V. FORESTRY

V. FORESTRY

CONTENTS

A. Forestry

1. Forestry Survey

1.1 Forests and forestry in Malaysia

Malaysia is known for her rich forest resources. The country has a forest land area of 2,400 million ha which accounts for as high as 66% of her total land area, and the total stand volume is estimated at 9,000 billion m^3.

This vast forest land abounds in various trees of high market value such as Meranti and other trees of Dipterocarpus species as well as in precious species including ironwood and Cassia species. Table V-1 shows the data of an inventory taken on commercial trees species in 1927. As seen in the table, Meranti accounts for 26.6% of the total stand volume and Dipterocarpus species as a whole for 58.3%.

The said inventory covered 3,642 acres (1,457 ha) of forest land in Peninsular Malaysia which embraces five states such as Pahang, and Negeri Sembilan. Although it was taken quite some time ago as mentioned above, the table is considered to present accurate figures of the stock and stand of natural tropical rain forests in the peninsula because the inventory report states specifically that the table was prepared to show the uniform stand composition of the forests in the peninsula.

The growth of forest trees in Malaysia is known to be quite vigorous. In terms of the volume of saw timber, however, the annual growth is estimated to be 50 - 65 ft^3/acre (3.4 - 4.5 m^3/ha). All forests are state-owned in principle, with their administration and management undertaken by the Forest Department which has branches and Forest Offices located in respective states. Virtually all forest and forestry experts are affiliated with these government organizations. For research in the field of forestry, Forestry Research Institute (F.R.I.) is located at Kepong, Kuala Lumpur.

Table V-1 Stocking of Commercial Timber Trees in Peninsular Malaysia

1 acre = 0.4ha 35.31ft^3 = 1m^3

No.	Species	Family name	Local name	Total number	Number per ha	Total stocking	Volume per ha	Stocking %
1	Shorea & Parashorea spp.	Dipt	Meranti	13,064	9.0	67,175	39.22	26.6
2	Dipterocarpus spp.	Dipt	Keruing	6,621	4.5	22,809	26.27	17.5
3	Koompassia malacensis	Legm	Kempass	2,829	2.0	13,185	9.06	6.1
4	Balanocarpus heimii	Dipt	Chengal	1,202	0.8	12,876	8.85	5.9
5	Vatica spp.	Dipt	Resak	2,445	1.8	9,423	6.44	4.4
6	Eugenia spp.	Myrt	Kelat	6,108	4.3	7,514	5.17	3.5
7	Lithea spp & others	11Fam	Medang	2,444	1.8	3,099	2.12	1.4
8	Dyera costulata	Apoc	Jelutong	407	0.3	3,144	2.12	1.4
9	Shorea spp.	Dipt	Seraya	288	8.2	2,985	2.85	1.4
10	Dialium	Legm	Keranji	1,486	1.0	2,576	1.77	1.2
11	Intsia spp.	Legm	Merbau	723	0.5	2,340	1.62	1.1
12	Quercus spp.	Fag	Mempening	1,661	2.5	2,252	1.53	1.1
13	Hopea spp.	Dipt	Merawan	1,632	2.5	2,910	1.42	0.9
14	Sindora spp.	Legm	Septer	751	0.5	1,686	1.13	0.8
15	Tarrietia spp.	Sterc	Mengkulang	714	0.5	1,658	1.13	0.5
16	Artocarpus lancaefolia	Marec	Keladang	795	0.5	1,577	1.06	0.7
17	Anisoptera spp.	Dipt	Mersawa	264	0.18	1,462	0.99	0.6
18	Koompassia excelsa	Legm	Tualang	204	0.14	1,508	1.06	0.7
19	Gluta spp. & Meranohrea spp.	Anac	Rengas	827	0.5	1,396	0.99	0.6
20	Palaquium spp.	Sapat	Nijatoh	889	0.5	1,377	0.92	0.6
21	Dryobalanops	Dipt	Keladan	294	0.20	1,377	0.92	0.6
22	Ochanostachys amoetana	Oteac	Pataling	997	0.8	1,195	0.78	0.6
23	Calophyllum spp.	Gutt	Bintangor	910	0.8	1,019	0.71	0.5
24	Shorea spp.	Dipt	Nemesu	108	0.87	728	0.49	0.3
25	Dillenia spp.	Dillen	Simpoh	380	0.3	634	0.42	0.3
26	Payena atilis		Betis	149	0.10	567	0.42	0.3
27	Scrodocarpus bomensis	Oleac	Kulim	407	0.28	567	0.42	0.3
28	Durio spp.	Bombac	Durian	259	0.18	551	0.35	0.3
29	Mesua ferra	Gutt	Penaga	261	0.18	314	0.21	0.15
30	Sloetia sideroxylon	Morac	Tenpinis	125	0.08	170	0.14	0.08
31	Dyospylos spp.	Ehenac	Arony	166	0.11	174	0.14	0.08
32	Fagraea gigantea	Legm	Tembusu	78	0.05	173	0.14	0.08
33	Pitheonlotium confertum	Legm	Kungkon	125	0.08	135	0.07	0.06
34	Campnosperma spp.	Anac	Terentang	57	0.03	130	0.07	0.06
35	Balanocarpus Perangianus	Dipt	Damar hitam	44	0.03	128	0.07	0.06
36	Parania spp.	Fag	Berangan	72	0.05	109	0.07	0.05
37	Coelostegia Griffithii	Bombac	Punggai	37	0.02	82	-	0.04
38	Strombasic jasanica	Oleac	Dedali	87	0.06	81	-	0.02
39	S. rotundifolia	Oleac	Kamap	36	0.02	44	-	0.04
40	Vitex spp.	Verb	Lebon	37	0.02	41	-	0.02
41	Cratoxylon spp.	Gutt	Geronggang	12	0.01	20	-	-
42	Lagerstramia spp.	Lgthr	Bongor	10	0.01	16	-	-
43	Other species			26,850	19.3	3,954	1.08	18.4
	Total			76,853	52.5	21,514	6.90	100.0

Remarks: Sample area: 1.457 ha

In Peninsular Malaysia, clear cutting is prohibited and selective cutting in a recycle period of 25 years is adopted. Export of logs is forbidden in Malaysia, and only sawn wood is supplied to the world market, mostly to EEC. Graded sawn timber exported in 1977 totalled 1,120,708 m^3 in 1977. Of this total, 55.3% was shipped to EEC, 19.4% to Singapore, 9.2% to Australia, 4.9% to Japan, 3.8% to the United States, and 7.4% to other parts of the world. The total export volume of ungraded sawn timber in 1977 was 887,823 m^3, of which 42.3% was supplied to Singapore, 41.8% to the Middle East, 3% to Thailand, 2.1% to Africa, and 3.3% to other countries.

1.2 Forests and forestry in the State of Trengganu

Trengganu State is blessed with an abundance of natural forests of large diameter trees covering 83% of the total land area (3.2 million ha). The forest land area included in the Trengganu Tengah Development Project is as wide as 908,200 acres (1972 figure). Many useful tree species including Meranti are found in the forests in the state of Trengganu. Under the selective cutting system practised in a recycle period of 25 years, Meranti is required to be larger than 24 inches in diameter, and restriction is placed on cutting general use timber not greater than 18 inches in diameter.

The greater part of sawn wood is exported to EEC and other areas of the world, and only pole timber is alloted for local consumption. Timber supplied for local consumption includes special species such as Terentang for manufacturing matches (Campnosperma spp.). Kempass (Koompassia malaccensis) with a diameter of 20 inches or more is used for making railway sleepers, of which the greater part is exported to Japan.

The 1972 stand volume per acre of primary saw timber was 2,371 ft^3 for Superior Hill Forest, 1,883 ft^3 for Good Hill Forest, and 1,526 ft^3 for Moderate Hill Forest as seen in Table V-2.

Table V-2 Volumes per Acre by Forest Type and Diameter Class (1972)

Forest Type	Volume (Cubic Feet) Diameter (inch) +12	+18	+24
Superios Hill Forest	2,371	890	742
Good Hill Forest	1,883	696	560
Moderate Hill Forest	1,526	535	434

Source: Hunting Technical Services Ltd. 'Regional Planning and Development Study' Vol. 4.

In Trengganu State, there are 29 saw mills with a total of 937 workers and 3 veneer and plywood manufacturing plants with a total of 250 workers. Most of the saw mills are equipped with 1 headrig, 2 frame (or band) saws, and 4 - 6 table band saws (or circular saws). The daily sawing capacity ranges from 40 to 50 m^3 at mills operated 8 hours a days, and some mills are run in two shifts of 8 hours. For operation of sawing machinery, electric power is used by 60% of the mills and internal combustion engines by 40%. The average number of workers is 20 per mill, and trees of Meranti group constitute the dominant part of saw-logs. As mentioned in Section 1-1, the sawn wood is exported primarily to EEC and also supplied to Australia, Japan and other countries.

2. Forest Survey in Bukit Bauk Area

2.1 Forests in Bukit Bauk area

The forest land in Bukit Bauk area, lying between the Paka river and the Dungun river, comprises 3,907 acres of swamp forest and about 3,000 acres of lowland forest surrounding the swamp forest. Hence, it covers an area of about 7,000 acres. The swamp forest adjoins paddy fields, Belukar (denuded forest in the cut-over area) and a rubber plantation on the south, and the lowland forest on all other sides.

The forest pattern consists of two types, i.e., the fresh water inland swamp forest type and the lowland Diptero forest type, the former being presented by the swamp forest and the latter by the lowland forest.

The lowland Diptero forest type belongs to Kapur forest pattern which is featured by the dominance of Kapur and mixed growth of Meranti trees, Balan, Keruing, etc. as seen in Table V-3.

Table V-3 Trees in Swamp Forest

No.	Name	Diameter (inch)	Height (feet) Under branch	Top ($30^{m}.27$)
1	Keruing (Dipterocarpus spp)	12 ∿ 20	20 ∿ 40	60 ∿ 120
2	Meranti White (Shorea spp)	10 ∿ 22	40 ∿ 70	80 ∿ 120
3	Meranti rambai-daun (Shorea accumusnata)	12	40	70
4	Meranti Paya (Shorea rugosa)	12 ∿ 20	40 ∿ 60	90 ∿ 120
5	Meranti Langgong (Shorea lepidata)	8 ∿ 25	36 ∿ 70	60 ∿ 120
6	Balan Red (Shorea spp)	12 ∿ 22	40 ∿ 70	60 ∿ 120
7	Alan batu (Shorea albida)			
8	Kelat (Enginia spp)	10 ∿ 12	40 ∿ 60	60 ∿ 80
9	Terentang (Campnosperma spp)	23 ∿ 30	40 ∿ 70	80 ∿ 120
10	Simpoh (Dillenia spp)	12	40	60
11	Kempass (Koompassia malaccensis)	20	50	100

Remarks: Standard tree: Keruing Height $30^{m}.27$
(Sample area 1.75 acre)

2.2 Swamp forests in Bukit Bauk area

As mentioned in the preceding section, the swamp forest in Bukit Bauk area is of the fresh water inland swamp forest type, and it is divided into shallow swamp forest and deep swamp forest according to the depth of peaty layer. The former has a peat soil depth of less than 2 feet and the latter's peat soil depth is greater than 2 feet.

Main tree species found in the shallow swamp forest are Bintangor, Terentang, Geronggang, Meranti paya, etc. and those found in the deep swamp forest are Bintangor, Keruing, Kempass, Meranti Bakau, Punak, Mattans (Calamus SPP.) and stemless palms.

The peat layer in the swamp forest has a thickness of about 4 inches (1 m) near the forest edge, becoming deeper toward forest inside to reach more than 16 inches (4 m). Hence, the greater part of the forest belongs to the deep swamp forest type. As will be stated in Section 2.2.2, dominant species are Terentang, Geronggang, etc. in the forest edge and Keruing, Meranti, Langgong, etc. inside the forest.

2.2.1 Survey method

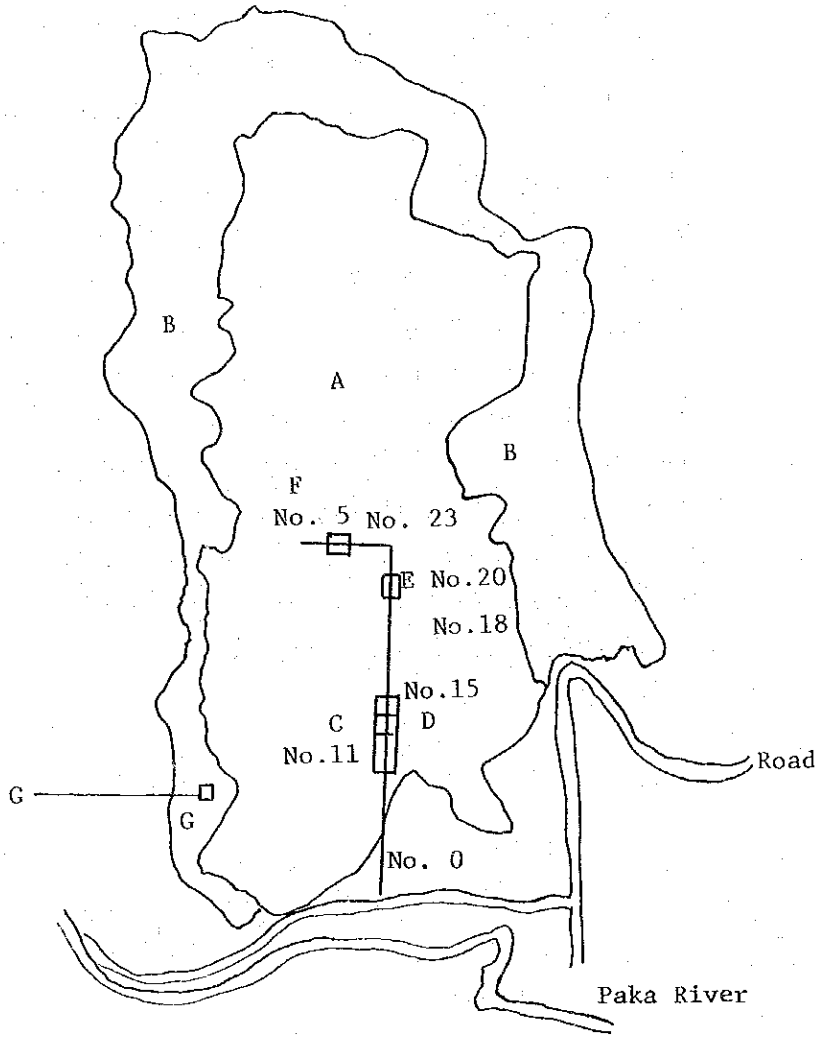
The inventory was taken along the central cutting line according to two methods. In one method, an area of 1.75 acres extending on both sides of the cutting line within 40 inches (10 m) therefrom between site No.11 (one yard (100 m) from the forest edge) and site No. 15 (5 yards (500 m) inward from the forest edge) was delineated, then the species, breast height diameter, height under branch of the forest trees forming the forest crown in this area as well as the height of representatives and standard ones of such trees were measured. The height was measured by triangulation using pocket compasses.

In the other method, timber cruise of forest trees with a breast height of more than 4 miles (10 m) was conducted in three such inventory areas (2 acres), the first one extending along the one yard (100 m) section of the cutting line between 13 and 14 (3 yards and 4 yards (300 and 400 m) respectively from the forest edge), the

second one extending along the 2 yards (200 m) section between 18 and 20 (8 yards and 10 yards (800 and 1,000 m) respectively from the forest edge), and the third one extending along the one yards (100 m) section between 4 and 5 (3 yards (300 m) each from the forest edge) set up on the branch line running to the west from 23 (13 yards (1,300 m) from the forest edge) as illustrated in Fig. V-1.

The first method was intended to obtain the stand composition and saw timber production of the swamp forest, and the second method to obtain the stand volume and stand distribution by diameter. A diameter gauge graduated in centimeters was used in the first method. For the purpose of volume calculation, the volume table of Malayan Forest Record No. 23 was used in the first method. However, since the table showed no figures for trees with a diameter of less than 15 inches, a volume-height correlation table was prepared to obtain the volume by extraploration. In the second method, the volume was obtained by conversion using the Japanese broad leaved tree volume table.

Fig. V-1 Survey Forest Area and Places



		acre		
Survey Area	C.	1.75	No. 11 ∿ No.	Swamp Forest
"	D.	0.5	No. 13 ∿ No. 14	
"	E.	1.0	No. 18 ∿ No. 20	
"	F.	0.5	No. 4 ∿ No. 5	
"	G.	0.3	Bukit Bauk Hill Forest	

A: Swamp Forest

B: Hill Forest

2.2.2 Survey results

Tables V-3 and 4 show the results of the forest survey in Bukit Bauk area. As seen in Table V-4, the following were the main tree species constituting the swamp forest.

Meranti Paya (Shorea rugasa)
Meranti white (Shorea spp.)
Meranti rambai daun (Shorea accuminate)
Meranti langgong (Shorea eepidota)
Balau red (Shorea guiso)
Keruing (Dipterocarpus spp.)
Kelat (Eugenia spp.)
Alarm batu (Shorea albida)
Kempass (Koompassia malaccensis)
Simpoh (Dillenia spp.)
Terentang (Campnosperma spp.)

Of those species, Meranti accounted for about 35% and other Dipterocarpus for about 20%, so that 55% of them belonged to Dipterocarpus spp. In Belukar, Terentang was found to be growing gregariously in many places and sprouts of Keruing were observed between fan palm trees.

Trees found in the forest edge area were Terentang, Keruing, Red Balau, Kelat, Kempass, Simpoh, etc. Inward from a distance of 5 yards (500 m) from the forest edge, Meranti trees observed increasingly and it was confirmed that some of them had a diameter of more than 30 inches.

Table V-4 Trees in Lowland Forest

No.	Name	Diameter (inch)	Height (feet) Under branch	Top
1	Meranti Kepong (Shorea ovalis)	25	70	154 (39m) 1)
2	Meranti melantai (Shorea macroptera)	7 ∿ 8	40	60
3	Meranti merumbung (Shorea smithiana)	6 ∿ 7	40	60
4	Meranti rambai-daun (Shorea accumusnata)	6	40	50
5	Meranti lenggong (Shorea lepidota)	15	50	80
6	Bintangor (Calophyllum spp)	10	40	80
7	Geronggang (Cratoxylon spp)	15	40	100
8	Kapur (Dryobalanops aromatica)	12 ∿ 14	40 ∿ 70	96 (24.3m) 1)
9	Keruing (Dipterocarpus spp)	20	50 ∿ 70	120
10	Kelat (Eugenia spp)	10	40	80
11	Jelutong (Dyera costulata)	30	70	140
12	Nyatoh (Sapotaceae)	10	40	80
13	Sepetir (Sindora spp)	7	30	60

1): Standard tree: No. 1 and No. 8
(Sample area 0.3 acre)

Table V-5 Result of Survey Swamp Forest Area and Stems

Forest area / Diameter (cm)	D 0.5 acre L100m x W20m	E 1.0 acre L200m x W20m	F 0.5 acre L100m x W20m	Total
10 ∿ 20	63 stems	138 stems	95 stems	296 stems
21 ∿ 30	17	76	22	115
31 ∿ 40	1	15	3	19
41 ∿ 99	4	12	8	24
100 ∿				
Total	85	241	129	455

Remarks: Diameter: 1.3m Breast Height
Stand Density: 227.5 stems/acre

(Sample area 2 acre) D.E.F. Plots

Table V-6 shows the results of volume survey conducted by the every tree measurement method on trees with a breast height diameter of more than 4 inches (10 cm) in the said 2 acre area. As seen in the table, the survey disclosed that the volume was 3,532 ft^3/acre (250 m^3/ha).

Table V-6 Volume of Swamp Forest

Breast H. Dia (cm)	Stems	Mean Dia(cm)	Mean Height(m)	Volume(m^3)	Total Volume(m^3)	Ref
10 ∿ 20	296	15	20	0.177	52.39	Tab
21 ∿ 30	115	25	20	0.477	51.41	
31 ∿ 40	19	35	30	1.293	24.57	
41 ∿	24	50	30	2.480	59.66	
1.00 ∿	1	100	40	11.930	11.930	
Total	455				199.96	

+10cm tree 250m^3/ha 3,532ft^3/acre

+31cm (+12 inch) tree 48.1m^3/ha 1,698ft^3/acre

+31cm (+12 inch) tree

64 ft^3 = 1 m^3 = 26.5 m^3/acre

yield of lumber 58% = 15.4 m^3/acre

yield of marketable 92.1% = 14.2 m^3/acre

(Sample area 2 acre)

Calculation worked out on the basis of the data of every tree measurement in the 1.75 acre inventory area (Table V-3) showed that the stand density of higher trees with a diameter of 8 inches and more was 27.4/acre and their volume was 1.825 ft^3/acre (Tables V-7.1 and 7.2). The volume of trees with a +12 inch diameter which are considered to be marketable was 1,511 ft^3/acre. The lumber volume converted from this figure turns out to be 876.4 ft^3 (13.7 m^3) as shown in Table V-7.3.

Table V-7 Volume of Swamp Forest

7.1 Classification of Breast Height Diameter and Stem

Dia (inch)	Meranti	Other Dipt.	Marketable species	Non-Marketable species	Total cc. ft
	stems %	stems %	stems %	stems %	stems %
+8	3 (6.3)	6 (2.1)	5 (10.3)	2 (4.2)	11 (22.9)
+12	10 (20.9)	5 (10.3)	5 (10.3)	1 (2.1)	21 (43.6)
+18	3 (6.3)	2 (4.2)	4 (8.3)	-	9 (18.8)
+24	3 (6.3)	1 (2.1)	2 (4.2)	1 (2.1)	7 (14.7)
Total	19 (39.8)	9 (18.7)	16 (33.1)	4 (8.4)	48 (100)

(Sample area 1.75 acre 1 acre 27.4 stems)

7.2 Volume (cc. ft)

Dia (inch)	Meranti	Other Dipt.	Marketable species	Non-Marketable species	Total cc. ft
	%	%	%	%	%
+8	85 (2.7)	48 (1.5)	163 (5.0)	110 (3.5)	406 (12.7)
+12	440 (13.8)	263 (8.2)	230 (7.2)	-	933 (29.2)
+18	300 (9.4)	196 (6.1)	430 (13.5)	-	926 (29.0)
+24	344 (10.8)	125 (3.9)	317 (9.9)	-	928 (29.1)
Total	1,169 (36.6)	632 (19.8)	1,140 (35.9)	252 (7.9)	3,193 (100)

(Sample area 1.75 acre 1,825 ft^3/acre)

7.3 Volume of Marketable Lumber in Swamp Forest

(Sample area 1.75 acre) (ft^3)

Dia (inch)	Meranti	Other Dip.	Marketable species	Total
+12	440	263	230	933
+18	300	196	430	926
+24	344	125	317	786
Total	1,084	584	977	2,645
1 acre	619	334	558	1,511
	(41%)	(22%)	(37%)	(100%)

Remarks: Net Volume (as lumber)

+12 inch: 1,511 ft^3 x 0.58 = 876.4 ft^3
= 13.7 m^3

+18 inch: 978 ft^3 x 0.58 = 567.2 ft^3
= 8.86 m^3

(* 64 ft^3 = 1 m^3)

+24 inch: 786 ft^3 x 0.6 = 471.6 ft^3
= 7.4 m^3

Further, from the results of every tree measurement in the 2 acre iventory area (Table V-6), it was found that the stand density of these with a breast height diameter of 10 cm or more was 227.5/acre and their volume was 3,532 ft^3/acre. As for the trees with a breast height diameter of 31 cm or more (+12 inches), the stand density was 22/acre and the volume was 1,698 ft^3 (48.08 m^3)/acre (26.5 m^3/acre). The calculations also indicated that the volume of marketable trees was 14.2 m^3/acre.

Comparison of the above measured data with the existing data (Tables V-8.1 and 8.2) produces the following fact.

Table V-8.1 Other Survey of Trengganu Swamp Forest

No.	Place	Dia (inch)	Volume (m^3/acre) (Ton)	Ref
1	Bukit Betu	+12	14.0	Ref. 11
2	Bukit Terendak	+12	14.7	measured by Gremal H.S. (1977)
3	Pasin Lawan	+12	11.1	
	Mean	+12	13.26	Ditto
	Bukit Bauk	+12	13.7	from Tab 8 - 3 measured by Kishimoto. s. (1978)
	"	+18	8.9	
4	"	+24	7.4 (all species)	
	"	+12	14.2	from Tab. 7
	marketable	+12	6.8	Ref. 11
5	all species	+12	13.3	measured by Gremal H.S. (1977)

The volume of higher trees with a diameter of 12 inches or more as calculated on the basis of the data of every tree measurement in the 1.75 acre inventory area is, as mentioned above, 13.7 m^3/acre, and this figure is approximately equivalent to 13.26 m^3/acre, the average of all species shown in the data of H.S. Grewal.

The same data of H.S. Grewal indicates that the volume of marketable trees is 6.8 m^3/acre, and this figure is close to 7.4 m^3/acre which is the volume of trees with a breast height diameter of 24 inches or more.

Comparison of measured stand density with the existing data is as shown in Table V-8.2. According to the every tree measurement conducted on trees with a breast height diameter of 4 inches (10 cm) or more in the 2 acre inventory area, the stand density is 227.5/acre. The stand density of trees with a diameter of 6 inches (15 cm) or more as converted from this figure is 184.5/acre which is quite smaller than 96.74/acre measured by the Forest Department as seen in Table V-8.2. However, the difference is smaller for trees with a diameter of 12 inches (31 cm) or more. Specifically, the density obtained by the present inventory is 19.93/acre and that of the Forest Department is 22/acre. These differences can be ascribed to the fact that the forest in Bukit Bauk has many small diameter trees, and it is probable that the forest is still untapped and retains the state of virgin forest.

For comparison of total stand volume of the swamp forest in Bukit Bauk area (Table V-6) with the volume of forest resources in Dungun area (Table V-2), the stand volume of 12 inch saw timber in Dungun is shown below.

Table V-8.2 Other Survey of Trengganu Swamp Forest

Place		Average Number of Stem per acre				
1) Bukit Betu	Dia (inch)	6 ∿ 12	12 ∿ 18	+18	+12	+6
	Stem	76.58	15.06	4.87	19.93	96.47
	Dia (cm)	10 ∿ 20	21 ∿ 30	31 ∿ 40	+41	+100
2) Bukit Bauk	Stem	148	56	9.5	12	0.5
	(inch)			+18 +45	+12 +30	+6 +15
	(cm)			8.5	22	154

1) Obtained from Forest Department Peninsular Malaysia Forest Management and Rehabilitation Surveys (1976)

2) Conducted by the Japanese Survey Team (1978)

Table V-9 Volume of Hill Forest Trees

(Sample area 0.3 acre)

9.1 Classification of Breast Height Diameter and Trees[1)]

(Stems)

Dia	Meranti	Other Dipt.	Marketable	Non Marketable	Total
	%	%	%	%	%
+6	6 (30)	-	3 (15)	1 (5)	10 (50)
+12	1 (5)	3 (15)	1 (5)	-	5 (25)
+18	-	2 (10)	-	-	2 (10)
+24	2 (10)	-	1 (5)	-	3 (15)
Total	9 (45)	5 (25)	5 (25)	1 (5)	20 (100)

* Calculated from Table V-5.

9.2 Volume[1)]

(ft^3)

Dia (inch)	Meranti	Other Dipt.	Marketable	Non Marketable	Total
	%	%	%	%	%
+6	120 (9.7)	-	90 (7.2)	10 (0.8)	220 (17.7)
+12	-	161 (13.0)	46 (3.7)	-	207 (16.7)
+18	56 (4.5)	181 (14.6)	-	-	237 (19.1)
+24	350 (28.3)	-	226 (18.2)	-	576 (46.5)
Total	526 (42.4)	342 (27.6)	362 (29.2)	10 (0.8)	1,240 (100)

1) Calculated from Table V-5

1 acre 4,130 ft^3 1 acre

+12 inch 3,400 ft^3/acre

Superior Forest 2,371 ft^3/acre

Good Forest 1,883 "

Moderate Forest 1,526 "

(Source: Investment Opportunities in Trengganu Temgah, Annex V, VI & VII)

The volume disclosed by the present survey for 12 inch saw timber was 1,698 and 1,825 ft^3 per acre (Tables V-6 and 7). Although this indicates that the swamp forest is inferior to Good Hill Forest, it is a valuable forest superior to Moderate Hill Forest, with Meranti accounting for 36 - 39% of its total stand volume and all Dipterrocarpus species for about 60%.

2.3 Lowland Forest Surrounding Bukit Bauk Swamp Area

As mentioned earlier, the lowland forest in this area has already been subjected to selective cutting twice in the past. Inventory of this forest was conducted by delineating a sample plot (230 x 40 m) for every tree measurement in the cut-over area opened in 1977 in Bukit Bauk National Aboretum located at the southwestern tip of the swamp area. The height measurement was conducted on a standard trees using pocket compasses (Table V-4).

In the cut-over area, large diameter injured trees and their residues were observed in large quantities, but the growth of weeds was not very conspicuous and regeneration to be in smooth progress.

The main tree species constituting the lowland forest were Meranti, Kapur, Keruing, Nyatoh, Kelat, Bintangor and Berangan. Among these different species, Meranti was dominant, accounting for about 45% of the total volume. Since other Dipterocarpus species occupied 25%, about 70% of the total volume comprised different useful trees of Dipterocarpus species.

The total volume was 3,400 ft^3/acre (Table V-10), which corresponds to the superior class of Dungun area lowland forest. However, forest assessment based on this total volume cannot be fully justified because of the small size of the sample lot.

3. Logging and Transportation

In the state of Trengganu, logging and transportation is performed by groups of workers each comprising loggers, skidders and haulers and paid on a completion basis.

Each group is composed of six workers, two loggers who cut trees with a chain saw, two skidders who operate a bulldozer for yarding, and two haulers who drive a tank lorry for transportation.

This system is applicable to the lowland forest but not to the swamp forest because its ground is too weak to withstand the surface load imposed by bulldozers and tank lorries. Swamp forest utilization therefore presupposes the development of a workable logging method. Some of the conceivable methods include laying of logs to provide a skidding track for tank lorries as practised in East Malaysia, use of a helicopter experimented in Japan for transportation of thinnings, and wire-rope transportation. The skidding method also calls for further study for improvement.

4. Potential and Evaluation of Forestry

The logging method being entirely different between the swamp forest and the lowland forest, large differences are inevitably produced in the assessment of the two forests. Although the swamp forest can be classified above the moderate class of Dungun area national forest in terms of stock and stand, it affords virtually no commercial value due to the absence of a payable logging method. It deserves attention, however, that the forest still remains untapped and presents the climax community of the area. From the viewpoint of zoo-ecology, too, the swamp forest is of great value as many different kinds of wild life are likely to have fled into it with the progress of exploitation of the surrounding lowland forest.

When the farmland development system is determined, the swamp area must be cleared quickly. At this stage, the forest trees should be logged and utilized efficiently as the swamp forest has the stock and stand surpassing the moderate class of Dungun national forest and abounds in many useful trees including Meranti. Conversion of logged trees will not entail any difficulty because there are many saw mills with an ample sawing capacity in the vicinity of the swamp area. Furthermore, as the swamp forest is not far from the market, there is probability that small diameter trees will also be utilized to the full.

The stand volume of trees of +12 inch diameter is 13.7 m^3/acre (Table V-7.3), which means that the swamp forest has a total stand volume of 53,500 m^3 in its 3,907 acre area.

The market price quoted in this area per m^3 of saw timber is M$200 - 300 for Meranti, M$300 - 400 for Merbaw, M$120 - 150 for Keruing, and M$100 for mixed light hard wood. As these are the prices of +24 diameter timber and reduced by M$10 for 21 - 23 and 18 - 20 inch diameters, the per m^3 price calculated from Table V-7.3 turns out to be about M$120. Rating the entire lot of saw timber as the lowest quality MLH timber by reason of possible defects such as pin hole and deterioration, the estimated income from the sale of the swamp forest timber amounts to M$5,350 thousand in total. Since just about the same income will be brought about by cutting the surrounding lowland forest, the estimated total income amounts to about M$10 million. In this area, the allowable cut of +24 inch diameter timber is set at 4 m^3 per acre. Assuming that timber of this diameter alone will be logged, calculation based on Table V-7.3 produces a cut volume of 7.5 m^3/acre which also promises a considerable amount of income.

5. Conclusion

From the viewpoint of zoo-ecology and other aspects, the swamp forest in Bukit Bauk area is of great scientific value. It is probable that the forest has remained untapped to date due to the lack of a suitable logging method and also because useful stands could be found in abundance elsewhere. When the clear-cutting of this forest becomes necessary for the projected farmland development, an adequate logging method needs to be devised.

The swamp forest has a total stand volume greater than that of Moderate Hill Forest and provides lots of trees of Diptercarpus species including Meranti. Accordingly, it will have great commercial value if a workable logging method is established. At present, saw mills in this area use only +24 inch diameter trees, disregarding pole timber and scrap wood. Many of small diameter trees are high in quality and suitable as materials of wooden ware, furniture and tools. It is therefore recommended that guidance be provided in the wood working technique applicable to these trees to promote the development of local handicraft and light industry.

As for utilization of scrap wood, it may be used for manufacturing various products with a portable kiln. It is hoped that these local techniques will be developed further to upgrade the people's livelihood in this area and ensure effective utilization of valuable natural resources.

Comments on Volume Calculation

Re: Table V-6

1. Diameter measurements was conducted with a Japanese-made calipers graduated in centimeters.

2. Height measurement was conducted on standard trees with a pocket compasses.

3. Volume was converted to values in cubic inches using the broad leaved trees volume table used for national forests in Japan.

4. 64 ft^3 was taken as 1 m^3 according to the practice of Malaysian timber dealers in the survey area who use a volume table in which 27 inches x 16 feet (63.62 ft^3) is taken at 1 m^3.

5. Sawing yield was taken at 58% because the above volume calculation method applies to a single tree and as a consequence, the calculated volume excludes defective parts including branches. However, the sawing yield varies from area to area. If the ratio of stock (all species) to shipment (marketable) in the data of the state of Trengganu is calculated on the basis of H.S. Grewal's report (section dealing with dimensions), stocking turns out to be 58.3% and net volume 57.1%.
   The sawing yield was set at 58% on the strength of this calculation, although it involves some theoretical question.

Re: Table V-7

1. Malaysian Forest Record No. 24 was used for volume calculation. As this volume table presents no figures for small diameters of less than 15 inches, a height-volume curve was prepared for volume calculation of 8 and 10 inch diameter timber by extrapolation.

2. In the differentiation of marketable and non-marketable timber, only special species and pole timber were excluded. Hence, the volume of marketable timber is greater than shown in H.S. Grewal's data, but the differences are generally negligible.

VI. LIVESTOCK

VI. LIVESTOCK

CONTENTS

A. Beef Cattle

(1) Animal Husbandry

Since the slopes and part of the lows are the grazing ground, it is not logical to expect much grass production from there.
In view of the available resources in terms of technology and labor, etc., the low-density rotational grazing will be appropriate. According to this system, the areas necessary per head will be calculated as follows:

Grass yield/head/day = 52.5 kg

Namely, the yearly amount of grass required is about 19.16 tons. In the case of grazing, all the grasses can not be turned to good account.

Partly because of hoof disease and partly because of excrement, the pasture gets infected, and its availability will probably be reduced to 65% – 75%. Supposing that the grass availability is 70% and that the grass yield is 50 tons per ha per year, the number of head to be put grass per ha us as follows:

50 tons x 0.7 / 19.16 = 1.8 heads

Namely, the area required per head is calculated at 0.54 ha (1.4 acre).

For the purpose of rotational grazing, the cattle will be divided into 7 groups. There are: 1) Nursing cows and sucklings; 2) Calves of 6 to 10 months old; 3) Cattle of 11 months or so in their nubility; 4) Heifers of suitable age of service, 16 to 18 months old; 5) Pregnant cows; 6) Steers of 1 to 2 years old; and 7) Steers of 2 to 3 years old.
Since the growth of grass differs between dry and rainy seasons, the grazing grounds will be divided into 3 (in the rainy season) to 7 (in the dry season) lots per group. Each group will turn from one lot to another every 5 to 10 days. The number of lots is determined according to the following formula.

Number of lots = (((Number of fallow days) / (Number of grazing days) + 1)) x (Number of groups)

Namely, the recommended number of lots is calculated as follows:

In the rainy season: -

$$(\frac{20}{10} + 1) \times 7 = 18 \text{ lots}$$

In the dry season: -

$$(\frac{30}{5} + 1) \times 7 = 49 \text{ lots}$$

It should be noted however that the values above are suggestive only, because the best grazing time is when the grass is 20 to 30cm high with much foliage and less stalk. In the grazing, utmost care should be exercised not to dilapidate the grazing grounds. Excessive grazing deprives the reproductive power of the grass bitterly.

For the purpose of protecting the cattle from heat, shade trees will be left at places in the grassland. Also, simple sheds will be provided to install lick-logs and health control equipment, and to protect the cattle from rain.

Herdsmen will be assigned to the cattle groups.

Each of them will care for 100 to 150 head, though his coverage depends on his experience.

The duties and responsibilities of the herdsman included chasing the herd from one feeding ground to another, inventory-taking, inspection of pens and fences, checkup for anomalous cattle and control and management of watering and lick stations.

(2) Buildup and management of grasslands

The farming communities around the project site use wild grasses as feed.

But agricultural species of grasses should be course be introduced into the Pilot Project.

Whereever the agricultural machinery is accessible in the low-lands, plowing, tilling, and harrowing should be carried out by making use of plows, disc harrows, etc., followed by manuring and seeding. Those steep slope areas with 10 to 15 degrees which defy mechanized grassland formation should not be applied because they suffer erosion easily. Rather, they should be conditioned in a slash-and-burn manner without tilling, manured direct over the ground and seeded.

The recommended agricultural species of grasses are as follows.

Grasses (Graminae):-

Guinea grass (Penicum meximum)
Para grass (Brachiaria mutica)
Pangola grass (Digitaria decumbens)
African star grass (Cynodon prectostachyus)
Guatemala grass (Tripsacum luxum)
Bermuda grass (Cynodon dactylon)

Legume (Leguminosae):-

Centro (Centrosema pubeses)
Stylo (Brazilian lucern), Stylosanthes guianesis
As regards legume grasses, tropical kudzu (Pueraria phaseoloides) which is seen everywhere in and around the project site is highly propagating, and is worthy of consideration as forage because it is rich in protein.
In the formation of grasslands, it is recommended to carry out mixed seeding of grasses and legumes for reasons explained below.

i) Legumes rich in protein and true grasses rich in hydrocarbon offer well-balanced alimentation to the cattle ranging free.

ii) Rhizobia parasitic on the legumes fix the nitrogen in the air, and this fixed nitrogen is available to the true grasses.

The project site is highly acidic, and should be conditioned with lime. Excessive application of lime makes no sense, however. This is because the lime will be washed away with stormwater. Even with a proper amount of lime, the soil will turn acidic with time. Thus, the application of lime should be made in a divided way; for example, 3 to 4 tons/ha for the first year, 2 to 3 tons/ha for the following one or two years, and a proper amount thereafter.

The grasses are eaten up clean several times a year, and the soil is strained nutrition. For this reason, the grasslands are always in need of fertilizer. For the present project, the application should preferably be in the range of 70 to 90 kg/ha/year (N: P_2O_5 : K_2O = 4 : 2 : 1) in view of economic conditions, etc. What is most important in the keeping of grasslands is weeding. There are various weeds. Of them, the most conspicuous in mimosa. It will be a good way that all the farmers and children practise manual weeding in full force once or twice a month.

(3) Production plan

An area of 1,730 acres will be assigned to the cattle breeding sector. Of it, 130 acres will go to roads and control facilities. The remainder (1,600 acres) will be used as grazing. Since the area required per head per year is 1.4 acre, it is possible to rear about 1,140 heads of adult cattle. It is therefore planned to graze 1,060 to 1,100 heads (in terms of adults) all the time. The breeders (heifers, 600 heads; seed bulls, 40 heads) will be imported from Australia. Healthy heifers of 13 to 15 months old or over will be singled out.

Seed bulls should also be healthy and stark. They should weigh more than 320 kg and be over 20 months.

The production plan is given in Table VI-1.

A through processes from breeding to fattening will be conducted. The steers will be fattened till 3 to 4 years of age and delivered to the market. Some of the calves will be kept in the farms, and the remainder will be released to the market, or farmers in other areas.

For the purpose of breeding, the following conditions are set.

i) The ratio of seed bulls to brood cows is 15 to 20.

ii) The calf yield is 60% for primiparae and 80% for multiparae. (The values are given in percentage on the ground that the weaning will take place in 9 months.)

iii) For all the cattle above 9 months, the motality rate after ablactation is set at 3%.

iv) The period during which the brood cows are available for economic replacement is set at 7 to 8 years.
Thus, the replacement rate is set at 5% for the second year, 10% for the third year and 15% thereafter.
The available period of seed bull is set at 6 years, and the replacement rate is set at 15% from the fourth year on.

v) Heifer and seed bull experience the first service when they are 2 years and 2.5 years old, respectively.

vi) The culling rate of heifers (2 to 3 years old) and steers (2 to 3 years old) is set at 5%.

Table VI-1 Livestock Production Plan

Items		Year 1st	2nd	3rd	4th	5th	6th	7th
Imported Cattle								
Males		40			10	4	4	10
Females		600						
Breakdown of All Cattle Herds								
Adult males			36	30	26	28	26	26
Adult females				482	414	340	394	402
Calves heifers			552			138	84	80
Female calves			166	194	188	218	184	184
Male calves			166	194	188	218	184	184
Females of 1 to 2 years old				162	188	182	212	178
Females of 2 to 3 years old					150	172	168	196
Steers of 1 to 2 years old				162	188	182	211	178
Steers of 2 to 3 years old					150	172	168	196
Total Number of Heads		640	920	1,224	1,502	1,654	1,636	1,634
Livestock Units		500	680	778	976	1,066	1,062	1,090
Off-springs								
Culls Beef cattle and breeders						146	248	228
Breakdown of culls								
Females	Number			54		8	20	4
	Live weight (350 kg)			18,900		2,800	7,000	1,400
Females	Number				54	60	50	58
	Live weight (400 kg)				21,600	24,000	20,000	23,200
Females (2 to 3 years old)	Number		30		8	10	8	8
	Live weight (300 kg)		9,000		2,400	3,000	2,400	2,400
Females (2 to 3 years old)	Number				8	10	8	8
	Live weight (400 kg)				3,200	4,000	3,200	3,200
Males	Number		2	4	4	6	6	4
	Live weight (450 kg)		900	1,800	1,800	2,700	2,700	1,800
Breakdown of Beef Cattle and Breeders								
Steers (Above 3 years old)	Number					146	166	154
	Live weight (420 kg)					61,320	69,720	64,680
Breeders (Above 3 years old)	Number						82	74
	Live weight (350 kg)						28,700	25,900
Total Weight of Shipment (kg)			9,900	20,700	29,000	97,820	133,720	122,580

Remarks: 1) It is said that the cattle feeds on growing grass by 15% of its weight a day. The grass intake is calculated on conditions that Drought-Master mature females (each counted as one livestock unit) weigh 350kg on the average.

2) The yearly production of manure by mature cattle is estimated at about 10 tons.

3) For the sake of convenience, mature cattle is estimated as 1.0, and others are defined as follows: Imported male..1.25 livestock unit (L.U.); Imported female..0.75 L.U.; Bull..1.25 L.U.; Mature female..1.0 L.U.; Ist calved heifer..1.0 L.U.; Female calf..0.25 L.U.; Male calf..0.25 L.U.; 1-2 year female..0.5 L.U.; 2-3 year female..0.75 L.U.

4) Shortage of grass due to drought, etc. are taken into account.

B. Water Buffalo

(1) General

The husbandry of water buffaloes in Malaysia is outlined as follows:

(i) The number of water buffalos has been decreasing due to various reasons such as feed shortage, and the widespread double cropping of paddy rice which has avated the labor shortage and the necessity of draft animals (more rental tractors are used for farming than before.)

(ii) A greater decrease in the number of male buffaloes than of female has changed the structure of breeding. Since it is difficult to find the mating period of water buffaloes, a certain number of male buffaloes must be maintained for a well-balanced natural breeding. However, it does not seen possible at present.

(iii) The number of farms who used to raise more buffaloes than cattle has decreased.

(iv) In the past, buffaloes were used for farming while they were young, and slaughtered when they became old. On the other hand, there is no need to use them for farming purposes at present and further, raising few beef buffaloes is not profitable since their growth is slow as the Table on the following page indicates.

(v) Farms usually raise beef buffaloes for their own consumption. Therefore, marketability is rather low.

(vi) Water buffaloes are often of local varieties with no improvement of breed. It is a usual practice to raise a few in the garden or vacant ground of a farm, rather than grazing in grass-lands.

Comparison of Cattle Varieties

Items	Kedah-Kelantan	Drought-Master	Water buffalo
Adult weight (kg)	270 ∿ 350	400	450
24 month weight (kg)	200	350	350
First calving age (months)	44	34	48
Calving interval (months)	15	12	18 ∿ 21
Conception rates (%)	60	80	60
Replacement (years)	6	6	8 ∿ 10
Grass yield (kg/head/day)	30	52.5	52.5
" (ton/head/year)	11.0	19.2	19.2
Heads per hectare	3.2	1.8	1.8
Acreage per head	0.8	1.4	1.4

(2) Animal Husbundry

Water buffaloes are of local varieties.
494 acres (200 ha) of swampy areas of which elevation lower than 6.0m are appropriated for grazing water buffaloes.
The total number of buffaloes can be grazed in the area would be 353 heads (494/1.4).

The number of heads per unit area is the same as that of cattle. Meat yield for buffaloes is, however, smaller in comparison with that for beef cattle since buffaloes are not so fertile as cattle. Meat yield ratio for buffaloes is given below together with that for beef cattle:

No. of cattle calvings: $\frac{(6 \times 12) - (34 - 12)}{12} = 4.2$

Meat yield: $\frac{(1 + 4.2) \times 400}{6} = 347$ kg/year/head

No. of buffalo calvings: $\frac{(8 \times 12) - (48 - 18)}{18} = 3.7$

Meat yield: $\frac{(1 + 3.7) \times 450}{8} = 264$ kg/year/head

Meat yield ratio: $\frac{\text{buffalo}}{\text{cattle}} = \frac{264}{347} = 0.76$

The number of heads and the total weight of meat for each year are as follows:

	1st	2nd	3rd	4th	5th	6th	7th
Livestock units	143	194	222	279	305	303	311
Total weight	-	2,410	4,390	5,990	21,140	29,170	26,610

. Grassland

The same standards as for cattles should be applied to the development of grasslands. A variety of grass which can grow in a marshy area and adapt to various soils, such as African Star, Para and other similar types should be introduced together with local rice.

Table VI-2 Livestock Production Plan (Buffaloes)

Items			Year 1st	2nd	3rd	4th	5th	6th	7th
Breeder Buffaloes									
Males			10			3	1	1	3
Females			170						
Breakdown of All Buffalo Herds									
Adult males				10	9	7	8	7	7
Adult females					138	118	97	112	115
Calves heifers				158			39	24	23
Female calves				47	55	54	62	53	53
Male calves				47	55	54	62	53	53
Females of 1 to 2 years old					46	54	52	61	51
Females of 2 to 3 years old						43	49	48	56
Steers of 1 to 2 years old					43	54	52	61	51
Steers of 2 to 3 years old						43	49	48	56
Total Number of Heads			180	262	346	430	471	468	468
Livestock Units			143	194	222	279	305	303	311
Off-springs									
Culls Beef buffaloes and breeders							42	71	65
Breakdown of culls									
Females	Number				15		2	6	1
	Live weight (350 kg)				4,050		540	1,620	270
Females	Number					15	17	14	17
	Live weight (450 kg)					4,500	5,100	4,200	5,100
Females (2 to 3 years old)	Number					5	6	5	5
	Live weight (300 kg)					1,150	1,380	1,150	1,150
Males	Number		1	1	1	1	2	2	1
	Live weight (500 kg)		340	340	340	340	680	680	340
Breakdown of beef Buffaloes and Breeders									
Steers (Above 3 years old)	Number						42	47	44
	Live weight (400 kg)						13,440	15,040	14,080
Breeders (Above 3 years old)	Number							24	21
	Live weight (300 kg)							6,480	5,670
Total Weight of Shipment (kg)			2,410	4,390	5,990	21,140	29,170	26,610	

Basic Data on Livestock

Item	Buffaloes	Cattle	Goats & sheep	Swine	Kampong chickens	Other chickens
Number[1]	29,137	60,057	11,434[2]	1,746		
Calving rate (%)	50	60	100			
Lactation (days)	220	180				
Age of first calving (months)	45	42				
Life cycle (year)	12	10	3.5			
Average live weight			18		1.2	
Live weight of cow (kg)	270	180				
Live weight of bull (kg)	360	220				
Dressing (%)	50	45	50	80		
Weight of hide cow (kg)	25	15				
Weight of hide of bull (kg)	30	20				
Slaughter weight (kg)				60		
Age at slaughter (months)				7.5		
Eggs/hen/year					7.5	
Eggs weight (g)					40	60

1) Department of Veterinary, Trengganu

2) 12,876 goats and 4,558 sheep

VII. FISHERIES

VII. FISHERIES

CONTENTS

A. Some Facts on Catfish Culture in Japan

Catfish culture is not yet practiced in commercial level in Japan. Various experiments however have been conducted in fisheries laboratores and stations for artificial spawing, hatchery and rearing of larvae and fry of catfish. Followings are the some of the technical data obtained from the results of these experiments. As this moment the most influencial factors for recoiling from the large scale commercial catfish culture in Japan seem not to be technical difficulties but the uncertainty of the cost, market value and countermeasure against disease.

Artificial Spawning[1)]

Number of egg removed by hormone injection per 1 kg of spawning adult. (Species: Parasilurus asotus)

	Weight (Average)	Egg weight/ Body weight x 100 (Average)	Egg volume per 1 kg of body weight	Egg no per 1 kg of body weight (x 1,000)
Adult reared in captivity	150 ∿ 240 g (193 g)	7.8 ∿ 31.1 (15.3)	153 g	77
Wild adult captured	640 ∿ 1,050 (761)	9.5 ∿ 14.8 (12.0)	120 g	60

1) Fukuda, M., 1972. Artificial seed production of catfish. Saitama Pref. Fishery Research Station Report 30

Egg Characteristics

Colour	Pale green
Egg diameter	2.1 2.6 mm, outside of which covered by jelly layer of 0.6 - 1.3 mm. Weak adhesive egg
Hatching time	72 - 82 hrs in 20° aerated water

Growth

72 - 82 hrs

Hatching
length;
4.2 - 4.6 mm

2 - 3 days

York sac
absorption

2 - 3 weeks

First diet;
rotifer & water flea
length; approx. 3 cm
Proper feeding ratio
is still not known

1 - 1.5 months

Mixed feed
Carp crumble, pellet
Eel mixed feed
Length; 5 cm
The most active feeding is observed in water temperature between 25 - 30°C. This size seems to be appropriate as the seed for culturing as the loss by carnibalism almost disappeares at this size.

B. Very Rough Cost Estimation for Catfish Culture

The cost estimation is made on the following assumptions.

1. Speices: Ictalurus punctatus (channel catfish) or economically equivalent speices is available in Malaysia.

2. Seed: Seed of adequate size (30 - 50 grms) can be produced locally and obtainable free of charge.

3. Water: Good quality of water is available freely.

4. Growth Rate: A 50g fingerling will grow to 600g size within 300 culture days at a daily feeding rate of 2.5% of body weight.

5. Facility Cost: The construction cost of a 1,000 m^2 earthen pond is estimated as M$5,000 and depreciated in 25 years. 3% of the construction cost is required for the annual maintenance cost.

6. Feed Cost: Estimated as M$0.9/kg from the existing price of poultry starter mash on protein conversion basis. Formula feed for catfish must contain 30% protain as a nutrient composition.

7. Stocking Density: One fish per square meter or in total 1,000 pieces in 1,000 M^2 pond.

Calculation of feed cost

Average body weight	275g
Body weight at stocking	50g
" " at harvesting	600g
Feeding rate (daily)	2.5% of body weight
Total number of fish	1,000 pcs.
Culture period	300 days

The total volume of feed required for 1,000 pieces of catfish is;

275g x 2.5% x 1,000 pcs x 300 days = 2,062.5 kg

The current ex-factory price of poultry starter mash is M$ 36 per picul which contains 20% protain. The cost for catfish feed is thus M$ 54 per picul or M$ 0.9/kg as 30% protain contents are required for fomula feed.

Thus the total estimated cost for feed is;

M$ 0.9 x 2,062.5 kg = M$ 1,860

Facility cost estimation

The construction cost for a 1,000 m^2 earthen pond including water supply and drainage system M$ 5,000

Depreciation period	25 yrs
Maintenance cost	3% annually

Thus the total annual facility cost is;

M$ 5,000 ÷ 25 yrs + $ 5,000 x 3% = $350

Expected annual yeild per 1,000 m^2 pond with the total estimated yeilding rate of 90% is thus;

1,000 pcs x 600g x 90% = 540 kg

The total production cost per 1,000 m^2 pond is as follows.

Seed cost	nil	Supplied free of charge
Feed cost	1,860	
Facility cost	350	
Labour cost	nil	By family labour
Miscelleneous cost	nil	Harvesting, processing, packaging cost or interest etc are not considered.
Total Production Cost	M$ 2,210	
Total Procuction	540 kg	

VIII. IRRIGATION AND DRINAGE

VIII. IRRIGATION AND DRAINAGE

CONTENTS

A. Irrigation

1. Calculation of Irrigation Water Requirement

(1) Paddy field

a) Water requirement for preparation of paddy field

. water requirement in depth for preparation of paddy field = 150 mm/day

. water requirement in depth for supply of paddy field = 8.7 mm/day

. irrigation efficiency = 0.85

. days for preparation of paddy field = 30 days

. hour for irrigation = 24 hours

Unit duty of water (q_1)

$$q_1 = \frac{(\frac{1}{30} \times 10{,}000 \times \frac{150}{1{,}000} + \frac{29}{30} \times 10{,}000 \times \frac{8.7}{1{,}000})}{0.85 \times 86{,}400}$$

$$= 0.00183 \text{ m}^3/\text{s/ha}$$

b) Water requirement for normal period

. water requirement in depth = 9.1 mm/day

. irrigation efficiency = 0.85

Unit duty of water (q_2)

$$q_2 = \frac{\frac{9.1}{1000} \times 10{,}000}{0.85 \times 86{,}400} = 0.00124 \text{ m}^3/\text{sec/ha}$$

c) Gross duty of water (Qmax)

1) Preparation of paddy field ($Qmax_1$)

$$Q_{(1)} = q_1\,^{m^3/s/ha} \times A^{ha}$$

$$= 0.00183 \times (337.8 + 30) = 0.662^{m^3/s}$$

2) Normal period ($Qmax_2$)

$$Q_{(2)} = q_2\,^{m^3/s/ha} \times A^{ha}$$

$$= 0.00124 \times (337.8 + 30) = 0.4488^{m^3/s}$$

(2) Upland crop

. daily consumptive use	5.6 mm/day
. irrigation efficiency	0.65
. hours for irrigation	24 hours
. irrigation method	furrow irrigation

Unit duty of water (q)

$$q = \frac{\frac{5.6}{1000} \times 10{,}000}{0.65 \times 86{,}400} = 0.00100 \text{ m}^3/\text{sec/ha}$$

Gross duty of water (Qmax)

$$Q_{(1)} = q^{m^3/sec/ha} \times A^{ha}$$

$$= 0.00100 \times 160.0 = 0.160^{m^3/s}$$

$$Q_{(2)} = 0.00100 \times 372.2 = 0.3732^{m^3/s}$$

(3) Irrigation water requirement

° water requirement for preparation period

paddy	0.662	m^3/s
upland crop	0.160	"
total	0.822	m^3/s

° water requirement for normal period

paddy	0.4488	m^3/s
upland crop	0.3732	"
total	0.822	m^3/s

2. Planning of Irrigation Channels

When irrigating water in the Pilot Project area by intaking water from the Paka river, the water intake point will be situated at an altitude of 2.0 meters while the maximum area intake point at 16 meters. Therefore, it is necessary to pump up water and convey it with pump. The water will be conveyed through pipes to reach the higher level areas and thereafter be distributed to each planted field via irrigation channels.

2.1 Irrigation channel network

Fig. VIII-1 shows the irrigation flow chart. The plan of irrigation canals is illustrated on DWG. VIII-1.

2.2 Hydraulic calculation

a. Hydraulic calculation of pipe lines

The calculation of pipe line hydraulics will be based on the William-Hayen formula:
The William-Hayen Formula

$$I{:}h/\ell = 10.666 \times C^{-1.85} \times D^{-4.87} \times Q^{1.85}$$

However,

- I : dynamic gradient
- C : coefficient of velocity C-130
- D : diameter of pipe (m)
- Q : rate of discharge (m^3/sec)
- h : friction loss of water head (m)
- ℓ : length of pipe (m)

The result of calculation is as shown in Table VIII-1.

b. Hydraulic scheme of irrigation channel

The hydraulic scheme of irrigation channel is based on the Manning's formula.
The Manning's Formula

$$V = \frac{1}{m} \times R^{2/3} \times I^{1/2}$$

$$Q = A \cdot V$$

However,

V : average rate of discharge (m/sec)

R : hydraulic mean depth (m) R = A/P

A : flowing water sectional area (m^2)

P : wetted perimeter length (m)

I : surface slope

m : Manning's roughness coefficient

Results of the calculation are as shown in Table VIII-2.

Table VIII-2 Results of Calculation

No.	Area	Unit duty of water (Land preparation)	Gross duty of water	Unit duty of water (Normal period)	Gross duty of water	Remarks
	ha	ℓ/s/ha	ℓ/s	ℓ/s/ha	ℓ/s	
1	12.6	1.83	23.1	1.24	15.6	Paddy
2	24.0	"	43.9	"	29.8	"
3	47.4	"	86.7	"	58.8	"
4	24.0	"	43.9	"	29.8	"
5	24.0	"	43.9	"	"	"
	30.0	1.00	30.0	1.00	30.0	(Technical center) Upland crop
6	24.0	1.83	43.9	1.24	29.8	(Technical center) Paddy
7	15.8	"	28.9	"	19.6	Paddy
8	16.0	"	29.3	"	19.8	"
9	"	"	"	"	"	"
10	"	"	"	"	"	"
11	"	"	"	"	"	"
12	30.0	"	54.9	"	37.2	"
13	24.0	"	43.9	"	29.8	"
14	"	"	"	"	"	"
15	"	"	"	"	"	"
16	"	"	"	"	"	"
17	(343.2) 130.0	1.00	130.0	1.00	343.2	"
Total			822.0		822.0	
Paddy	337.8					
(Technical center)	24.0					
"						
Sub-total	361.8		662.0		448.8	
Upland crop	(343.2) 130.0					
(Technical center)	30.0					
"						
Sub-total	(373.2) 160.0		160.0		373.2	
Total	(735.0) 521.8		822.0		822.0	

Fig. VIII-1 Irrigation Flow Chart

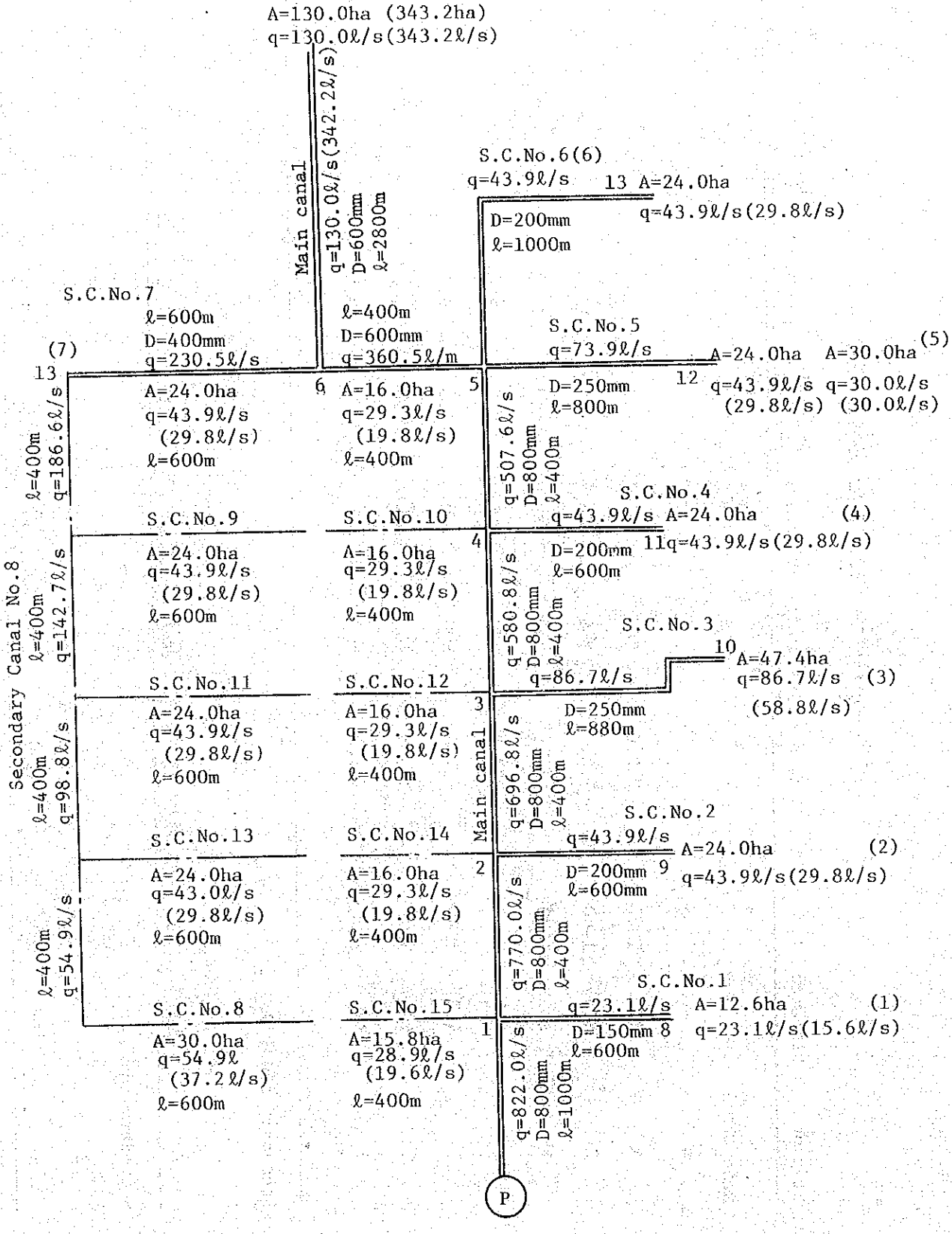


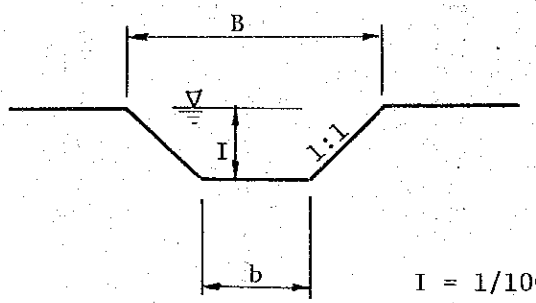
Table VIII-1 Results of Calculation

Station	Distance	T.L.	E.L.	Discharge	Diameter	Velocity	Hydraulic gradient	Headless	Elevation head	Effective head	Remarks
	m			ℓ/s	mm	m/s	0/00	m	m	m	
Main Canal											
P		0	2								
1	1000	1000	3	822.0	800	1.64	4.4	4.4			
2	400	1400	4	770.0	800	1.53	4.0	1.6			
3	400	1800	4	696.8	800	1.39	3.2	1.3			
4	400	2200	4	580.8	800	1.16	2.4	1.0			
5	400	2500	5	507.6	800	1.00	1.8	0.7			
6	400	3000	5	360.5	600	1.28	3.6	1.4			
7	2806	5800	16	343.2	600	1.21	3.2	9.0			
								19.4			
Secondary canal No. 1											
1		0	3								
8	600	600	2	23.1	150	1.31	21.0	12.6			
Secondary canal No. 2											
2		0	4								
9	600	600	3	43.9	200	1.40	16.5	9.9			

Station	Distance	T.L.	E.L.	Discharge	Diameter	Velocity	Hydraulic gradient	Headless	Elevation head	Effective head	Remarks
Secondary canal No. 3											
3			0								
10	880	880		86.7	250	1.77	19.0	16.7			
Secondary canal No. 4											
4			0								
11	600	600		43.9	200	1.40	16.5	9.9			
Secondary canal No. 5											
5											
12	800			73.9	250	1.51	21.0	16.8			
Secondary canal No. 6											
5											
12	1000			43.9	200	1.40	16.5	16.5			
Secondary canal No. 7											
6											
13	600			230.5	400	1.83	10.5	6.3			

Type	b	H	B	Discharge	Remarks
type A	0.3^{m}	0.3^{m}	0.9^{m}	$0.056^{m^3/s}$	$V=0.31^{m/s}$
type B	0.5	0.5	1.5	0.215	V=0.43

Section of canal (irrigation)



I = 1/1000

Name	Length	Remarks
Main canal	2,600m	D=800mm (Q=507.6ℓ/s ∿ 822.0ℓ/s)
"	3,200	D=600mm (Q=343.2ℓ/s ∿ 360.5ℓ/s)
sub-total	5,800	
Secondary canal No. 1	600	D=150mm (Q=23.1ℓ/s)
" No. 2	600	D=200mm (Q=43.9ℓ/s)
" No. 3	880	D=250mm (Q=86.7ℓ/s)
" No. 4	600	D=200mm (Q=43.9ℓ/s)
" No. 5	800	D=250mm (Q=73.9ℓ/s)
" No. 6	1,000	D=200mm (Q=43.9ℓ/s)
" No. 7	600	D=400mm (Q=230.5 ℓ/s)
" No. 8	2,200	type B (Q=54.9ℓ/s ∿ 186.6ℓ/s)
" No. 9	600	type A (Q=43.9ℓ/s)
" No.10	400	" (Q=29.3ℓ/s)
" No.11	600	" (Q=43.9ℓ/s)
" No.12	400	" (Q=29.3ℓ/s)
" No.13	600	" (Q=43.9ℓ/s)
" No.14	400	" (Q=29.3ℓ/s)
" No.15	400	" (Q=29.3ℓ/s)
sub-total	10,680	
Total		

2.3 Planning of pumping facility

(1) Total lift of pumping facility

Actual lift : Ha = 16.0 - 1.0 = 15.0 m

Pumping volume : $Q = 822^{\ell/sec} = 49.3^{m^3/min.}$

Pipeline friction loss : Hc = 19.4 m

Total head : H

$H = Ha + Hc = 15.0 + 19.4 = 34.4m = 35$ m.

(2) Needed electric power for pump

$$P = \frac{k \times \gamma \times Q \times H}{\eta p \times \eta t \times \eta g} (1 + \alpha)$$

However,

P : output of prime mover (kw) (PS)

k : in case of kw unit 0.163
in case of PS unit 0.222

γ : specific gravity of water

Q : pump discharge rate (m^3/min)

H : total head of pump (m)

ηp : pump efficiency P = 0.82

ηq : conductivity using reduction gear 0.95

ηe : conductivity using reduction gear 0.96

α : margin coefficient of prime mover
in case of diesel engine 0.2

$$P = \frac{0.163 \times 1.0 \times 49.3 \times 35}{0.82 \times 0.95 \times 0.96} \times (1 + 0.2) = 451 = 500kw$$

$$P = \frac{0.222 \times 1.0 \times 49.3 \times 35}{0.82 \times 0.95 \times 0.96} \times (1 + 0.2) = 615 = 700 \text{ PS}.$$

(3) Pump specifications

Diameter : 600 mm

Type : Longitudinal axial diagonal flow type

Number of pump: 1

Prime Mover : Diesel Engine 700 PS

2.4 Paka river low flow calculation

The Hydrological Procedure No. 12 will be applied in obtaining the presumption of the low flow of the Paka river.

Catchment area = 200 square miles

Catchment mean annual rainfall = 112 inches

Location of station : R_3

$$V = C \times A^a \times P^b \quad \ldots\ldots\ldots \quad (1)$$

However, V is extreme value (cusecs)

A is catchment area (square miles)

P is catchment mean annual rainfall (inches)

and C, a and b are constants respectively.

$C = 9.9 \times 10^{-5}$, a = 0.93 and b = 2.05

Thus, $V = 9.9 \times 10^{-5} \times 290^{0.93} \times 112^{2.05} = 306.6$ cusecs

In case the recurrence interval in Region R_3 is 10 years, the dimensionless ordinate qt/v will be 0.27.

The annual 7-day minimum flow is calculated as follow:

However, F = 1.18

$qt = 0.27 \times 306.6 = 82.8$ cusecs

q_7 day = qt.F = $82.8 \times 1.18 = 97.7$ cusecs

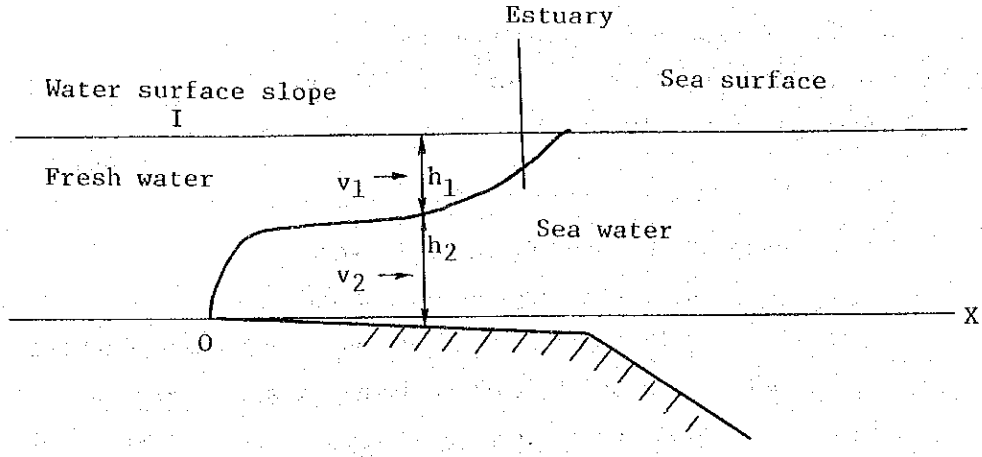
This $q_{7\text{-day}} = 97.7$ is equivalent to specific discharge 3.68×10^{-3} $m^3/sec/km^2$.

Accordingly, as the minimum flow of the Paka river during the dry season is 97.7 cusecs (2.77 m^3/sec), the intake of irrigation water of q = 0.82 m^3/sec is possible.

2.5 Salt wedge examination

The intake point in the Pilot Project area is situated about 15 kilometers upstream from the mouth of the Paka river. As the river-bed gradient is gentle, the intake point is also a tidal compartment.

Here, considerations were made on whether there is a possibility of salt water entering into the irrigation system through the intake point.



This is the rough sketch of a salt wedge. The slope bordering on the tip of the wedge and on the mouth of the river is steep while it becomes gentle in the center part.
The upper part of the salt wedge is fair current, while the river bed surface is counter-flow, thus in an equilibrium state. Although the tide moves the salt wedge up and down the river, the transformation of the salt wedge is generally considered slow, thus the river is thought to follow an action of a steady flow.

The phenomenon of the salt wedge generally differs according to the river, and therefore, an accurate value can only be obtained by conducting actual measurements. However, by applying Mr. Farmer and Mr. Morgan's formula, an approximate value can be obtained.

The range of tide in the South China Sea is not too large. And as the eastern coastline of Malaysia is comparatively straight, the influence of the saltwedge is not considered too great.

$$L = \frac{n_{2*}^2}{6} \cdot \frac{\rho_1 \beta^1 g h_o^2}{k} (3 - 2n_2*)$$

where,

L : length of salt wedge

$n_2* = 1 - n_1* = 1 - 0.360 = 0.640$

$$n_1* = \frac{h_1*}{h_0} = \left(\frac{2}{\beta} Fr^2\right)^{1/3} = \left(\frac{2}{0.025} \times 5.842 \times 10^{-4}\right)^{1/3} = 0.360$$

ρ_1 : density of fresh water = 1.000

$$\beta^1 = \frac{\rho_2 - \rho_1}{\rho_2} = \frac{1.025 - 1.000}{1.025} = 0.024$$

ρ_2 : density of sea water = 1.025

g : gravitational acceleration

$h_0 \fallingdotseq h_1 + h_2 \fallingdotseq 1.50$ m

$$\beta = \frac{\rho_2 - \rho_1}{\rho_1} = \frac{1.025 - 1.000}{1.000} = 0.025$$

$$Fr^2 = \frac{q^2}{g h_0^3} = \frac{0.139^2}{9.8 \times 1.50^3} = 5.842 \times 10^{-4}$$

$q = qmin/b = 2.77/20 = 0.139 \quad m^3/sec/m$

$k = ti = f.\rho_1 (v_1 - v_2)^2 = 10^{-3} \times 1.000 \times 0.093^2$

$= 8.65 \times 10^{-6}$

$f \fallingdotseq 10^{-3}$

$v_1 = g/h = 0.139/1.50 = 0.093$ m/sec

$v_2 = 0$

$$L = \frac{0.640^2}{6} \times \frac{1.000 \times 0.024 \times 9.8 \times 1.50^2}{8.65 \times 10^{-6}} (3 - 2 \times 0.640)$$

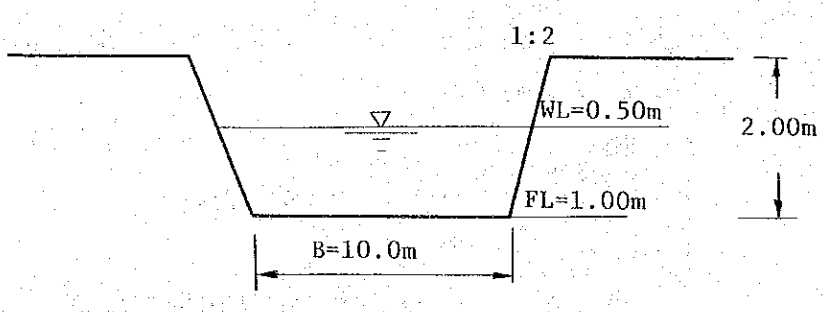
$$= 0.068 \times \frac{6.120}{10^{-4}} \times 1.720 = 7{,}158 \text{ m} \fallingdotseq 7.2 \text{ km}$$

The distance of the salt wedge moving up the Paka river is considered to be about 7 kilometers at the furthest from the estuary. As the intake point is located 15 kilometers upstream in the Pilot Project area, there is no fear of directly intaking salt water.

Our water quality test conducted as a part of the Feasibility Study has revealed that the salinity at the intake point was between 20 and 30 ppm and found no salt water. Therefore, it is regarded that the application of any intake method is possible. However, the water level is subjected to change due to the influence of backwater caused by the rise and fall of the tide.

2.6 Calculation of water intake from Paka river

The droughty water level at the intake point in the Paka river is considered as EL = 0.5 ∿ 1.0m. The average sectional view of the driving channel is supposed as follow:



When the surface slope is 1/1000 under natural flow, the rate of discharge will be:

$$V = \frac{1}{n} I^{1/2} R^{2/3}$$

$$= \frac{1}{0.03} \times 0.001^{1/2} \times \left(\frac{19.5}{16.7}\right)^{2/3} = 1.17 \text{ m/sec.}$$

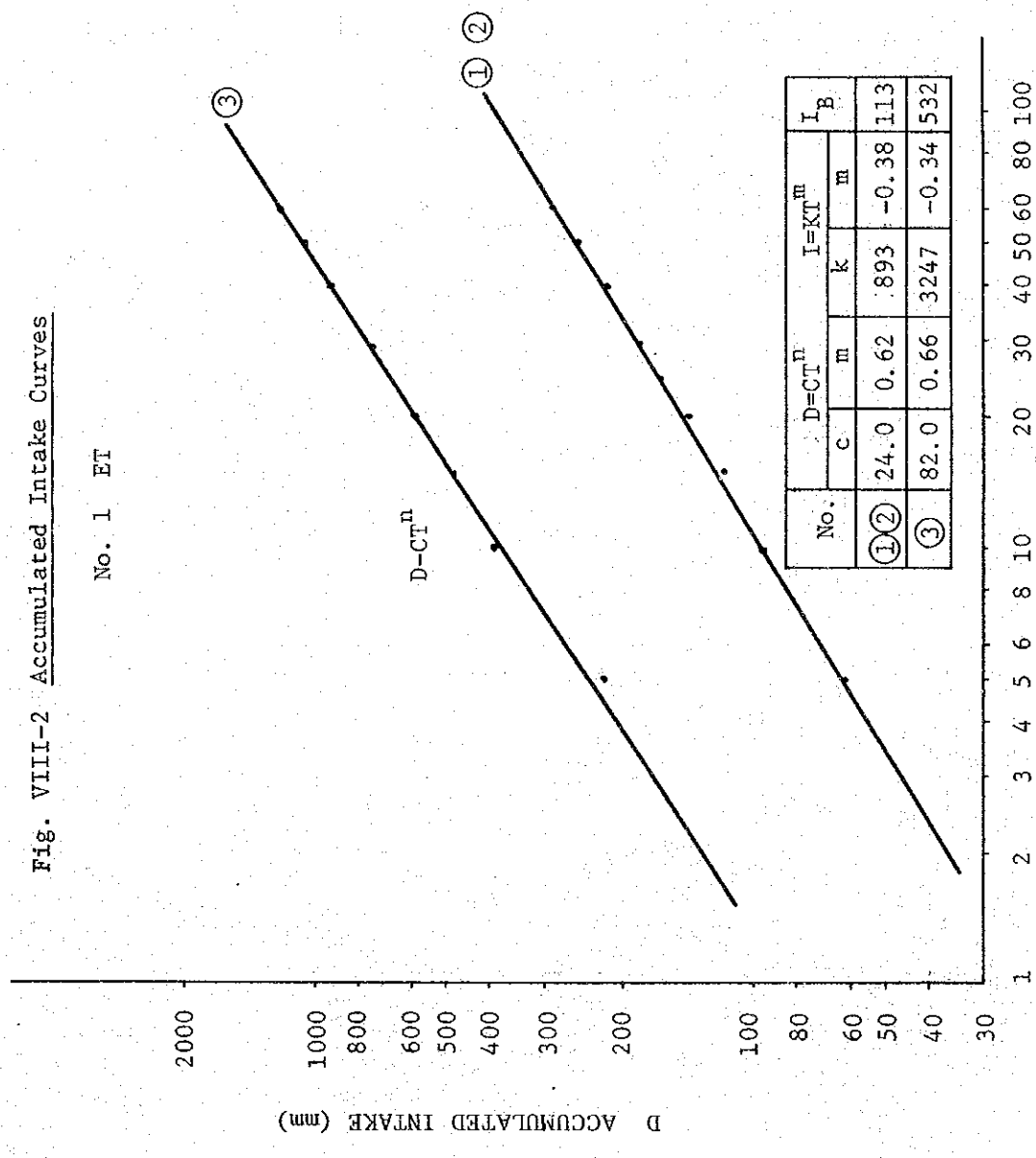
$$A = \frac{10 + 16}{2} \times 1.5 = 19.5 \text{ m}^2$$

$$Q = AV = 19.5 \times 1.17 = 22.8 \text{ m}^3/\text{sec}$$

Even considering the head loss of the box culvert when passing through the embankment, the sectional view is regarded sufficient.

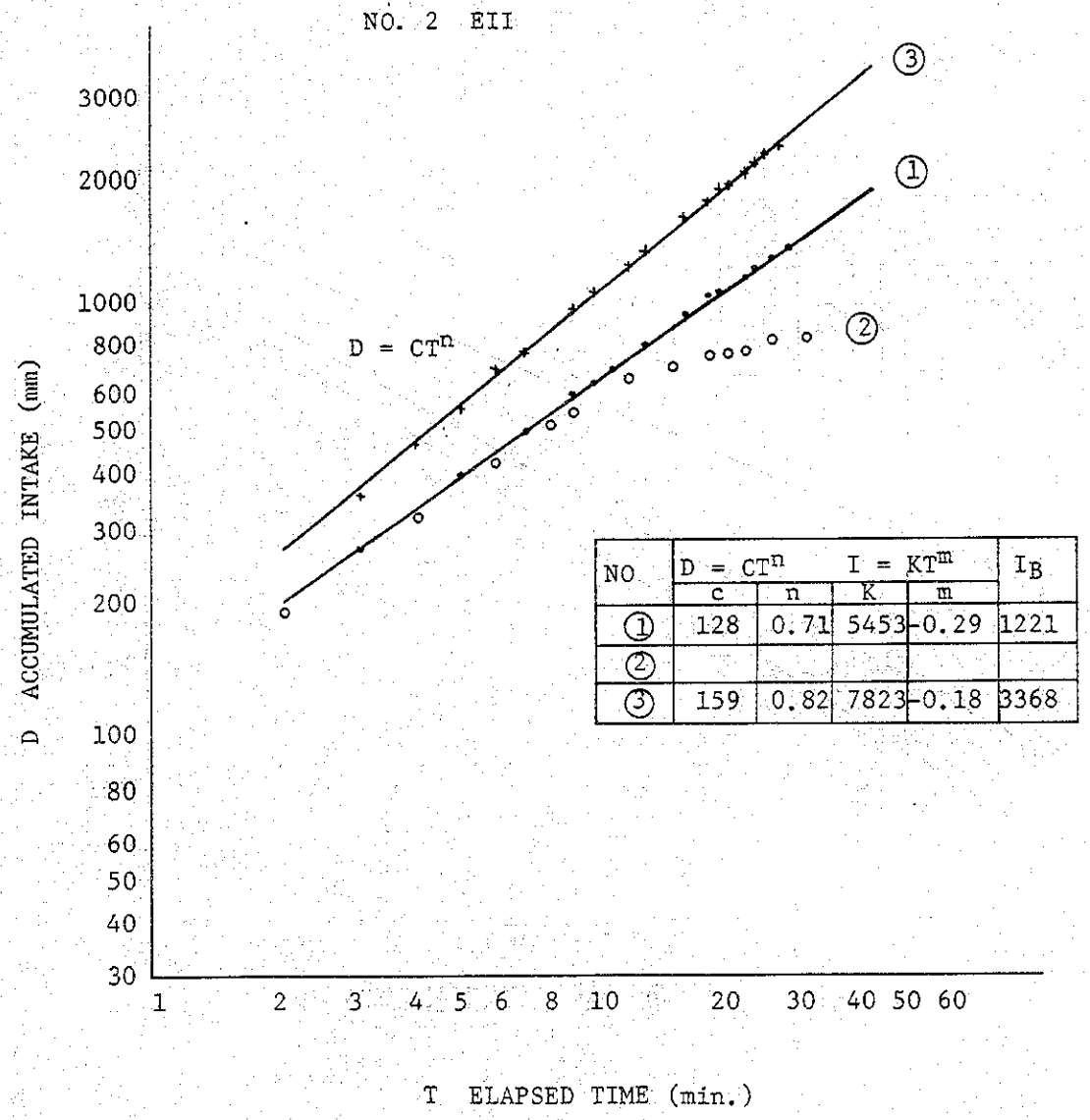
The bed width of the sectional view of the driving channel was set at 10.0 meters in case of flood water discharge.

Fig. VIII-2 Accumulated Intake Curves



No.	$D=CT^n$		$I=KT^m$		I_B
	c	m	k	m	
①②	24.0	0.62	.893	-0.38	113
③	82.0	0.66	3247	-0.34	532

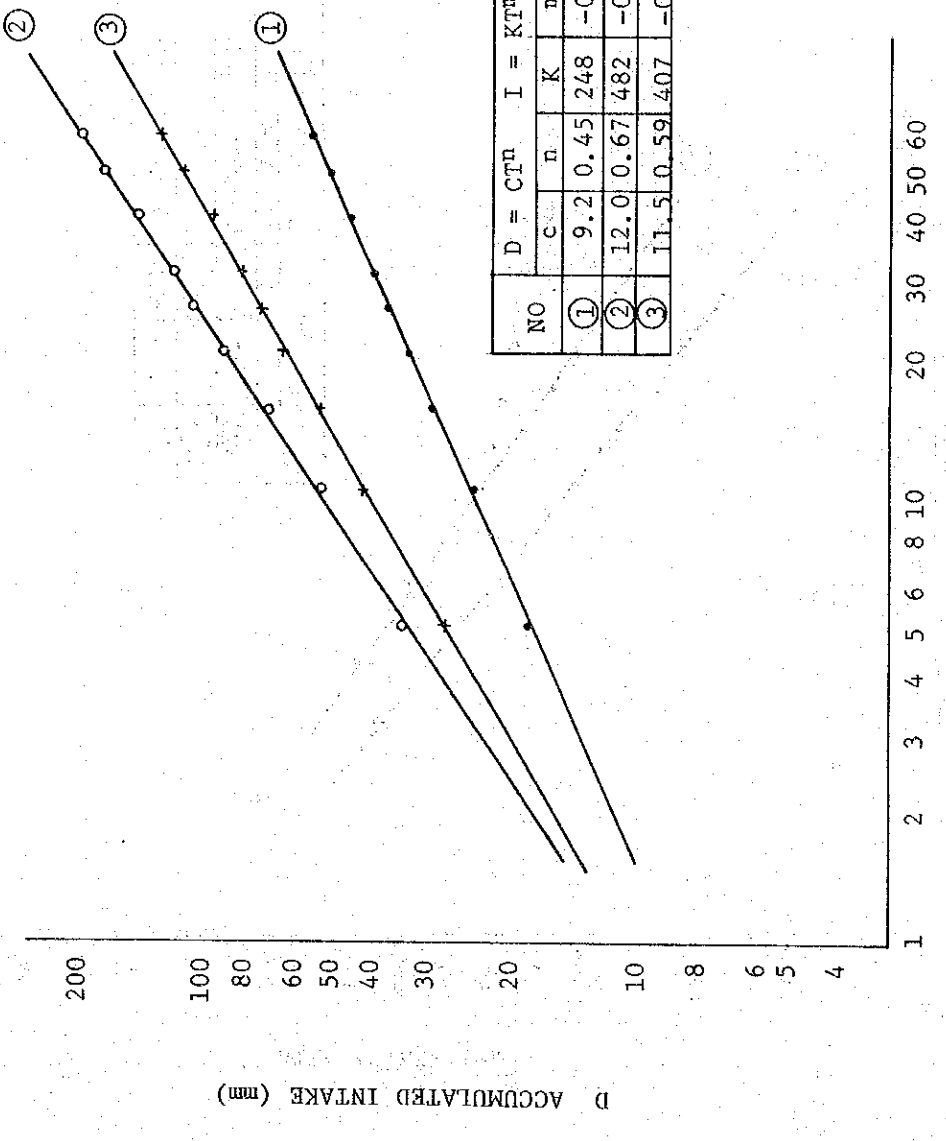
Accumulated Intake Curves



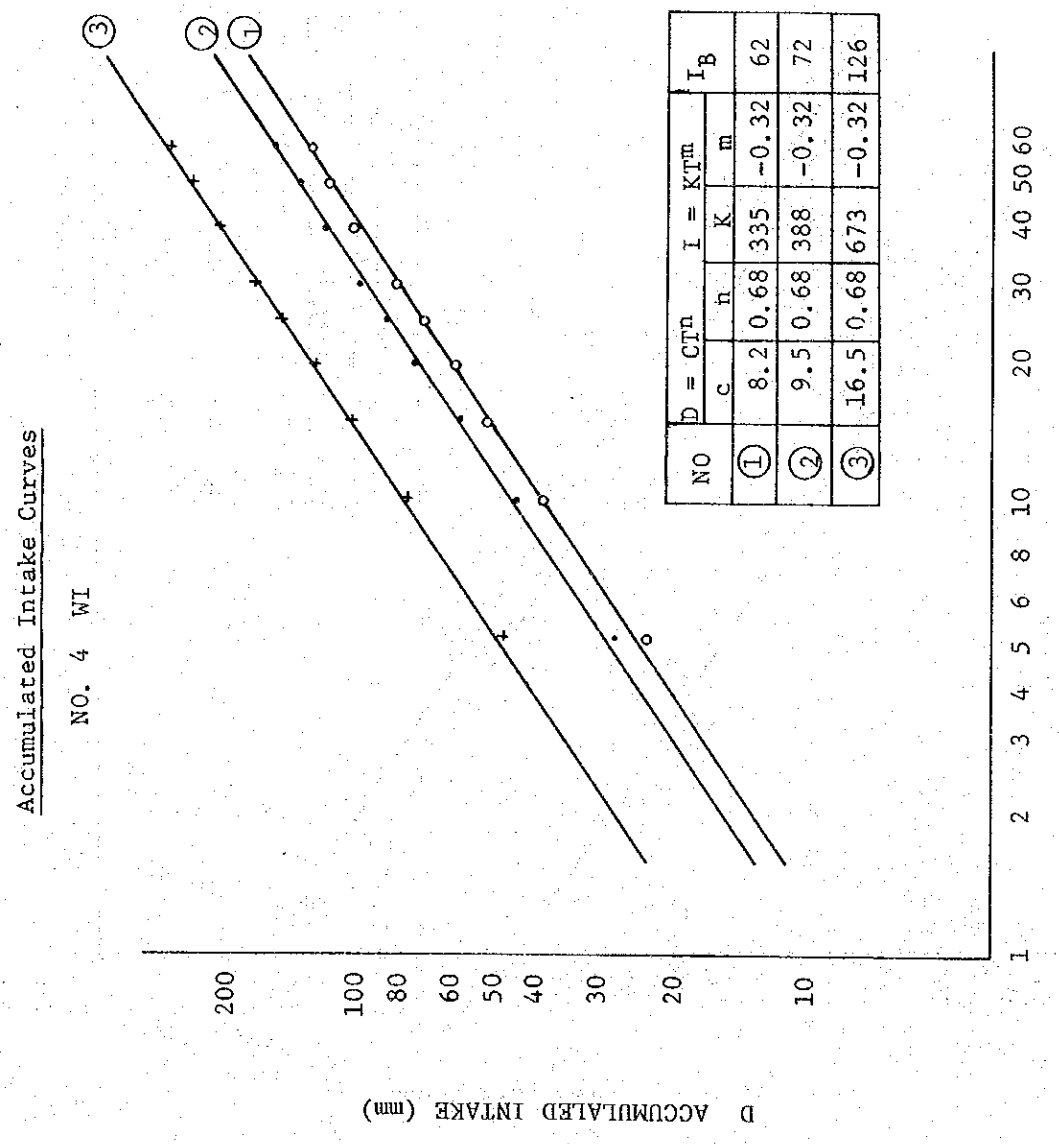
NO	$D = CT^n$		$I = KT^m$		I_B
	c	n	K	m	
①	128	0.71	5453	-0.29	1221
②					
③	159	0.82	7823	-0.18	3368

Accumulated Intake Curves

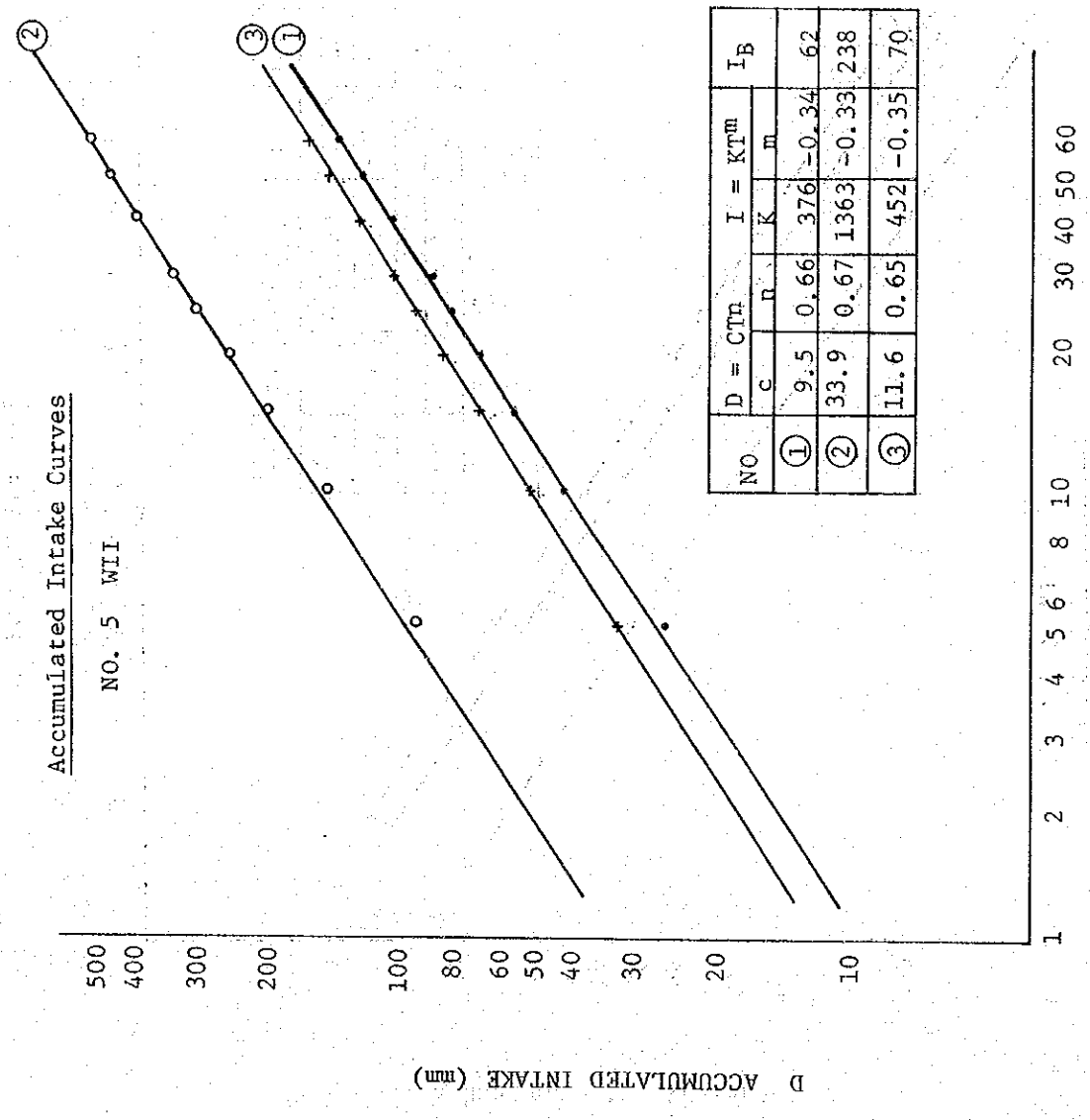
NO. 3 E.III (rubber field)



NO	$D = CT^n$		$I = KT^m$		I_B
	c	n	K	m	
①	9.2	0.45	248	-0.55	10.2
②	12.0	0.67	482	-0.33	84.2
③	11.5	0.59	407	-0.41	42.6



NO	$D = CT^n$		$I = KT^m$		I_B
	c	n	K	m	
①	8.2	0.68	335	-0.32	62
②	9.5	0.68	388	-0.32	72
③	16.5	0.68	673	-0.32	126



NO	D = CTn		I = KTm		I_B
	c	n	K	m	
①	9.5	0.66	376	-0.34	62
②	33.9	0.67	1363	-0.33	238
③	11.6	0.65	452	-0.35	70

Fig. VIII-3 Tolerance Limit of Paddy on Salinity in terms of Cl' Contents in Irrigation Water

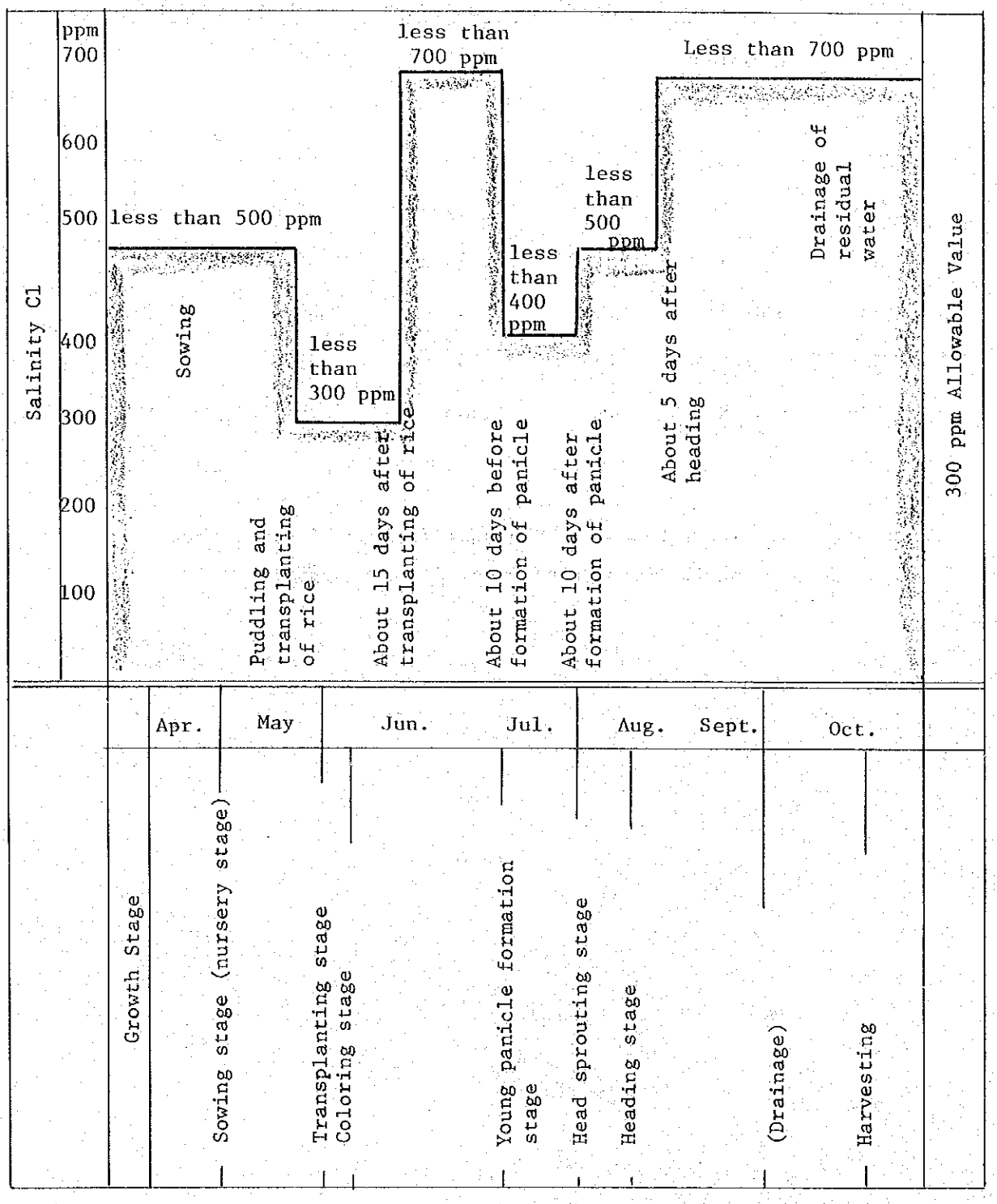


Table VIII-3 Relationship between Salinity and Growing of Paddy

Chlorine (ppm)	Height of Paddy(cm)	Tillering (Stalk)	Weight of Paddy (g)	Weight of Stalks(g)	Ratio of Weights (%)
5,000	Withered	-	-	-	-
3,000	Withered	-	-	-	-
2,000	77.5	22.0	36.0	49.0	67
1,000	79.9	20.5	46.5	56.0	86
500	78.1	21.5	47.5	55.0	88
300	81.4	19.5	47.0	59.0	87
100	82.6	19.5	52.0	59.0	97
0	80.9	21.0	53.5	59.3	100

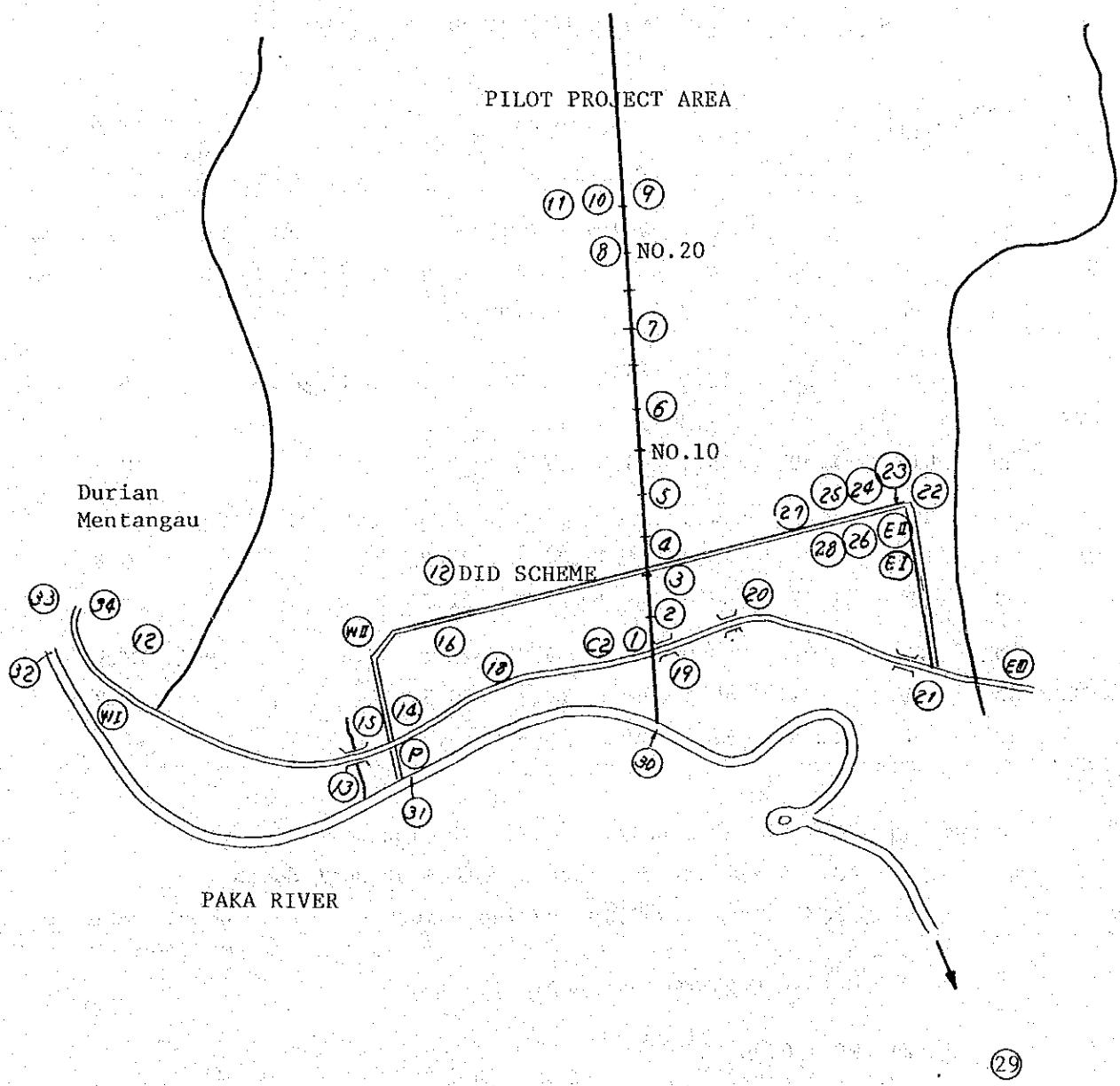
Source: Water Resources Handbook (Yamaguchi Prefecture Agricultural Experiment Station Japan)

Table VIII-4 Data on Water Quality in Bukit Bauk Area

Site No.	pH	Electrical Conductivity µv/cm	NaCl (ppm)	Remarks
1.	4.0	44	20	in swamp
2.	4.0	53	25	"
3.	4.2	35	16	"
4.	4.0	56	26	"
5.	4.1	80	36	"
6.	4.2	43	20	in jungle swamp
7.	4.2	40	18	"
8.	4.2	40	18	"
9.	4.3	39	18	"
10.	4.3	39	18	"
11.	4.2	44	20	"
12.	4.9	38	17	drainage canal
13.	4.6	21	9	river
14.	6.7	33	15	distribution canal
15.	6.9	34	15	paddy field
16.	5.8	31	14	distribution canal
17.	7.1	31	14	paddy field
18.	4.8	27	12	drainage canal
19.	4.1	44	20	"
20.		70	30	"
21.	4.5	55	24	"

Electrical Conductivity

Site No.	pH	µv/cm	NaCl (ppm)	Remarks
22.	4.8	30	14	
23.	4.0	46	21	drainage canal
24.		55	25	"
25.	4.6	65	29	
26.	3.9	45	20	drainage canal
27.		39	17	distribution canal
28.	4.3	58	25	drainage canal
29.	7.2	8,900	4,600	PAKA bridge site
30.	6.8	42	19	PAKA river
31. Surface	6.4	40	18	"
2m deep	6.7	38	17	"
32. Surface	6.5	40	18	"
2m deep	6.5	34	15	"
33.	5.8	65	28	DURIAN MENTANGAH (well)
34.	5.6	78	34	"
	8.1	20,000	11,000	Sea Water (in Dungun)



1 - 34 Surreying point on water quality

EI - WII Surreying point on FC and Intake rate

Fig. VIII-4 Surreying Point on Water Quality and Cylinder Intake for Irrigation Plan

PHYSICAL PROPERTIES OF SOILS HAVING CLOSE CONNECTION WITH IRRIGATION ENGINEERING IN UPLAND FIELD

	Depth	Texture	Apparent Density	Total Pore Spare	Soil Moisture F.C	Soil Moisture W.P	AM/10 cm	R=30 cm	R=45 cm	R=60 cm	Vapour Phase	I_B
	cm		gr/cc	%	Vol %	Vol %	mm	mm	mm	mm	%	mm/hr
EI	5	HC	1.08	54.0	48.1	23.6	24.5	45.9	68.9	90.1	5.9	113
	20	HC	1.32	45.7	45.2	22.1	23.1				0.5	
	5	Sic	1.18	52.8	47.3	23.2	24.1	45.1	67.8	91.9	5.6	43
EIII	20		1.57	37.2	35.5	17.0	18.5				1.7	
	35	Lic	1.59	36.4	36.0	17.3	18.7				0.4	
	5	Lic	1.23	54.5	50.3	24.8	25.5	47.8	71.7	95.6	4.2	72
WI	35	SL	1.36	45.8	45.5	22.2	23.3				0.3	
	50	SL	1.37	45.6	43.9	21.4	22.5				1.8	
	5	SCL	1.05	60.0	41.0	19.9	21.1	39.6	59.3	79.1	19.1	70
VII	35	SL	1.34	49.6	40.6	19.7	20.9				9.0	
	50	SL	1.40	47.4	30.2	14.3	15.9				17.2	

Notes: 1) FC: Field capacity, WP: Wilting point

AM: Available moisture per 10cm of soil depth

TRAM: Total readily available moisture = Amount of water supplied by each irrigation

R : Effective root depth

2) $WP = 0.36\ FC^{1.08}$

3) I_B: Basic intake rate

Evaporation at Dungun

(mm/month)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Pan A Evaporation	167	169	202	191	179	153	160	171	159	156	129	142	1978
Open Water Evapo.	150	152	182	172	151	138	144	154	143	140	116	128	1778
Forest Evapo.	134	135	162	153	143	122	128	137	127	125	103	112	1581
Grass Evapo.	125	127	152	143	135	115	121	128	119	117	97	105	1484

Source: Evaporation in Peninsular Malaysia (1976)
Water Resources Publication No. 5

Pan Coefficient

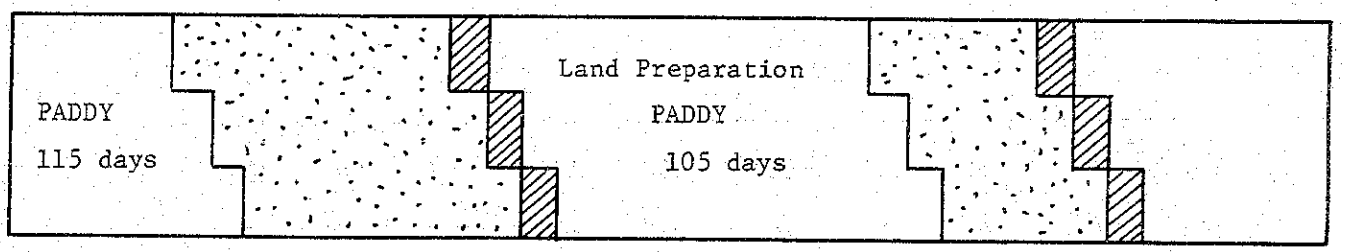
Surface	Pan Coefficient
Open Water	0.9
Forest	0.8
Grass land	0.75

Source: Evaporation in Peninsular Malaysia (1976)
Water Resources Publication No. 5

Water Requirement in Pilot Project Area

(1) Paddy (105 days) + Paddy (115 days)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
Plan A evaporation ET (mm)°	167	169	202	191	179	153	160	171	159	156	129	142	
Average rainfall 22 yrs (mm)	283	115	148	120	143	144	128	169	163	245	537	639	1957 - 1977

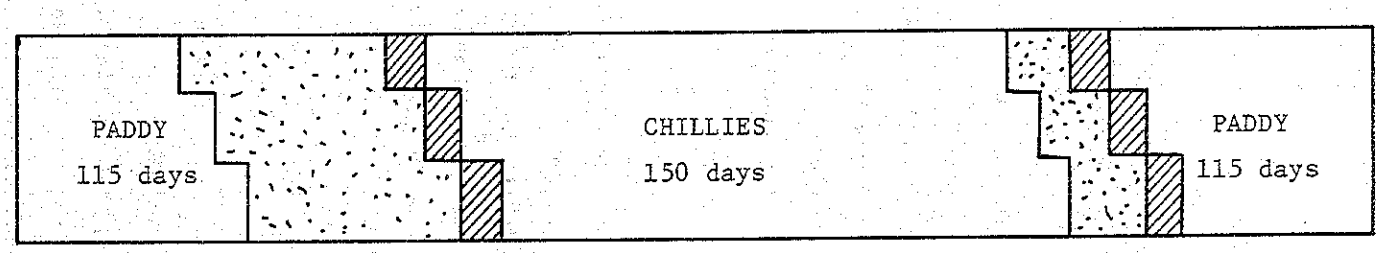


Land preparation (mm)	0	0	0	150.0	0	0	0	0	100.0	50.0	0	
ET crop (mm)	197.1	129.7	10.1	4.8	168.4	189.4	170.0	31.9	17.3	121.2	164.8	
Deep percolation Losses (mm)	60.0	46.8	3.3	20.0	60.0	60.0	56.7	13.3	6.7	53.3	60.0	
Total	257.1	176.5	13.4	211.8	228.4	249.3	226.7	45.2	124.0	224.5	224.8	

Water Requirement in Pilot Project Area

(2) Chillies (150 days) + Paddy (115 days)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	
Plan A evaporation ET_o (mm)	167	169	202	191	179	153	160	171	159	156	129	142	
Average rainfall 22 years (mm)	283	115	148	120	143	144	128	169	163	245	537	639	1957 - 1977



Paddy 115 days													
Land preparation (mm)	0	0	0							100	50	0	
ET crop (mm)	197.1	129.7	10.0							17.3	121.2	164.8	
Deep percolation losses (mm)	60.0	46.8	3.3							6.7	53.3	60.0	
Sub Total	257.1	176.5	13.4							124.0	224.5	224.8	
Chillies 150 days													
Land preparation (mm)				26.7	13.3	0	0	0	0	0			
ET crop (mm)				13.8	115.9	136.1	159.9	169.1	130.7	15.9			
Sub Total				40.5	129.2	136.1	159.9	169.1	130.7	15.9			
Total	257.1	176.5	13.4	40.5	129.2	136.1	159.9	169.1	130.7	139.9	224.5	224.8	

B. Drainage Plan

1. General

The Bukit Bauk catchment area is the 2835.4 ha (7,006 acres) at an elevation of 16m, and which discharges into the Paka and Dungun rivers. The catchment area which discharges into the Paka river is 1911 ha, while the area which discharges into the Dungun river is 924.4 ha. The discharge flow into the Dungun river is natural drainage, while the flow into the Paka river will be forced drainage using pumps. An embankment will be constructed along the district road running to Durian Mentangau to prevent overflow of the Paka river, and thereby protect crops inside the area from possible flood damage.

2. Main Canal

The main canal will run more or less north-south through the center of the area and discharge into the Paka river. The canal will be constructed as an earthen waterway with an embankment of a 1:3 slope (because of the rather soft ground). Discharge rates calculated by rational method are estimated to be 43 to 157 cub.m/sec. There will be 5,885 m of canal extensions.

3. Secondary Canals

Secondary canals will meet the main canal practically at right angles. Like the main canal, these canals will also be constructed as earthen waterways, but with a 1:2 sloped embankment. According to rational method calculations, discharge rates will be from 5 to 31 cub.m/sec. There will be 23,250 m of canal extensions.

4. Calculations

(1) Discharge rates

Discharge rates are calculated according to the rational method. The formula used for this calculation is:-

$$Q = 0.2778.f.r.A$$

where Q is the peak flood rate (cub.m/sec),
f is the flow coefficient (0.7),
r is the maximum average hourly rainfall (mm/hr) resulting in flood conditions,
and A is the catchment area (sq.km).

The value for r is determined according to:-

$$r = \frac{r24}{24} \cdot \left(\frac{24}{t}\right)^n$$

where r_{24} is the maximum daily rainfall (mm) (which equals 293.7mm/day),
t is the time required to reach flood conditions,
and n is a coefficient determined according to the district.

The value for t is calculated from

$$t = \frac{L}{W}, \text{ and W from } W = 72\left(\frac{H}{L}\right)^{0.6}$$

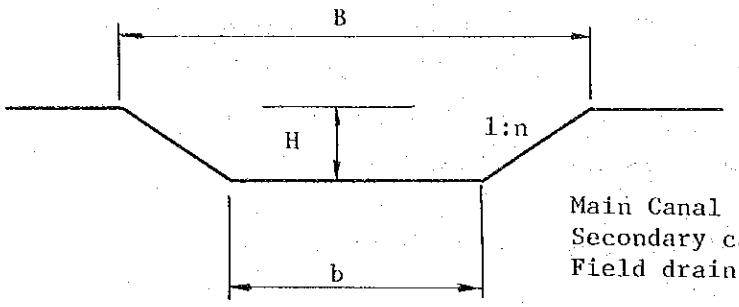
where L is length of water course (km) (L = 4.8km),
W is the flood propagation speed (km/hr)
and H the height difference (km) (H = 0.014 km)

$$W = 72\ \left(\frac{0.014}{4.8}\right)^{0.6} = 2.2 \text{ km/hr.}$$

$$A = \frac{4.8}{2.2} = 2.2 \text{ hr.}$$

$$r = \frac{293.7}{24} \cdot \left(\frac{24}{2.2}\right)^{0.5} = 40.4 \text{ mm/hr.}$$

(2) Section of canal



Main Canal n=3
Secondary canal n=2
Field drain n=2

Main canal I=1/400
Secondary canal I=1/1000

Type	b	H	B	Discharge	Remarks
Main canal A type	5.0m	2.0m	17.0m	42.5m³/s	V=1.93m/s
" B "	15.0	"	27.0	92.4	V=2.20 "
" C "	23.0	"	35.0	124.7	V=2.15 "
" D "	27.0	"	39.0	154.4	V=2.34 "
Secondary canal A type	1.0	1.5	7.0	5.3	V=0.89m³/s
" B "	3.0	"	9.0	9.0	V=1.00 "
" C "	6.0	"	12.0	14.9	V=1.10 "
" D "	12.0	"	18.0	26.8	V=1.19 "
" E "	14.0	"	20.0	30.9	V=1.21 "
Field drain A type	1.5	1.0	5.5	2.6	V=0.74m/s
" B "	1.0	"	5.0	2.1	V=0.71 "

Canal name	Catchment area	Drainage discharge	Canal type	Tentative drainage discharge	Tentative canal type	Remarks
	(km^2)	m^3/s	Main canal	m^3/s	Main canal	
Main canal	5.253	41.3	A type	14.7	A type	L=2,400m
"	11.594	91.3	" B type	30.3	" A type	L=1,200
"	15.263	119.9	" C "	37.0	" A "	L=1,150
"	19.110	150.1	" D "	40.6	" A "	L=1,135
						Σ=5,885
Secondary canal No.1	3.172	24.9	Secondary canal D type	2.9	Secondary canal A type	L=2,790
" No.2	0.240	1.9	" A type	0.2	" A type	L=600
" No.3	0.502	3.9	" A "	0.5	" A "	L=1,000
" No.4	0.240	1.9	" A "	0.2	" A "	L=600
" No.5	0.568	4.5	" A "	0.5	" A "	L=1,000
" No.6	1.619	12.7	" C "	4.1	" A "	L=2,130
" No.7	0.500	3.9	" A "	0.5	" A "	L=1,000
" No.8	0.240	1.9	" A "	0.2	" A "	L=600
" No.9	0.558	4.4	" A "	0.5	" A "	L=1,000
" No.10	1.386	10.9	" C "	3.9	" A "	L=2,750
" No.11	2.596	20.4	" D "	7.3	" B "	L=3,800
" No.12	1.561	12.3	" C "	4.4	" A "	L=2,450
" No.13	1.210	9.5	" C "	3.4	" A "	L=1,450
" No.14	1.690	13.3	" C "	4.7	" A "	L=1,020
" No.15	3.635	28.6	" E "	10.1	" C "	L=1,060
						Σ=23,250m
Field drain	0.300	2.4				Field drain A type
"	0.200	1.6				" B type

Canal cross-sections have been calculated on the basis of Hydrological Procedure No. 18 "Hydrological Design of Agricultural Drainage Systems, 1977". According to this procedure, drainage calculations are designed to drain 5 year's probable rainfall within the drainage time determined for the particular type of crop.

If, in the future, it becomes desirable to use large-scale agricultural machinery, or to cultivate high grade crops, it will be necessary to drain the fields free of water. In this case, the canal cross-sectional area will probably have to be sufficient to permit drainage of peak flow calculated according to the rational method for situations where field flooding is not required. The canals planned for, however, are of the following provisional cross-sectional areas.

Drainage discharge rates calculated according to "Hydrological Procedure No. 18".

Canal name		Drainage discharge	Remarks
Main canal		14.7 m^3/s	L=2400 m
"		30.0	1200
"		37.0	1150
"		40.6	1135
			Σ=5885
Secondary canal	No. 1	2.9	L=2,790
"	No. 2	0.2	600
"	No. 3	0.5	1,000
"	No. 4	0.2	600
"	No. 5	0.5	1,000
"	No. 6	4.1	2,130
"	No. 7	0.5	1,000
"	No. 8	0.2	600
"	No. 9	0.5	1,000
"	No.10	3.9	2,750
"	No.11	7.3	3,800
"	No.12	4.4	2,450
"	No.13	3.4	1,450
"	No.14	4.7	1,020
"	No.15	10.1	1,060

Number	Area	R	t	$Q = \frac{A.R.}{t}$	Remarks
1	40.5 ha	240.8 mm	72 hr	0.4 m^3/s	
2	27.0	"	"	0.3	
3	317.2	"	"	2.9	
4	50.2	"	"	0.5	
5	24.0	"	"	0.2	
6	56.8	"	"	0.5	
7	24.0	"	"	0.2	
8	50.0	"	"	0.5	
9	24.0	"	"	0.2	
10	55.8	"	"	0.5	
11	24.0	"	"	0.2	
12	77.8	"	24	2.2	
13	60.1	"	"	1.7	
14	60.0	"	"	1.7	
15	138.6	"	"	3.9	
16	28.3	"	"	0.8	
17	199.6	"	"	5.6	
18	240.0	"	"	6.7	
19	285.3	"	"	8.0	
20	127.8	"	"	3.6	
21	169.0	"	"	4.7	
22	121.0	"	"	3.4	
23	363.5	"	"	10.1	
	30.0	240.8	72	0.3	
	"	"	24	0.8	
	20.0	"	72	0.2	
	"	"	24	0.6	

(3) Considerations Based on the DID Method

The above calculations have also be checked according to DID Hydrological Procedure No. 5.

Main canal peak flood rate

Return period T_1 = 10 years
Catchment area A = 4,722 acres = 7.37 sq. miles
Slope S = 0.25%
Length of main stream L = 2.98 miles
Development from jungle ≒ 90%

According to Fig. 2 of Procedure No. 5

Tc/L ≒ 0.78
Tc = 0.78 x 2.98 = 2.32 hr
X(10, 2.24) = 5.39/2.32 = 2.32 inch/hr
c = 0.52
Q = CXA = 0.52 x 2.32 x 4,722 = 5,697 cusecs
= 161 m^3/sec

Since this value is very similar to the flood rate of Q = 150.1 cub.m/sec calculated earlier, the earlier value will be used.