21

Note

*1/ Home Made Mature Compost

*2/ Chicken Dropping

Ammophos 16-20- 0
13-13-21
18-18-18

3) Pesticides

The collective works are the only way to exert the effects of the pest control. The collective pest control by the well-organized farmers is essentially required. The necessary amounts per ha for each crop is shown as fallows:

Table C-15 Pesticides

- Unit: kg/ha -

Item / Crops	Insecticides		Fungicides		Herbicides
Paddy, HYV (Dry Season)	Furadan (powder)	30	Daithane (wetable powder)	3 kg	Macette 18.75 Heddonan " (granular)
	Sevin-85 (liquid)	6.25			
	Malathion (liquid)	3			
Paddy, LV (Rainy Season)	Sevin-85 (liquid)	6.25	Daithane (wetable powder)	3 kg	Macette (granular) 18.75
	Furadan (powder)	30			
Paddy, HYV (Rainy Season)	Sevin-85 (liquid)	6.25	Daithane (wetable powder)	3 kg	Macette (granular) 18.75
	Malathion (liquid)	3			Heddonan "
Mungbeans	Sumithion (liquid)	3	-		Macette (granular) 18.75
Cucumber	PAP (emulsion)	20 ℓ	TPB (powder)	30 kg	Macette (granular) 18.75
Sugar Cane	-		-		Simagin (wetable powder) 10-15
Banana Other Tree Crops	Malathion (liquid)	3	-		-

Most of the pesticides are so harmful to man and animals that a great care should be given not to affect fishes in the rivers and ponds as well as to keep the chemicals in the locked boxes and keep the book for receiving and delivery of the chemicals. The pest occurs explosively, and the pesticides should be stocked systematically in the agencies and cooperatives.

C-5-6. Labor Input by Crops

The labor demands by crops and work-types in the Project Area are tabulated in Table C-16 which has been prepared based on the crops to be introduced, upgraded filed husbandry, and so forth.

The plan defines the details as follows:

1) The nursery should be practised in collective works (1-1.8 ha) for the irrigation unit (20 - 30 ha) so that effective water management and nursery works can be performed in collaboration.

2) The land leveling should be conducted more evenly than at present lest the transplanted seedling should be damaged. The regular transplanting should be employed so as to secure the designed number of the seedling for the unit area. Automatic transplanting machines would be introduced in future, although the proposed plan will not involve the mechanization in transplanting.

3) The water management for irrigation and drainage is omitted from the individual farmers' works because of being practised under collective works, excepting pumping irrigation for the dry season cropping.

4) All of the pest control should be carried out under collective works.

5) Reaping and harvesting will be practised by manpower for the time being, but mechanized in the near future.

6) The family labor input should be limited to 90 persons at maximum for one cropping, and hired labors should be used for further requirements.

The crop-wise labor demands per ha based on th worktypes are shown in Table C-17.

1) The farm mechanization was planned with the power tillers as representative machines and the quoted values include the converted numbers of buffaloes and draft cattle.

2) The seasonal distribution of the labor is obtained by cropping pattern and calendar.

The estimated labor demands and machine requirements are illustrated in Tables C-18 and C-19 and Figures C-6 and C-7, according to the cropping pattern and the calendar for the whole Project Area. In general, the total supply of the labor and machine power can balance with the requirements.

A series of estimation was made based on the following presumptions;

1) The target year of the Project completion was taken at 1995, and in 1990 and forward, the family labor was assumed not to increase any further.

2) Increase rate of farming machines in number keeps about 30 percent at present; in future, however, the declining tendency would appear in the near future and after 1990 the said rate was assumed to keep about 11 percent.

3) The number of farming machines were estimated on the basis of the power tillers; actually, however, large-sized tractors and draft animals are employed for operation as some surplus machine powers.

Table C-16-1 Proposed Farming Practice and Labor Requirement

Crops(Item)	Nursery Works / Variety	Land Preparation: Plowing	Furrowing	Manure and Fertilizing Puddling	Seeding or Transplanting x Random	Irrigation and Drainage	Weeding and Cultivation	Manureing and Fertilizing 10kg(t/rai)	Chemical Spraying	Harvesting: Cutting Bundling	Threshing 2.3t.yield/ha	Others	Total	Family Labor	Hired Labor
Rainy Season Transplanting Local															
Period (month)	Jun.-Jul. 30days	5	6	7	6-8	7-8	7-9	6.8	7.9	12.1	-	-	-	-	-
Times	24wa/rai	1	1	1	30cm x 25cm	-	2	1	1	-	3.5t/ha	-	-	-	-
Manpower	5	3	3	4	25	-	-	2	1	32	7	1	83	59	14
Animal	-	1	1	1	-	-	-	-	-	-	-	1	4	1	3
Machinery	1	2	2	1	-	-	-	-	-	-	2	-	9	5	4
New Variety (HYV)															
Period	7	6	7	8	7-9	8	8-9	8-9	8-10	12	12	-	-	-	-
Times	20wa/rai	1	1	1	25cm x 25cm	-	-	-	-	-	4.2t/ha	-	-	-	-
Manpower	5	3	3	5	29	-	-	2	2	33	9	1	92	68	14
Animal	-	1	1	1	-	-	-	-	-	-	-	1	4	1	3
Machinery	1	2	2	4	-	-	-	-	-	-	2	-	11	7	4
Dry Season Transplanting (HYV)															
Period	2	1-2	2	3	2-3	3-5	3-4	3-4	3-5	6	6	6	-	-	-
Times	20wa/rai	1	1	1	25cm x 25cm	-	2	1	2	-	4.5t/ha	-	-	-	-
Manpower	5	3	3	5	29	2	-	2	2	33	9	1	94	57	37
Animal	-	1	1	1	-	-	-	-	-	-	-	1	4	1	3
Machinery	1	2	2	2	-	2	-	-	-	-	2	-	11	8	3
Sugar Cane (Planting)															
Period	3-4	1-2	2-4	5-6	5-6	-	5-8	6-8	6-8	11-4	-	11-4	-	-	-
Times	wa/rai	-	-	-	40 x 135 18,500piece/ha	-	-	-	-	-	50°t	-	-	-	-
Manpower	4	3	3	3	20	-	37	3	1	32	-	4	110	60	50
Animal	-	-	-	-	2	-	2	1	-	1	-	1	7	1	6
Machinery	-	6hour	5H	5H	-	-	-	-	-	-	-	-	16hour	-	16hour
Sugar Cane (Ratooning)															
Period	-	-	-	-	-	-	3-4	-	-	-	-	-	-	-	-
Times	wa/rai	-	-	-	(kg)t/Rai	-	-	-	-	-	50t/ha	-	-	-	-
Manpower	-	-	-	-	-	-	36	3	1	32	-	4	76	30	46
Animal	-	-	-	-	-	-	2	1	-	3	-	1	5	5	0
Machinery	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Table C-16-2 Proposed Farming Practice and Labor Requirement

Crops(Item)	Nursery works / Variety	Land Preparation: Plowing	Furrowing	Manure and Fertilizing Puddling t/Rai	Seeding or Transplanting Q Row planting X Random	Irrigation and Drainage	Weeding and Cultivation	Manureing and Fertilizing t/Rai name	Chemical Spraying t/Rai name	Harvesting: Cutting Bundling	Threshing yield t/ha	Others	Total	Family Labor	Hired Labor
Banana															
Period		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower		10	10	14	13	37	82	40	-	14	-	-	220	97	123
Animal		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery		1	1	1	-	4	-	-	-	-	-	-	7	-	7
Lime(Lemon)															
Period		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower		2	-	-	22	30	39	6	35	44	-	7	185	97	88
Animal		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery		2	-	-	-	20	5	-	-	-	-	-	27	-	27
Cucumber															
Period		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower		12	12	12	20	80	70	11	2	61	-	4	284	142	142
Animal		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery		1	-	1	-	1	-	-	1	-	-	-	8	8	-
Mungbeans															
Period		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Times		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Manpower		3	-	3	-	1	1	1	1	42	7	-	59	39	20
Animal		-	-	-	-	-	-	-	-	-	-	-	-	-	-
Machinery		3	-	5	-	-	-	-	-	-	-	-	8	8	-

Table C-17 Proposed Labor Requirement Per ha

			Month	Jan.			Feb.			Mar.			Apr.			May			Jun.			Jul.			Aug.			Sep.			Oct.			Nov.			Dec.			
	Item		10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	Total
Paddy	Rainy Season LV	Manpower			1										1	1	1	1	4	5	6	6	6	6	6	4	2	2	2	-	2	2	2	2	6	6	6	3	83
		Machine			1										1	1	1	1	1	1	1	1	1											1	1	1				13
	Rainy Season HYV	Manpower		1												1	1	2	4	5	6	6	6	6	6	2	2	2	2	1	1	2	9	9	9	3			92
		Machine		1												1	1	1	1	1	1	1	1	1	1	1							1	1	1				15
	Dry Season HYV	Manpower	3	3	3	4	6	8	8	7	6	7	7	7	8	8	4																			1	2		94
		Machine	1	1	1	1	1	1	1	1		1	1	1	1	1																			1	1		15
	Dry Season Mung-beans	Manpower		1	1	2	2	2		1	1	1	5	10	10	10	5	5																				56
		Machine		1	1	2	2	2						1	1	1																							11
Upland Crops		Manpower	5	5	5	5	5	5	10	10	10	10	5	5	5	5	5	10	10	10	5	5	5	5	5	5	8	8	8	10	10	10	15	15	15	10	10	10	284
		Machine							1	1	1						1	1															1	1	1				8
Tree Crops	Banana	Manpower	2	2	2	4	5	5	8	8	8	5	5	5	10	10	10	10	10	10	10	10	10	9	4	4	5	5	5	4	4	4	4	4	4	5	5	5	220
		Machine													1	1	1	1			1	1	1																7
	Coconuts	Manpower	2	2	1	1	1	1	2	2	2	1	1	1	2	2	2	2	2	2	2	2	2	-	-	-	-	-	-	1	1	1	2	2	2	2	2	2	50
		Machine														1	1																						2
	Lemon (Manan)	Manpower	2	2	2	4	5	5	5	5	5	10	10	10	6	6	6	5	5	5	4	4	4	6	6	6	4	4	4	5	5	5	6	6	6	4	4	4	185
		Machine				1	1	1	1	1	1	2	2	2	1	1	1	1	1	1				1	1	1				1	1	1	1	1	1				27

Table C-18 Proposed Labor Requirement

Unit: manday/ha

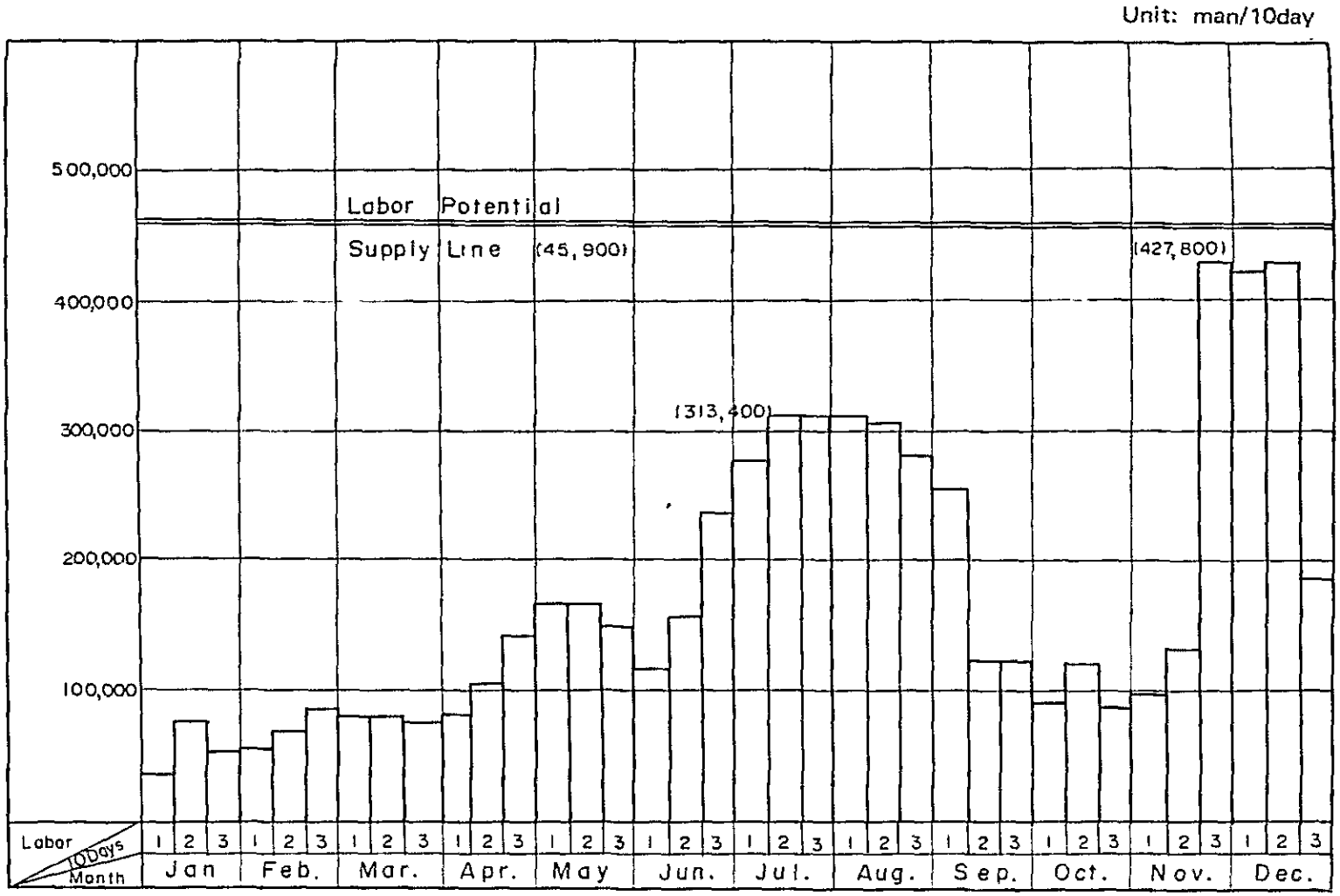
Item	Area (ha)	Jan. 1	Jan. 2	Jan. 3	Feb. 1	Feb. 2	Feb. 3	Mar. 1	Mar. 2	Mar. 3	Apr. 1	Apr. 2	Apr. 3	May 1	May 2	May 3	Jun. 1	Jun. 2	Jun. 3	Jul. 1	Jul. 2	Jul. 3	Aug. 1	Aug. 2	Aug. 3	Sep. 1	Sep. 2	Sep. 3	Oct. 1	Oct. 2	Oct. 3	Nov. 1	Nov. 2	Nov. 3	Dec. 1	Dec. 2	Dec. 3	Total
Rainy Season Paddy Local	14,100	-	-	-	-	-	-	-	-	-	-	-	-	14,100	14,100	84,600	84,600	28,200	-	28,200	84,600																1,170,300
														14,100	56,400	84,600	84,600	28,200	28,200	28,200	84,600																
														14,100	70,500	84,600	56,400	28,200	28,200	84,600	42,300																
Rainy Season Paddy HYV	34,600	-	-	-	-	-	-	-	-	-	-	-	-	34,600	173,000	207,600	207,600	69,200	34,600	311,400																	3,183,200
														69,200	207,600	207,600	69,200	69,200	69,200	311,400	103,800																
														34,600	138,400	207,600	207,600	69,200	34,600	311,400																	
Dry Season Paddy HYV	7,000	21,000	28,000	56,000	49,000	56,000	-	-	-	-	-	-	-	-	-	-	-	-	-	7,000	658,000																
		21,000	42,000	49,000	49,000	56,000	-	-	-	-	-	-	-	-	-	-	-	-	-	14,000																	
		21,000	56,000	42,000	49,000	42,000	-	-	-	-	-	-	-	-	-	-	-	-	-																		
Dry Season Mungbeans	7,300	-	14,600	-	7,300	73,000	36,500	-	-	-	-	-	-	-	-	-	-	-	-	-	408,800																
		7,300	14,600	7,300	36,500	73,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-																	
		7,300	14,600	7,300	73,000	36,500	-	-	-	-	-	-	-	-	-	-	-	-	-	-																	
Vegetable	1,600	8,000	8,000	16,000	16,000	8,000	16,000	8,000	8,000	12,800	16,000	24,000	16,000	454,400
		8,000	8,000	16,000	8,000	8,000	16,000	8,000	8,000	12,800	16,000	24,000	16,000																						
		8,000	8,000	16,000	8,000	8,000	16,000	8,000	8,000	12,800	16,000	24,000	16,000																						
Banana	1,000	2,000	4,000	8,000	5,000	10,000	10,000	10,000	9,000	5,000	4,000	4,000	5,000	220,000
		2,000	5,000	8,000	5,000	10,000	10,000	10,000	4,000	5,000	4,000	4,000	5,000																						
		2,000	5,000	8,000	5,000	10,000	10,000	10,000	4,000	5,000	4,000	4,000	5,000																						
Coconuts	1,000	2,000	1,000	2,000	1,000	2,000	2,000	2,000	-	-	1,000	2,000	2,000	50,000
		2,000	1,000	2,000	1,000	2,000	2,000	2,000	-	-	1,000	2,000	2,000																						
		1,000	1,000	2,000	1,000	2,000	2,000	2,000	-	-	1,000	2,000	2,000																						
Lemon (Manan)	300	600	1,200	1,500	3,000	1,800	1,500	1,200	1,800	1,200	1,500	1,800	1,200	55,500
		600	1,500	1,500	3,000	1,800	1,500	1,200	1,800	1,200	1,500	1,800	1,200																						
		600	1,500	1,500	3,000	1,800	1,500	1,200	1,800	1,200	1,500	1,800	1,200																						
Total		33,600	56,800	83,500	81,300	164,900	114,700	278,800	311,000	254,800	91,700	94,600	420,200	
		75,500	72,100	83,800	102,500	164,900	155,100	313,400	306,000	116,400	119,900	129,200	427,200																						
		54,000	86,100	76,800	139,000	149,000	238,400	313,400	277,800	116,400	85,300	427,800	184,300																						
		163,100	215,000	244,100	322,800	478,800	508,200	905,600	894,800	487,600	296,900	651,600	1,031,700	6,210,200

Table C-19 Proposed Machinery Requirement

Unit: Set/day

Crops	Area (ha)	Month / 10days	Jan. 1	Jan. 2	Jan. 3	Feb. 1	Feb. 2	Feb. 3	Mar. 1	Mar. 2	Mar. 3	Apr. 1	Apr. 2	Apr. 3	May 1	May 2	May 3	Jun. 1	Jun. 2	Jun. 3	Jul. 1	Jul. 2	Jul. 3	Aug. 1	Aug. 2	Aug. 3	Sep. 1	Sep. 2	Sep. 3	Oct. 1	Oct. 2	Oct. 3	Nov. 1	Nov. 2	Nov. 3	Dec. 1	Dec. 2	Dec. 3	Total
Rainy Season Paddy Local	14,100		-	-	-	-	-	-	-	-	-	-	-	-	14,100	14,100	14,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14,100			
			-	-	-	-	-	-	-	-	-	-	-	-	14,100	14,100	14,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14,100			183,300
			14,100	-	-	-	-	-	-	-	-	-	-	-	14,100	14,100	14,100	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	14,100	-		
Rainy Season Paddy HYV	34,600		-	-	-	-	-	-	-	-	-	-	-	-	-	34,600	34,600	34,600	34,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34,600		
			34,600	-	-	-	-	-	-	-	-	-	-	-	-	34,600	34,600	34,600	34,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34,600		519,000
			-	-	-	-	-	-	-	-	-	-	-	-	34,600	34,600	34,600	34,600	34,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	34,600	-	
Dry Season Paddy HYV	7,000		7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
			7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	7,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,000		105,000
			7,000	7,000	-	7,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,000	
Dry Season Mungbeans	7,300		-	14,600	-	-	-	-	-	-	-	-	-	-	7,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
			7,300	14,600	-	-	-	-	-	-	-	-	-	-	7,300	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	80,300
			7,300	14,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Upland Crop Vegetable	1,600		-	-	1,600	-	-	-	-	-	-	-	-	-	1,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,600	-	-	-	-	-	-	
			-	-	1,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,600	-	-	-	-	-	-	12,800
			-	-	1,600	-	-	-	-	-	-	-	-	-	1,600	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,600	-	-	-	-	-	-	
Banana	1,000		-	-	-	-	-	-	-	-	-	-	-	-	1,000	1,000	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7,000
			-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Coconuts	1,000		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
			-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2,000
			-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Lemon (Manan)	300		-	300	300	300	600	300	300	-	300	-	300	300	300	-																					
			-	300	300	300	600	300	300	-	300	-	300	300	300	-																					8,100
			-	300	300	300	600	300	300	-	300	-	300	300	300	-																					
Total	66,900		7,000	21,900	8,900	7,600	29,700	51,600	49,700	34,900	34,600	300	1,900	48,700																							
			48,900	21,900	8,900	7,600	30,700	49,000	49,700	34,900	-	300	1,900	55,700																							
			28,400	21,900	1,900	14,900	52,600	49,000	49,700	34,900	-	300	50,600	7,000																							
			84,300	65,700	19,700	30,100	113,000	149,600	149,100	104,700	34,600	900	54,400	111,400	83,300																						

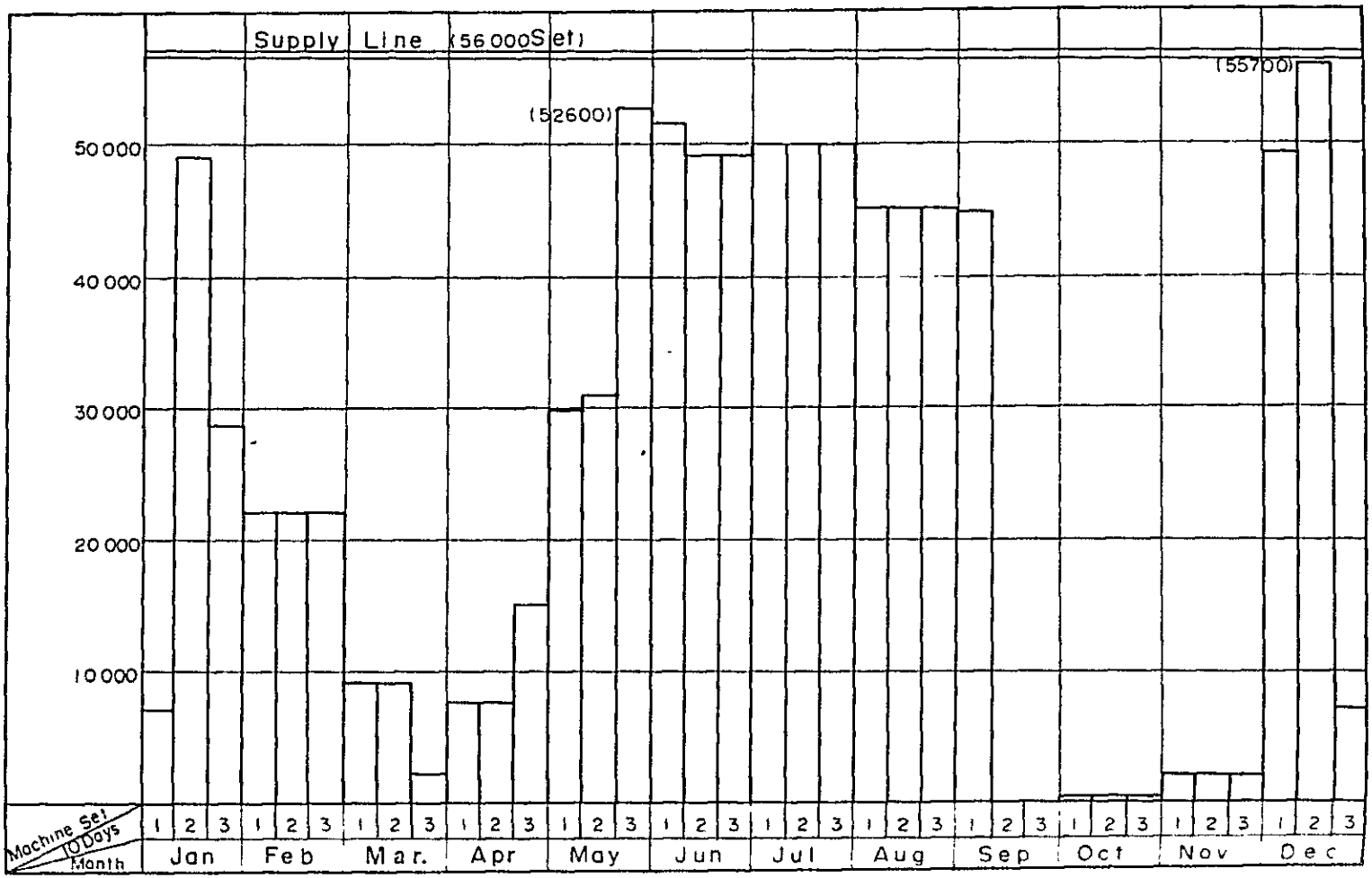
Figure C-6 Proposed Labor Requirement



Proposed Supply Labor Male 30,800
(in 1990 Year) Female 33,200 x 0.8 = 26,560) = 57,360 x 0.8 = 45,900

Figure C-7 Proposed Machinery Requirement

Unit: set/10day



C-5-7 Grouping Plan for Cooperative

1) Farming Group: The basic unit of farming groups is taken by the irrigation unit, which is the area of 20 - 30 ha commanded by one or two turn-outs.

Management group: This is a group of 10 - 20 farmers, specified as group belonging to the land, and the unit of collective farming works such as nursery, puddling, pest control, etc. and also the unit for O & M of the farming machinery.

Organization of the management group: One group chief and sub-chieves for irrigation management, farming, O & M machinery, collective works, etc will be assigned to control and promote the water allotment, farming works and other collective works.

2) Water Users Service Unit: This unit is composed of three or four management groups belonging to the same irrigation, covering the area of 100 - 300 ha, and this unit is a group belonging to lands as well. The unit, involving 50 - 100 farmers, shall control and support the infrastructural management groups as well as collect levies and impositions and give necessary credits from time to time.

These organizations should closely cooperate with RID, extension agents, agri-cooperatives concerned for successful execution of the works. One check leader and an accountant will be assigend and the operation of the unit shall be made on the basis of the consultative meeting of the related group chieves. Every unit shall provide one or two common irrigater for effective water management in the down-stream of turn-outs according to the indication of check leader under the supervision of the RID zone man.

3) A commission made up of the RID staff in charge of the irrigation zone A, B and C, and the relevant check leaders shall arrange the effective water management and the rational farm management.

4) The regulations and rules in details should be provided for effective and efficient operation of the irrigation water supply. The detailed design of the Project shall include the estimation of the costs for establishment and operation of these farmers' organization.

C-5-8. Farm Mechanization Plan

The study made in paragraph 6) suggests that the necessary number of the farming machines for encouraging the irrigated agriculture in the Project Area will be fully supplied. However, unsystematic introduction of the machines which has been performed at present, will prevent the machines from proper operation to meet the requirements of the successful irrigated agriculture.

For improvement of the situation, the inventory of the farming machines available at present should be made on the management group basis, and further procurement of the machines shall be made along with the results of the inventory so as to reduce idle machines and properly operate for the planned irrigated agriculture.

The typical organization of the groups for the purpose can be illustrated as follows:

Area Commanded: 28 ha
No. of farmers concerned: 10 farmers
No. of power tillers: eight units with accessories.
(Equivalent to eight draft cattle or to four buffaloes)
Other equipment: Pumps, sprayers, etc.

In the management groups, the power tillers should belong to the individual farmers under their own maintenance, while the operation of these machines should be controlled under the member in charge of the farming machine management.

The estimated number of the farming machines required for the successful Project Implementation is 55,700 units, based on which the neccessary number for one group was estimated at three units.

APPENDIX D IRRIGATION AND DRAINAGE

APPENDIX D IRRIGATION AND DRAINAGE

Contents

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APPENDIX D IRRIGATION AND DRAINAGE

D-1 Irrigation

D-1-1 Existing Irrigation Facilities

(1) Kaeng Krachan Storage Dam

General Information

Purpose: Irrigation, flood control, domestic water supply, fish and wildlife preservation and hydropower generation

Location: On the Phetchaburi river approximately 70 km west of Phetchaburi

Constructed: 1962 -1966, by the RID

Water Supply: Phetchaburi river

Drainage Area: 4,048 sq.km of which 2,210 sq.km are contributing to Kaeng Krachan storage

Reservoir:

Area: 50 sq.km of water surface at elevation 99.0 MSL

Reservoir storage allocations:

Purposes	Elevations	Storage, MCM
Flood control	99.0 - 102.7	170
Irrigation	70.0 - 99.0	685
Conservation	Streambed to 70.0	15
Dead storage	Streambed to 65.0	10

The flood storage between elevation 99.0 and 102.7, in combination with the spillway, will protect the embankment against a peak flood inflow of 4,720 cu.m/s with a volume of 265.2 MCM. The routed peak through the spillway will be 1,260 cu.m/s at elevation 102.7.

Kaeng Krachan Dam — Composed of main dam and two saddle embankment

Type: Zoned rolled earthfill

Foundation: Siltstones, slates and slaty shists of the Silurian Period of the Paleozoic Era

Slope Protection: Layer of select rock on upstream and downstream slopes

Dimensions:

	Main Dam	Dike No.1	Dike No.2
Height: (m)			
Above streambed	48	-	-
Above lowest excavation	58	50	22
Crest length (m)	760	305	255
Crest elevation (MSL)	106.0	106.0	102.7
Volume (cu.m)	3,425,000	704,000	188,000

Slopes: Upstream --- 3 to 1 from toe to elevation 80.0 then, 2 to 1 from elevation 80.0 to elevation 106.0

Downstream --- 2.25 to 1 from toe to elevation 106.0

Cutoff trench: 10 m bottom width with side slopes 1 to 1

The volume of fill placed in the three embankments totals 4,316,000 cu.m.

Spillway

Type of spillway: Overflow uncontrolled crest, open channel, unlined

Dimensions: Crest length 128 m formed by a 6-m-wide concrete roadway with small ogee wier crest at the unstream edge of the slab

Crest elevation: Elevation 99.0 above MSL

Maximum discharge: 1,260 cu.m/s with water surface at elevation 102.7 MSL

Outlet Works

Elevation of lip of intake structure: Elevation 65.0

Upstream outlet conduit: Circular 3.5 m diameter and 90.5 m long

Gate chamber: 18.30 m long

Gates: Two guard gates, 2.60 m by 1.80 m

Maximum discharge through gates: 90.0 cu.m/s with water surface at elevation 99.0

Downstream outlet conduit: Horseshoe 7.70 m radius and 93.5 m long

Discharge shute: Flip bucket with energy dissapator blocks with a length of 25.0 m

Stilling basin: Length 31.0 m

(2) Phet Diversion Dam and Canals

The Phet diversion dam, completed in 1950, is the compound type of a fixed weir providing 18 m crest elevation in MSL and four gates with 4.0 m height and 6.0 m width. The said dam has diverted the water for irrigation use and domestic and industrial use through four main canals, three at the right bank and one at the left bank. The river discharge has been dammed up to maintain the water level by 17.50 m in MSL. The dimensions of the head regulators provided at each main irrigation canal are illustrated as follows;

Canal	Gate	Max. Diversion Amount cu.m/s
Right No.1	2-2.0m(W) x 2.25m(H)	9.7
Right No.2	1-2.0m(W) x 2.25m(H)	7.0
Right No.3	2-2.0m(W) x 2.25m(H)	30.2
	2-2.5m(W) x 2.25m(H)	
Left main	3 x 1.5m(W) x 1.60m(H)	18.5

In the field investigation the design drawings of the canal were available for the whole route, excepting the course downstream from Station No.10 + 200 of the Right Main canal No.3. These drawings indicated that some parts of the canals were constructed as earth canal, although originally designed in concrete lining and vice versa. The capacities of these canals were calculated by the Team on the basis of the roughness coefficient by n = 0.014 for the concrete canals and n = 0.0225 for the earth canals. The total length of the Right Main canal No.3 was estimated by 25,900 m based on the maps (scale:1/10,000). The Project Area complies 45 major canals, of which the Right Main No.1 system provides four canals used for domestic and industrial water supply (1L-1R-1, 2L-1R-1, 2R-2R-1 and 1L-2R-1). The respective length and the capacities of the remaining 41 irrigation canals are illustrated in Table D-1, and the total length was measured by 373,919 m, of which 207,396 m were concrete-lined in 5.0 to 7.0 cm thickness.

D-1-2 Present Irrigation

(1) Irrigable Area

The existing irrigation area of the Phetchaburi Irrigation Project complies the four irrigation systems of the Left Main, and the Right Mains of No.1, No.2 and No.3. The Left Main canal, diverting the water form the Phetchaburi river at left bank, 2.0 km upstream of the Phet diversion dam, runs 36 km northward along the Phetchaburi river branching off the five lateral canals on the course, while the three main canals on the right bank divert the water at the Phet diversion point to irrigate the farm lands extending in the right bank.

The data and information on the acreage of the Phetchaburi Project irrigable areas are available by a) the Phetchaburi Project Map (scale:1/50,000) prepared by RID, b) the Irrigation Zone Map (scale:1/50,000) prepared by O & M Office and c) the other irrigation

canal data prepared by O & M Office, and these data and information can be summarized as follows.

Project Map: The data available from the Map are the total length of the respective four main canals, irrigable areas and the related discharges, and among these, the irrigable areas are tabulated below:

Irrigable Area (1) by Project Map

- Unit: ha -

Items	Gross Area	Irrigable Area
Right Bank		
Main No.1 (Stage I)	7,736	5,803
Main No.2 (Stage I)	7,094	5,321
Main No.3 (Stage I)	13,286	10,629
Main No.3 (Stage II)	15,010	13,508
Sub-total	43,126	35,261
Left Bank		
Left Main (Stage I)	13,168	11,851
Left Main (Stage II)	6,864	6,178
Sub-total	20,032	18,029
Total	63,158	53,290

Irrigation Zone Map: The Map covers the data and information on 33 irrigation zones specified in terms of water management and O & M for the facilities, detailing the respective gross areas and the acreages of the paddy fields concerned. The summary is tabulated as follows:

Irrigable Area (2) by Zone Map

- Unit: ha -

Items	Gross Area	Paddy Field	Nos. of Zone
Right Bank	44,105	35,714	23
Left Bank	18,890	15,749	10
Total	62,995	51,463	33

Other data & information: The other related data and information, which were prepared by O & M Office, cover the gross area concerned, the respective irrigable areas, the total length of each canal and capacities for every canal under the control of the O & M Office. The data comply those for 41 related canals and their commanding irrigable areas are sumarized in the following table:

Irrigable Area (3) by O & M Office

- Unit: ha -

Items	Gross Area	Irrigable Area
Right Bank: Stage I	28,115	23,030
Stage II	15,405	14,168
Sub-total	43,520	37,198
Left Bank: Stage I	13,168	10,587
Stage II	6,864	5,415
Sub-total	20,032	16,002
Total	63,552	53,200

The acreages of the irrigable areas quoted in the above three kinds of data are, although slightly, different each other. This study made an estimation of the irrigable areas by the canal systems

based on the topo-map (scale:1/10,000, contour intervals:1 m) prepared by RID in 1980. The relevant topo-map involves many data, besides the irrigation canals, such as ditches, drainage canals, spot elevations and the land use categories for providing more detailed and correct information of the canal systems concerned. The estimation of the irrigable areas under the existing canal systems based on the said topo-map has resulted in about 48,850 ha as shown in Table D-2. Furthermore, when adding the irrigable areas of 7,600 ha in the extension area along the seadikes, the total irrigable farm lands come to 56,450 ha in total in the Project Area.

(2) Canal Capacities and Irrigation Requirements.

The data of the irrigable areas and irrigation requirements presented by O & M Office indicate that the irrigation requirements are 1.11 cu.m/s for the Stage I area (33,617 ha) and 0.94 - 0.91 cu.m/s for the Stage II area (19,583 ha), and the average values by the canal systems are tabulated as follows:

Present Irrigation Requirements

Canal System	Area (ha)	Irrigation Requirements (cu.m/s)	(cu.m/s/1,000 ha)
Right No.1	6,400	7.388	1.15
Right No.2	5,800	6.471	1.12
Right No.3	25,000	24.990	1.00
Left	16,000	16.884	1.06
Total	53,200	55.733	1.05

The canal-wise irrigation requirements that was obtained by multiplying the canal-wise irrigable areas shown in Table D-2 by the average irrigation requirements can be summarized as follows;

- Difference between the irrigation requirements and the canal capacity ranges within ± 10.0 percent ..... 19 canals

- The canal capacity exceeds the irrigation requirements by more than 10.0 percent ..... 16 canals
- The canal capacity is less than the irrigation requirements by more than 10.0 percent ..... 6 canals

Total 41 canals

The six canals with capacity in short are detailed as follows:

Canal	(1) Canal Capacities (cu.m/s)	Irrigable Area (ha)	(2) Irrigation Requirements (cu.m/s)	((2)-(1))/(2) Shortage (%)
1R-2R-1	0.205	214	0.246	17
1R-1R-1R-2	0.394	438	0.491	20
3R-1L-3	2.875	3,233	3.233	11
7R-1L-3	0.502	605	0.605	17
2R-Left	0.660	800	0.840	21
1L-Left	0.469	824	0.865	46

The comparison of the canal capacities at the uppermost stream of the respective main canals and the irrigation requirements has resulted in as follows. For references, the capacity of the Right Main canal No.1 was obtained by deducting 2.34 cu.m/s for the domestic and industrial use from the total capacity. The said table suggests that all of the main canals have provided the sufficient capacity; however, the relevant capacities quoted above are those designed in the original plan and the actual capacities have been evidently decreased from the original ones due to insufficient O & M services.

Table D-1 List of Irrigation Canals

Canal	Capacity (cu.m/s)	Length (m) lined	earth	Total
Right Main No.1	11.94 - 0.16	9,100	7,560	16,660
1R-1	3.45 - 1.33	20,000	-	20,000
2R-1	2.84 - 0.29*	8,850	-	8,850
1R-2R-1	0.21 - 0.12	-	2,526	2,526
1L-2R-1	0.37 - 0.10	-	2,300	2,300
1L-1	0.31 - 0.14	-	2,600	2,600
Sub-total		37,950	14,986	52,936
Right Main No.2	9.41 - 0.11*	12,500	7,056	19,556
1R-2	2.27 - 0.22	-	6,500	6,500
1R-1R-2	2.09 - 0.27	6,250	-	6,250
1R-1R-1R-2	0.39 - 0.10*	-	3,775	3,775
Sub-total		18,750	17,331	36,081
Right Main No.3	22.82 -	10,500	15,400	25,900
1R-3	0.38 - 0.11	-	4,000	4,000
2R-3	0.46 - 0.14	-	3,075	3,075
3R-3	1.07 - 0.13	-	8,000	8,000
1L-3	12.83 - 0.56	28,050	-	28,050
1R-1L-3	1.68 - 0.23	7,400	-	7,400
2R-1L-3	0.62	2,860	-	2,860
3R-1L-3	2.88 - 0.65	11,292	-	11,292
1R-3R-1L-3	1.32 - 0.56	8,664	-	8,664
4R-1L-3	2.06 - 0.72	8,650	-	8,650
5R-1L-3	2.24 - 0.21	8,924	-	8,924
1L-5R-1L-3	1.07 - 0.42	8,431	-	8,431
2L-5R-1L-3	0.73 - 0.31	5,940	-	5,940
6R-1L-3	0.73 - 0.39	8,150	-	8,150
7R-1L-3	0.50	3,990	-	3,990
8R-1L-3	0.74 - 0.49	5,665	-	5,665
9R-1L-3	0.73 - 0.38	3,800	-	3,800
1L-9R-1L-3	0.21	2,940	-	2,940
10R-1L-3	0.20	3,060	-	3,060
11R-1L-3	0.28	2,520	-	2,520
2L-3	3.91 - 0.16	-	14,000	14,000
1L-2L-3	0.76 - 0.35	-	4,675	4,675
2L-2L-3	0.55 - 0.35	-	2,875	2,875
Sub-total		130,836	52,025	182,861
Left Main	14.57 - 0.72	2,600	33,730	36,330
1R	4.94 - 1.63	-	26,460	26,460
1L-1R	1.31 - 1.10	-	2,824	2,824
2R	0.66 - 0.35	-	8,087	8,087
3R	1.24 - 0.70	5,660	-	5,660
1L	0.47 - 0.19*	-	5,300	5,300
2L	2.51 - 0.64	11,600	-	11,600
1R-2L	0.85 - 0.48*	-	5,810	5,810
Sub-total		19,860	82,211	102,071
Total		207,396	166,553	373,949

Notes: Data Source: Drawings of canals by RID
*: calculated by the team

Table D-2 Present Irrigable Area by Canal System

- Unit: ha -

Canal	Paddy	Upland Orchard	Total
Right Main No.1	2,975	385	3,360
1R-1	1,236	244	1,480
2R-1	1,129	149	1,278
1R-2R-1	201	13	214
1L-2R-1	275	40	315
1L-1	264	9	273
Sub-total	6,080	840	6,920
Right Main No.2	3,341	679	4,020
1R-2	752	57	809
1R-1R-2	846	87	933
1R-1R-1R-2	391	47	438
Sub-total	5,330	870	6,200
Right Main No.3	2,722	538	3,260
1R-3	246	24	270
2R-3	282	37	319
3R-3	694	134	828
1L-3	1,799	250	2,049
1R-1L-3	1,158	146	1,304
2R-1L-3	622	18	640
3R-1L-3	1,806	48	1,854
1R-3R-1L-3	1,355	24	1,379
4R-1L-3	1,174	24	1,198
5R-1L-3	572	6	578
1L-5R-1L-3	1,105	18	1,123
2L-5R-1L-3	753	3	756
6R-1L-3	672	13	685
7R-1L-3	602	3	605
8R-1L-3	793	9	802
9R-1L-3	401	-	401
1L-9R-1L-3	161	3	164
10R-1L-3	160	-	160
11R-1L-3	170	6	176
2L-3	1,638	305	1,943
1L-2R-3	673	30	703
2L-2R-3	522	21	543
Sub-total	20,080	1,660	21,740
Left Main	4,240	200	4,440
1R	3,998	170	4,168
1L-1R	402	22	424
2R	771	29	800
3R	815	160	975
1L	793	31	824
2L	1,500	37	1,537
1R-2L	741	81	822
Sub-total	13,260	730	13,990
Total	44,750	4,100	48,850

Canal Capacities and Irrigation Requirements

- Unit: cu.m/s -

Canal	Canal Capacity	Irrigation Requirement
Right Main No.1	9.60	7.96
Right Main No.2	9.41	6.94
Right Main No.3	22.82	21.74
Left Main	14.57	14.60
Total	56.40	51.24

(3) Commandable Areas with Gravity

In general, the FSL for the existing irrigation canals is paratively low to the field surface. The low FSL observed along the canal in the upstream of the Project Area is due to the local topographical conditions, whereas the FSL observed in the low-lying flat lands in the downstream is commonly low. The commandable areas with gravity under the FSL of the existing canals were estimated based on the topo-map (scale: 1/10,000, contour intervals: 1 m) under the conditions as follows:

- Off-take loss from canal to ditch --------- 0.1 m
- FSL in ditch above surface of paddy field - 0.2 m
- Slope of ditch ---------- 1/3,000

The above conditions are deemed necessary for the successful water management in the on-farm development works. The farm lands not to meet these conditions are not considered to absolutely require the pumping facilities for irrigation, although specified as those which are unirrigable by gravity system. A greater part of these farm lands has been inundated in the peak of the rainy season. Such inundation, however, has not been brought by artificial irrigation through canals, but caused by rainfalls, damming-up in the drainage canals, surplus water from the upstream areas, etc., which have not permitted to carry out the timely and adequate irrigation in a short time.

The commandable areas with gravity by the FSL available at present and increased in future are summarized in Table D-3. The farm lands irrigable by gravity cover about 21,100 ha or 43 percent of the total farm lands. The system-wise acreages are 6,100 ha irrigable by gravity out of 21,740 ha under the Right Main No.3 system (28 percent, the lowest availability), and the availability for the Left Main system comes the next by 33 percent. The low availability of the farm lands under these two systems has resulted from the fact that the both canal systems, flowing long distance, carry the water to the low-lying flat lands in the downstream and decrease their water levels in the flat areas.

Table D-3 Commandable Area with Gravity

- Unit: ha -

Canal	Irrigable Area	Commandable Area with FSL of			
		Present	+ 0.2m	+ 0.5m	+ 0.7m
Main No.1	3,360	2,820	2,870	3,030	3,360
1R	1,480	1,110	1,250	1,300	1,480
2R-1	1,807	1,050	1,290	1,490	1,529
1L-1	273	180	200	230	273
Sub-total	6,920	5,160	5,610	6,050	6,642
Main No.2	4,020	3,560	3,650	3,770	3,800
1R-2	2,180	1,630	1,860	1,980	2,080
Sub-total	6,200	5,190	5,510	5,750	5,880
Main No.3	3,260	1,540	2,500	2,750	3,000
1R-3	270	170	180	180	200
2R-3	319	200	210	210	300
3R-3	828	230	480	570	600
1L-3	13,874	2,670	4,990	10,786	13,108
2L-3	3,189	1,290	2,370	2,704	2,850
Sub-total	21,740	6,100	10,730	17,200	20,058
Total	34,860	16,450	21,850	29,000	32,580
Left Main	4,440	3,300	3,620	3,900	3,960
1R	4,592	200	1,560	3,300	3,830
2R	800	330	570	650	800
3R	975	-	-	65	180
1L	824	450	510	640	650
2L	2,359	370	390	445	600
Total	13,990	4,650	6,650	9,000	10,020
Grand Total	48,850	21,100	28,500	38,000	42,600
(%)	(100)	(43)	(58)	(78)	(87)

D-1-3 Return Flow

The Extension Area of 7,300 ha, lying between the seadikes and the existing irrigation area, takes its water sources from rain waters and return flows out of the irrigated fields in the up-stream areas. The paddy fields in the Extension Area, extending in strip along the boundary with the existing irrigation area, are crossed through by most of the drainage canals which discharge the water to the gulf of Thailand. Under the situation, the fields in the Extension Area are in a position to utilize the most of the excess water from the existing irrigation area. The simple return flow survey was made during the survey period for securing a knowledge of the actual status of these return flows. The objective area of this survey was selected by about 6,200 ha of the paddy fields out of the Right Main No.1, No.2 and No.3, lying between the national highway and the railroad, in taking into consideration the easiness of the measurement of balance of the waters for irrigation and drainage. The discharge measurement with current meters was conducted at selected nine points along the four major irrigation canals and five points along the drainage canals covering the relevant area (See Figure D-1.). The measurement was made at the irrigation period for land soaking for paddy fields, and the information suggested that the water had been supplied by 130 mm/day with 600 ha of the fields under the daily rotation system.

The water sources of the return flows to the area are 1) percolation, 2) operational losses in the canals and 3) application losses at the fields. The percolation was estimated at 1.5 mm/day on an average, which is deemed comparatively small. Almost absence of the terminal drainage facilities and the flat topographical conditions in the area suggest that a part of the percolation water, returned to the drainage canals as the surface water would be negligible small. A greater part of the losses specified as 2) and 3) above, although slightly reduced in the amount due to seepage and evaporation, could be utilized in the downstream areas. The Project Area, poorly

developed in the drainage networks at on-farm levels, has discharged the most of the excessive waters through plot-to-plot drainage. The amount of such waters, however, are not measurable. In this study, the inflows amount by plot-to-plot drainage into the return flow survey area was considered to offset with the outflows therefrom. No rainfalls were observed during the said survey (27 to 29, July, 1981). Furthermore, the study defines the return flow utilization rate at the terminal fields of the survey area as follows:

$$(1) = \frac{\text{return flow}}{\text{intake}}, \text{ or}$$

$$(2) = \frac{\text{return flow}}{\text{intake-net water requir.}} = \frac{\text{return flow}}{\text{loss water}}$$

where:

return flow = excess water in irrigation canals at the end + return flow in drainage canals

return flow in drainage canals = flow at the end - flow at the head

net water requirement = 9.03 cu.m/s

The result of estimation of the return flow utilization rate in the area can be summed up as follows on the above definition basis: About 78 percent of the irrigation water losses has been used on an average in the downstream, and this figure corresponds to almost 27 percent of the intake amount at the upstream. The irrigation efficiency, when the measurement was carried out, was presumed to be 66 percent on an average, which, comparatively high efficiency, indicates that the measurement was made at the period when the rotational water supply had been practiced in the Area and the local farmers had been exercising the effective water management.

Rate of Return Flow

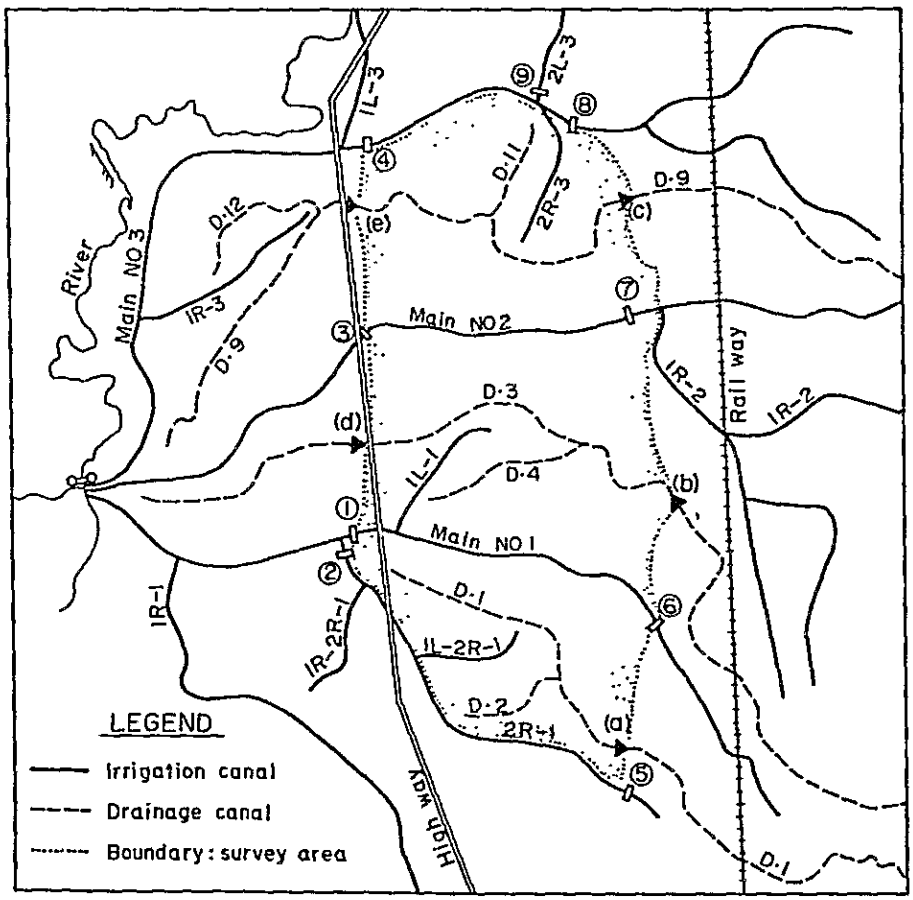
- Unit: cu.m/s -

Date	(1) Intake	(2) Losses	(3) Return Flow	Rates of Return Flow in % (3)/(2)	(3)/(1)	Irrigation Efficiency (%)
Jul. 27	13.96	4.93	3.37	68	24	65
Jul. 28	14.16	5.13	3.79	74	27	64
Jul. 29	13.15	4.12	3.91	95	30	69
Average	13.76	4.73	3.69	78	27	66

Notes: (2) = (1) - 9.03

Irrigation efficiency = 9.03/(1)

Figure D-1 Location of Return Flow Survey



D-1-4 Water-intake and Reservoir Release.

The diversion water at the Phet diversion dam and the reservoir release from the Kaeng Krachan dam have been recorded on the daily basis by RID and EGAT, respectively. Table D-4 illustrates the water-intake and the reservoir release for these last five years from 1976 to 1980. The comparison between the water-intake records and the cropping acreages in the Area, recorded by the Phetchaburi O & M Office, is summarized as follows; in 1980, in spite of a little rainfalls observed, the water-intake was recorded lowest due to restriction of the reservoir release.

Annual Water-intake and Reservoir Release

Year	Total Irrigation Area (ha)	Reservoir Release (MCM)	Water-intake (MCM)	Water-intake (mm)	Rainfall (mm)
1976	56,930	807.0	803.5	1,411	1,023
1977	56,450	885.8	694.5	1,230	1,020
1978	56,565	811.5	790.8	1,398	1,144
1979	59,761	1,097.3	925.1	1,548	435
1980	55,546	651.8	648.0	1,126	753

Table D-4 Monthly Water-intake and Reservoir Release (1976 - 1980)

Month	1976 Intake cu.m/s	1976 Intake MCM	1976 Reserv. Release MCM	1977 Intake cu.m/s	1977 Intake MCM	1977 Reserv. Release MCM	1978 Intake cu.m/s	1978 Intake MCM	1978 Reserv. Release MCM
Jan.	3.3	8.7	27.2	1.4	3.7	28.9	1.0	2.7	28.8
Feb.	11.4	27.5	39.0	8.9	21.6	41.3	4.9	11.9	36.4
Mar.	14.7	39.4	52.9	13.6	36.5	57.5	11.6	31.1	52.3
Apr.	15.7	40.7	52.7	14.1	36.6	55.1	17.8	46.2	54.1
May	15.2	40.8	49.1	15.2	40.6	54.4	17.1	45.7	42.2
Jun.	28.7	74.3	87.3	31.4	81.5	97.5	26.2	68.0	67.3
Jul.	41.7	111.6	116.2	37.9	101.4	103.7	35.2	94.2	73.7
Aug.	43.8	117.2	112.9	36.5	97.7	105.3	35.3	94.6	94.9
Sep.	41.7	108.0	82.6	36.2	31.3	97.8	44.2	114.5	105.3
Oct.	47.1	126.1	109.5	34.4	92.0	79.7	47.1	126.2	88.3
Nov.	35.7	92.6	44.8	43.4	112.4	114.6	45.4	117.8	117.3
Dec.	6.2	16.6	32.8	14.6	39.2	50.0	14.1	37.9	50.9
Total		803.5	807.0		694.5	885.8		790.8	811.5

Month	1979 Intake cu.m/s	1979 Intake MCM	1979 Reserv. Release MCM	1980 Intake cu.m/s	1980 Intake MCM	1980 Reserv. Release MCM
Jan.	5.3	14.2	39.9	3.1	8.3	26.7
Feb.	16.9	40.8	61.8	13.9	33.6	54.7
Mar.	25.5	68.4	81.9	18.0	48.2	61.3
Apr.	24.9	64.6	81.7	16.5	42.7	53.8
May	28.0	74.9	87.4	13.9	37.2	44.0
Jun.	29.0	75.1	83.4	15.6	40.5	38.9
Jul.	37.9	101.4	108.2	14.9	39.9	44.2
Aug.	41.8	111.9	129.6	27.1	72.6	65.0
Sep.	32.9	85.3	125.0	47.0	121.7	84.7
Oct.	48.3	129.3	129.0	34.6	92.6	69.3
Nov.	44.3	114.8	114.3	30.3	78.6	73.2
Dec.	16.6	44.4	55.1	12.0	32.1	36.0
Total		925.1	1,097.3		648.0	651.8

D-1-5 Irrigation and Paddy Yield

In this study, the farm economic survey has been conducted for selected 273 farm households in the Project Area (See Appendix G). The average paddy yield data for these recent three years (1978-1980), which were obtained through the survey, were arranged into 22 samples on the averaging of the village unit. On top of the above, a unit acreage harvesting survey (Tsubo-gari), one of the simple way of harvesting survey, was conducted at 14 points to have the paddy yield, and the analysis was made on the relations between 36 sample yields and the irrigation conditions of the surveyed fields.

The irrigation conditions affecting the paddy yields, which are metrically handled, are 1) density of ditches, 2) commandability with gravity and 3) relative distance from diversion points. The commandability with gravity was analyzed in D-1-4. The relative distances from diversion points are expressed by percentage of the total distance of the canals (Main No.1, No.2 and No.3, and the Left Main) against the distances between the relevant sample plots and the related diversion points. The percentages obtained are the indices based on the fact that the paddy fields in the down-stream areas are less advantageous in irrigation to those in the upstream areas when the decrease in the discharge capacity of the canals and/or the shortage in water to be supplied take place. The ditch density was measured on the basis of the topo-map (scale: 1/10,000). The location of the sample plots, yields, ditch density are shown in Figure D-2.

The relationship between the paddy yields and the ditch density/ relative distance from the diversion points are illustrated in Figure D-3. As learnt from the said Figure, the commandable areas with gravity are prone to more increase in their yields with providing higher density of the ditches, whereas the fields out of the command with gravity have no correlations between their yields and the ditch density.

The dry season paddy, grown in the fields advantageous in irrigation in their locations along the irrigation or drainage canals, has little relationship in the yield with the ditch density.

In general, the paddy yield inclines to decrease as the distance between the paddy fields and the diversion dams becomes longer, excepting for the three samples found in the irrigation system IR-1. The concrete-line Hua Hin canal, since providing a sufficient supply capacity including the domestic and industrial use and yet a sufficient FSL against the field elevation, has permitted those fields far from the diversion point to be easily irrigated.

The low yields from the fields along the seadikes which are located far from the diversion dam would indicate generally the decrease in capacity of the existing earth canals, the low FSL, the definite shortage of the canal capacity, etc., besides the problem of the comparatively high soil salinity therein. These problems have hindered the paddy cropping from practising timely and adequate irrigation water supply, resulting in the yield being restricted.

A series of these analyses has been carried out through direct comparison of the paddy yields with the irrigation conditions only. The results of the analyses will suggest the future approach in the improvement works of the irrigation systems of the Project Area, though the paddy yields are closely affected by not merely irrigation but the varieties, soil conditions such as fertility and salinity concentration, farming techniques and so forth.

Figure D - 2 Location of Samples for Paddy Field and Irrigation Condition

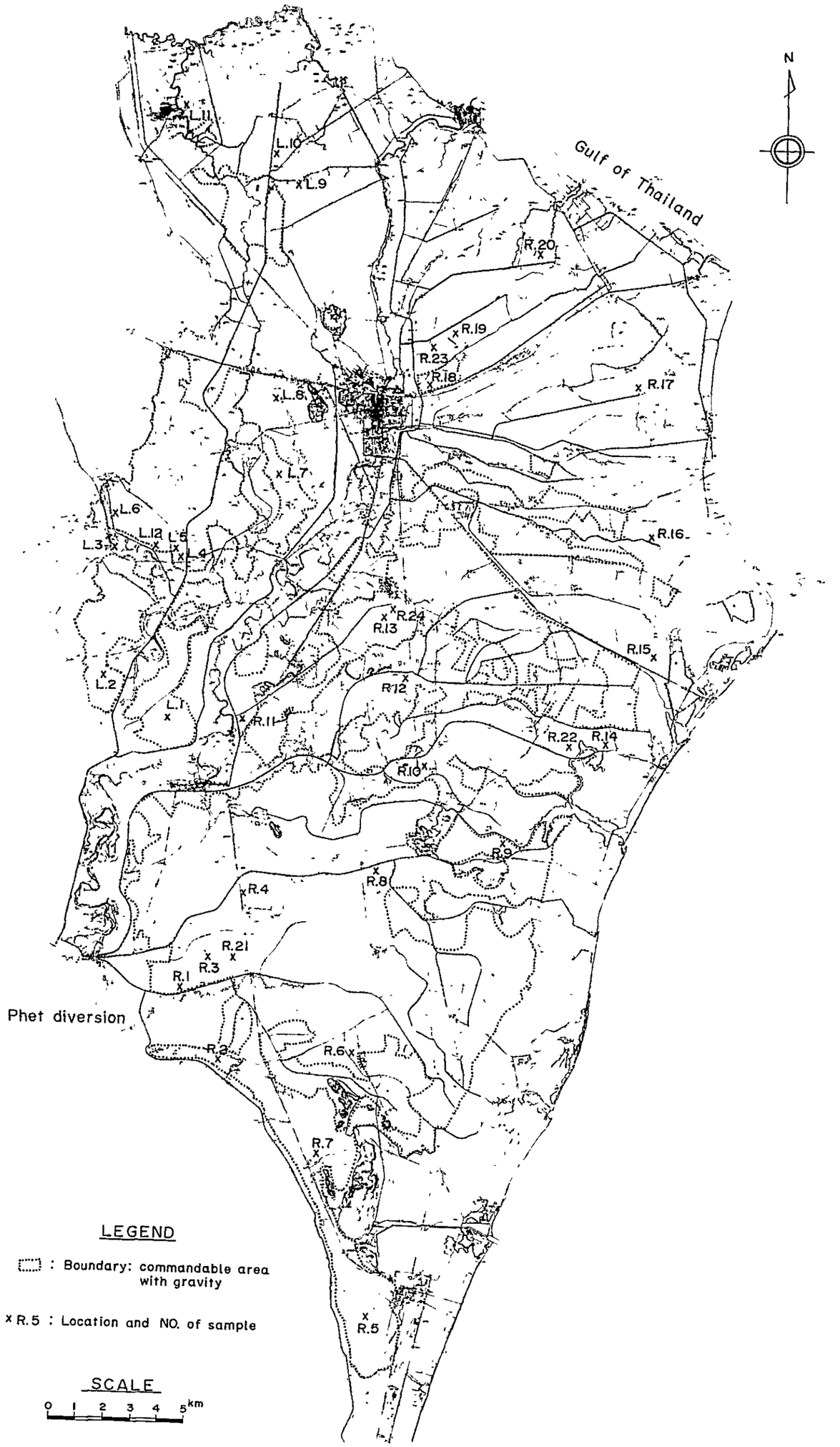
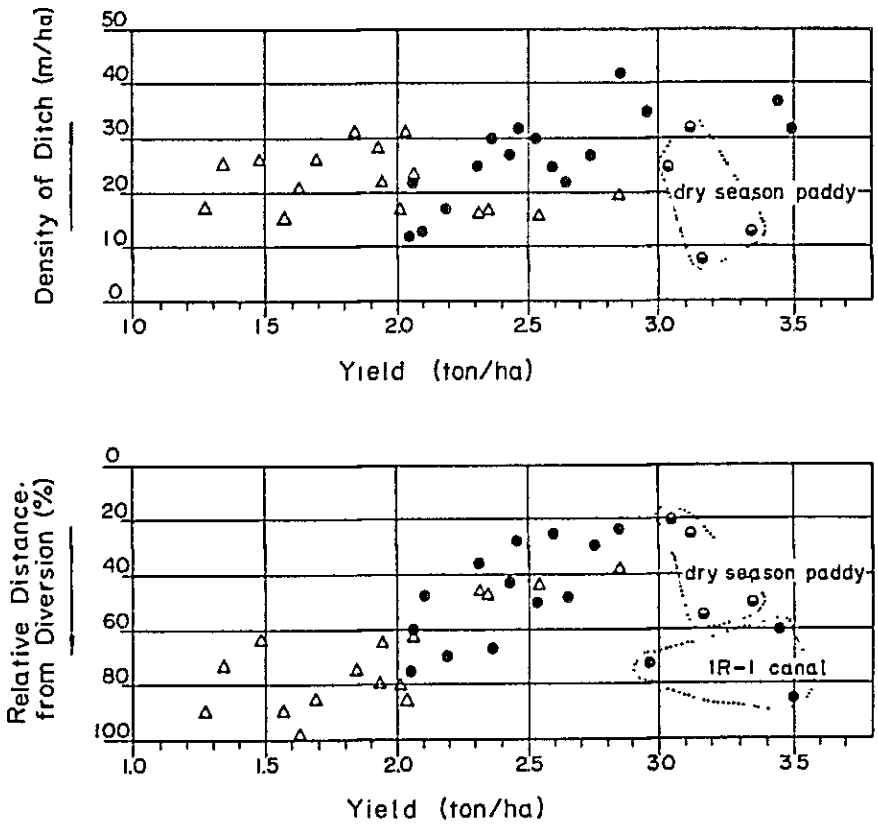


Figure D-3 Correlation between Paddy Yield and Irrigation



Notes: ● : rainy season paddy, commandable with gravity
⊖ : dry season paddy, commandable with gravity
△ : rainy season paddy, uncommandable

V-1-6 Proposed Irrigation Requirements

(1) Crop Water Requirements

The CWR can be calculated in following the procedures shown below:

CWR = consumptive use of water by crop (Cu) + land preparation (Lp)/pre-irrigation (Lp) + percolation (P) - effective rainfall (Re)

Consumptive Use of Water by Crops (Cu)

The Cu can be obtained by multiplying the reference evapotranspiration (ETo) by varying crop factors (Kc) with kind and type of crops, their growing stage, etc.

The ETo in the case was estimated as follows by using the modified Penman method in applying the meteorological data available at Hua Hin (See Appendix A, Hydrology).

Reference Evapotranspiration (ETo)

- Unit: mm -

Month	ETo	Month	ETo	Month	ETo
Jan.	152	May	173	Sep.	137
Feb.	154	Jun.	154	Oct.	140
Mar.	190	Jul.	152	Nov.	145
Apr.	196	Aug.	144	Dec.	156

The RID carried out the water requirements survey for paddy at three water use experimental stations 1978 through 1979. According to the results obtained from the survey, the relationship between crop factors and the paddy growing days in process is illustrated in Figure D-4, taking the necessary growing days at

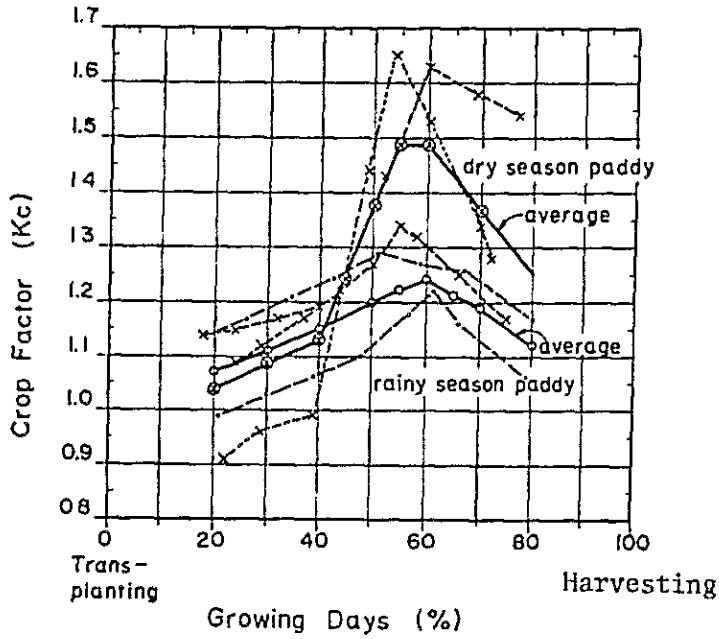
every stage by percentage against the total growing days from transplanting through harvesting.

Figure D-4 indicates the crop factors varying with the respective growing stages for the paddy with certain given growing days. Since no data of the crop factors for the crops other than paddy, the values used for the study of the Mae Klong Irrigated Agriculture Development Project were applied to the current study. The growing-stage-wise crop factors of each crop are shown below, and for references, the crop factor in land preparation was taken by 1.00.

Crop Factor (Kc)

Growing Stage (month)	Rainy Season Paddy HYV	Rainy Season Paddy LV	Dry Season Paddy, HYV	Dry Season Upland Crops
1	1.03	1.01	1.03	0.5
2	1.13	1.12	1.28	0.8
3	1.21	1.22	1.26	1.1
4	1.00	1.12		0.9
5		1.00		

Figure D-4 Cron Factor and Growing Days



Other Requirements

Besides the consumptive use by crop, percolation and water for the land preparation are needed for paddy growing, while pre-irrigation water for those cropping other than paddy. The percolation in the uplands is regarded as the irrigation losses. The average percolation in the Area was estimated at 1.5 mm/day on the basis of the measurement data by RID at the Phetchaburi Water Use Experimental Station and those obtained at 30 points surveyed in this study. The average porosity of the soils in the Project Area is about 45 percent. Under the conditions of water-fill of 70 percent of the porosity up to 30 cm below field surface and the flooding by 50 mm over the fields, the land preparation water required will be about 150 mm in depth. In addition, however, the water of 50 mm in depth is planned to be further supplied for initial leaching, totaling 200 mm in depth for land preparation. The pre-irrigation water required for uplands was designed by 50 mm in reference to the data available from the other similar-natured projects in the country.

Effective Rainfall

The effective rainfalls can be estimated by taking the probable minimum monthly rainfall as the design rainfall (See Appendix A. A-2). The minimum monthly rainfall with five-year return period was applied to estimating the irrigation canal capacity. The monthly-base design rainfalls for two-and five-year return periods are shown as follows:

Monthly Design Rainfall

- Unit: mm -

Month	Return Period 2 years	5 years	Month	Return Period 2 years	5 years
Jan.	-	-	Jul.	87	58
Feb.	-	-	Aug.	91	53
Mar.	-	-	Sep.	129	87
Apr.	-	-	Oct.	186	115
May	92	51	Nov.	54	19
Jun.	67	33	Dec.	-	-

(2) Irrigation Efficiencies

A part of the irrigation waters flowing through the downstream portion from the farm turn-outs will become uneffective for irrigation due to operation losses and horizontal seepage through the sides of the dikes and ditches. The application efficiency in the Project was estimated to be increased to 70 percent in paddy cropping and 60 percent in upland cropping after completion of the on-farm development, although varying by the conditions of on-farm facility consolidation and skillfulness of the farmers' water management practices.

The water conveyance losses will take place in the main and lateral canals due to evaporation, seepage from canals, miss-operation, and so forth. In this study, the conveyance efficiency for the irrigation canals, which will be concrete-lined, was estimated at 85 percent, and also the irrigation efficiency was calculated as follows:

Irrigation Efficiencies

- Unit: % -

Item	Paddy	Other Crops
Application	70	60
Conveyance	85	85
Overall	60	50

(3) Irrigation Requirements

According to the five cropping patterns and calendars proposed in the agricultural development plan (See Appendix C), following two irrigation requirements were estimated, and one, which is the irrigation requirements for the normal years, was estimated based on the design rainfall with two-year return period, while the other, which was derived for calculation of canal capacity, was estimated based on the rainfall with five-year return period. The average monthly irrigation requirements were computed to be shown in Table D-5, according to the cropping pattern-wise cropped areas which resulted from the reservoir operation analysis to be discussed later in D-1-7. Table D-6 can backup Table D-5 in details. On the other hand, the 10-day peak irrigation requirements by cropping patterns can be tabulated below and detailed in Table D-7.

Peak Irrigation Requirements

Cropping Pattern	ℓ/s/ha	Occurrence Data
Rainy Season Paddy, LV	1.30	Jul. II
Rainy Season Paddy, HYV	1.31	Aug. I
Tree Crops and Upland Crops	1.06	Apr.
Dry Season Paddy, HYV	1.82	Feb. II
Dry Season Mung Beans	1.53	Apr. II

The proposed cropping pattern has allowed to calculate the peak irrigation requirements for the whole area of 52,600 ha by about 59.3 cu.m/s, to be required in August, the land preparation season for the rainy season paddy cropping.

Table D-5 Irrigation Requirements

- Unit: MCM -

	Rainy Season Paddy		Tree Crop	Dry Season Crop		
Month	LV (14,100ha)	HYV (34,600ha)	Upland (3,900ha)	Paddy (7,000ha)	Beans (7,300ha)	Total (66,900ha)
Jan.	-	-	8.3	22.1	7.2	37.6
Feb.	-	-	8.4	27.4	14.2	50.0
Mar.	-	-	10.4	30.9	23.5	64.8
Apr.	-	-	10.7	26.1	27.4	64.2
May	5.6	-	2.3	1.2	-	9.1
Jun.	28.5	40.8	3.2	-	-	72.5
Jul.	35.0	73.4	1.5	-	-	109.9
Aug.	26.4	75.4	0.7	-	-	102.5
Sep.	17.2	39.1	-	-	-	56.3
Oct.	4.7	-	-	-	-	4.7
Nov.	25.8	7.6	3.7	-	-	37.1
Dec.	3.5	4.2	8.5	9.1	-	25.3
Total	146.7	240.5	57.7	116.8	72.3	634.0

Table D-6 Average Monthly Irrigation Requirements by Crop

Month	ETo	Kc	Cu	Lp	P	Re	CWR	IWR (mm)	IWR (MCM)
Rainy Season Paddy, LV (14,100 ha)									
Jan.	-	-	-	-	-	-	-	-	-
Feb	-	-	-	-	-	-	-	-	-
Mar.	-	-	-	-	-	-	-	-	-
Apr.	-	-	-	-	-	-	-	-	-
May	173	0.185	32	75	9	92	24	40	5.6
Jun.	154	0.565	87	75	26	67	121	202	28.5
Jul.	152	0.940	143	50	43	87	149	248	35.0
Aug.	144	1.090	157	-	47	92	112	187	26.4
Sep.	137	1.146	157	-	45	129	73	122	17.2
Oct.	140	1.136	159	-	47	186	20	33	4.7
Nov.	145	0.840	122	-	42	54	110	183	25.8
Dec.	156	0.045	7	-	8	-	15	25	3.5
Total			864	200	267	707	624	1,040	146.7
Rainy Season Paddy, HYV (34,600 ha)									
Jan.	-	-	-	-	-	-	-	-	-
Feb.	-	-	-	-	-	-	-	-	-
Mar.	-	-	-	-	-	-	-	-	-
Apr.	-	-	-	-	-	-	-	-	-
May	173	0.017	3	25	1	29	-	-	-
Jun.	154	0.312	48	75	15	67	71	118	40.8
Jul.	152	0.710	108	75	31	87	127	212	73.4
Aug.	144	1.055	152	25	46	92	131	218	75.4
Sep.	137	1.109	152	-	45	129	68	113	39.1
Oct.	140	0.793	111	-	37	148	-	-	-
Nov.	145	0.324	47	-	20	54	13	22	7.6
Dec.	156	0.017	3	-	4	-	7	12	4.2
Total			624	200	199	606	417	695	240.5

Month	ETo	Kc	Cu	Re	CWR	IWR (mm)	IWR (MCM)
Tree Crops (3,900 ha)							
Jan.	152	0.70	106	-	106	212	8.3
Feb.	154	0.70	108	-	108	216	8.4
Mar.	190	0.70	133	-	133	266	10.4
Apr.	196	0.70	137	-	137	274	10.7
May	173	0.70	121	92	29	58	2.3
Jun.	154	0.70	108	67	41	82	3.2
Jul.	152	0.70	106	87	19	38	1.5
Aug.	144	0.70	101	92	9	18	0.7
Sep.	137	0.70	96	96	-	-	-
Oct.	140	0.70	98	98	-	-	-
Nov.	145	0.70	102	54	48	96	3.7
Dec.	156	0.70	109	-	109	218	8.5
Total			1,325	586	739	1,478	57.7

Month	ETo	Kc	Cu	Lp	P	Re	CWR	IWR (mm)	IWR (MCM)
Dry Season Paddy, HYV (7,000 ha)									
Jan.	152	0.520	79	56	24	-	159	315	22.1
Feb	154	0.916	141	56	36	-	235	392	27.4
Mar	190	1.147	218	-	47	-	265	442	30.9
Apr.	196	0.980	192	-	41	9	224	373	26.1
May	173	0.450	78	-	24	92	10	17	1.2
Jun.	154	0.026	4	-	4	8	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug	-	-	-	-	-	-	-	-	-
Sep	-	-	-	-	-	-	-	-	-
Oct.	-	-	-	-	-	-	-	-	-
Nov.	-	-	-	-	-	-	-	-	-
Dec.	156	0.103	16	56	4	-	78	130	9.1
Total			728	200	182	109	1,001	1,669	116.8
Dry Season Inland Crops (7,300 ha)									
Jan.	152	0.099	15	34	-	-	49	98	7.2
Feb.	154	0.526	81	16	-	-	97	194	14.2
Mar.	190	0.847	161	-	-	-	161	322	23.5
Apr.	196	0.959	188	-	-	-	188	376	27.4
May	173	0.208	36	-	-	36	-	-	-
Jun.	-	-	-	-	-	-	-	-	-
Jul	-	-	-	-	-	-	-	-	-
Aug.	-	-	-	-	-	-	-	-	-
Sep.	-	-	-	-	-	-	-	-	-
Oct.	-	-	-	-	-	-	-	-	-
Nov.	-	-	-	-	-	-	-	-	-
Dec.	-	-	-	-	-	-	-	-	-
Total			481	50	-	36	495	990	72.3

Notes:

ETo: reference evapotranspiration in mm

Kc : weighted mean of crop factor

Cu : consumptive use in mm = ETo x Kc

Lp : land preparation in mm

P : percolation in mm

Re : effective rainfall in mm

CWR: crop water requirement in mm = Cu + LP + P - Re

IWR: irrigation water requirement in mm

CWR ÷ 0.6 for paddy

CWR ÷ 0.5 for other crop than paddy

irrigation water requirement in MCM

(CWR in mm) x (area in ha) x 10^{-6}

Table D-7 Peak Irrigation Requirements

Month	ETo	Kc	Cu	LP	P	Re	IWR	Kc	Cu	LP	P	Re	IWR
Rainy Season Paddy, LV								Rainy Season Paddy, HYV					
Jul.I	49	0.82	40	25	12	19	1.12	0.57	28	25	8	19	0.81
II	49	0.96	47	25	14	19	1.30	0.71	35	25	10	19	0.98
III	54	1.04	56	-	17	19	0.95	0.84	45	25	13	19	1.12
Aug.I	46	1.06	49	-	15	17	0.90	0.99	46	25	14	17	1.31
II	46	1.09	50	-	15	17	0.93	1.07	49	-	15	17	0.90
III	52	1.11	58	-	17	19	0.98	1.10	57	-	17	19	0.96
Dry Season Paddy, HYV								Dry Season Mung Beans					
Feb.I	55	0.79	43	28	12	-	1.60	0.40	22	16	-	-	0.88
II	55	0.94	52	28	14	-	1.82	0.55	30	-	-	-	0.69
III	44	1.05	46	-	12	-	0.84	0.65	29	-	-	-	0.84
Mar.I	60	1.10	66	-	15	-	1.56	0.75	45	-	-	-	1.04
II	61	1.16	71	-	15	-	1.66	0.85	52	-	-	-	1.20
III	69	1.18	81	-	17	-	1.71	0.93	64	-	-	-	1.34
Apr.I	65	1.15	75	-	15	-	1.74	0.98	64	-	-	-	1.48
II	68	0.97	66	-	14	-	1.54	0.97	66	-	-	-	1.53
III	63	0.81	51	-	12	-	1.10	0.92	58	-	-	-	1.22

Month	ETo	Kc	Cu	Re	IWR
Tree Crops/Upland Crops					
Mar.	190	0.70	133	-	1.00
Apr.	196	0.70	137	-	1.06
May	173	0.70	121	-	0.53
Jun.	154	0.70	108	-	0.58
Jul.	152	0.70	106	-	0.35
Aug.	144	0.70	101	-	0.35

Notes:

ETo: reference evapotranspiraion in mm

Kc : weighted mean of crop factor

Cu : consumptive use of water in mm = ETo x Kc

LP : land preparation in mm

P : percolation in mm

Re : effective rainfall in mm

IWR: irrigation water requirement in ℓ/s/ha

(Cu + LP + P - Re) x 10/ (0.6 x 86.4) for paddy

(Cu + LP - Re) x 10/(0.5 x 86.4) for other crops

D-1-7 Reservoir Operation

A plan has been made up to more develop the land use in the Project Area through inclusion of the extension area along the sea-dikes into the Phetchaburi irrigation areas as well as increase in the dry season paddy cropping areas. The largest bottleneck in executing this plan is the water availability of the Phetchaburi river. And a study was made to pursue the coverage of the existing Kaeng Krachan reservoir as the water sources for proper irrigation. The reservoir operation study has been carried out for seven years from August, 1974 when the power plant operation was started to December, 1980.

(1) Irrigable Area

The expected net irrigable area in the surveyed area will be decreased from the present acreage of 56,450 ha including the Extension Area to 52,600 ha in due consideration of the land deduction by implementation of the on-farm development. In the land use plan, the first priority will be given to an introduction of irrigated agriculture to the Extension Area of 7,100 ha, and next comes the increase in the dry season paddy cropping acreage.

Net Irrigable Area in ha

System	Paddy Field	Orchard Upland	Total
Main No.1	5,660	800	6,460
Main No.2	4,950	830	5,780
Main No.3	18,890	1,580	20,470
Left Main	12,100	690	12,790
Sub-total	41,600	3,900	45,500
Extension Area	7,100	-	7,100
Total	48,700	3,900	52,600

The dry season cropping was planned that mungbeans would be grown in the area of 7,300 ha as the second cropping of the rainy season paddy cropping, besides that the dry season paddy cropping acreages might be variable according to the water availability. Mungbeans will be cropped by 5,200 ha in the right bank, while by 2,100 ha in the left bank. The cropping ration of the Lv and HYV of paddy in the rainy season is expected at 0.3 : 0.7. The orchards and the upland fields will be grown with perennial crops.

(2) Water Demand

Irrigation Requirements: For the proposed five cropping patterns involving the rainy season LV and HYV paddy, the dry season HYV paddy, the dry season mungbeans and tree crops/upland crops, the irrigation water requirements can be obtained by multiplying necessary irrigation water amount for 1,000 ha by the above cropping acreages. In this computation, the cropping rate of the rainy season LV paddy and HYV paddy was taken by 0.30 : 0.70

The irrigation requirements below the peak requirements will reduce the water level in the irrigation canal below the designed full supply water level, resulting in poor control in diversing the water in the lateral canals and the ditches, when such water level in the main canal is considerably decreased. The improvement of the situation of lowering in the water level was planned, in the Project, to release the water from the reservoir for maintaining the canal water level within a certain range. The operation analysis of the reservoir in varying the minimum irrigation water requirements in the canal revealed that the reservoir would have a heavy burden when the minimum water requirements would exceed 15 percent of the peak irrigation

requirements. The minimum water requirements in this Project, taken by 15 percent of the peak water requirements, were determined by 5.34 cu.m/s for the right bank and 2.16 cu.m/s for the left bank, totaling 7.50 cu.m/s.

Minimum River Discharge: The reservoir release will be controlled so that the Phetchaburi river discharge can be maintained at least by 5.0 cu.m/s at the immediately downstream of the Phet diversion dam.

Domestic and Industrial Water Supply: The Right Main canal No.1 will take the water at the rate of 2.34 cu.m/s for the supply of the domestic and industrial water to Cha-am and Hua Hin.

Hydropower Generation: For power generation, the reservoir release will be made on the basis of the actual release results obtained for power from 1974 to 1980.

(3) Water Availability

The data of the inflow to the Kaeng Krachan reservoir (catchment area: 2,210 sq.km) are available from the records taken since August, 1974, by EGAT. The local runoff from the catchment area of 1,850 sq.km extending between the reservoir and the diversion dam was estimated at 40 percent of the inflow to the reservoir. The estimation was made on the basis of the discharge records at the Phet diversion point (intake records and diversion records to the downstream).

In the Extension Area at the right bank, the return flow from the upstream area is available for irrigation. The current study has taken 25 percent of the irrigation water for the existing irrigated paddy fields in the right bank as return flow available

for the Extension Area in reference to the results of the actual survey on the return flow (See D-1-3). Such a return flow accounts for about 63 percent of the estimated irrigation losses (about 40 percent of the intake water amount) in the unstream, and it is expected to secure the said return flow, in taking into account that the irrigation in the Extension Area is planned to be carried out by the runoff of rainwater from the unstream area as well as the stored water of the return flow in the proposed irrigation/drainage canals of the Extension Area.

(4) Water Budget

The reservoir operation analysis was made for seven years from 1974 to 1980 with variation of the paddy cropping acreage in the dry season. The reservoir loss was estimated by working-out the relationship of the stored water in the reservoir and losses, which were available from the records taken by EGAT. The designed reservoir release would be determined by the larger amount, either the irrigation requirements plus downstream demands or the hydropower demands.

The most appropriate irrigation acreage under the Project was determined by the maximum irrigable area available to meet the following conditions in the reservoir operation for the years from 1974 to 1980.

- The reservoir should store the water at its full water surface level in 1973 of the rainy year.
- In December, 1980, the stored water should not be below 154 MCM of the actual water amount.

The analysis revealed that the above conditions could be fulfilled when the paddy cropping acreage in the dry season should be fixed at 7,000 ha. Therefore, the Project should provide the cropping areas as follows, and the related reservoir water budget for seven years from 1974 to 1980 is illustrated in Table D-8.

Items		Rainy Season (ha)	Dry Season (ha)
Paddy Field			
Right Bank:	Existing Area		
	- Paddy	29,500	4,200
	- Mungbeans	-	5,200
:	Extension Area		
	- Paddy	7,100	1,100
Left Bank :	- paddy	12,100	1,700
	- Mungbeans	-	2,100
Sub-total		48,700	14,300
Orchard/Upland			
Right Bank:	Existing Area	3,210	3,210
Left Bank		690	690
Sub-total		3,900	3,900
Total		52,600	18,200

D-1-8. Proposed Canal Systems

As learnt from the reservoir operation study discussed in D-1-7, the peak irrigation requirements take place in the land preparation period for the rainy season cropping, since the dry season paddy cropping intensity is only 35 percent. More specifically, the peak irrigation requirements appear in the first decade of August when the peak irrigation requirements of the HYV paddy cropping take place because the HYV paddy in the rainy season

Table D-8 Reservoir Operation with Project

- Unit: MCM -

Year Manth	Downstream Demand Irrig.	Others	Total	Local Runoff	Short-age	Power Demand	Water Budget Inflow	Release	Loss	Storage
(1974)										
Aug.	121.8	19.7	141.5	146.6	-	68.4	366.4	361.1	5.3	710.0
Sep.	19.4	19.0	38.4	55.9	-	107.3	139.8	134.5	5.3	710.0
Oct.	20.1	19.7	39.8	124.1	-	121.6	310.2	304.9	5.3	710.0
Nov.	22.4	19.0	41.4	35.9	5.5	117.9	89.7	117.9	5.3	676.5
Dec.	20.1	19.7	39.8	13.4	26.4	39.8	33.4	39.8	5.0	665.1
(1975)										
Jan.	20.3	19.7	40.0	12.3	27.7	31.2	30.8	31.2	5.0	659.7
Feb.	44.0	17.8	61.8	5.4	56.4	42.8	13.5	56.4	4.9	611.9
Mar.	57.0	19.7	76.7	9.4	67.3	55.1	23.6	67.3	4.6	563.6
Apr.	55.3	19.0	74.3	13.0	61.3	70.5	32.6	70.5	4.3	521.4
May	20.1	19.7	39.8	21.6	18.2	76.6	54.0	76.6	4.0	494.8
Jun.	98.6	19.0	117.6	41.4	76.2	104.4	103.5	104.4	3.8	490.1
Jul.	93.2	19.7	112.9	30.8	82.1	117.3	77.1	117.3	3.8	446.1
Aug.	71.6	19.7	91.3	80.6	10.7	120.1	201.6	120.1	3.5	524.1
Sep.	67.1	19.0	86.1	49.9	36.2	112.8	124.7	112.8	4.0	532.0
Oct.	20.1	19.7	39.8	63.0	-	79.6	157.4	79.6	4.1	605.7
Nov.	47.7	19.0	66.7	25.0	41.7	53.7	62.4	53.7	4.6	609.8
Dec.	20.1	19.7	39.8	12.0	27.8	27.7	30.0	27.8	4.6	607.4
(1976)										
Jan.	33.3	19.7	53.0	8.7	44.3	27.2	21.7	44.3	4.6	580.2
Feb.	45.5	18.4	63.9	7.1	56.8	39.1	17.7	56.8	4.4	536.7
Mar.	54.3	19.7	74.0	7.9	66.1	52.9	19.8	66.1	4.1	486.3
Apr.	53.0	19.0	72.0	8.0	64.0	52.7	20.1	64.0	3.8	438.6
May	20.1	19.7	39.8	27.0	12.8	49.1	67.5	49.1	3.4	453.6
Jun.	36.1	19.0	55.1	27.1	28.0	87.3	67.8	87.3	3.5	430.6
Jul.	97.1	19.7	116.8	37.6	79.2	113.6	93.9	113.6	3.4	407.5
Aug.	100.2	19.7	119.9	53.7	66.2	83.6	134.3	83.6	3.2	455.0
Sep.	34.5	19.0	53.5	61.6	-	70.5	154.0	70.5	3.5	535.0
Oct.	20.1	19.7	39.8	28.6	11.2	91.6	71.4	91.6	4.1	510.7
Nov.	36.1	19.0	55.1	42.8	12.3	44.8	107.0	44.8	3.9	569.0
Dec.	20.9	19.7	40.6	9.8	30.8	29.5	24.4	30.8	4.3	558.3
(1977)										
Jan.	33.3	19.7	53.0	6.0	47.0	25.5	14.9	47.0	4.2	522.0
Feb.	42.8	17.8	60.6	4.0	56.6	41.3	10.1	56.6	4.0	471.5
Mar.	56.7	19.7	76.4	10.1	66.3	57.5	25.3	66.3	3.7	426.8
Apr.	56.9	19.0	75.9	6.0	69.9	55.1	15.0	69.9	3.4	368.5
May	20.1	19.7	39.8	16.2	23.6	54.4	40.4	54.4	3.0	351.5
Jun.	52.1	19.0	71.1	15.2	55.9	97.5	38.1	97.5	2.9	289.2
Jul.	57.4	19.7	77.1	29.2	47.9	102.0	73.1	102.0	2.4	257.9
Aug.	60.7	19.7	80.4	66.6	13.8	58.9	166.5	58.9	2.2	363.3
Sep.	60.2	19.0	79.2	74.0	5.2	95.7	184.9	95.7	2.9	449.6

- to be continued -

- continued -

Year Month	Downstream Demand Irrig.	Others	Total	Local Runoff	Short-age	Power Demand	Water Budget Inflow	Release	Loss	Storage
Oct.	20.1	19.7	39.8	46.8	-	78.0	117.0	78.0	3.5	485.1
Nov.	59.3	19.0	78.3	17.1	61.2	98.0	42.8	98.0	3.8	426.1
Dec.	22.7	19.7	42.4	9.9	32.5	50.0	24.8	50.0	3.4	397.5
(1978)										
Jan.	30.2	19.7	49.9	7.1	42.8	28.8	17.7	42.8	3.2	369.2
Feb.	40.1	17.8	57.9	7.2	50.7	36.4	18.0	50.7	3.0	333.5
Mar.	57.0	19.7	76.7	6.0	70.7	52.3	14.9	70.7	2.7	275.0
Apr.	46.1	19.0	65.1	11.9	53.2	54.1	29.8	54.1	2.3	248.4
May	20.1	19.7	39.8	20.7	19.1	42.2	51.8	42.2	2.2	255.8
Jun.	19.4	19.0	38.4	24.2	14.2	67.3	60.6	67.3	2.2	246.9
Jul.	20.1	19.7	39.8	30.6	9.2	73.7	76.6	73.7	2.2	247.6
Aug.	144.0	19.7	163.7	122.7	41.0	38.6	306.8	41.0	2.2	511.2
Sep.	19.4	19.0	38.4	67.1	-	91.1	167.7	91.1	3.9	583.9
Oct.	40.3	19.7	60.0	103.3	-	79.6	258.2	127.7	4.4	710.0
Nov.	76.4	19.0	95.4	23.7	71.7	112.9	59.3	112.9	5.3	651.1
Dec.	22.7	19.7	42.4	9.9	32.5	50.9	24.7	50.9	4.9	620.0
(1979)										
Jan.	33.3	19.7	53.0	9.2	43.8	38.3	23.1	43.8	4.7	594.6
Feb.	44.0	17.8	61.8	9.0	52.8	61.8	22.5	61.8	4.5	550.8
Mar.	57.0	19.7	76.7	6.5	70.2	81.9	16.2	81.9	4.2	480.9
Apr.	55.7	19.0	74.7	11.0	63.7	81.7	27.5	81.7	3.7	423.0
May	34.5	19.7	54.2	11.7	42.5	87.4	29.2	87.4	3.3	361.5
Jun.	102.2	19.0	121.2	22.8	98.4	83.4	57.1	98.4	2.9	317.3
Jul.	110.3	19.7	130.0	53.1	76.9	104.8	132.8	104.8	2.6	342.7
Aug.	138.0	19.7	157.7	111.0	46.7	113.7	277.5	113.7	2.8	503.7
Sep.	29.6	19.0	48.6	38.0	10.6	108.4	95.0	108.4	3.9	486.4
Oct.	112.1	19.7	131.8	30.9	100.9	108.7	77.2	108.7	3.8	451.1
Nov.	69.2	19.0	88.2	14.3	73.9	98.9	35.8	98.9	3.5	384.5
Dec.	22.7	19.7	42.4	7.4	35.0	55.1	18.6	55.1	3.1	344.9
(1980)										
Jan.	33.3	19.7	53.0	6.4	46.6	26.8	15.9	46.6	2.8	311.4
Feb.	40.9	18.4	59.3	9.0	50.3	54.7	22.6	54.7	2.6	276.7
Mar.	56.7	19.7	76.4	8.7	67.7	61.3	21.7	67.7	2.4	228.3
Apr.	54.0	19.0	73.0	8.2	64.8	42.3	20.5	64.8	2.0	182.0
May	40.2	19.7	59.9	17.9	42.0	26.8	44.8	42.0	1.7	183.1
Jun.	41.4	19.0	60.4	17.2	43.2	25.9	42.9	43.2	1.7	181.1
Jul.	115.6	19.7	135.3	24.9	110.4	26.8	62.3	110.4	1.7	131.3
Aug.	73.0	19.7	92.7	34.2	58.5	60.0	95.4	60.0	1.4	165.3
Sep.	116.2	19.0	135.2	47.0	88.2	84.7	104.9	88.2	1.5	180.5
Oct.	20.1	19.7	39.8	37.9	1.9	68.8	94.8	68.8	1.5	205.0
Nov.	48.4	19.0	67.4	16.0	51.4	63.7	40.0	63.7	1.7	179.6
Dec.	20.3	19.7	40.0	9.2	30.8	31.1	22.9	31.1	1.4	170.0

cropping occupies about 70 percent of the total paddy cropping in the rainy season. In this case, the average irrigation requirements are 1.19 cu.m/s/1,000 ha (0.90 x 0.3 + 1.31 x 0.7) for the rainy season paddy cropping and 0.35 cu.m/s/1,000 ha for the upland cropping (See Table D-7).

The irrigation system-wise irrigable areas for the existing irrigation area of 45,500 ha are shown in Table D-9. Table D-10 illustrates the accumulated irrigable areas for the existing irrigation area under the respective canal systems. A comparison of the peak irrigation requirements with the capacity of the existing canals was made (Table D-11), in taking the aforesaid average peak irrigation requirements and the results shown in Table D-10 into consideration. Table D-11 indicates that 16 canals out of the 41 existing irrigation canals have been suffering from the shortage in the canal capacity. The following shows the relevant proposed peak irrigation requirements.

Proposed Peak Irrigation Requirement

- Unit: cu.m/s -

Irrigation System	Paddy Field	Orchard Upland	Total
Left Main	14.40	0.24	14.64
Main No.1	6.74	0.28	7.02
Main No.2	5.89	0.29	6.18
Main No.3	22.48	0.55	23.03
Extension Area	8.45	-	8.45
Total	57.96	1.36	59.32

The proposed irrigable areas after implementation of the on-farm development works are estimated at 52,600 ha as shown below. The existing irrigable areas under the direct command of the respective irrigation canals are shown in Table D-9.

Proposed Irrigable Area in ha

Irrigation System	Paddy Field	Orchard Upland	Total
Existing Area			
Left Main	12,100	690	12,790
Main No.1	5,660	800	6,460
Main No.2	4,950	830	5,780
Main No.3	18,890	1,580	20,470
Sub-total	41,600	3,900	45,500
Extension Area	7,100	-	7,100
Total	48,700	3,900	52,600

As mentioned already, the Extension Area in the right bank does not belong to the existing Phetchaburi Irrigation System.

The following four alternatives were taken into account for the study of the water supply by involving the Extension Area under the systematic irrigation services; 1) to provide a new canal system inclusively used for the said area, 2) to enlarge the capacity of the existing canals, 3) to supply water through the drainage canals as it is carried out at present, and 4) to apply any combination of the above. The alternative 1) was not employed in the Project due to its high cost.

The irrigation coverage of the Extension Area of 7,100 ha by the existing irrigation system can be specified as follows.

Irrigable Area by Canal for Extension Area

- Unit: ha -

Canal	Paddy	Canal	Paddy
Main No.1	204	4R-1L-3	148
1R-1	362	5R-1L-3	325
2R-1	800	2L-5R-1L-3	603
1R-2R-1	500	1L-5R-1L-3	436
No.2	575	6R-1L-3	260
1R-2	316	8R-1L-3	510
No.3	548	9R-1L-3	297
2L-3	167	1L-9R-1L-3	102
1R-3R-1L-3	418	10R-1L-3	37
3R-1L-3	492	Total	7,100

The required canal capacity for the case was computed to find some shortage in capacity of 23 canals out of 41 existing ones. The capacity enlargement is inevitably required for these canals for the full courses from the diversion to the terminal. Such improvement works need much fund in following to the alternative 1).

The peak irrigation requirements, which determine the irrigation canal capacity, will not last long. The Project plans to supply the water to the Extension Area through the existing irrigation canals in the off-time of the peak irrigation required. For further shortage in water, particularly for the requirements in the land preparation, the water should be supplied before the peak requirements take place and stored in the dual purpose irrigation/drainage canals to be constructed in the Extension Area.

The Extension Area can utilize about 25 percent of the irrigation water in the upstream paddy fields as the return flow (D-1-3). Furthermore, in the same way as used at present, a part of the rainfalls in the upstream area (63,900 ha in gross), as well as in the Extension Area is expected to be stored for irrigation.

The stored water for irrigation in the Extension Area was estimated as shown in Table D-12. In the estimation, the design rainfall was taken by 813 mm of actual rainfalls in 1965, which is very close to 827 mm of the minimum annual rainfalls with five-year return period. The study revealed that the accumulated shortage in water would be 5.76 MCM at maximum, while the necessary water to be stored would be 6.5 MCM with some allowance. The sections of the canals to be provided in the Extension Area should have the capacity to store the amount of 6.5 MCM.

In the left bank area, three irrigation canals of 1R-2R, 2R-2R and 2R-Extra will be constructed so as to correct the imbalance of the density of the existing irrigation canals. The Extension Area will be subdivided into five sub-areas, and will be provided with new dual-purpose canals of irrigation/drainage to surround the respective sub-areas. Figure D-5 illustrates the proposed irrigation system.

Table D-9 Irrigable Area by Canal for Existing Irrigation Area

- Unit: ha -

Canal	paddy	Upland	Total
Main No.1	2,770	367	3,137
1R-1	1,150	232	1,382
2R-1	1,050	142	1,192
1R-2R-1	188	12	200
1L-2R-1	256	38	294
1L-1	246	9	255
Sub-total	5,660	800	6,460
Main No.2	3,100	648	3,748
1R-2	700	54	754
1R-1R-2	787	83	870
1R-1R-1R-2	363	45	408
Sub-total	4,950	830	5,780
Main No.3	2,560	510	3,070
1R-3	231	23	254
2R-3	265	35	300
3R-3	652	128	780
1L-3	1,690	238	1,928
1R-1L-3	1,089	139	1,228
2R-1L-3	586	17	603
3R-1L-3	1,700	46	1,746
1R-3R-1L-3	1,275	23	1,298
4R-1L-3	1,105	23	1,128
5R-1L-3	538	6	544
1L-5R-1L-3	1,040	17	1,057
2L-5R-1L-3	709	3	712
6R-1L-3	633	12	645
7R-1L-3	567	3	570
8R-1L-3	746	9	755
9R-1L-3	378	-	378
1L-9R-1L-3	151	3	154
10R-1L-3	151	-	151
11R-1L-3	160	6	166
2L-3	1,540	290	1,830
1L-2L-3	633	29	662
2L-2L-3	491	20	511
Sub-total	18,890	1,580	20,470
Left Main	3,870	190	4,060
1R	3,650	160	3,810
1L-1R	367	21	388
2R	705	27	732
3R	740	151	891
1L	724	29	753
2L	1,370	35	1,405
1R-2L	674	77	751
Sub-total	12,100	690	12,790
Total	41,600	3,900	45,500

Table D-10 Accumulated Irrigable Area by Canal for Existing Area

- Unit ha -

Canal	Paddy	Upland	Total
Main No.1	5,660	800	6,460
1R-1	1,150	232	1,382
2R-1	1,494	192	1,686
1R-2R-1	188	12	200
1L-2R-1	256	38	294
1L-1	246	9	255
Main No.2	4,950	830	5,780
1R-2	1,850	182	2,032
1R-1R-2	1,150	128	1,278
1R-1R-1R-2	363	45	408
Main No.3	18,890	1,580	20,470
1R-3	231	23	254
2R-3	265	35	300
3R-3	652	128	780
1L-3	12,518	545	13,063
1R-1L-3	1,089	139	1,228
2R-1L-3	586	17	603
3R-1L-3	2,975	69	3,044
1R-3R-1L-3	1,275	23	1,298
4R-1L-3	1,105	23	1,128
5R-1L-3	2,287	26	2,313
1L-5R-1L-3	1,040	17	1,057
2L-5R-1L-3	709	3	712
6R-1L-3	633	12	645
7R-1L-3	567	3	570
8R-1L-3	746	9	755
9R-1L-3	529	3	532
1L-9R-1L-3	151	3	154
10R-1L-3	151	-	151
11R-1L-3	160	6	166
2L-3	2,664	339	3,003
1L-2L-3	633	29	662
2L-2L-3	491	20	511
Left Main	12,100	690	12,790
1R	4,017	181	4,198
1L-1R	367	21	388
2R	705	27	732
3R	740	151	891
1L	724	29	753
2L	2,044	112	2,156
1R-2L	674	77	751

Table D-11 Comparison of Peak Irrigation Requirement with Canal Capacity

- Unit: cu.m/s -

Canal	Paddy	Others	Total	Present capacity	Shortage (%)
Main No.1	6.74	0.28	7.02	9.60	-
1R-1	1.37	0.08	1.45	1.95	-
2R-1	1.78	0.07	1.85	2.00	-
1R-2R-1	0.22	0.01	0.23	0.21	9
1L-2R-1	0.30	0.01	0.31	0.37	-
1L-1	0.29	0.01	0.30	0.31	-
Main No.2	5.89	0.29	6.18	9.41	-
1R-2	2.20	0.06	2.26	2.27	-
1R-1R-2	1.37	0.04	1.41	2.09	-
1R-1R-1R-2	0.43	0.02	0.45	0.39	13
Main No.3	22.48	0.55	23.03	22.82	-
1R-3	0.27	0.01	0.28	0.38	-
2R-3	0.32	0.01	0.33	0.46	-
3R-3	0.78	0.04	0.82	1.07	-
1L-3	14.90	0.19	15.09	12.83	15
1R-1L-3	1.30	0.05	1.35	1.68	-
2R-1L-3	0.70	0.01	0.71	0.62	13
3R-1L-3	3.54	0.02	3.56	2.88	19
1R-3R-1L-3	1.52	0.01	1.53	1.32	19
4R-1L-3	1.31	0.01	1.32	1.08	18
5R-1L-3	2.72	0.01	2.73	2.24	18
1L-5R-1L-3	1.24	0.01	1.25	1.07	14
2L-5R-1L-3	0.84	0.01	0.85	0.73	14
6R-1L-3	0.75	0.01	0.76	0.73	4
7R-1L-3	0.67	0.01	0.68	0.50	26
8R-1L-3	0.89	0.01	0.90	0.74	18
9R-1L-3	0.63	0.01	0.64	0.73	-
1L-9R-1L-3	0.18	0.01	0.19	0.21	-
10R-1L-3	0.18	-	0.18	0.20	-
11R-1L-3	0.19	0.01	0.20	0.28	-
2L-3	3.17	0.12	3.29	3.91	-
1L-2L-3	0.75	0.01	0.76	0.76	-
2L-2L-3	0.58	0.01	0.59	0.55	7
Left Main	14.40	0.24	14.64	14.57	-
1R	4.78	0.06	4.84	4.94	-
1L-1R	0.44	0.01	0.45	1.31	-
2R	0.84	0.01	0.85	0.66	22
3R	0.88	0.05	0.93	1.24	-
1L	0.86	0.01	0.87	0.47	46
2L	2.43	0.04	2.47	2.51	-
1R-2L	0.80	0.03	0.83	0.85	-

Table D-12 Water Budget for Extension Area

- Unit: mm/10days -

Month	(1) (IWR)	(2) 113-(1)	(3) (2)-(1)	Return Flow	Rain-fall	(4) Balance (MCM)
May III	15	98	83	4	198	20.24
Jun.I	45	68	23	11	53	6.18
II	58	55	- 3	15	-	0.85
III	72	41	- 31	18	-	- 0.92
Jul.I	70	43	- 27	18	200	13.56
II	85	28	- 57	21	-	- 2.56
III	97	16	- 81	24	19	- 2.70
Aug.I	113	-	-113	28	78	- 0.50
II	78	-	- 43	20	57	2.41
III	83	30	- 53	21	69	2.63

Notes: (1): irrigation water requirement

(2): expected supply to the Extension Area through the existing irrigation canals with an average capacity of 11.3 mm/day when water is conveyed at full supply levels.

(3): water balance at the upstream reach of the Extension Area

Return flow: (1) x 0.25

Rainfall: weighted mean = 0.4 x R x 63,900/7,100 = 3.6R

Where: upstream drainage area = 63,900 ha

Extension Area = 7,300 ha

runoff coefficiency = 0.4

R = rainfall in 1965

(4): water balance in the Extension Area =

((3) + return flow + rainfall) x 0.071

Maximum shortage = 2.56 + 2.70 + 0.50 = 5.76 MCM

Figure D - 5 Proposed Irrigation System