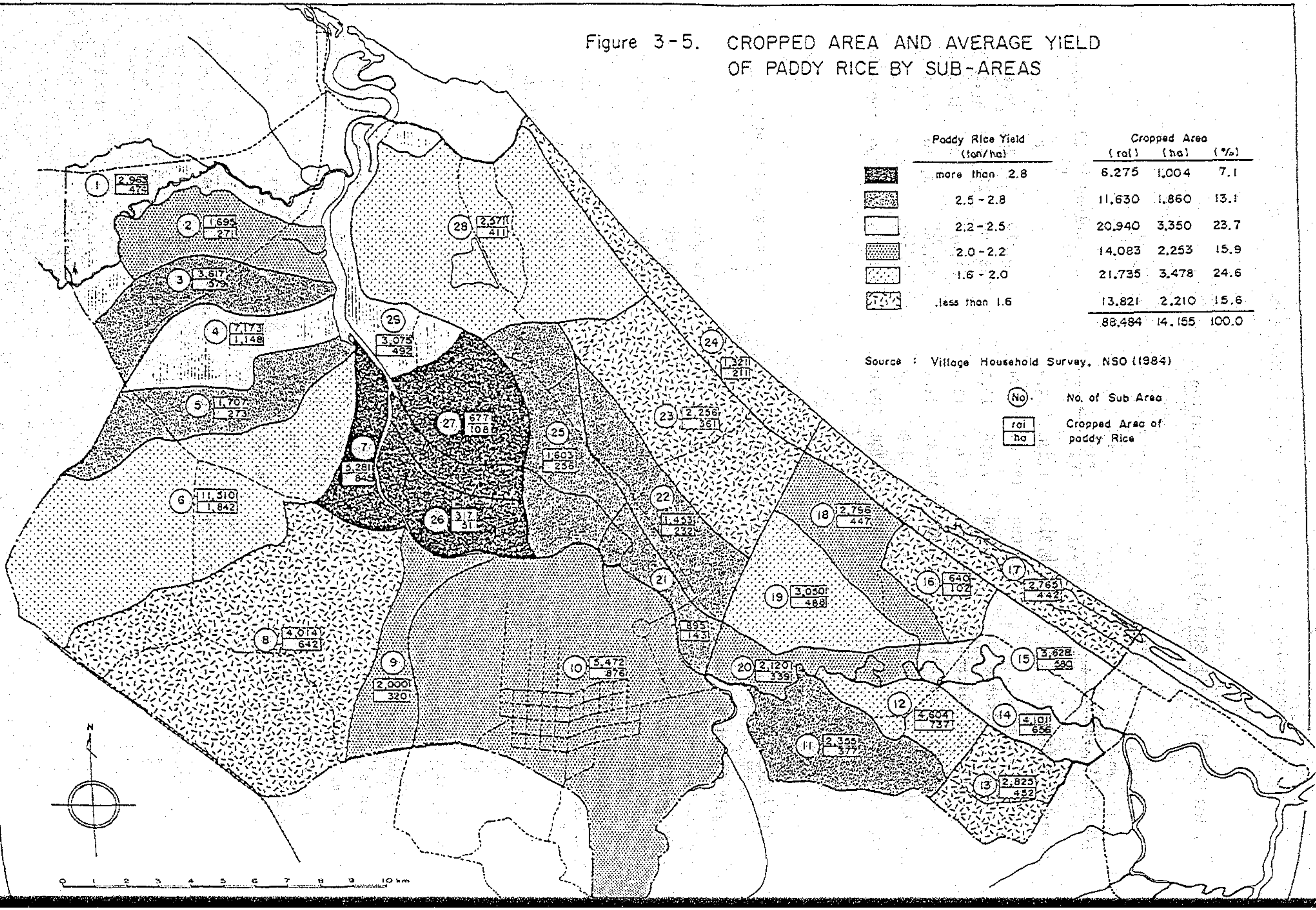
Table 3-10. Soil Suitability Classification

Suitability Class	Rice			Upland Corps		
	rai	ha	%	rai	ha	%
1 - Highly Suitable	8,310	1,330	2.9	0	0	0
2 - Suitable	115,000	18,400	39.4	78,310	12,530	26.9
3 - Marginally Suitable	44,060	7,050	15.1	138,690	22,190	47.5
4 - Currently Not Suitable	54,380	8,700	18.6	47,070	7,530	16.1
5 - Permanently Unsuitable	64,880	10,380	22.2	22,560	3,610	7.7
Water Bodies	5,250	840	1.8	5,250	840	1.8
Total	291,880	46,700	100.0	291,880	46,700	100.0

Suitability Class	Vegetables			Forage & Pasture		
	rai	ha	%	rai	ha	%
1 - Highly Suitable	15,060	2,410	5.2	15,060	2,410	5.2
2 - Suitable	14,880	2,380	5.1	126,190	20,190	43.2
3 - Marginally Suitable	181,620	29,060	62.2	100,940	16,150	34.6
4 - Currently Not Suitable	55,940	8,950	19.1	31,060	4,970	10.6
5 - Permanently Unsuitable	19,130	3,060	6.6	13,380	2,140	4.6
Water Bodies	5,250	840	1.8	5,250	840	1.8
Total	291,880	46,700	100.0	291,880	46,700	100.0

Suitability Class	Tree Crops		
	rai	ha	%
1 - Highly Suitable	10,310	1,650	3.5
2 - Suitable	28,940	4,630	9.9
3 - Marginally Suitable	86,440	13,830	29.6
4 - Currently Not Suitable	106,380	17,020	36.5
5 - Permanently Unsuitable	54,560	8,730	18.7
Water Bodies	5,250	840	1.8
Total	291,880	46,700	100.0

Figure 3-5. CROPPED AREA AND AVERAGE YIELD OF PADDY RICE BY SUB-AREAS



Paddy Rice Yield (ton/ha)	Cropped Area (rai)	(ha)	(%)
more than 2.8	6,275	1,004	7.1
2.5 - 2.8	11,630	1,860	13.1
2.2 - 2.5	20,940	3,350	23.7
2.0 - 2.2	14,083	2,253	15.9
1.6 - 2.0	21,735	3,478	24.6
less than 1.6	13,821	2,210	15.6
	88,484	14,155	100.0

Source : Village Household Survey, NSO (1984)

(No.) No. of Sub Area

rai / ha: Cropped Area of paddy Rice

For upland crops such as mungbeans, groundnuts and corn as well as for vegetables such as tomatoes, chilli and water melons, about three quarters of the Study area are suitable, while most of them are marginally suitable. Major constraints are flooding and impeded drainage in lowlands and moisture stress as well as low fertility in uplands. For forage and pasture, about 80 percent of the Study area are suitable because of the introduction of ill-drainage tolerant species as para grass. For tree crops including fruit trees and rubber trees, only 43 percent of the Study area are suitable. Major constraints are flooding and impeded drainage in lowlands.

ii) Irrigation Suitability Classification

The irrigation suitability for paddy and for upland crops has been classified separately. In the specifications, soil acidity is independent from other soil limitations, because the soil acidity changes under different moisture regimes induced by oxidation or leaching process. Accordingly, the soil acidity is expressed in parenthesis, for example, R3std(a). Based on the classification specifications (Table 3-11), each soil series is assorted into arable (Classes 1 to 3) or non-arable (Class 6) as shown in Table 3-12.

As the results, the irrigation suitability for paddy and for upland crops are shown in Figures 3-6 and 3-7, respectively. And the extent of each class is given as below:

Suitability Class	For Rice			For Upland Crops		
	rai	ha	%	rai	ha	%
1 - Highly Suitable	8,320	1,330	2.8	0	0	0
2 - Moderately Suitable	115,000	18,400	39.4	49,630	7,940	17.0
3 - Marginally Suitable	57,750	9,240	19.8	180,750	28,920	61.9
6 - Non-Arable	105,560	16,890	36.2	56,250	9,000	19.3
Water Bodies	5,250	840	1.8	5,250	840	1.8
Total	291,880	46,700	100.0	291,880	46,700	100.0

Table 3-11. Irrigation Suitability Classification Specifications

Bang Nara Irrigation & Drainage Project

Land Characteristics	Rice			Upland Crops		
	Class 1	Class 2	Class 3	Class 1	Class 2	Class 3
Soils						
Texture-Surface (0-30cm)	fSL to p.C SL or CL<30cm	LS to v.p.C LS<15, SL<30cm	LS to CL LS<15, SL<60cm	fSL to friable CL	LS to p.C LS<30cm	LS to s.p.C LS<60cm
-Subsurface	p.C to v.s.p.C	CL to p.C	SCL to v.p.C	SL to CL	SL to p.C	fSL to v.s.p.C
Thickness of Organic layer from the surface	<25cm	<50cm	<125cm	<25cm	<50cm	<125cm
Depth to compacted layer	>75cm	>50cm	>25cm	>100cm	>75cm	>50cm
Water-holding capacity in 120cm depth	Not applicable	Not applicable	Not applicable	>15cm	>11cm	>8cm
Depth to pyrite rich layer	>50cm	>25cm	>25cm	>100cm	>50cm	>25cm
ECe × 10^3 (mS/cm)	<4	<6	≤8	<4	<8	<10
Exchangeable sodium (me/100g)	<3	<4	<4	<2	<2	<3
Cation exchange capacity (me/100g)	>10	>5	>3	>10	>10	>5
Topography						
Slope	<1%	<3%	<5%	0.25-2%	<4%	<6%
Relief (surface)	Smooth	Slightly uneven	Rough	Smooth	Slightly uneven	Rough
Leveling requirement	None	Low	Moderate (terracing)	None	Low	Moderate
Trees or Brush cover (clearing requirement)	Slight	Moderate	Heavy	Slight	Moderate	Heavy
Drainage						
Depth to water-table	Not applicable	Not applicable	Not applicable	>150cm	>150cm	>120cm
Surface (dependent on slope & relief)	Good	Fair	Poor	Good	Good-Fair	Fair
Sub-surface	Poor	Poor	Fair	Good	Fair	Poor
Flooding	Infrequent	Periodic	Annual	None	None	Occasional
(Acidity)						
pH	5.0 - 8.0	4.5 - 8.5	4.0 - 8.5	5.5 - 8.0	5.0 - 8.5	4.5 - 8.5

Class 6: Lands where soils do not meet the minimum requirements for the other land classes, and are not suitable for irrigation. Included are areas of coarse-textured beach sands, soils having low water-holding capacity, swamps, acid sulfate soils etc.

Table 3-12. Irrigation Suitability Classes of Soil Series and Association

Soil Series	Map Symbol	Irrigation Sutiability Class For Paddy Rice	Irrigation Sutiability Class For Upland Crops
Beach Ridges & Sand Bars or Dunes			
Hua Hin	Hh	6 st	6 st
Bacho	Bc	6 st	3 s
Ban Thon	Bh	6 st	3 s
Depression between Beach Ridges			
Pattani	Pti-ly	3 sd	3 sd
Takua Thung	Tkt-ly	2 sd	3 sd
Former Tidal Flat			
Tak Bai	Ta-ly	2 sd	2 d
	Ta-fc	2 sd	3 sd
	Ta-fc-na	1	3 d
	Ta-ly-na	1	2 d
Rangae	Ra-ly-a_2	2 sd	3 sd
	Ra-ly-a_3	3 sd(a)	3 sd(a)
	Ra-m.sub	2 sd	3 d
	Ra-o	3 sd	6 sd(a)
	Ra-dm.sub	3 sd(a)	6 sd(a)
	Ra/Kd-o	6 sd(a)	6 sd(a)
Muno	Mu-ly	6 sd(a)	6 sd(a)
Chian Yai	Cyi-ly	3 sd(a)	3 sd(a)
	Cyi-o	3 sd(a)	6 sd(a)
	Cyi-r.sub	3 sd(a)	6 sd(a)
	Cyi/Mu-ly	6 sd(a)	6 sd(a)
Thon Sai	Ts-ly	3 sd(a)	3 sd(a)
	Ts-col	6 sd	3 sd
	Ts-o	3 sd(a)	6 sd(a)
Flood Plain, Levees & Breach Deposits			
Chon Buri	Cb-ly	2 sd	2 d
	Cb-fc	1	3 sd
Alluvial Complex	AC	3 s	3 d
Sai Buri	Bu	2 s	2 s
Ruso	Ro	2 s	2 s
Low Terrace			
Pileng	Pil-ly	2 sd	3 sd
Khok Kian	Ko-ly	2 d	3 d
Tha Sala	Tsl-ly	2 sd	3 sd
Pattalung	Ptl-ly	2 sd	3 sd
	Ptl-m.sub	3 sd	6 sd
	Ptl/Ba-m.sub	3 sd	6 sd
Bangnara	Ba-ly	2 sd	3 sd
	Ba-m.sub	2 sd	3 sd
	Ba/Ptl-ly	2 sd	3 sd
	Ba/Tsl-ly	2 sd	3 sd
	U1/71	2 sd	3 sd
Sungai Padi	Pi	2 s	3 sd
Sungai Kolok	Gk	2 s	3 sd
Nam Krachai	Ni	6 st	3 s
Middle Terrace			
Kohong	Kh	6 st	2 s
	U2/71	3 st	2 s
Lamphu La	Ll	6 st	2 t
Hills & Foothill Slopes			
Huai Pong	Hp	6 st	3 t
Phuket	Pk	6 st	6 st
Yi-ngo	Yg	6 st	6 st
Slope Complex	SC	6 st	6 st
Domed Bogs			
Narathiwat	Nw-d_1	3 sd	3 sd
	Nw-d_{1+2}	6 sd(a)	6 sd(a)
	Nw-d_2	6 sd	6 sd
	Nw-d_3, a_{1+2}	6 sd	6 sd
	Nw-d_3, a_2		
Kap Dang	Kd-a_2	3 sd	3 sd
	Kd-a_3	3 sd(a)	6 sd(a)
	Kd-a_4	6 sd(a)	6 sd(a)

Note 1/ S : soil limitation (acidity, organic layer, coarse-texture, shallow soil depth etc.)
t : topography limitation (steep slope)
d : drainage limitation (permeability, shallow groundwater, flooding etc.)
(a): acidity limitation

Figure 3-6 IRRIGATION SUITABILITY FOR RICE

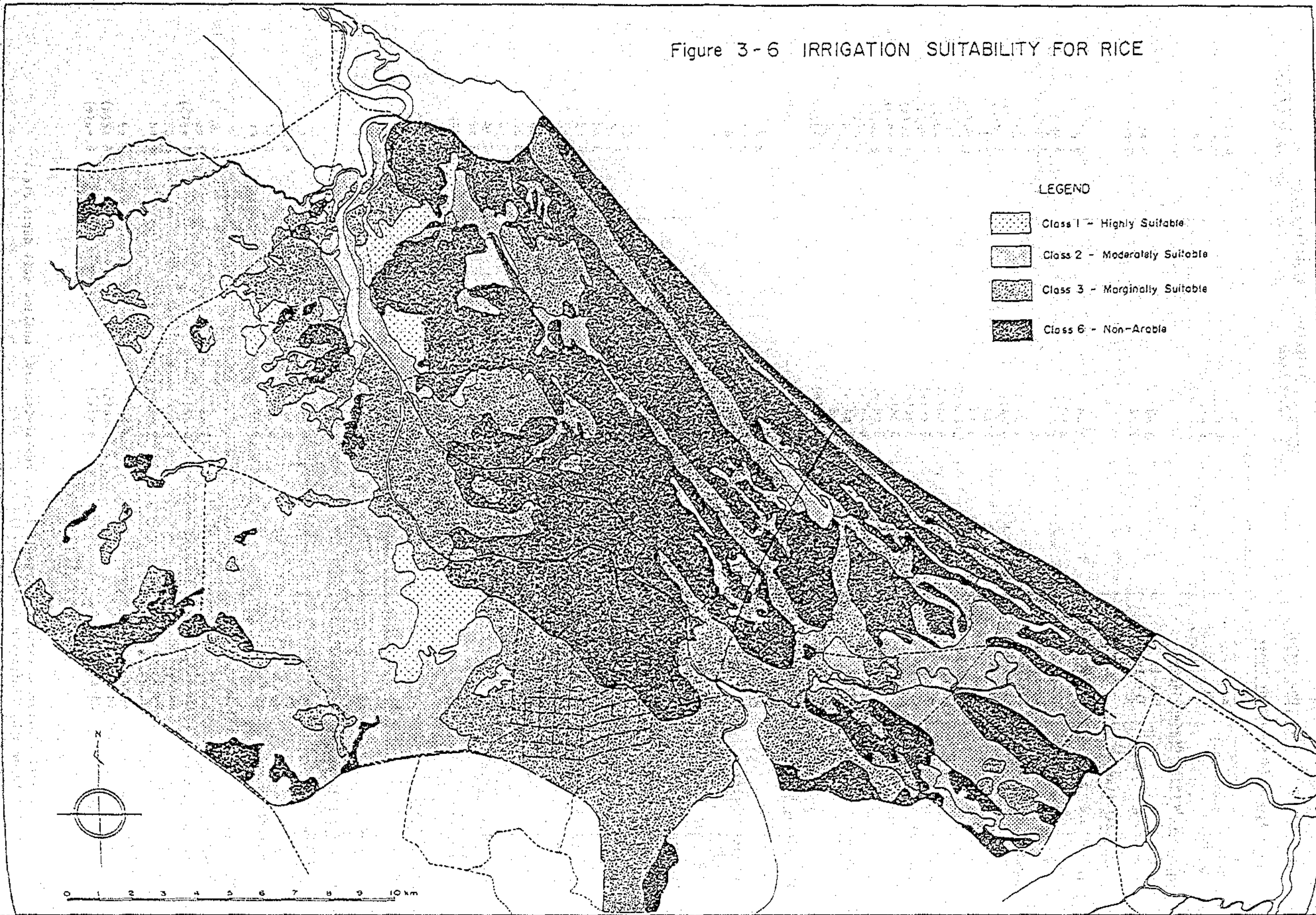
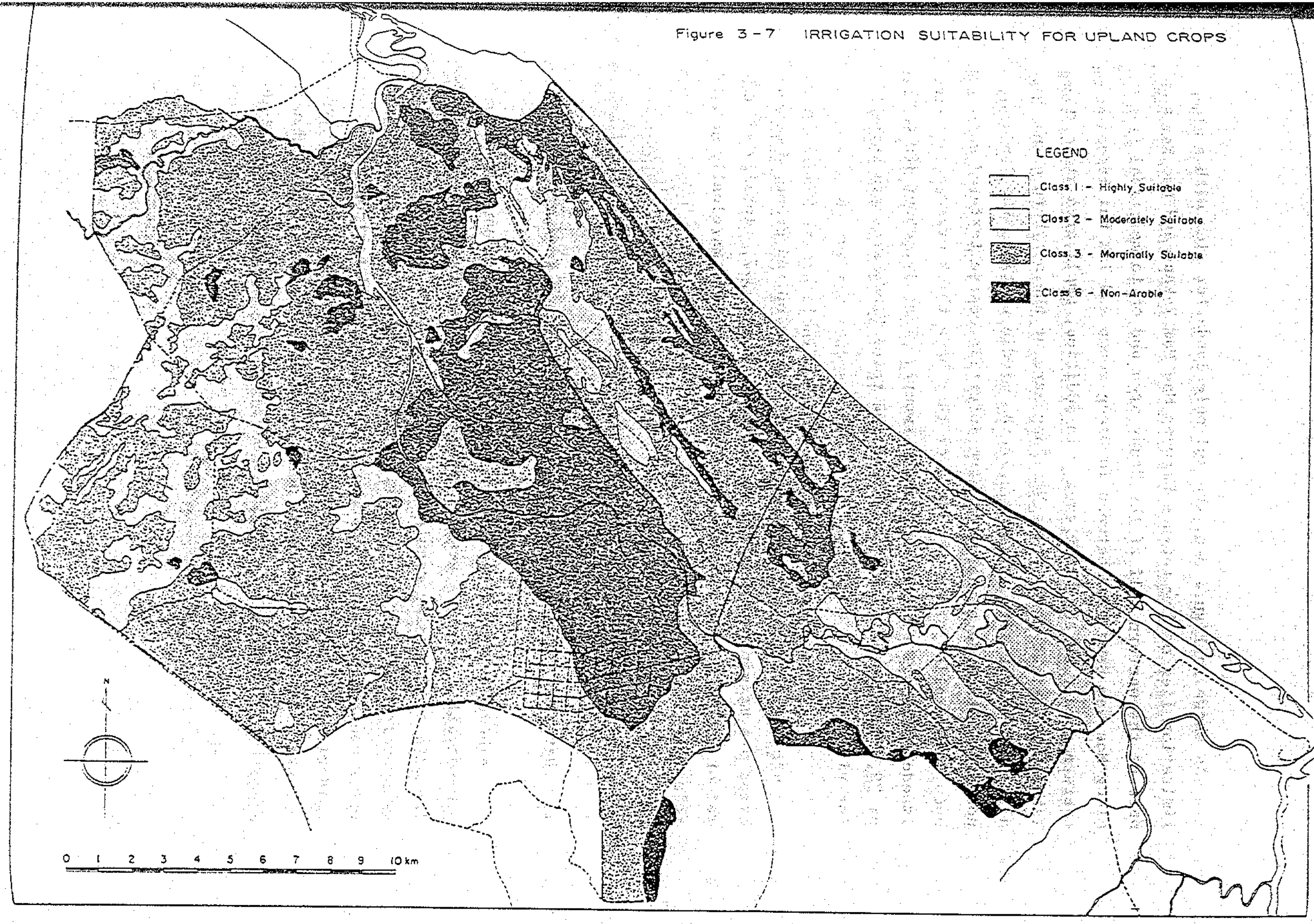


Figure 3 - 7 IRRIGATION SUITABILITY FOR UPLAND CROPS



As shown in Figure 3-6, the suitable lands for rice with a minor limitation lies on low terrace between Mae Nam Yakang and Mae Nam Bang Nara at the western half of the Study area and on former tidal flat along Mae Nam Bang Nara between To Daeng swamp and Tak Bai lagoon at the eastern corner of the Study area. In addition, small area along Khlong Yabi at the right bank of Mae Nam Bang Nara at the northern corner has also high suitability for rice. In the middle portion, the lands are non-arable because either they have infertile coarse textured soils and undulating relief of beach ridges or they have thick organic layer and impeded drainage of depressions and swamps. Finally, about 180,000 rai or 29,000 ha, namely, 62 percent of the total Study area are suitable for rice.

As regards the irrigation suitability for upland crops, dominant areas are marginally suitable as shown in Figure 3-7. Totally 230,000 rai or 37,000 ha are suitable, but most of them are marginally suitable (class 3).

(5) Further Studies

i) Detailed Survey

Since the soil distribution patterns have been mapped at the semi-detailed level, a general soil survey does not seem to be required. The main additionally required field survey would be to assess the geohydrological characteristics of the lowland soils to determine the water control practices to prevent pyrite enriched horizon from oxidation. In addition, physical characteristics of peat, that is, shrinkage and subsidence also need to be further investigated when the fringes of swamp forests would be utilized for agriculture in future.

For improvement of the problem soils, several institutions concerned with land resources development have commenced their activities to obtain the basic data as follows:

- Land Classification Branch (RID) has started the detailed soil and water quality monitoring survey in the northeast of Mae Nam Bang for about 5 months from the beginning of March 1986. The survey will be continued in the next year for the southwest of Mae Nam Bang Nara.
- Pikulthong Center (DLD) has carried out the lime application experiment on acid soils at farmer's fields in various locations in the area during the 1985 rice cropping season.
- The Second International Soil Management Workshop entitled "Classification, Characterization and Utilization of Peat Land" will be held at Hadyai and Jahor Baharu in the beginning of April 1986.

The fruitful results from such efforts should be surely indispensable to the development of irrigated agriculture in the Study area.

ii) Sulfate Flushing Test of Acid Sulfate Soil

In order to find out the most practicable method and water requirement for improvement of acid sulfate soils, the SO_4 flushing test is recommended to carry out at both laboratory and field plot levels. An example of the laboratory test apparatus is shown in Appendix IV-11.

iii) Study on Soil-Crop Relationship

Under the condition of reliable water supply, the crop yields would be increased owing to the optimum fertilizer and lime application. Therefore, the following studies are recommended to be conducted:

- Lime application.
- Fertilizer (N,P,K) application.

- Micro-element deficiency
- Soil-plant water relationships with special regard to the influence of drainage.

These studies will be continued at the Pikulthong Center and will be initiated at the demonstration farms to be established in the proposed Project. Moreover, these studies would be combined with trials at farmers' fields. Through these trials and the evaluation of cost and benefit for the farmers, guidelines for the extension services could be formulated.

3.3.4 Water Resources

(1) Seasonal Variation of the Bang Nara Water Level

Considerable variation in tide type can be found throughout the southeast Asian region where the waters are subject co-oscillating tides under the influence of both the Pacific and Indian Ocean basins. The South China Sea has, in general, a mixed diurnal tide where semi-diurnal tides appear as small amplitudes, while further north from the Study area into the Gulf of Thailand the diurnal tide is amplified and an almost pure diurnal tide is found.

Mae Nam Bang Nara is tidal running along the east coast of the Gulf of Thailand, with a drainage area of about 1,500 sq.km with three river mouths of Narathiwat, Taba and the Nam Baeng canal constructed in 1983, respectively. Since there is almost no river slope with Mae Nam Bang Nara, the tidal fluctuation affects the water level of all river channel. Figure II-4-10 in Appendix II shows that the fluctuation of water level along Mae Nam Bang Nara is fairly affected by ocean tide. The fluctuation in water level of Mae Nam Bang Nara ranges from EL -0.5 m to 0.5 m acording to tidal fluctuation during the period when there is a small rainfall from February to April.

On the other hand, during the northeast monsoon season, there is about 1,300 mm rainfall which is almost equal to a half of the annual rainfall in the Bang Nara river basin. Because of the influence of such rainfall runoff, the water level near the river mouth ranges from EL +0 to 1 m.

In order to estimate the flooding condition of Mae Nam Yakang by a non-uniform flow analysis, the river cross-section survey was made during the Phase I field work. Then, flow profiles of Mae Nam Yakang were studied in relation to each discharge as shown in Figure 3-8; as a result, it has been summarized that partial overflow from the natural bank with increasing discharge starting from more than 200 cu.m per sec and the total overflow starting from more than 400 cu.m per sec take place. With the flooding of Mae Nam Yakang mentioned above and the run-off from other tributaries of Mae Nam Bang Nara, the low-lying land around Mae Nam Bang Nara is inundated for some days. In this case, the water level in the middle point of Mae Nam Bang Nara would reach more than EL 2.0 m. Figure 3-9 shows the maximum inundation area resulting from five-year return period flood in December 1984 which reappears in a hydraulic simulation model explained in section 4.2.2. and its inundation lasts for a week.

In order to observe the fluctuation of the water level at the important points along Mae Nam Bang Nara, the water level gauges were installed in September 1985 during the Phase I Field Work. Locations of the water level gauges provided by JICA are at Narathiwat (X160), Tak Bai (X161) and Nam Baeng Bifurcation (X162) as shown in Figure II-1-7 of Appendix II. Figure 3-10 shows the range of water level fluctuation at these three points from September 1985 to January 1986 which is arranged in relation to spring and neap tide. Among these points, the largest amplitude of water level occurs at Tak Bai where the range is between 1.04 m in spring tide and 0.56 m in neap tide on the average respectively, and the second largest amplitude that occurs at Narathiwat is in a range from 0.72 to 0.37 m, and the smallest amplitude that occurs at Nam Baeng bifurcation is from 0.53 to 0.28 m, respectively.

FIGURE 3-8. FLOW PROFILE OF THE YAKANG RIVER

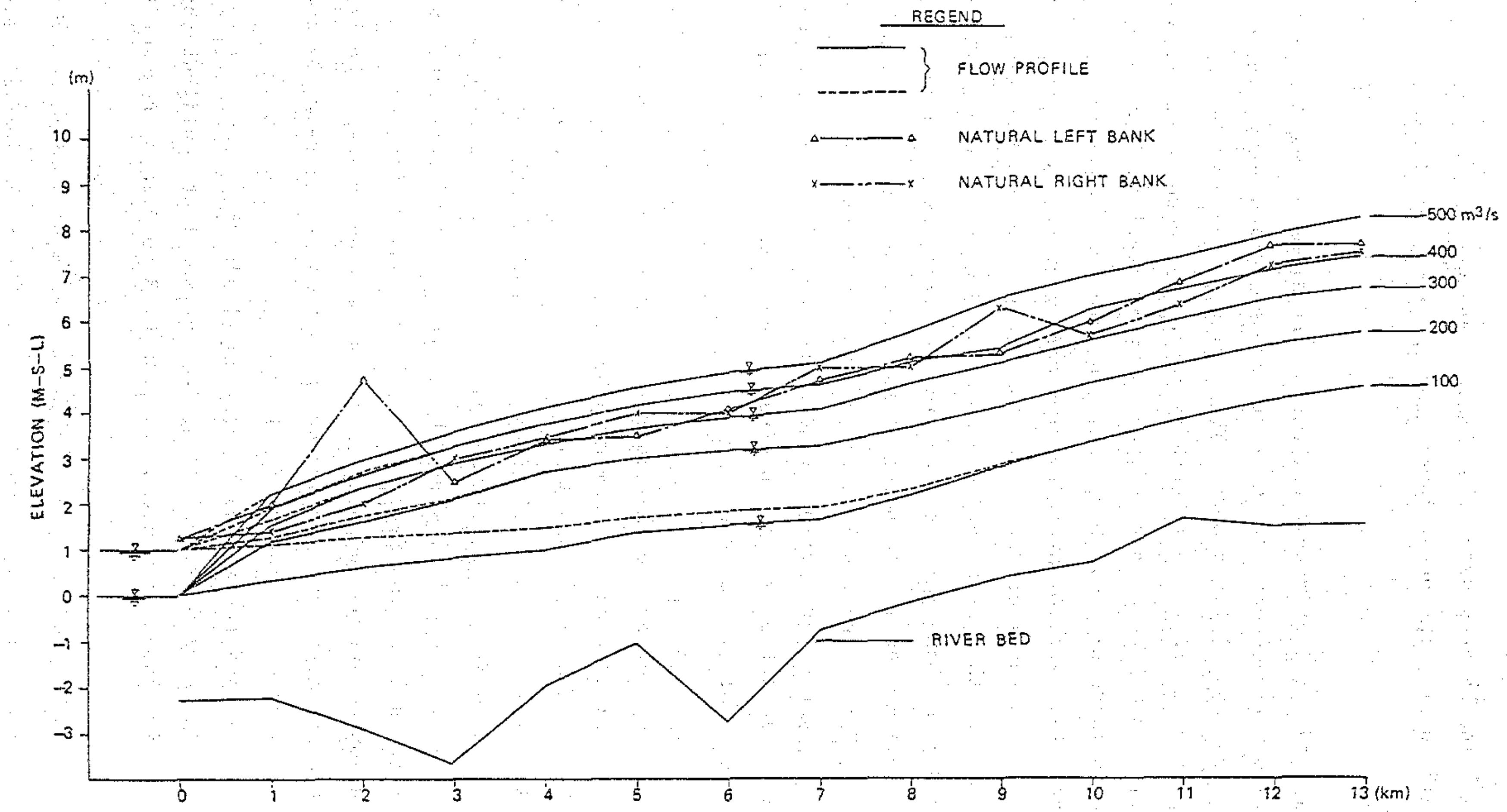


FIGURE 3-9. **MAXIMUM WATER LEVEL DURING FLOOD STAGE IN DECEMBER 1984**

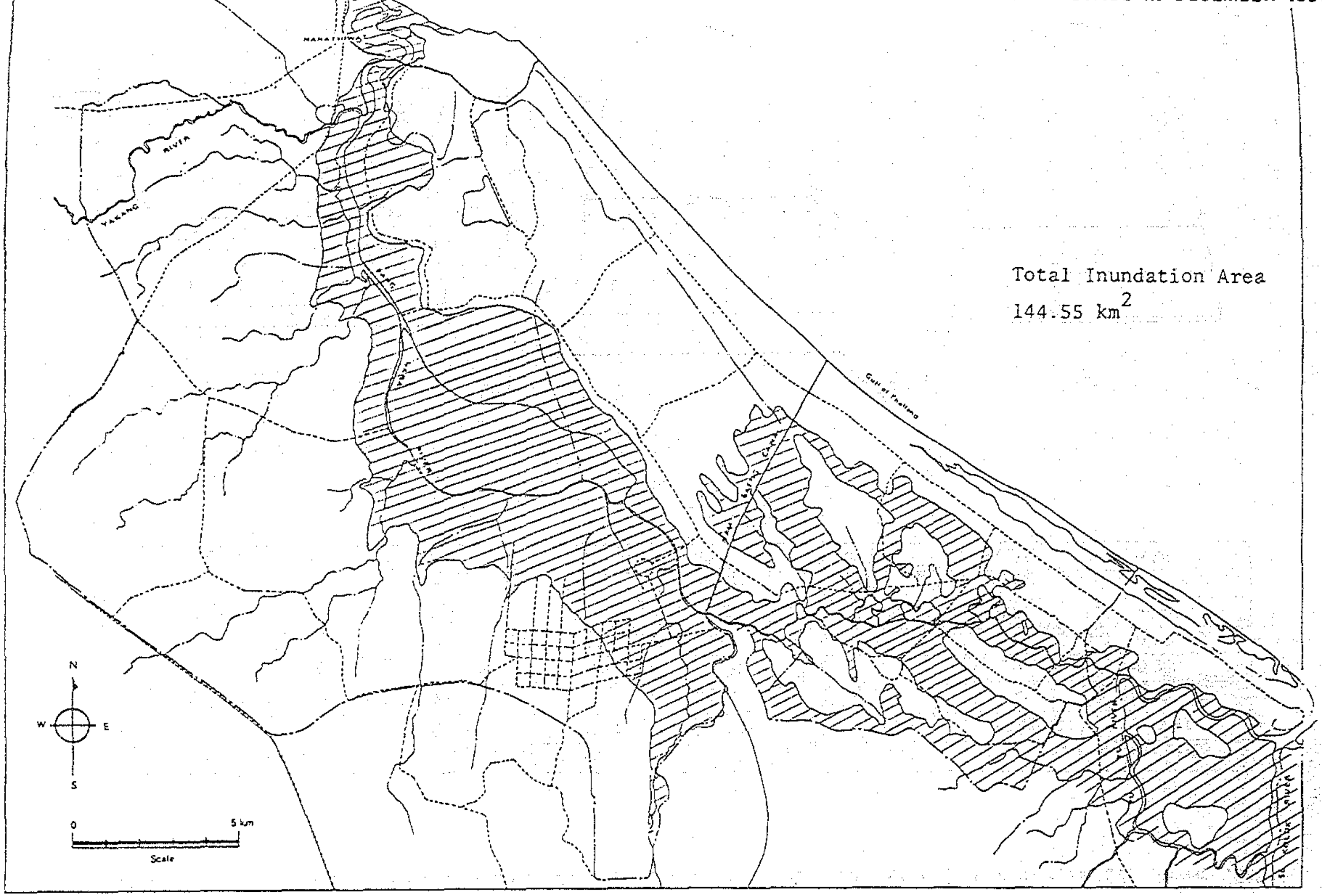
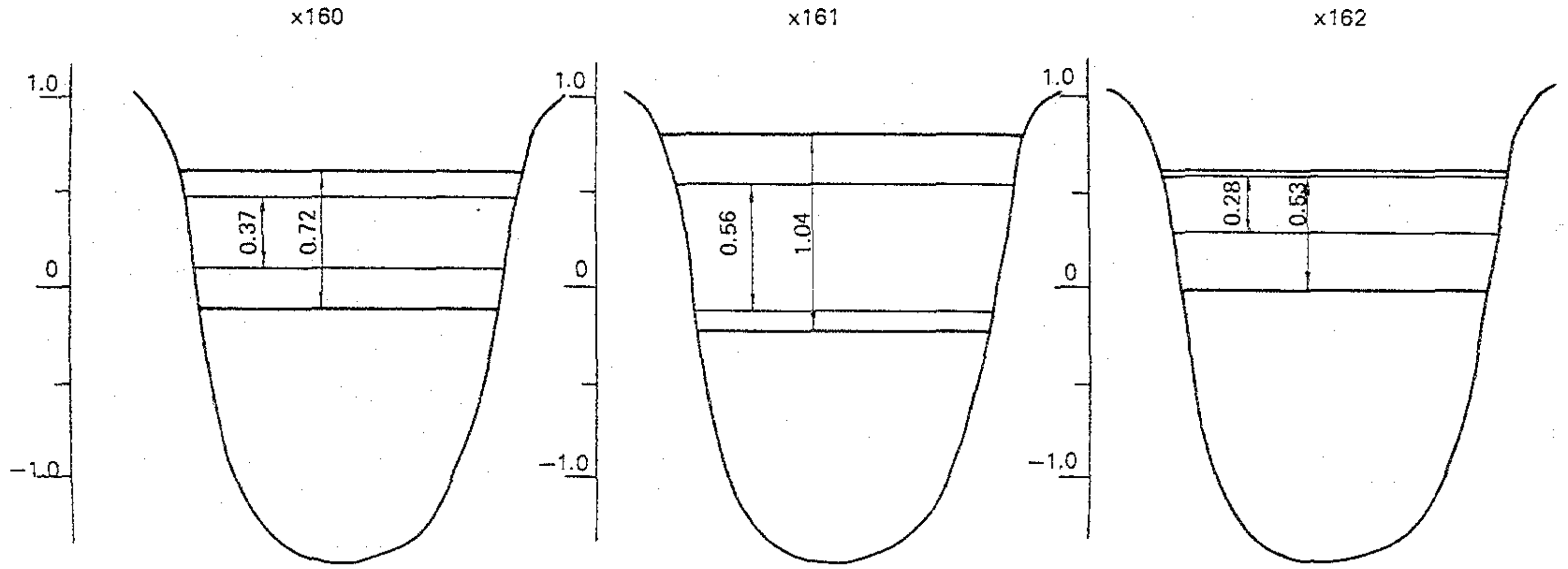


FIGURE 3-10 **WATER LEVEL AT JICA PROVIDED GAUGE IN SPRING AND NEAP TIDE** (September 1985 - January 1986)

STATION NAME	x160 (NARATHIWAT)				x161 (TAK BAI)				x162 (NAM BAENG)			
TIDE	SPRING		NEAP		SPRING		NEAP		SPRING		NEAP	
Mean Water Level (High)	0.60	(0.72)	0.46	(0.37)	0.79	(1.04)	0.53	(0.67)	0.60	(0.63)	0.56	(0.28)
– do – (Low)	–0.12		0.09		–0.25		–0.14		–0.04		0.28	
Highest Water Level (H)	0.74	(0.82)	0.87	(0.16)	1.05	(1.35)	0.92	(0.98)	0.70	(0.45)	0.99	(0.09)
– do – (L)	–0.08		0.71		–0.20		–0.06		0.25		0.90	
Lowest Water Level (H)	0.46	(0.86)	0.04	(0.35)	0.69	(1.26)	0.24	(0.62)	0.52	(0.78)	0.15	(0.39)
– do – (L)	–0.40		–0.31		–0.57		–0.38		–0.26		–0.24	



LEGEND
Mean Low – Water, High – Water Level (Spring Tide)
– do – (Neap Tide)

And, the more detailed water level records in relation to spring and neap tide with time for the duration explained above are shown in Figure II-4-12 of Appendix II. At Tak Bai, particularly, the continuous short interval cycle of the water level fluctuation is observed on the recording paper, although the curve in Figure II-4-12 of Appendix II is found smooth. It is supposed that a kind of seiche may occur under some specific conditions which would be caused by the shape of the river channel, the tidal fluctuation and the inflow into the river.

(2) Surface Water

i) Basic Input Data

a) Catchment Area

The map at the scale of 1:50,000 has been used for determining the boundary of the related watersheds and planimetering the respective areas, and the map at the scale of 1:25,000 was used together with the above for further clarification for the low-lying areas. The topography is extremely flat in these areas and the catchment boundary is dictated by the layout of drainage channels, roads and railway lines, rather than by the natural watershed. During significant floods, overspill can occur from Sg. Kelantan into the Kolok basin. The total catchment area of Mae Nam Bang Nara is 1,401 sq.km, and Mae Nam Yakang occupies 724 sq.km, accounting for 52 percent of the total. The other major tributaries and their catchment areas are shown as follows:

Name	Catchment Area (sq.km)	Ratio (%)
Khlong Sg. Pade	164	12
Khlong Chuap	108	8
Chang Canal	89	6

(Refer to Figure II-2-1 of Appendix II)

These rivers, when running through the low-lying areas, have a slope ranging from 1/4,000 to 1/600 and these flow length therethrough occupies about 90 percent of the total river length, while, in the mountainous areas, have river slope less than 1/10 and the shorten flow length to the total. (Refer to Figure II-2-2 of Appendix II)

b) Water Level Gauging Station and Observation Period

There are 15 water level gauging stations in and around the Mae Nam Bang Nara basin, location of which is presented in Figure II-1-7 of Appendix II and in Table II-2-1 of Appendix II. Among these stations, two stations (X43 at Sg. Padi and X73 at Mae Nam Yakang) have the daily water level records covering more than 15 years. But at the X43 station, the measurement has been stopped. (Refer to Figure II-2-3 of Appendix II.)

During the period of the field survey, three sets of the automatic water level recorders (Richard Type) were installed at the following points along Mae Nam Bang Nara:

- Confluence of Mae Nam Bang Nara and Mae Nam Yakang (RID X-160)
- Confluence of Mae Nam Bang Nara and Nam Baeng canal (RID X-162)
- Confluence of Mae Nam Bang Nara and Khlong Pu Yu (RID X-161)

The observation of those stations were started at the beginning of September 1985. The data available at the Narathiwat harbor (HD) and the river mouth of Mae Nam Kolok (RID X-100) are used as the boundary condition for the hydraulic simulation study as stated in Chapter 4. The data at the other stations are available for only several years with many interruption in observation.

c) Rating Curve

The rating curve developed on the relationship between water level and discharge has been prepared for those points of X43, X119, X121 and X45, respectively. The rating curve at X43 on Khlong Sg. Padi could be applied to estimate inflow discharge to Mae Nam Bang Nara, however, its catchment area is small and its observation was stopped after construction of a weir immediately downstream under the RID Small Scale Irrigation Program in 1982. Therefore, these data could not be used for the Study.

The data at X45 which is located on the middle reaches of Mae Nam Sai Buri, were applied for the analysis of effective rainfall for surface runoff since the river is in neighbouring Mae Nam Yakang and a topographical condition and land use are similar to each river basin.

In order to calculate discharge of Mae Nam Yakang which occupies almost half of the total catchment area of Mae Nam Bang Nara, the rating curve developed at X73 in cooperation with RID staff at the end of 1985 which is compiled in Figure II-2-25 of Appendix II is used in this study. Confirmation of the procedures to prepare the rating curve at X73 has been made from every corner; however, any defect has not been detected to date. Under thses situations, it has been inevitably understood that the runoff observed at X73 are reliable.

ii) Flood Runoff Analysis

a) Methodology

The Nakayasu's method to make synthetic unit hydrograph could be applied for analyzing flood runoff by using only topographic characters when no data are available. The parameters of a unit hydrograph are given as follows:

$$Qmax = A*Ro/(3.6 * (0.3T_1 + T_{0.3}))$$

The ascending curve of a unit hydrograph

$0 < t < T_1$ $$\frac{Qa}{Qmax} = \left(\frac{t}{T}\right)^{2.4}$$

The descending curve of it

$1 > \frac{Qd}{Qmax} > 0.3$ $$\frac{Qd}{Qmax} = 0.3^{(t - T_1)/T_{0.3}}$$

$0.3 > \frac{Id}{Qmax} > 0.3^2$ $$\frac{Qd}{Qmax} = 0.3^{(t - T_1 + 0.5 T_{0.3})/1.5 T_{0.3}}$$

$0.3^2 > \frac{Qd}{Qmas}$ $$\frac{Qd}{Qmas} = 0.3^{(t - T_1 + 1.5 T_{0.3})/2.0 T_{0.3}}$$

Where

- Qmax : maximum discharge of a unit hydrograph (cu.m/sec)
- Qa, Qd : discharge when a unit hydrograph ascends or descends (cu.m/sec)
- A : catchment area (sq.km)
- Ro : unit rainfall
- T_1 : time from the beginning of run-off to maximum discharge
- $T_{0.3}$: time from maximum discharge to 0.3 times the maximum discharge

Nakayasu defines a unit hydrograph as mentioned above and T_1, $T_{0.3}$ are expressed as a function of the basin characteristics as follows:

where

- tg: lag-time (hr)
- L : maximum stream length from outlet to divide (km)

In the case of $L \leqq 15$ km

$$tg: 0.21L^{0.7}$$

In the case of $L > 15$ km

$$tg: 0.4 + 0.058L$$

The relation of the basin form and To.3

$$T_{0.3} = 0.47(A.L)^{0.25}$$

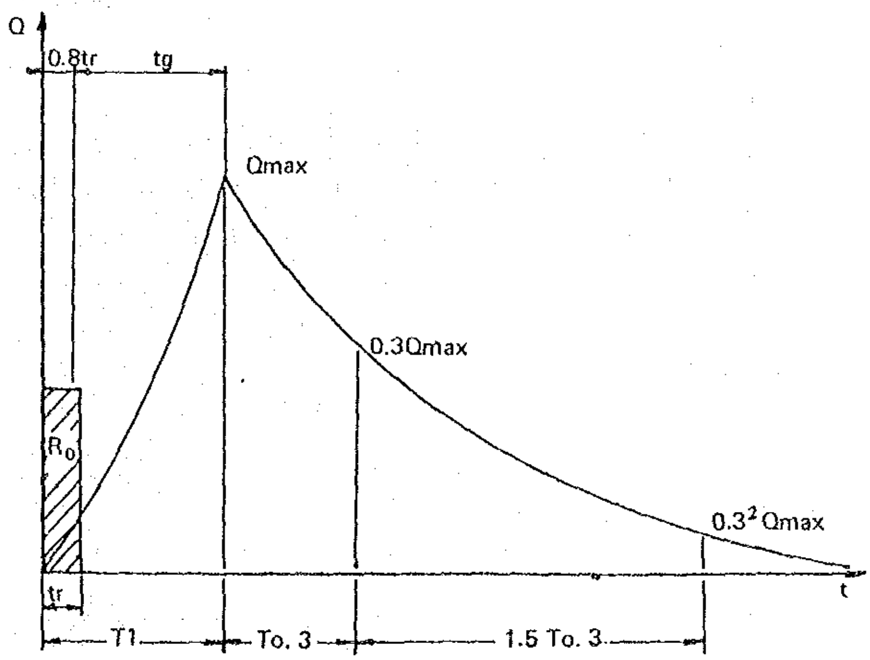
The time of peak discharge

$$T_1 = tg + 0.8tr$$

where

tr: duration of a unit rainfall

These relations are found in the actual discharge materials.



b) Effective Rainfall for Surface Runoff

The effective rainfall has been analyzed by using the data at X45 station which is located at the middle reach of Mae Nam Sai Buri covering the catchment area of 1,555 sq.km and the similar conditions of vegetations and topography to those of Mae Nam Yakang.

The five discharge data were selected to specify two items, (1) direct runoff including surface runoff and interflow, and (2) base runoff. In general, the component of the base runoff in flood is negligibly small compared with surface runoff amount. The constant amount of the base runoff could be used for this analysis. (Refer to Figure II-2-4 and -5 of Appendix II)

The rate between the amount of rainfall and it of direct runoff is obtained by the following procedures:

- Runoff coefficient of about 10 percent is observed when the amount of rainfall is smaller, and 80 percent when heavy.

- Runoff coefficient of about 25 percent is applied when the amount of cumulative rainfall is less than 80 mm. When cumulative rainfall is over 80 mm, runoff coefficient of 100 percent is used, because the soil in the catchment area would be fully saturated under this condition.

c) Runoff Analysis by using Heavy Rainfall with Five-Year Return Period

The catchment areas of Mae Nam Bang Nara and the Nam Baeng canal are divided by nine (9) and two (2) sub-areas by its tributaries. And the catchment area and its river length are shown in Table II-2-2 of Appendix II.

Mae Nam Bang Nara Basin

1. Yakang river basin (A+B)
2. Khlong To Che (C+D)
3. Chang canal (E)
4. Khlong Chuap (F)
5. Khlong Ai Rong (G)
6. Khlong Sg. Padi (H)
7. Khlong Pu Yu and Khlong to Daeng (J+K)
8. Khlong Pu Cho Ya Mu (L+N+R)
9. Other remaining area

Nam Baeng Canal Basin

1. Nam Baeng canal sub-area-1 (M)
2. Nam Baeng canal sub-area-2 (O)

Note: The alphabet symbols in the parentheses correspond to each catchment sub-area which is shown in the map of the catchment area. (refer to Table II-2-2 of Appendix II.)

According to the actually observed hydrograph at Mae Nam Sai Buri, the time lag of 20 hours between the peak rainfall pint and the peak discharge point is observed during the flood season. The over-topping discharge at Mae Nam Yakang is recognized during the flooding period by the field survey. The river course of Mae Nam Yakang is divided into two parts, (1) the upstream section from the highest point of the basin to X73 and (2) the downstream part from X73 to the conference with Mae Nam Bang Nara.

- Upstream section (L=44 km):
  The time lag of 3 hr is calculated by the Nakayasu equation.

- Downstream section (L=12 km):
  Runoff discharge is overtopping during the flooding period, and the discharge is running over the plain area or through many streams in the plain area. The time lag is calculated by

the Manning formula. Hydraulic radius of R=1.0, hydraulic gradient of I=1/4000 and roughness coefficient of n=0.045 are employed. Mean velocity of flood is 0.35 cu.m per sec and the necessary time (Tg2) from the overtopping point to Mae Nam Bang Nara is calculated at about 10 hr.

- Total time lag:

  Tg1 + Tg2 = 13 hr

For the other tributaries of Mae Nam Bang Nara, those are also computed by using the Nakayasu equation.

To estimate flood discharge of the objective rivers, the actual observed 6-day consecutive rainfall at the Narathiwat station which occurred on the 20th to 25th day of December 1984 being equivalent to the amount of the estimated rainfall with 5-year return period, has been employed. According to the result of the flood discharge analysis, the peak discharge of 1,257 cu.m per sec with 80 hr time lag has been calculated at Mae Nam Yakang. The specific runoff discharge of the above is 1.74 cu.m per sec per sq.km. The peak discharge of Khlong Pu Yu and Khlong To Daeng is 958 cu.m per sec and its specific discharge is 3.29 cu.m per sec per sq.km. (Refer to Figures II-2-8 and -10 of Appendix II.) The peak discharge of the other tributaries of Mae Nam Bang Nara at the flooding period is summarized in Figure II-2-9 of Appendix II.

During the flood period, both of the Khlong Pu Yu and Khlong To Daeng have over-topping discharge towards the Mae Nam Bang Nara basin, however, during the non-flood period the both are separately flowing to the river basins of Mae Nam Kolok.

The total amount of flood discharge of Mae Nam Yakang, Khlong Pu Yu and To Daeng, and the other tributaries are computed at 395, 159 and 327 MCM, respectively, and that of the Mae Nam Bang Nara basin is calculated at 881 MCM. This amount of Nam Baeng canal is 41 MCM. Therefore, the total amount of flood discharge into the Bang Nara water storage during this flood period is 922 MCM.

The total amount of surface runoff of 1,143 MCM and 1,658 MCM from the Mae Nam Bang Nara basin and Nam Baeng drainage canal basin are calculated by using probable 5-day consecutive rainfall with return period of 10 and 50 years, respectively as shown in Table 3-13.

d) Flood Runoff in 1985

The most heavy amount of rainfall of 196.7 mm was observed at the Narathiwat station during the period of seven days from 10th day to 16th of December 1985. According to the probable analysis of 7-day consecutive rainfall at the Narathiwat station, the probable rainfall of 346.7 mm with the return period of two years is presented by the Iwai method. Therefore, it is supposed that the amount of rainfall in December 1985 would occur in every year.

The hourly rainfall data observed at the Lingae school station during the same period is used in order to estimate the peak discharge of Mae Nam Yakang, because such daily rainfall distribution is similar to those of other stations and the hourly rainfall data is available only at this station. During this period, the total amount of rainfall of 111.5 mm is recorded at this station.

Runoff coefficient of 50 percent would be applied up to the total amount of accumulated rainfall of 80 mm and 100 percent more than 80 mm, since it is supposed that soil moisture in 1985 is smaller than that of other years because of the smaller amount of rainfall in 1985.

Table 3-13. ESTIMATED FLOOD DISCHARGE

(unit: MCM)

No.	River		Flood Discharge (1)	Flood Discharge (2)	Flood Discharge (3)
Mae Nam Bang Nara Basin					
1	Mae Nam Yakang	(A+B)	394.58	488.92	709.30
2	Khlong To Che	(C+D)	52.32	64.83	94.05
3	Chang Canal	(E)	48.51	60.10	87.19
4	Khlong Chuap	(F)	58.86	72.93	105.81
5	Khlong Ai Rong	(G)	8.72	10.80	15.68
6	Khlong Sg. Padi	(H)	89.38	110.75	160.67
7	Khlong Pu Cho Ya Mu	(L+N+R)	41.97	52.00	75.44
8	Surrounded Area	(I+P)	28.34	35.12	50.94
9	Khlong Pu Yu+To Daeng	(J+K)	158.60	196.51	285.09
	Sub-total		881.28	1,091.96	1,584.17
Nam Baeng Canal Basin					
10	(M)		23.98	29.71	43.11
11	(O)		16.90	20.93	30.37
	Sub-total		40.88	50.64	73.48
	Total		922.16	1,142.60	1,657.65

Notes: (1) Flood discharge "(1)" is calculated by using the actual 5-day consecutive rainfall from 20 to 24, December, 1984, that is equivalent to the amount of probable rainfall once in five years.

(2) Flood discharge "(2)" is calculated by using 5-day consecutive rainfall with 10-year return period.

(3) Flood discharge "(3)" is calculated by using 5-day consecutive rainfall with 50-year return period.

According to the results of the runoff analysis, the coefficients in the Nakayasu method have been obtained as follows:

Time lag (Tg) = 35.2 hr

(Refer to Figure II-2-13 of Appendix II.)

On the other hand, the necessary running time of runoff in Mae Nam Yakang from X73 to the conference of Mae Nam Bang Nara is calculated as follows:

The peak discharge of this period		100 cu.m/sec
Water depth at the station X73		4.4 m
Average river width		20 m
Mean velocity	100/(4.4 x 20) =	1.1 m/sec
Length of river course		31,500 m
Necessary running time (Tg2)		
Tg2 = 31,500/(1.1 x 3,600) =		8.0 hr

Consequently, the total time lag is calculated at 43.2 hr (35.2+8.0=43.2).

The discharge of other tributaries is also computed by the Nakayasu method with the hourly rainfall observed at the Bukit rainfall station. The estimated discharge of Mae Nam Yakang, the other tributaries of Mae Nam Bang Nara and the Nam Baeng canal are 94.2 MCM, 104 MCM and 12 MCM, respectively. The total discharge is at 210 MCM. The accumulated discharge curve is shown in Figure II-2-15 of Appendix II. (Refer to Figures II-2-12, -13 and -14 of Appendix II.)

iii) Low Flow Analysis

a) Sugawara's Tank Model and Input Data

In general, the low flow is more greatly affected by percolation, evapotranspiration and seepage. It is, however, rather difficult to grasp these amounts. There are many kinds of the method to estimate low flow, however, the Tank Model method by Dr. Sugawara is most applicable for this Study. (Refer to the Figure II-2-16 of Appendix II.)

The hydrological input data to estimate the long-term low flow discharge are long-term daily rainfall, mean daily discharge and mean daily evapotranspiration. The Mae Nam Yakang basin is the objective area to establish the Tank Model because the basin has the above observed data. The areal rainfall obtained by the Thiessen method are used as daily rainfall data. The mean daily evapotranspiration in eachmonth observed at the X45 station is employed for the representative value of each month in this basin. The related data at the Narathiwat station have not been used because of many blanks in records. The rate of 50 percent to the mean daily evapotranspiration is applied for the rainy day.

b) Determination of Tank Model Dimension

The hydrological data for two years on 1983 and 1984 have been used to determine the Tank Model dimension. Those observed runoff at X73 have been examined with a view to discussing the areal rainfall and runoff coefficient. With a careful evaluation of the Rangae rainfall which could be considered rather low in most years as compared with the nearby ones, the daily runoff during two years of 1983 and 1984, when the Rangae rainfall could be believed reliable, have been selected for the subsequent examination. The daily discharge data during the period of 1975 to 1982 are not used for this purpose, because the data in 1982 is lacking and the annual amount of rainfall is smaller than the mean annual rainfall.

The three conditions to determine each Model factor have been taken up:

1. The depletion curve of discharge should well coincide with the observed one;
2. In the low flow, the calculated flow regimes should coincide with the observed flow regimes; and,
3. The correlation coefficient between actual value and calculated one should be more than 0.8.

Year	Areal Rainfall (mm)	Observed Runoff (million cu.m)	Runoff Coefficient
1983	2,585	640.5	0.74
1984	3,007	815.2	0.82

The runoff coefficient in these two years when deemed rather wet would be exceptionally high. There would be the actual areal rainfall more than the calculated, and there would be something in the X73 basin which can not be grasped with the present observation network. The results of this analysis are shown in Figure II-2-17 of Appendix II.

c) Long-Term Low Flow Data

The Mae Nam Bang Nara basin is roughly divided into two parts, (1) the Mae Nam Yakang basin (catchment area of 724 sq.km) and (2) the Mae Nam Bang Nara basin (677 sq.km).

At Mae Nam Yakang, the daily water level observation at 5:00, 9:00, 12:00, 15:00 and 18:00 in a day is carrying out at the X73 station since 1975, and in 1985 the rating curve has been established based on the actual measurement of discharge and water level during the period of 8 July 1985 to 18 December 1985. By using the rating curve, the daily discharge data at X73 are obtained. (Refer to Figure II-2-25 of Appendix II.)

The analysis period is 31 years from 1955 to 1985. The discharge from 1975 to 1985 actually observed at the X73 station has been applied to estimate the total discharge of the Mae Nam Yakang basin because the catchment area of 336 sq.km at the point of the X73 station occupies 46 percent of the total catchment area of the Mae Nam Yakang basin.

Comparing with both rainfalls between Narathiwat and Lingae School, the rainfall patterns would be similar and the amounts of rainfall would be nearly equal. The former station is located at the downstream area of Mae Nam Yakang and the other at the upstream area. Therefore, the total amount of discharge from Mae Nam Yakang is estimated by using the catchment area rate of 2.15.

To estimate the discahrge of the Mae Nam Bang Nara basin, evapotranspiration has been specially considered from the lowest tank when the upper tank is empty, because almost all tributaries of the basin may be dried up at least during the months of March and April.

Table 3-14 shows the mean discharge of the both basins. Monthly mean discharge for 31 years is shown in Table 3-15. The probable drought discharges from February to October in terms of MCM and the probable drought discharge of the Mae Nam Yakang basin in terms of cu.m per sec are presented in Table 3-16.

Table 3-14. MEAN FLOW REGIME

(unit: cu.m/s)

River Basin	Catchment Area (sq.km)	Ordinary (185th day)	Low (275th day)	Draughty (355th day)
Mae Nam Yakang	724	20.1	12.2	7.8
Mae Nam Bang Nara	677	9.5	4.0	1.4

Table 3-15. MONTHLY MEAN DISCHARGE

(unit: MCM)

River Basin	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Mae Nam Yakang	193.5	58.4	42.5	35.2	49.4	51.8	50.1	57.5	70.3	83.0	176.5	265.5	1,133.7
Mae Nam Bang Nara	124.2	33.4	22.5	14.7	18.9	22.0	23.6	30.6	36.7	48.9	123.1	202.0	700.6
Total	317.7	91.8	65.0	49.9	68.3	73.8	73.7	88.1	107.0	131.9	299.6	467.5	1,834.3

(unit: MCM)

River Basin	Period		Annual
	Feb. to Oct.	Nov. to Jan.	
Mae Nam Yakang	498.2	635.5	1,133.7
Mae Nam Bang Nara	251.3	449.3	700.6
Total	749.5	1,084.8	1,834.3

Table 3-16 Probable Discharge during February to October

River Basin	Return Period (years)	Discharge (MCM)
Mae Nam Yakang	5	317.3
	10	275.2
Mae Nam Bang Nara	5	125.2
	10	93.9

Probable Droughty Discharge
(Mae Nam Yakang)

Return Period (years)	Discharge (cu.m/s)
2	6.9
5	5.3
10	4.8
20	4.4
50	4.2

(3) Groundwater

(a) Hydrogeology

The Study area can be divided into four groundwater provinces: granitic aquifer, colluvial aquifer, Chao Phraya aquifer and beach-sand aquifer. (Refer to Figure II-3-3 of Appendix II.) The deep groundwater of Chao Phraya and colluvial aquifers are both constituting confined groundwater which can be taken by tube well, while shallow groundwater refers to unconfined groundwater which can be taken by hand-dug well. The water level of Chao Phraya aquifer is approximately EL +0.2 to 1.0 m.

Granitic Aquifer

Granite cannot constitute an aquifer in its fresh zone, but stores primarily deep groundwater in its weathered zone, faults and the like. Granite is hardly distributed within the Study area, but since the colluvial aquifer is not a good aquifer, there are cases in which water is taken from the weathered zone of the granite layer distributed beneath colluvium.

Colluvial Aquifer

Shallow groundwater, the water level of which is between EL -1 to -8 m is distributed. This groundwater is considered to be the rain water stored in cracks, etc. Accordingly, many of the shallow wells which use this aquifer often dry up during the dry season.

Deep groundwater exhibits groundwater tables along the gradient of topographical configuration and is stored as the confined groundwater. This layer is not a good aquifer since it contains a lot of clay, but groundwater is mainly stored in sand, gravel and laterite.

Chao Phraya Aquifer

Shallow groundwater slightly varies according to the microtopographical conditions. In other words, at minor heights which are probably the old beach ridges, the quantity and quality of water are sufficient to be utilized for personal wells of the village, but in the old swamps and old lagoons, the water quality is inferior and the quantity of water available is also meager. The water level of the former is around EL +1 to 1.5 m, while that of the latter is low at around EL 0 to +1 m, which seem to be mainly attributable to the differences in soil quality and vegetation. This groundwater seems to be recharged by rain water only, as can be seen from the low EC values.

Seasonal change of the shallow groundwater level would have two distinct characteristics:

* "Swamp and Old Swamp" has the water level of less than 1 m below ground surface without seasonal change.

* "Flood Plain" maintains at 1 to 2 m below ground surface in July 1985 and then gets higher following the rainfall pattern.

The aquifer of deep groundwater is the sand and gravel layers distributed deeper than 20 - 30 m below ground surface. The distribution of both layers is totally undefinable comprising an interfingering relationship. The layers occasionally intercalate thin layers of clay in some parts, and the quantity of water stored also varies. Nevertheless, this is the best aquifer in the Study area and stores confined groundwater that indicates the water level in the range of EL +0.5 to +1.0 m. Being confined, this groundwater is considered to be almost immobile and judged as not beeing replenished either. The groundwater of this aquifer in the coastal zone is subject to intrusion of saline water.

Beach-sand Aquifer

This aquifer consists of beach-sand over the Chao Phraya aquifer in the coastal zone and is distributed approximately less than 20 m from the ground surface. The geology of this aquifer consists of fine to coarse grain sand, and because of its loose layer, it constitutes a good aquifer. The groundwater stored is unconfined, and the water level has been observed at 0.2 to 0.9 m below the ground surface during the highest period. Seasonal range at each well varies from 0.7 to 2.0 m in connection with the rainfall amount.

Although this groundwater is drawn as freshwater from the hand-dug wells of each village, salinization is recognized in wells at a depth of EL -2.5 m and deeper, thus suggesting the groundwater to be in two tiered structure.

(b) Quantity of Groundwater

(i) Colluvial Aquifer

Shallow Groundwater

As mentioned before, many of the existing wells become dry during the dry season. Shallow groundwater is, therefore, not considered as the object of groundwater development.

Deep Groundwater

By comparison to the Chao Phraya aquifer, the volume of throughflow to this aquifer is generally small. There are instances, therefore, where existing wells in this area are unable to obtain groundwater in this aquifer and have to be drilled further downward as far as the granite distributed underneath it. The potential yield of existing wells is roughly ranging between 20 and 50 litre per min per well.

(ii) Chao Phraya Aquifer

Shallow Groundwater

Since this aquifer mainly consists of clay except in the old beach ridges, it is unlikely to be the object of substantial groundwater development, as in the case of the colluvial aquifer. As a hypothetical case, the critical yield of BS-4 well was estimated to be around 1.8 cu.m per day.

Deep Groundwater

The largest groundwater storage in the Study area is anticipated to be the deep groundwater of this aquifer. Hardly and throughflow exists because it is the confined groundwater, and recharging is presumed to commence only after drawing water from wells. The potential throughflow in such an event is difficult to predict, but a rough estimate may be obtained by the following formula based on the penetration ratio of rainfall into the ground obtained from the hydrological balance in Mae Nam Sai Buri.

$$Q = P.A.Pr$$

where

Q: Groundwater throughflow

P: Precipitation (2,500 mm/yr)

Pr: Penetration ratio (5%)

A: Area of Basin (1,400 km^2)

Thus

$$Q = 1.75 \times 10^8/m^3/yr$$

The yield per one deep well differs for the sand layer and gravel layer but is considered to range between 110 and 300 litre per min or on average roughly 170 based on the conditions of existing wells.

But, this deep groundwater is used as drinking water at very few places or totally unused at many places because of its high iron contents of 10 ppm or more.

Beach-sand Aquifer

The groundwater throughflow to this aquifer is considered to be the direct replenishment of rainfall in view of the shallow groundwater, the topographical conditions of the area and the geology of the aquifer being composed of sand good permeability.

It is difficult to predict the throughflow as the hydraulic constants have not been obtained yet, but if the penetration ratio is assumed to be 10 percent, it can be approximated according to the aforementioned formula:

$$Q = P.A.Pr = 2{,}500 \text{ mm/yr} \times 110 \text{ km}^2 \times 10\% = 2.75 \times 10^7 \text{m}^3/\text{yr}$$

The potential yield per well is, according to the data on existing wells, in the range of 75.7 - 399.9 litre per min, so that 100 litre per min or so can probably be expected. However, intrusion of saline water is observed and fresh groundwater is anticipated to be found to the depth of about 4 m from the water table. Since the drawdown of well is considered to be more than 5 m, a special method would be necessary to obtain fresh water only.

(4) Water Quality

1) General

The water quality of Mae Nam Bang Nara and its tributaries in the Study area have been studied by RID, NEB and DOF as follows:

- Bang Nara River & Existing Project Area, Narathiwat Governor's Office, NEB in September 1983.
- Bang Nara & Bacho Project Area, Narathiwat Office, Chemistry Laboratory, RID since 1983.
- Muno Project Area, Land Classification Branch, RID since April 1985.
- Hydro-Biophysicochemical Survey in Bang Nara River, DOF, 1984.

Following the review of these existing data, the water quality survey was started in order to investigate (1) seawater intrusion in Mae Nam Bang Nara by tidal effect and (2) origin and distribution of acidic water, in such manner that since the water quality fluctuates widely by time owing to the climate, tidal effect and cropping activities, the water quality would be monitored regularly.

For the analysis of seawater intrusion in Mae Nam Bang Nara by tidal effect, EC and pH as well as flow rate and water temperature were measured by depth at one meter interval from the bottom at the center of river flow. These measurements were continued until the end of March 1986 at 15-day interval in order to check the fluctuation by tidal effect.

For chemical analysis, water samples were collected at about 50 cm deep from the water surface at 17 points of Mae Nam Bang Nara and its tributaries including existing drainage canals. The monthly water samplings were continued until the end of March 1986. The water samples were sent to PSU for chemical analysis. The location of water sampling is shown in Figure 3-11, and the results of water quality analysis are given in VIII-1-6 of Appendix VIII.

Meanwhile, the water quality monitoring, that is, water temperature, EC, pH and DO measurements were carried out by the staff of Narathiwat Irrigation Office using a Water Quality Checker. The location of water quality monitoring is shown in VIII-1-1 of Appendix III.

2) Water Quality of Mae Nam Bang Nara and Its Tributaries

Water quality of Mae Nam Bang Nara and other surface water has been severely deteriorated by seawater intrusion near the rivermouths and by acidic water inflow from the To Daeng and Kap Daeng swamps and their peripheries. For utilization of the river water to irrigate the farm lands, the seawater intrusion and the acidic water inflow are two main problems, therefore, both were further studied based on the results of monitoring in addition to the previous studies by RID, NEB and DOF. Table 3-17 is the outline of water quality of Mae Nam Bang Nara and its tributaries, and the summary of water quality analysis is given in Table 3-18.

Irrigation water quality standards for local and improved paddy varieties as well as for upland crops are proposed as shown below:

Item	Irrigation Water Quality Standard			Japanese Standard*/
	Paddy		Upland Crops	
	Local	Improved		
pH	5.0 - 7.5	5.5 - 7.5	variable	6.0 - 7.5
COD, ppm	<6	<6	N.A.	<6
SS, ppm	<100	<100	N.A.	<100
DO, ppm	>5	>5	N.A.	>5
T-N, ppm	<1	<1	N.A.	<1
EC, mS/cm	<1.0	<0.3	variable	<0.3
As, ppm	<0.05	<0.05	<0.05	<0.05
Zn, ppm	<0.5	<0.5	<0.5	<0.5
Cu, ppm	<0.02	<0.02	<0.02	<0.02

*/ For paddy

As shown in the above table, some local rice varieties can tolerate saline or acidic condition.

3) Seawater Intrusion

The limit of seawater intrusion by tidal effect was checked by water quality survey and is indicated as Figure 3-12. The results clearly agreed with the change in natural vegetation along Mae Nam Bang Nara. Namely, the mangroves associated vegetations (Rhizophora spp.) and Nipa palms (Nipa fruticans), which grow under brackish water environment, can be found many from the rivermouth at the Narathiwat side up to Ban Ba Ngo Pa Sae Pu Tae and found few up to Ban Bang Po. From the rivermouth at the Tak Bai side, these vegetations can be found

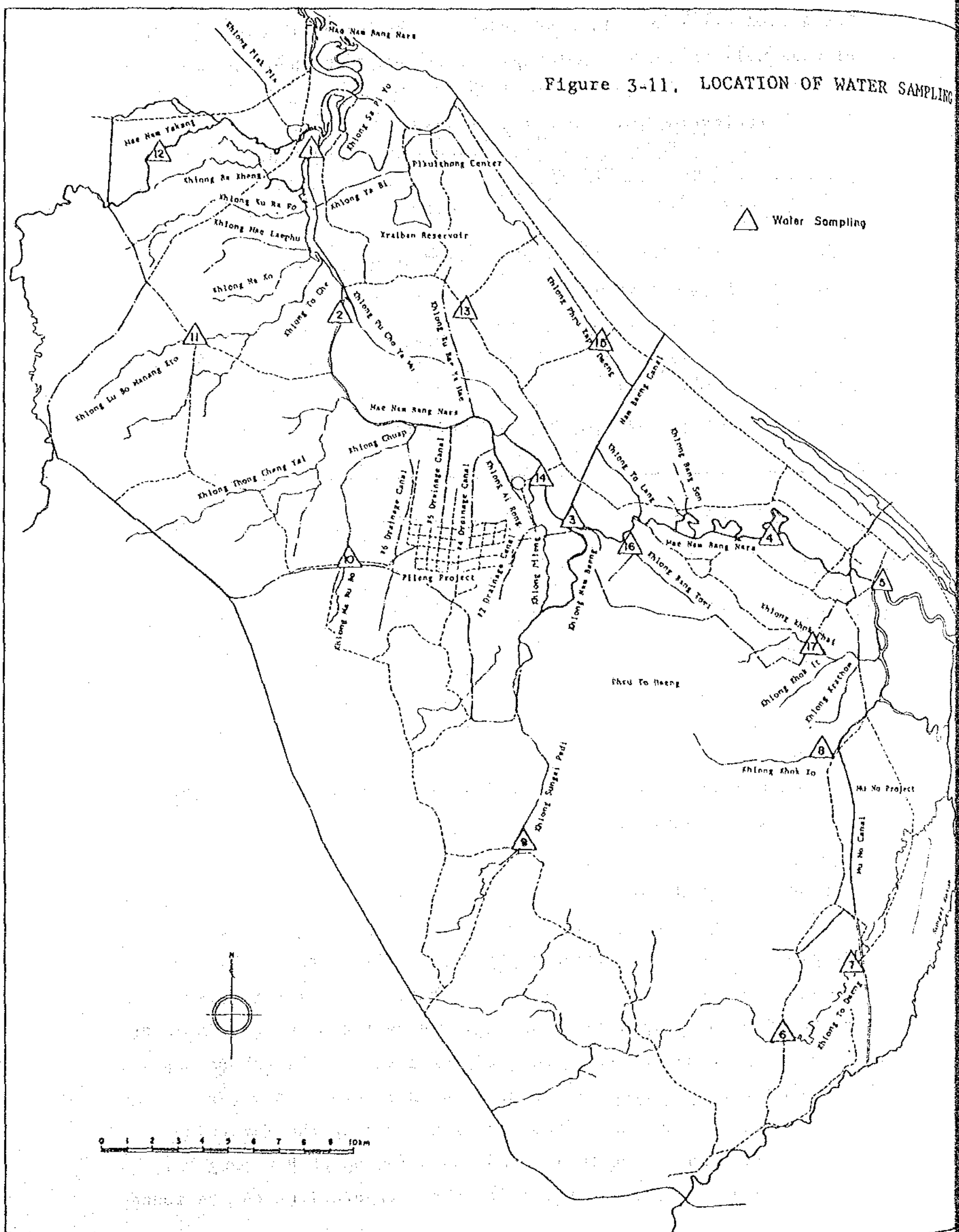


Figure 3-11. LOCATION OF WATER SAMPLING

Table 3-17. Summary of Water Quality

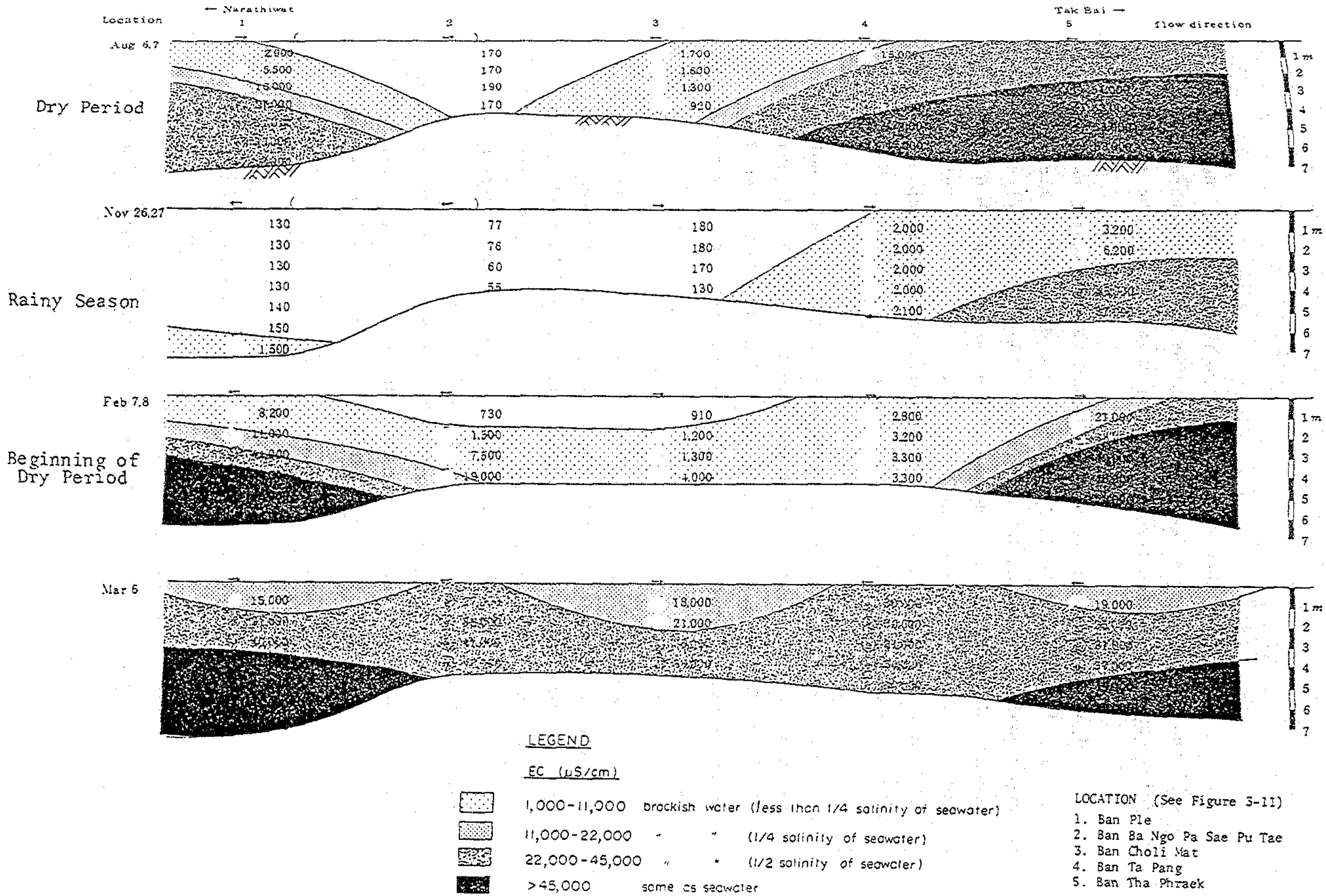
Bang Nara River	: high salinity near rivermouths, high acidity in midstream portion.
Mae Nam Yakang	: clear good quality; low salinity, low acidity.
Golok River	: high salinity near rivermouth, high acidity near conjunction with Kh. To Daeng.
Kh. Sungai Padi Group	: low salinity, high acidity in downstream near Pileng Project Area.
Kh. Phru Kap Daeng Group	: generally low salinity, high acidity with brown color.
Kh. Yabi Group	: generally low salinity except for vicinity of conjunction to the Bang Nara River, high acidity.
Kh. To Che Group	: generally low salinity, low acidity.
Kh. Chuap Group	: low salinity, generally low acidity.
Kh. Ku Bae Ya Hae Group	: low salinity, high acidity but small discharge.
Kh. To Lang Group	: low salinity, high acidity.
Kh. Bang Toei Group	: low salinity, high acidity with brown color.
Kh. Khok Phai Group	: generally low salinity, high acidity with brown color.

1/

Kh. Sungai Padi Group	: Kh. Sungai Padi/Kh. Pileng/Kh. Nam Baeng, Kh. Ali Rong and drainage canals in Pileng Project.
Kh. Phru Kap Daeng Group	: Kh. Phru Kap Daeng and Nam Baeng Canal.
Kh. Yabi Group	: Kh. Yabi and Kh. Sa Pi Yo.
Kh. To Che Group	: Kh. To Che/Kh. Lu Bo Mauang Kro, Kh. Ba Kheng, Kh. Ku Ra Po, Kh. Mae Lamphu and Kh. Na Ko.
Kh. Chuap Group	: Kh. Chuap/Kh. Ma Ru Bo and Kh. Thong Chang Yai.
Kh. Ku Bae Ya Hae Group	: Kh. Ku Bae Ya Hae and Kh. Pu Cho Ya Mu.
Kh. To Lang Group	: Kh. To Lang and Kh. Bang Son.
Kh. Bang Toei Group	: Kh. Bang Toei and Small Streams from To Daeng Swamp.
Kh. Khok Phai Group	: Kh. Khok Phai, Kh. Khok It and Kh. Krathom.

Table 3-18. Summary of Water Analysis

Location	Name of River		BOD (mg/ℓ)	S.S (mg/ℓ)	Acidity (mg/ℓ as $CaCO_3$)	Sulfate (mg/ℓ)	Total-N (mg/ℓ)	Total-P (μg/ℓ)	Total-Fe (mg/ℓ)
1	Mae Nam Bang Nara	max min	2.15 0.3	12,162 48	3420 1.71	593.9 2.0	4.76 0.14	11.43 0.16	14.51 0.09
2	"	max min	1.05 0.10	17,105 58	2960 4.61	509.2 1.9	11.76 0.84	15.12 0.35	8.48 0.09
3	"	max min	1.1 0.3	10,384 36	3180 9.94	435.5 7.2	5.60 0.44	17.41 0.02	10.20 0.20
4	"	max min	1.00 0.1	24,520 61	3090 5.54	1523.3 5.9	7.84 1.67	25.79 6.55	12.50 0.20
5	"	max min	2.00 0.2	26,847 52	3700 11.23	968.3 6.3	12.60 1.06	9.41 1.65	8.20 0.15
6	Khlong To Daeng	max min	2.15 0.1	248 44	16.40 3.92	25.2 3.0	12.88 0.82	21.95 1.00	18.01 0.16
7	"	max min	2.20 0.2	187 5	18.40 1.87	28.2 2.6	24.08 3.64	20.26 0.02	5.10 1.15
8	Khlong Khok Ko	max min	2.40 0.2	176 58	33.49 7.63	35.9 4.4	32.11 3.08	15.69 0.02	18.50 3.85
9	Khlong Sungai Padi	max min	1.85 0.1	85 10	7.83 5.47	13.3 2.0	3.92 0.84	18.55 0.03	14.80 0.95
10	Khlong Chuap	max min	1.50 0.3	95 11	2.55 0.70	11.8 1.3	5.32 1.12	10.64 1.65	2.10 1.44
11	Khlong To Che	max min	2.80 0.5	184 15	8.17 0.22	13.2 1.5	6.77 1.68	18.55 1.32	5.40 0.75
12	Mae Nam Yakang	max min	1.60 0.1	108 39	7.36 1.00	10.3 0.5	5.60 2.24	25.40 0.01	3.50 0.85
13	Khlong Ku Bae Ya Hae	max min	2.40 0.1	664 29	74.42 2.20	148.4 2.9	7.28 1.61	15.69 9.74	3.37 0.45
14	Khlong Pileng	max min	1.25 0.1	3,459 37	48.13 4.91	269.3 2.9	11.76 0.56	10.86 0.002	12.20 0.20
15	Khlong Phru Kap Daeng	max min	32.63 0.2	183 37	28.46 11.27	43.5 7.5	5.88 0.97	14.27 1.64	8.88 1.23
16	Khlong Bang Toei	max min	1.90 0.35	9,540 169	68.20 13.74	446.1 4.7	8.68 0.46	11.43 0.03	11.60 0.55
17	Khlong Khok Phai	max min	1.50 0.1	5,734 77	79.87 21.37	340.9 4.5	16.80 1.68	5.83 0.64	22.80 1.63


Location
← Narathiwat
Tak Bai →
flow direction
1
2
3
4
5
Aug 6,7
Dry Period
Nov 26,27
Rainy Season
Feb 7,8
Beginning of Dry Period
Mar 6
1 m
LEGEND
EC (μS/cm)
1,000-11,000 brackish water (less than 1/4 salinity of seawater)
11,000-22,000 " " (1/4 salinity of seawater)
22,000-45,000 " " (1/2 salinity of seawater)
>45,000 same as seawater
LOCATION (See Figure 3-11)
1. Ban Ple
2. Ban Ba Ngo Pa Sae Pu Tae
3. Ban Choli Mat
4. Ban Ta Pang
5. Ban Tha Phraek

many up to Ban Bang Khon Thong and few up to Ban Yu Yo. Between these villages in the upper stream, various kinds of trees such as Malaleuca leucadendron form dense swamp forests along the river.

Figure 3-13 shows the spatial distribution of water salinity expressed in micro S/cm in August 1985 and March 1986. According to the water quality survey as is explained in VIII-1-2 of Appendix VIII , the seawater intrusion is more severe at the Tak Bai side than Narathiwat side. This may associate with the tidal current of the Gulf of Thailand, and also, the seawater intrusion is greatly dependent upon the condition of rivermouth, that is, sand bar formation.

The vertical distributions of water salinity at five points in Mae Nam Bang Nara are schematically shown in Figure 3-12 and detailed in VIII-1-3 of Appendix VIII). The water salinity profiles show a typical wedge shape, i.e. non-mixed type because of very slow flow rate in the river.

The monthly changes in EC values of the Bang Nara water are indicated in Figure 3-15 and detailed in VIII-1-5 of Appendix VIII. The wide seasonal fluctuations of water salinity are observed, namely, the water salinity substantially increases in the dry season from March to May. Occasionally, the seawater intrudes to the upper stream, for example, the seawater came up near the Pileng project due to the storm of tropical depression on 4 March 1986. As the result, the EC values showed the maximum value at all the points and many fresh-water fishes died and floated on the water surface near the Pileng No.7 check gate.

4) Acidic Water Inflow

Two main origins of acidic water have been recognized:

- Organic acids from swamp forests.
- Inorganic acid sulfate floodwater from the leachate of acid sulfate soils.

Figure 3-13. Spatial Distribution of Water Salinity in August and March

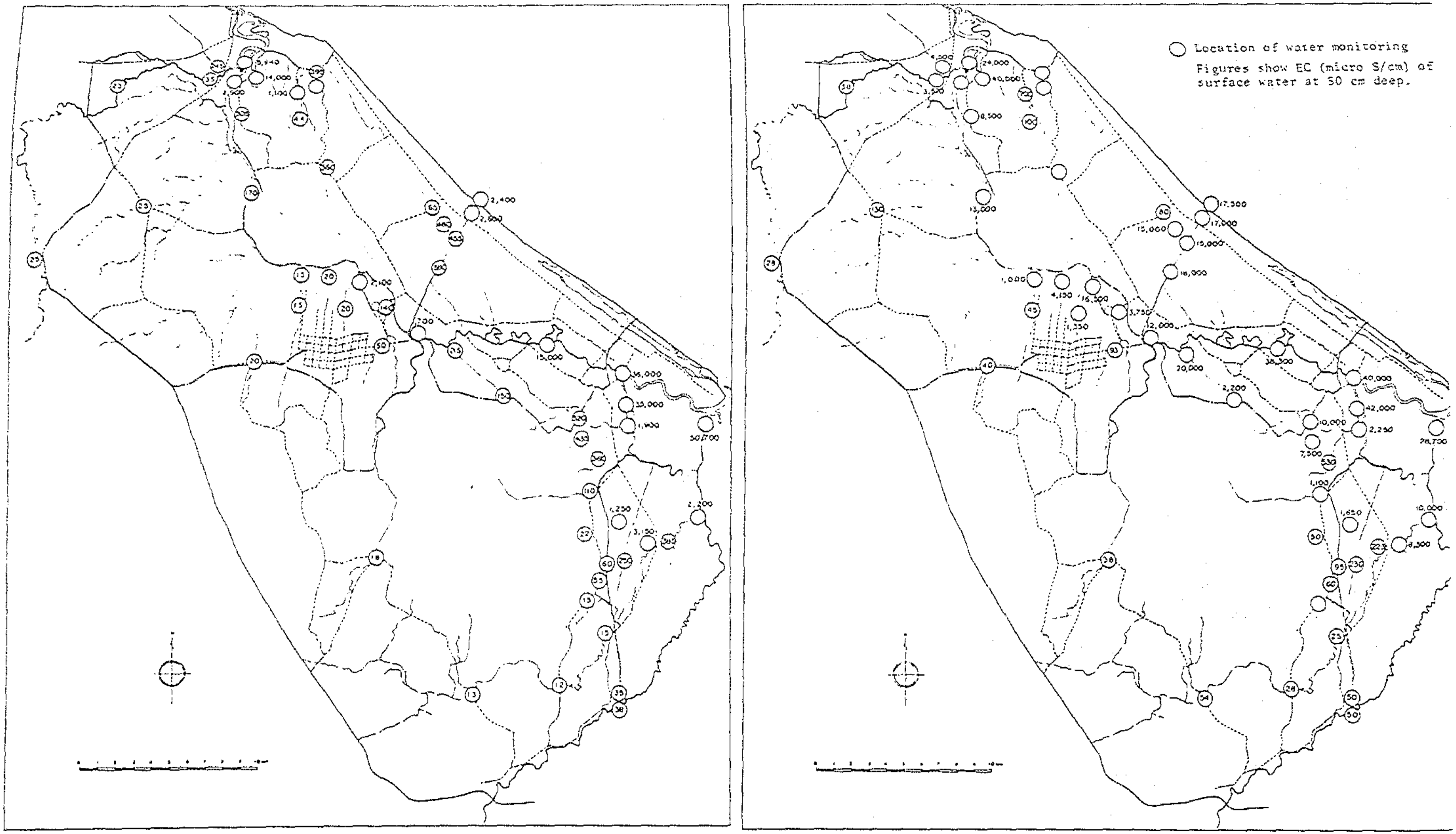


Figure 3-14. WATER SALINITY OF BANG NARA RIVER

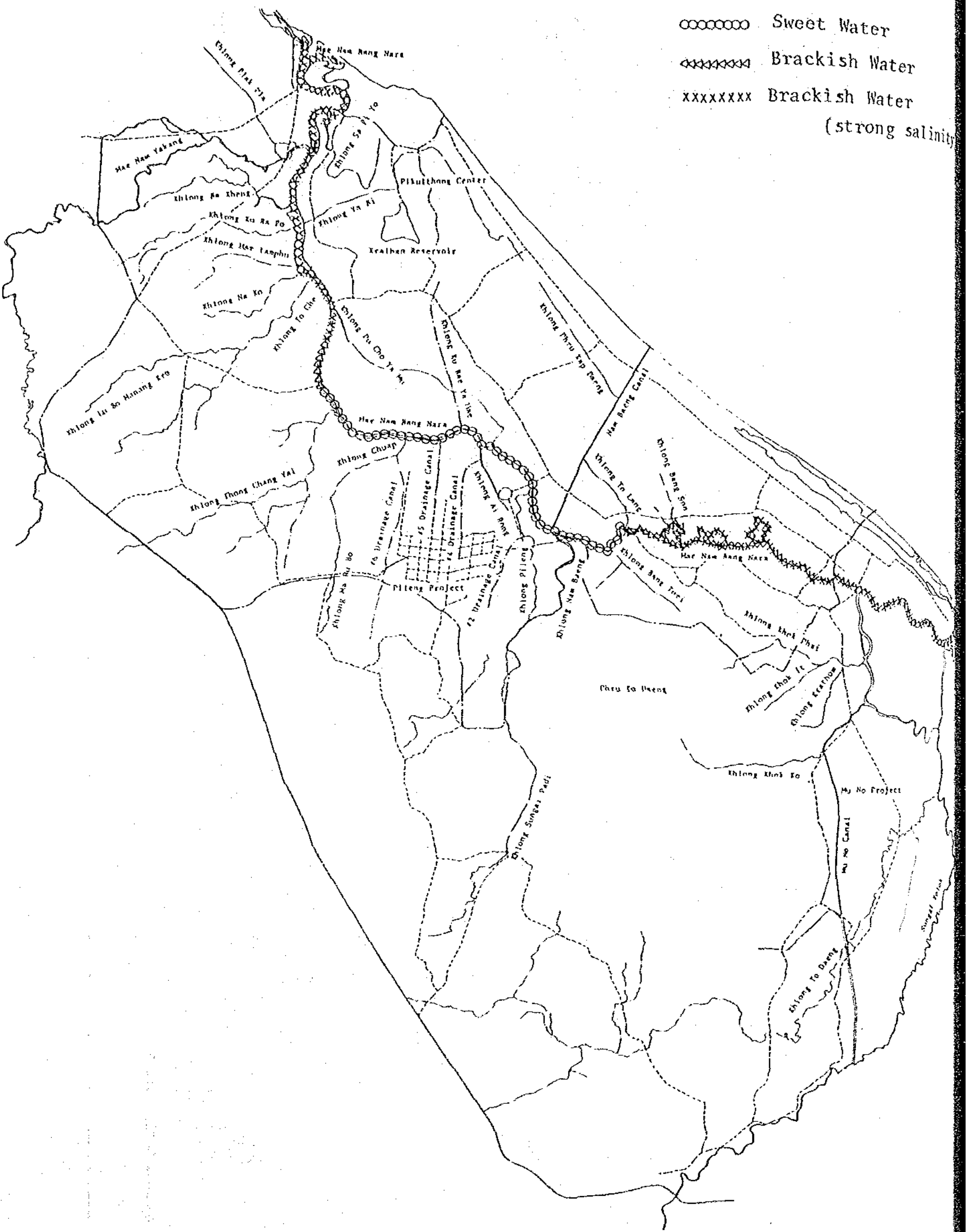


Figure 3-15. Monthly Fluctuations of EC and pH of Bang Nara River Water

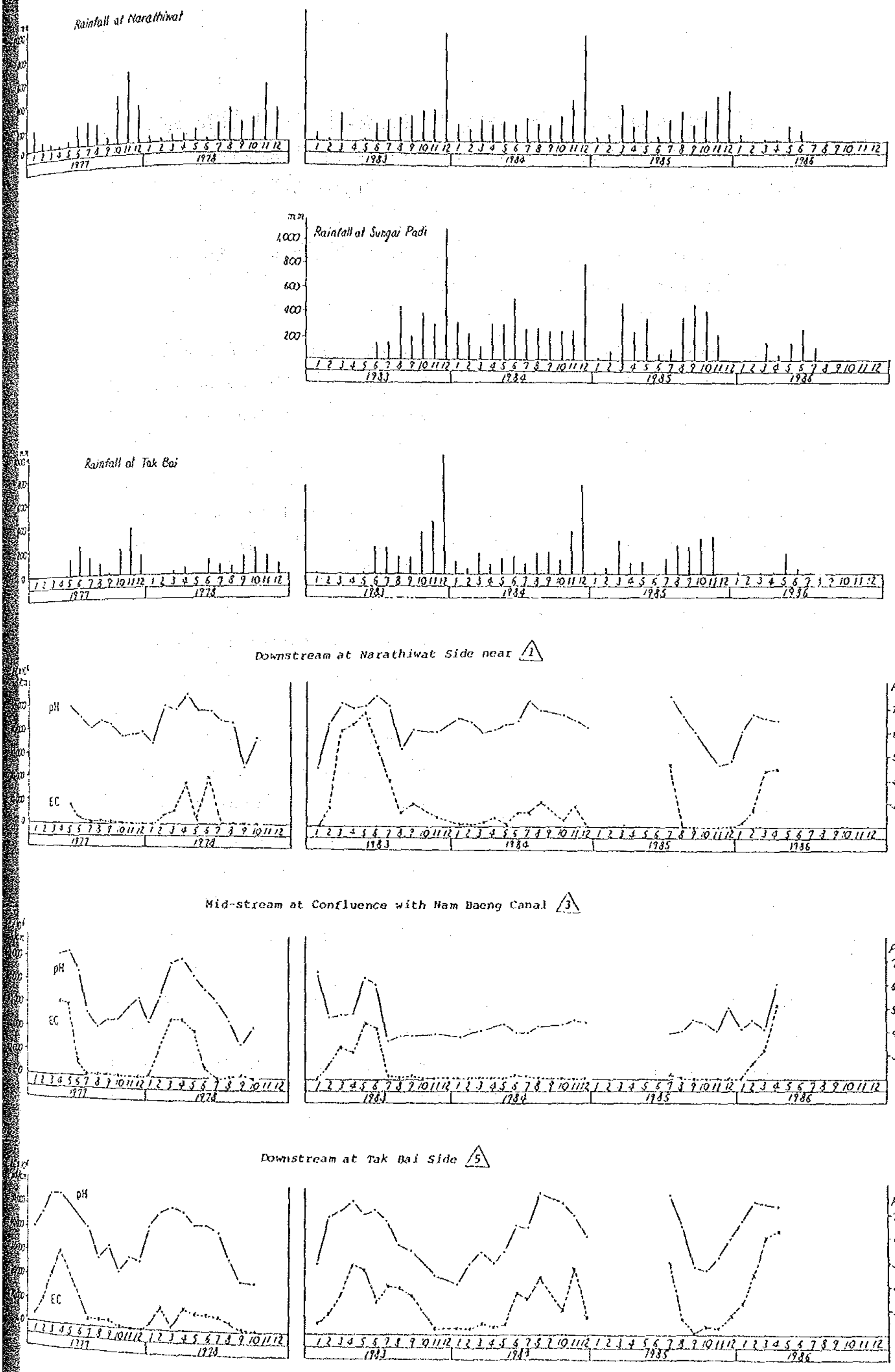


Figure 3-16 shows the spatial difference in water acidity expresses in pH values */ (for details, refer to VIII-1-4 of Appendix VIII). The monthly changes in pH values are shown in Figure 3-17.

*/ : In this Study, the acidic water is defined as the water showing pH values less than 5.0.

The major contributors of acidic water flowing into Mae Nam Bang Nara would be concluded as Figure 3-18, including Khlong Sapi Yo, Kh Yabi, Kh Pu Cho Ya Mu, Kh Ku Bae Ya Hae, Kh Ai Rong, Kh Pileng, Kh Nam Baeng, Kh Bang Toei, Kh To Lang and Kh Bang Son. In addition, Khlong Ku Ra Po, Kh Na Ko, Kh To Che, Kh Chuap as well as the drainge canals in the Pileng project should be continuously checked to examine their possibilities to be acidic water source of the Bang Nara water storage. Furthermore, Khlong Phru Kap Daeng flowing into the Nam Baeng Canal commonly shows high acidity. Meanwhile, Khlong Khok Phai which flows into the Kolok River system has severe acidity, therefore, some measures to neutralize the acidity would be required for irrigation use.

As shown in Figures 3-16 and 3-18, the acidic water is mainly coming from the fringe of swamp forests where the existing projects are undergoing. In general, the small streams from the swamp forests show dark brown color and less acidity. Passing through the fringe of the swamp forest where acid sulfate soils cover, the streams collect the drain water containing sulfate and the acidity of water increases rapidly. The acidic water from the To Daeng and Kap Daeng swamps is transparent and colored dark brown due to the natural extraction of lignin and tannin into the water from accumulated peats in swamp forest. The water shows acidic reaction because of organic acids formed by decomposition of organic materials under unaerobic condition. As shown in Figure 3-17, the pH values fluctuate within relatively narrow range from 4.5 to 5.0 throughout the year.

The floodwater from actual acid sulfate soils contains sulfate having been leached out by rain or floods. Usually, such water is transparent and colorless. The pH values fluctuate seasonally in wide range from 3.0 to 6.0. The pH values keep relatively high during the dry season and fall sharply with the start of rainy season from July in general and continue at low level. Disolution of sulfate which is formed in the soils during the dry season contributes to the drop of pH values. Comparing with the acidic water originated by organic acids, the acidity of water of acid sulfate origin is more severe. In some cases, it declines below 3.0.

To prevent the formation of sulfate from pyrite in potential acid sulfate soils, the groundwater table should be carefully controlled, namely, the water level should be maintained shallower than the pyrite-enriched horizon throughout the year.

Figure 3-16. Spatial Distribution of Water Acidity in August and March

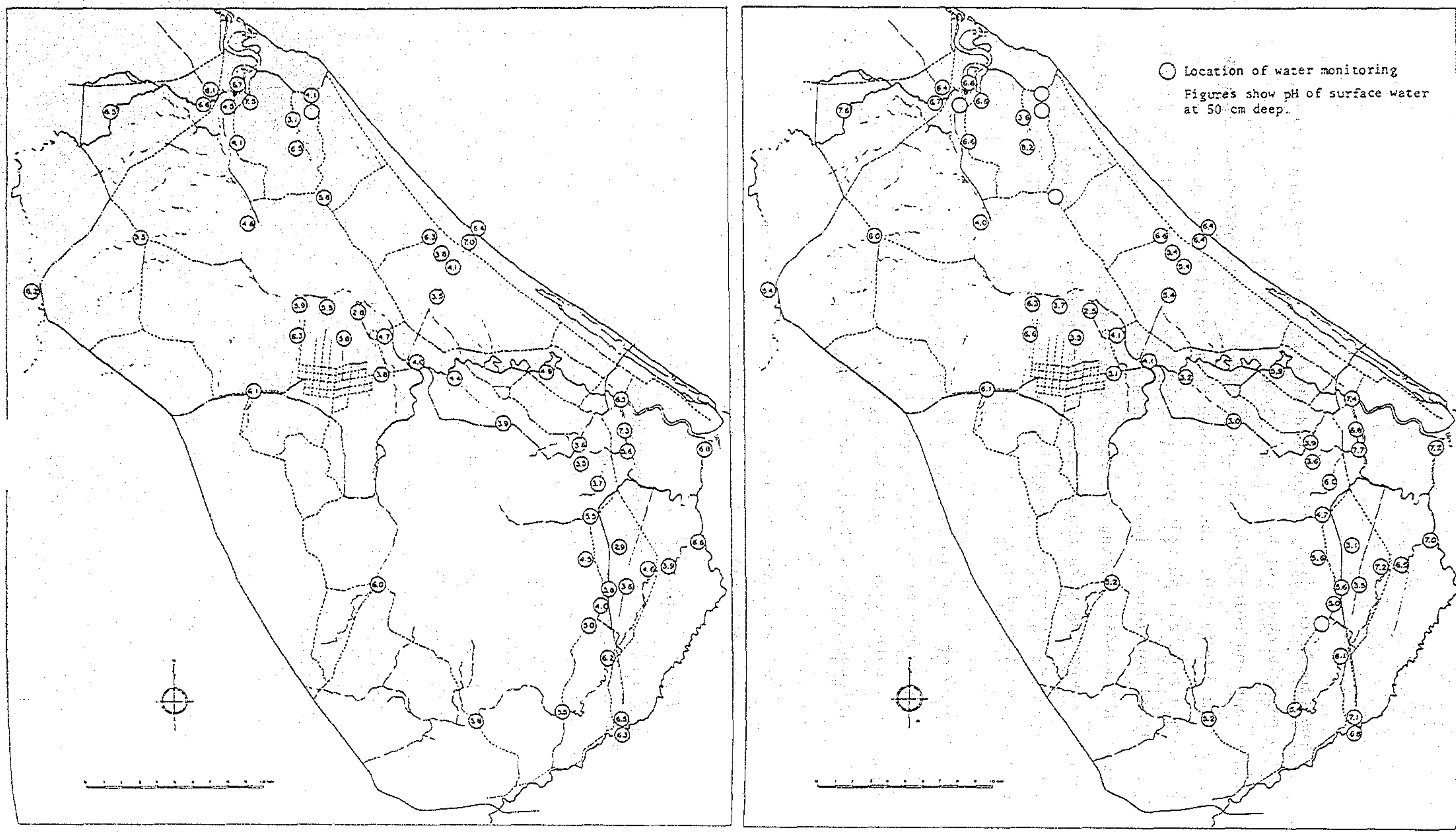


Figure 3-17. Monthly Fluctuation of pH of Acidic Water

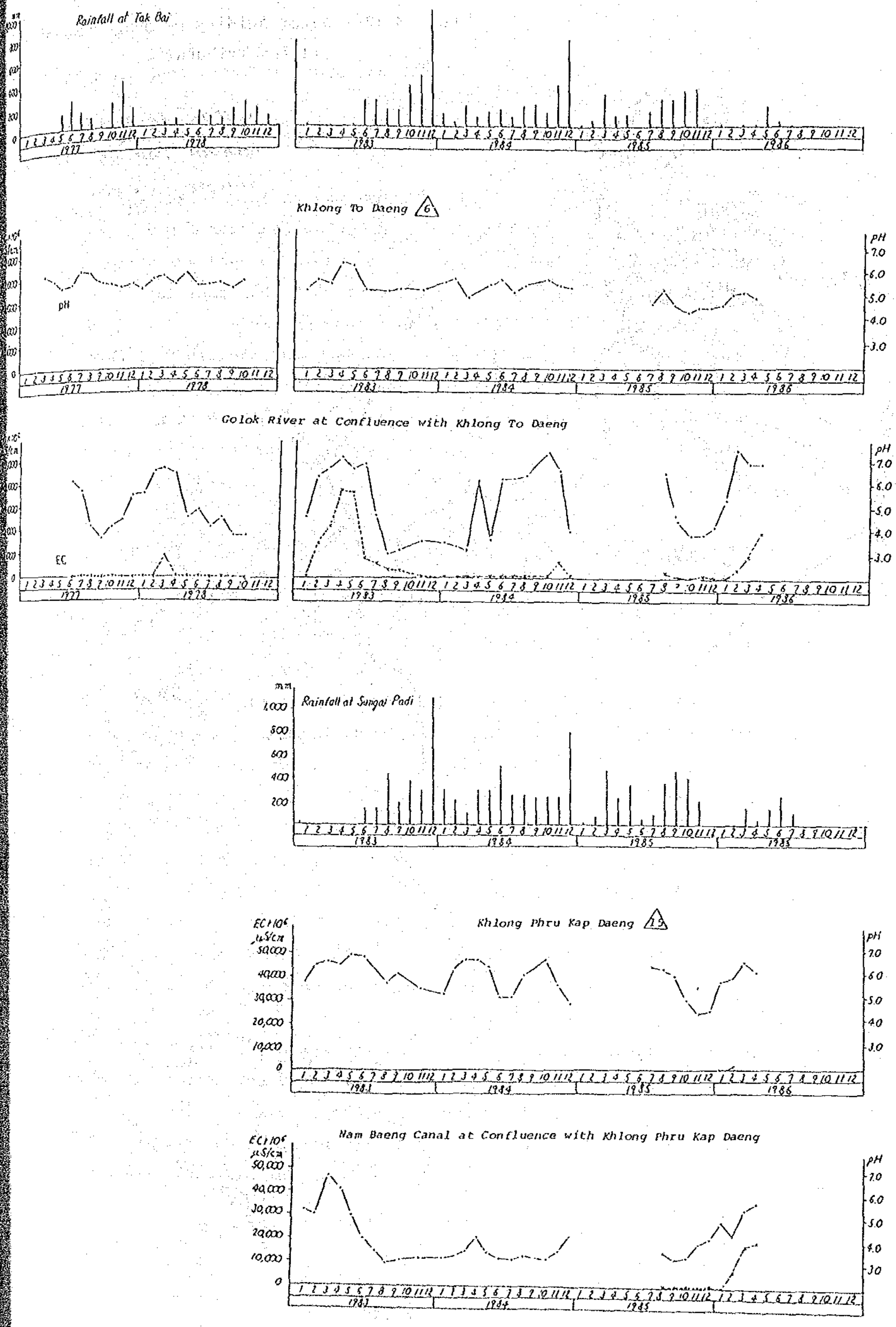
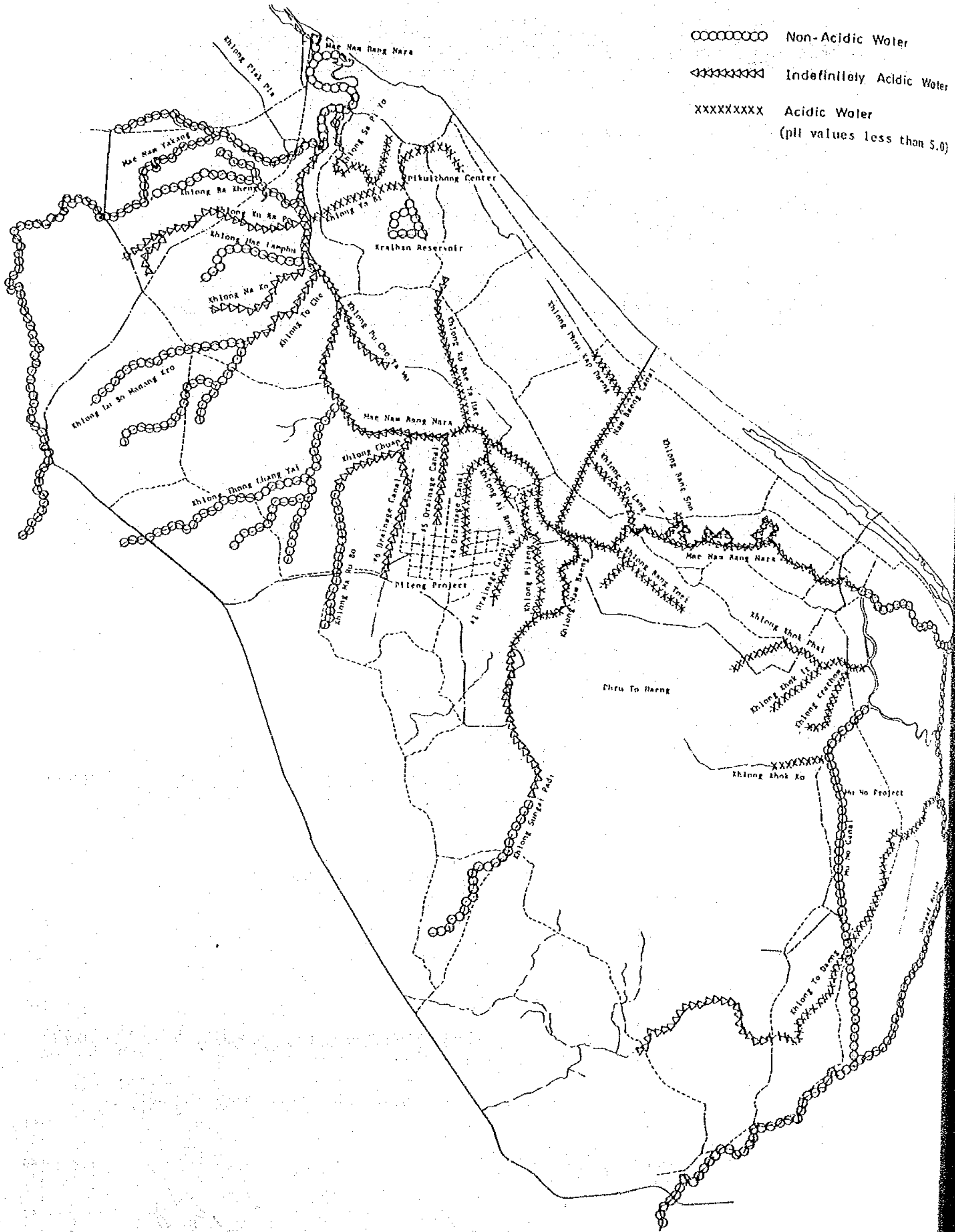


Figure 3-18. Water Acidity of Bang Nara River and Its Tributaries



3.3.5. Conditions of Coastline and Estuaries

(1) Coastline Morphology

The Thai Peninsula East Coast generally forms a beach under the aggravating conditions caused by the littoral transport due to wave action during the northeast monsoon from December to next March. The Gulf of Thailand is quite shallow with an average depth of less than 20 m 30 km from the coastline and of only 80 m in the center of the Gulf; therefore, the seashore is mostly composed of flat sandy beach with many transitional sand bars and splits near the river mouths. More particularly, the Study areas's coast from Khao Tanyong to the entrance of Mae Nam Kolok makes up a long crescent-shaped sandy beach.

The coastal alignment at the entrance of Mae Nam Bang Nara at Narathiwat is at an approximate bearing of 125°, with almost no variation of its coastline shape as is seen in two topographical maps at a scale of 1:50,000 in 1969 and ata scale of 1:25,000 in 1982 being likely in relation to the rocky coast at Khao Tanyong. While the coastal topography near the entrance of Nam Baeng canal had not changed in comparison with the above mentioned two topographical maps, the entrance of Mae Nam Kolok with the coastal alignment at a bearing of 125° is being on a receding conditions to the northwest of the Kelantan river delta in Malaysia. GRBDS reports that with a coastline recession of some 300 to 500 m over the period of 1949 to 1974, the entrance of Mae Nam Kolok which forms the border of Thailand and Malaysia has moved in a southeastern direction with current encroaching of the Kelantan river delta and extending up of the Thai coast. The northeast monsoon generates the most significant conditions to ocean waves across the South China Sea and the Gulf of Thailand providing direct wave attack upon the coastline of the Study area with considerable littoral drift of sand up the coast towards Thailand from the Kelantan river which would supply a major source of such sediment to the above mentioned morphological system.

The tidal range at the entrance of Mae Nam Bang Nara and Kolok is generally less than one meter. Under this condition, it is not expected that the tidal currents are significant in this nearshore ocean area. Although the sediment loads transported by both the rivers during major flooding in December are appreciable, much of these sediments would tend to deposit beyond the sand bar at the river entrance and to transport by wave induced currents.

The whole system as summarized above have generated the marked changes at the river mouths, and then, the deposition patterns of littoral drift sand due to shoaling and choking of the outlets to the sea in the form of a bar at the entrance have aggravated the flooding over the lower reaches of Mae Nam Bang Nara and Kolok.

(2) Wave Climate

In order to carry out the study of river mouths, it is, as the first step, required to evaluate the ocean wave conditions prevailing in the Study area which are used to determine the longshore sediment transport rates and the ocean wave heights for river mouth improvement arrangements including training/breakwater work and for navigational requirements of suction dredger.

GRBDS compiles the data of long-term ocean wave visual heights derived from 26,396 ship observations in the South China Sea through the period of 1949 to 1982. Summarized data are compiled in Table II-4-1 of Appendix II. It is observed from this table that the strong prevalence of waves during the northeast monsoon (Dec. to Mar.) from the 60° and 90° directions with approx. 12 and 9 percent respectively of all observations under those conditions, while the more widespread and moderately strong wave presence from 180° to 270° during the southwest monsoon (Jun. to Sept.) and wave generated in all directions during the transition periods with greater occurrence at 60° and 90° are seen. It is noted that the waves during the southwest monsoon are of the lower height than those generated with the northeast monsoon and have little relevance to the nearshore conditions at both river mouths.

(3) Longshore Sediment Transport

It is important for the river entrance study to estimate the quantities of sediment transported in both directions along the coast on a seasonal and annual basis. It is understood that the nearshore zone is subject to onshore-offshore and alongshore transport under the conditions of various wave-induced and tidal currents.

Computation of the longshore sediment transport at Kolok is seen in the GRBDS's report on River Mouth and Near Coastal Study (March 1985), with the following summary:

LONGSHORE SEDIMENT TRANSPORT AT KOLOK

(unit: cu.m)

Bearing of Ocean Wave (°N)	Dec. to Mar.	Jun. to Sept.	Transition
0	- 4,500	- 1,400	- 7,300
30	+ 4,610	-	+ 4,300
	- 70,240	-	- 12,850
60	+ 970,670	+ 1,860	+ 260,930
90	+ 699,630	+ 4,100	+ 241,540
330	-	- 37,490	- 14,840
Total (1)	+ 1,600,170	- 32,930	+ 471,780
Total (2)	(+ 2,187,730)		(- 148,620)

Notes: (1) + ... Northwest transport
- .... Southeast transport
(2) Dec. to Mar. ..... Northeast monsoon
Jun. to Sept. .... Southwest monsoon
Transition .... Apr. to May and Oct. to Nov.

The above table shows (1) the predominance of transport to the northwest being 15 times greater than the southeast, and (2) the significant effect of the northeast monsoon on the transport rate with 77 percent to the northwest during this period. It is also identified that the deepwater wave angles of N 60° and 90°E which are the two most predominant wave directions generating attack to the beach account for 99.6 percent of all to the northwest. It is, therefore, considered that any proposed river entrance work would be required to adequately by-pass large quantity of sand to the northwest taking into account the magnitude of the sediment transport rate as well as the highly mobile nature of the coastal zone.

(4) River Mouth Improvement

As far as the proposed Project is concerned, the improvement of river mouths at Narathiwat and Taba would have the immediate objective to achieve a stable river entrance location and opening with the minimization of head loss across the sand bar to reduce water levels upstream thus reducing flooding during the northeast monsoon season when the significant river discharges are brought for extended period. In addition, the above would introduce another benefit for the improvement of navigation so that fishing boats could cross the river bar in most weather conditions.

To achieve this objective, the following two alternatives could be conceived:

i) Maintenance Dredging

The large surf zone sediment transport rates as mentioned previously indicates the necessity of providing a channeled and protected flow passage through the near coast zone where the shoaling would be severe. The movement of large sediment, however, precludes the use of a dredged channel only, since this would fix very rapidly and need extensive and repetitive maintenance dredging.

It has been revealed by HD that a cutter suction dredger currently employed for maintenance dredging at Narathiwat channel would not be operated against the ocean waves higher than one meter, and this means that such dredger could not stand during the northeast monsoon in connection with the seasonal record of frequency of ocean waves by height as is explained previously.

ii) Construction of a Training Wall or Breakwater System

This would allow for littoral sand to by-pass the work without causing shoaling at the mouth of entrance channel and protect the entrance to provide adequate wave conditions in the entrance for navigation purpose.

(5) Entrance of Mae Nam Kolok

i) General Situations

Historical changes in the Kolok river mouth reveal the very dynamic nature of the coast, as mentioned in para (1). The present instability at the Kolok mouth affects the demarcation of the international border which is presently defined as not necessarily the center line but the deepest point for navigation. At certain times, access to the ocean for fishing boats is impeded due to the sand bar and wave conditions at the river mouth, so that a stable and navigable channel is required to provide a regular access to the fishing grounds.

Construction of a channel to the ocean to avoid the sand bar would also enable a more rapid discharge of the Kolok flood water. River mouth improvements would provide significant flood relief for the Ko Sathon (Thailand) and Simpangan (Malaysia) areas in the Kolok upstream. Because water levels in Mae Nam Bang Nara would be reduced, it helps drainage of the area south of the lower Bang Nara river basin.

ii) Effect of the Sand Bar on Water Levels

Water level recorder at Taba and Pengkalan Kubor in Malaysia side which are located inside the river estuary does not express the hydraulic head loss across the river entrance sand bar. In addition, there is no way of knowing the sea level during the periods of high outflow during the month of December. In GREDS, the physical model tests were carried out to determine the effects of existing river entrance, in particular the head loss associated with the shoals forming a bar at the entrance, on the water levels within Mae Nam Kolok. In the model, Mae Nam Kolok was set to flow at discharges of 500 to 2,000 cu.m per sec over the bar at tide levels of EL + 0.5 and + 1.0 m. Test results are summarized below:

		Water Level (EL-m)		Head Loss (m) to Ocean from	
Ocean Level (EL-m)	Discharge (cu.m per pec)	River Entrance	Pengkalan Kubor	River Entrance	Pengkalan Kubor
+ 0.50	500	+ 0.76	+ 0.87	0.26	0.37
	1,000	+ 1.10	+ 1.31	0.60	0.81
	1,500	+ 1.41	+ 1.68	0.91	1.18
	2,000	+ 1.75	+ 2.16	1.25	1.66
+ 1.00	500	-	+ 1.26	-	0.26
	1,000	+ 1.35	+ 1.44	0.35	0.44
	1,500	+ 1.55	+ 1.86	0.55	0.86
	2,000	+ 1.85	+ 2.16	0.85	1.16

The river mouth would change considerably during the course of flood; however, the above would give a good indication of the magnitude of head loss across the bar. More particularly, approximately 70 to 75 percent of the total loss at the ocean level of + 0.5 m and 65 to 80 percent at + 1.0 m are directly attributable to the entrance bar and shoals. On the other hand, only 20 to 35 percent is associated with the friction loss due to the river length back to Pengkalan Kubor. A greater scope is, therefore, available for reduction in flood water levels over the lower reaches of Mae Nam Kolok by avoiding the shoaling at the entrance. The head loss across the river mouth bar has been increasingly important if river improvement works are carried out to increase the peak discharges.

iii) GRBDS's Breakwater Arrangement

GRBDS indicates that in line with the river entrance hydraulic model study, significant improvements in the Kolok river mouth could be achieved by the construction of breakwaters on both sides of the entrance giving rise to better navigational conditions and an entrance relatively free of shoaling, and some reduction in flood levels over the lower reaches of Mae Nam Kolok. The breakwater arrangement 12 which best met the above requirements consists of a pair of breakwaters with the outer one extending to the open sea with bed contour of EL-3.5 m and taking a more sweeping curvature towards the northwest as shown in Figure II-4-1 of Appendix II. The target dimension of navigation channel is given at 200 m wide entrance and invert level of EL-3.0 m.

- The model demonstrates that the entrance could be expected to maintain shoal free during the period of medium river flows to occur annually during the monsoon season, and at other times lesser shoals would encroach a little closer to the entrance with a need of some minor dredging. This indicates that the river entrance with the proposed facilities should remain substantially clearer of shoals than the existing one.

The measurement of velocity and head losses for river flow operations at ocean level of EL+0.5 m shows the following figures:

Discharge (cu.m per sec)	Head Loss (m) from Ocean to Pengkalan Kubor		Velocity (m/s)	
	Existing	W.Breakwater	Average	Peak
500	0.37	0.00	0.90	1.12
1,000	0.81	0.50	1.61	2.12
1,500	1.18	0.90	2.17	2.57
2,000	1.66	1.54	2.40	2.57

For the purpose of preliminary layout of the breakwater and its cost estimate, two distinct design arrangements of the breakwater were considered, viz. (1) to be constructed entirely from quarry stone and riprap materials and (2) with the external layer made from concrete armour units (tribars). The cost estimates indicate that the initial cost of both types of breakwaters is similar and has an order of ฿420 million.

To this end, GRBDS explains that construction of the breakwaters at the mouth of Mae Nam Kolok is recommended for inclusion in the basin development plan with the particular concern with the border stabilization and demarcation between Thailand and Malaysia. It continues that this joint project would be implemented by RID, Thailand and DID, Malaysia with cost sharing between both countries. It can be considered, however, that there would be a number of institutional, legal and management issues to be solved before identification on the prospect of this joint project implementation.

(6) Entrance of the Nam Baeng Channel

Drainage of the flood water directly from the Bang Nara flood plains to the Gulf to Thailand via new outlet channels would be considered effective taking into account the advantage to reduce friction losses due to the shortening of the drainage passage length. However, in accordance with the experience in operation of existing Nam Baeng Regulator 1/, it would be quite difficult to maintain an entrance of the drainage channel to the ocean.

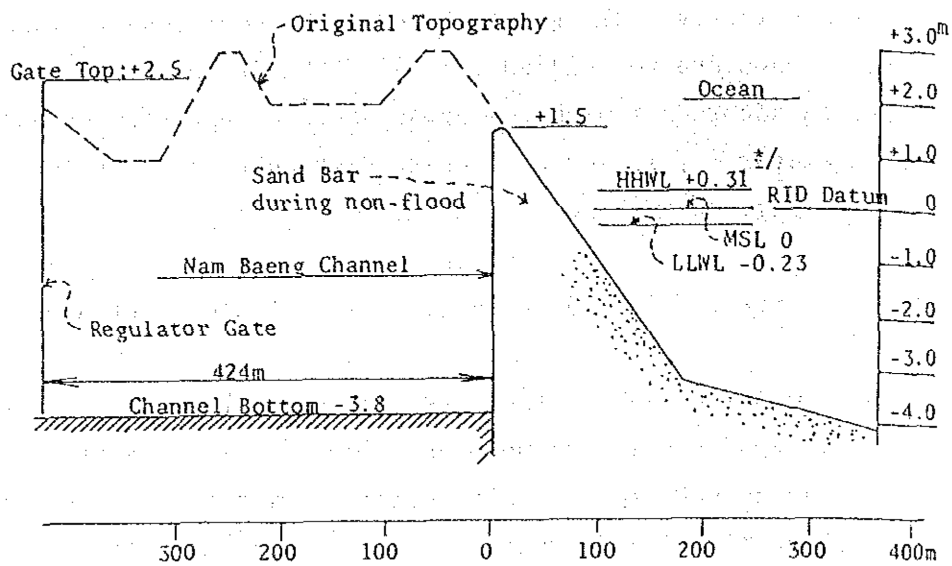
1/ ... Reference is made to Figures II-4-2 and -3 of Appendix II.

The Nam Baeng channel from Mae Nam Bang Nara to the ocean with a tail tidal regulator about 400 m upstream from its channel-end was open sometime during the high flood seasons, but was soon blocked from the ocean side by a sand bar brought cross the opening to a level of approx. EL+2.0 m 2/. During the 1984 flood, the sand bar was opened by digging a narrow ditch and then adding the flowing water for flushing sand. The water level behind the bar peaked at EL+2.1 m. As mentioned perviously, approx. 2.5 million cu.m of the longshore sediment moves along the coast and most of it are generated during the northeast monsoon period. When the tidal gate is closed, the tidal movement between the gate to ocean is too small in amount to flush the sand bar; therefore, it is considered that any outlet directly to the ocean would silt up rapidly.

2/ ... Channel bottom = EL-3.8 m
Bottom width = 45 m

Some explanatory notes on the entrance of the Nam Baeng Channel during the 1984/1985 northeast monsoon are given below:

Profile of the Nam Baeng Channel



Status of the Channel Outlet: Nov. 1984 to Jun. 1985

(Judged from the RID water level records, immediately downstream of Nam Baeng Regulator)

Status	Period	Water Level during the Period (EL-m, RID Datum)
Opened	1 Nov. to 12 Dec. 1984	- 0.54 to + 0.33
Closed	13 to 22 Dec. 1984	- 0.44 to + 0.60
Opened	23 Dec. 1984 to 17 Jan. 1985	- 0.66 to + 1.38
Closed	18 Jan. to End-Jun. 1985	- 0.76 to + 0.66

In order to make any outlet open, much of the sand would have to be artificially moved from the east side of the outlet to its west side. Following this, the Bang Nara water contribution to the ebb discharge should be needed to keep the outlet open to an extent that the volume of drift sand transported to the outlet during the flood tide is almost equilibrated with the sand flushed by the water to be released from Mae Nam Bang Nara.

(7) Entrance of Mae Nam Bang Nara at Narathiwat

i) General Situations

The Narathiwat port and channel are under the jurisdiction of the Harbour Department (HD) and serve the fishing vessels. "South Thailand Regional Planning Study (STRPS)" in 1975 explains that the quantity of cargo including rubber and domestic goods passing through Narathiwat was small due to the shallow water at the entrance bar and the exposed anchorage position used by large vessels when loading from lighters. At present, there is virtually no record of the cargo handling at Narathiwat. It has been explained that some cargo handled at Narathiwat previously has been diverted to the Pattani port, and only the private fishing activities are taking place to lesser extent.

HD carried out the capital dredging for Narathiwat channel during May to August in 1979 with a target dimension such as length of 2 km, width of 40 m and depth of 2 m below LLW to accommodate the 300 GT vessel. To date, the following maintenance dredgings were carried out by HD with no charge on port users.

Year	Dredging Period	Volume (cu.m)	Length (km)	Remark
1979	May to Aug. (93 days)	97,763	-	Capital
1980	Jun. to Aug. (93 days)	189,524	0.9	Maintenance
1981	Jul. to Oct. (74 days)	164,575	2.6	- do -
1982	-	-	-	
1983	Aug. to Sep. (56 days)	162,780	0.7	- do -
1984	N.A.	248,220	0.8	- do -
1985		210,000	2.0	HD programme

The target location of maintenance dredging at Narathiwat channel is explained in Figure II-4-4 of Appendix II. The maintenance dredging is being done by a cutter suction dredger, 1981 commissioning manufactured in Thailand with 14 inch discharge pipe and 250 cu.m per hour of average dredging capacity. Disposal site is situated offshore about 300 m northwest of the river mouth.

ii) STRPS's Recommendation (1975)

Pattani is an important export port for rubber and also has a significant domestic cargo trade. This port will be affected by any development at Songkhla, and a scheme at Narathiwat which will divert some cargo from Pattani has been proposed. There would be the possibility of improving the Narathiwat port, because there are underexploited fish resources off the coast and current fishing techniques are limited by the constraints of the port. There would be other benefits in promoting development in this region which is currently suffering from political unrest. To this end, STRPS recommends three projects at Narathiwat port including training works, fisheries and port development.

In the Pre-Feasibility Study for Port Development of Narathiwat conducted by ENEX of New Zealand, two proposals were made. The first one is that river training works should be constructed in order to maintain a depth of 3 m to allow fishing and coastal vessels and lighters to enter the port. This scheme may cost about 25 to 30 million Baht at 1974 price (about 50 million Baht at 1985 price), being subject to confirmation by a feasibility study. This scheme would not overcome the problem met in lightering cargo to the ocean-going carriers anchored offshore, since heavy swell during the northeast monsoon period currently limits the lightering operations to nine months, and even after the construction of river training work, this problem would impede the growth of foreign exports from this port. It was, therefore, suggested by ENEX that an artificial island be constructed in order to allow vessels to anchor in the sheltered water so that the lighterage could proceed throughout the year. The cost of this island was estimated to be also about 25 to 30 million Baht at 1974 price, but again this would require confirmation by a feasibility study.

It has been estimated using very simple assumptions that the rate of return on the training works alone would be eight percent, but the benefits from the development of fishing industry have not been quantified although these would be one of the main justifications for the scheme. There would also be a number of other social and economic benefits from a development scheme in this area. It is recommended that a feasibility study be initiated including that aimed at establishing a suitable site for a fishing and cargo wharf, and once traffic has built up sufficiently following the construction of training works, the construction of such a wharf should be considered. It is not recommendable that the artificial island is constructed until the long-term export prospects of the area are much clearer.

In spite of the above mentioned affirmative recommendation, nothing has been done for development of the Narathiwat port by the Thai Government to date.

iii) Recent Study by JICA

JICA has carried out the feasibility study of the Dredging Plant Development Project in Thailand covering 43 ports and channels under the jurisdiction of HD to formulate a long-term dredging plan for such channels up to the year 2000 and a development plan for the dredging fleet including maintenance and repair facilities. Narathiwat port and channel are included in the study as one of fishing ports. The study was initiated in the beginning of June 1985 and a draft Final Report was submitted in March 1986.

The study made a review of the target dimension for Narathiwat channel with the following basic data of fishing boats:

- Number of the fishing vessels by size:

Classified vessel size (GT)	1-3	3-6	6-10	10-20	Total
	100	150	40	10	300

- Number of the entry ot the fishing vessels by size per day:

Classified vessel size (GT)	1-3	3-6	6-10	10-20	Total
Nov. to Feb. (120 days)	26	19	4	1	50
Mar. to Oct. (245 days)	42	31	6	1	80

The study mentions that the target depth and width are both suitable for existing fishing boats; while large boats are sometimes forced to wait for high tides, however, the waiting times are not long. The study also estimates the annual dredging volume at 100,000 cu.m.

The report indicates that there are many channels where littoral drift prevails in the Peninsular East Coast, and the effects of littoral drift are most pronounced at the channels of Lungsnan, Tha Sala, Natab, Sakorm, Nong Jik and Narathiwat where the channel shoaling rates are so severe that it is necessary to remove a great volume by continuous maintenance dredging. In this study, the countermeasures to provide a simple solution in order to minimize the annual maintenance volume to be dredged at the channel entrance are discussed at the sites of Lungsuan and Narathiwat. The proposed countermeasures at Narathiwat which are based upon tentative ideas apart from the HD's development plan are outlined below:

° Judging from the predominant direction of littoral drift, two paranel jetties with different length are proposed. The east jetty should be longer than the west one, and the entrance of these jetties should be directed towards the lower side from the littoral drift. On the other hand, the combination of a breakwater and a groin is also suitable. In both cases, the jetties and breakwater should extend to an area which is deeper than the depth of breaking.

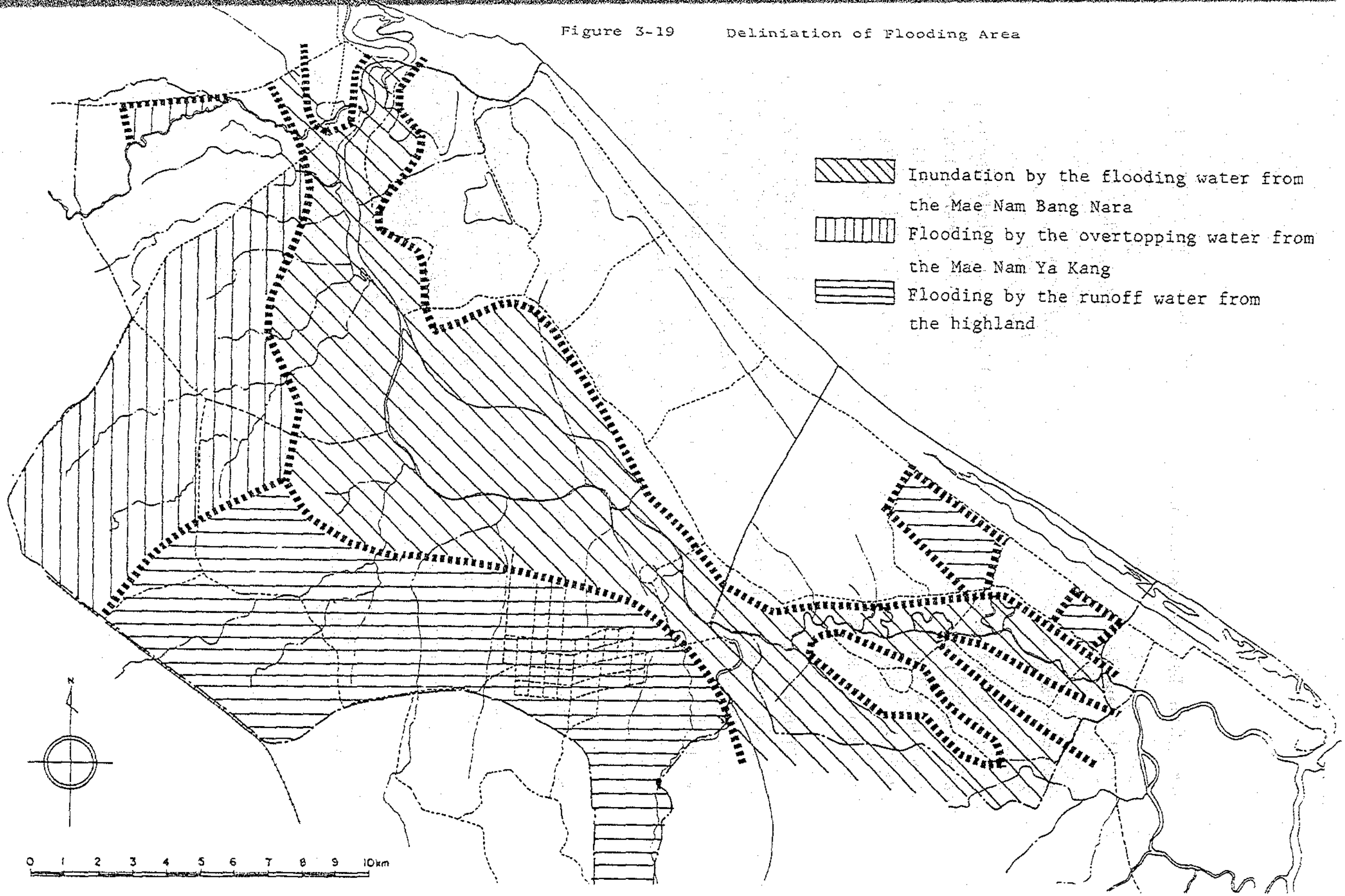
° The top elevation of jetties should be more than EL+3 m at the end and reduce to EL+2 m towards the land. The opening width should be narrow as possible in the range of 150 to 200 m, but permit the vessels to make safe entry. The type of structure would be quarry stone or riprap materials to maintain a calm area protected by the reflection of incident waves. The tentative layouts are shown in Figures II-4-5 of Appendix II.

° The initial construction costs would be ₿25 million for breakwater and groin or ₿32 million excluding dredging for training jetties. It is anticipated that occasional dredging at intervals of several years might be necessary to maintain the channels after the initial construction. To this end, the report suggests that detailed examination should be conducted in future studies.

3.3.6. Existing Flooding Condition

In the Study area, there are two kinds of inundation, i.e. one is the ponding by the rising water level of Mae Nam Bang Nara and other is the flooding water from Mae Nam Yakang and from the mountaineous area. According to the field interview survey, above mentioned inundation would be delineated in Figure 3-19 (refer to para. VII-1 of Appendix VII). For these two types of inundation, definite difference is duration of inundation and velocity of flooding water. Inundation by ponding due to the rising water level of Mae Nam Bang Nara continues more than one week. Inundation with about 1 m water depth by the latter flooding water continues for only 3 to 4 days, however, its inundation has comparatively high water velocity so that small and medium animals are sometimes damaged and owners of the livestocks shift them to the highland before the coming flood. In general,various damages to the paddy cultivation, farmers' properties, public facilities and so forth occur by the above mentioned floodings, however, the statistical data about flood damages were not yet prepared in the Study area.

Figure 3-19 Deliniation of Flooding Area



3.4. Land Use and Agriculture

3.4.1. Land Use

(1) General

The Study area has relatively long history as settlement area. A comparison of the newest aerial photographs taken in March 1984 with those in March and April 1975 shows very little changes in land use pattern. This indicates that land use has already been stabilized to a high degree in the major part of the Study area.

Paddy cultivation is practised on almost all the land of the low terraces, some of the basins, the flood plain and most of the lower and middle parts of the undulating plain of the middle terraces excluding swamp areas. One of the major perennial crops is rubber which is concentrated in undulating to moderately steep areas mainly in Amphoe Rangae followed by Amphoe Muang Narathiwat. Coconut is also a major perennial crop in the Study area, and it is concentrated mainly in Amphoe Muang Narathiwat and Tak Bai along the coast.

Some other crops such as soybeans, tobacco and sugarcane are also cultivated but only to a minor extent. Mixed orchards are generally localized within the dwelling areas. In all areas there are scattered trees. Forest areas, or what is left as forest, cover most of the wet areas, and also the swamp areas are distributed mainly in the western and southern part of the Study area.

The present land use in the Study area is outlined below:

	ha	rai	%
Total Study Area	46,700	292,000	100.0
Paddy field outside Forest Reserve	11,030	69,000	23.6
- do - inside Forest Reserve	1,400	8,800	3.0
Sub-total	12,430	77,800	26.6
Rubber	8,320	52,000	17.8
Coconut	4,380	27,400	9.4
Orchard	1,180	7,400	2.5
Forest Reserve	12,400	77,500	26.6
Others	9,400	58,800	20.1

Changwat Narathiwat Office has explained that in the Study area, (1) any wildlife propagation site and archaelogical and historical and cultural treasure have not been recognized to date, and (2) at present, there is no wildlife conservation site, but a study area(300 rai) for the wildlife inside the Forest Reserve "Kok Mai Rua", while the non-hunting area is in the Forest Reserve "Laem Nam Bang Nara I and II".

(2) Methodology

The land use survey has been done through the interpretation of black and white aerial photographs with a scale of 1:15,000 taken in March 1984 and also those in March and April 1975. The survey has been followed by a field check in close cooperation with RID counterparts.

The land use classification for the preparation of the land use map is based on the result mentioned in the GRBDS Report, in due consideration of the DLD's classification criteria.

(3) Land Use Classification

The land use pattern is largely divided into five classes, namely (a) Urban Land; b) Agricultural Land; (c) Forest Land; (d) Water Body;

and (e) Miscellaneous Land. And respective classes are re-divided as is mentioned in V-1 of Appendix V. In preparing the land use map with a scale of 1:50,000 for the Study area, the following criteria has been applied from the viewpoint of the practical use in due consideration of the above-mentioned GRBDS.

Legend Zone	Acreage (ha)	Percent
1) Urban Land (U)	480	1.0
Dwellings with home orchards and mixed horticultural crops		
2) Agricultural Land (A)	32,140	68.8
Paddy (R)	12,430	
Coconuts (Cn)	3,970	
Rubber (Ru)	6,550	
Rubber and Coconuts (Ru+Cn)	1,845	
Coconuts and Rubber (Cn+Ru)	1,190	
Rubber, Coconuts and Tree (Ru, Cn+Tr)	345	
Coconuts, Rubber and Tree (Cn, Ru+Tr)	900	
Rubber and Tree (Ru+Tr)	2,550	
Coconuts and Tree (Cn+Tr)	180	
Field Crops (Fc)	720	
Orchards (Orc)	980	
Grass (Grass)	480	
3) Forest Land (F)	12,710	27.2
Tree (Tr)		
Swamp Forest (Sf)		
4) Water Body (W)	1,030	2.2
5) Miscellaneous (M)	340	0.8
Shrub (Sh)	85	
Non-Utilizing Land (Non)	155	
Others (O)	100	
Total	46,700	100.0

Note : Actually measured utilizing the land use map.

Respective land use classes are briefly explained as below:

(a) Dwellings with home orchards and mixed horticultural crops
--Urban Land (U)--

This is an inseparable integrated unit, the typical land use pattern of the area. The unit, situated in relatively higher areas and on localized low knols which are scattered throughout the Study area, is generally densely structured. Mixed orchards comprise various kind of fruit trees, tree crops and others.

(b) Agricultural Land (A)

This is mainly rainfed paddy area which generally left bare during the dry season, and rubber and coconuts fields. Rotation of paddy with other crops, i.e. tobacco, soybeans and vegetables is practised only to a minor extent in areas near the homesteads and near available water sources.

(c) Forest Land (F)

The forest of the Study area comprises evergreen and the second succession dry diptercarp which covers the poor soils.

(d) Water body (W)

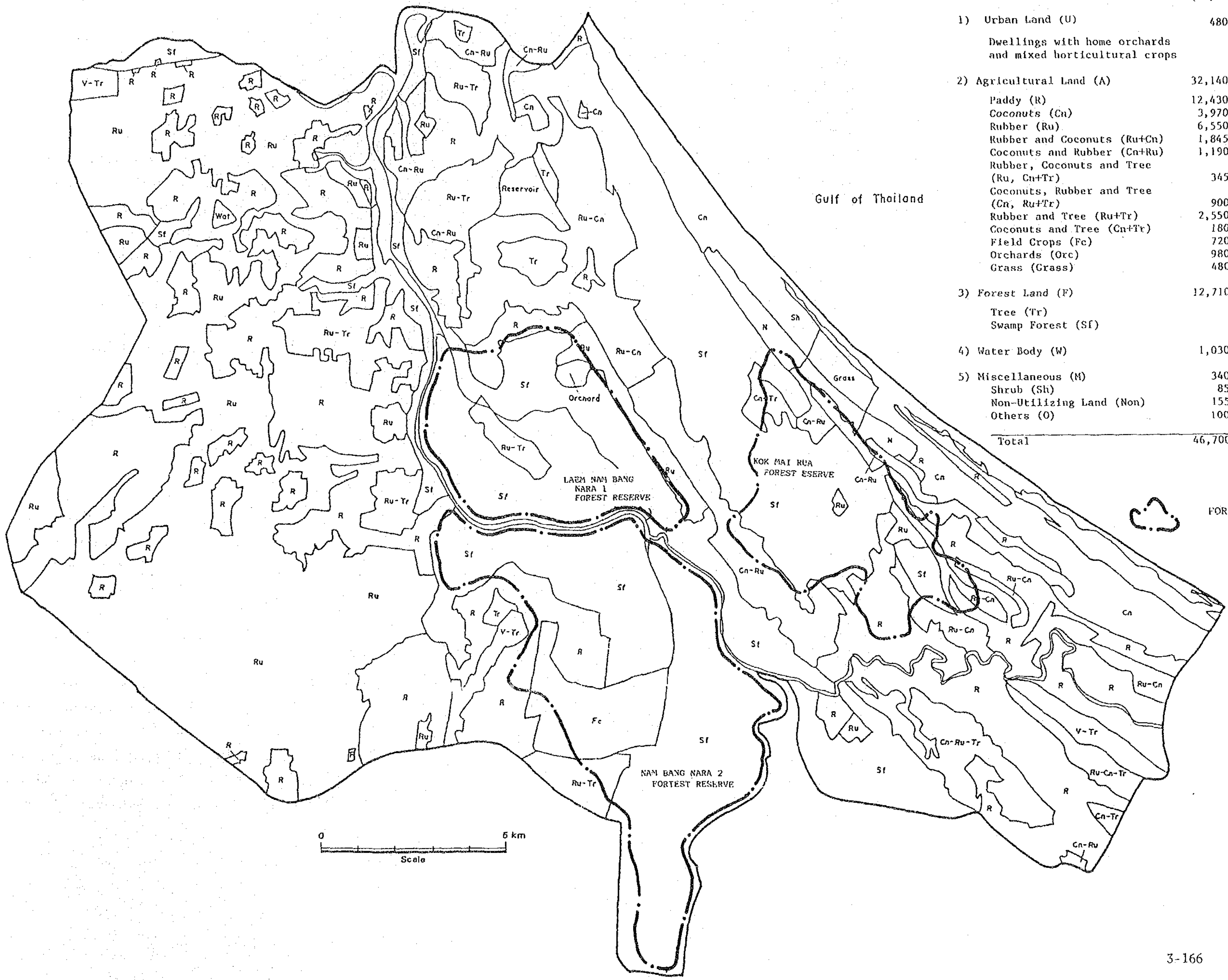
The body is mainly river, reservoir areas.

(e) Miscellaneous Land (M)

This unit comprises the areas not used for cultivation due to flash floods or prolonged deep flooding which damages the crops. The unit includes open forest, low shrub, small ponds, barelands and swamps. The main area is extended along both sides of Mae Nam Bang Nara.

After a field check as well as a photo-interpretation utilizing, preparation of the land use maps has been carried out. Figure 3-20 is the land use map.

Figure 3-20 PRESENT LAND USE MAP



Zone	Acreage (ha)	Percent
1) Urban Land (U)	480	1.0
Dwellings with home orchards and mixed horticultural crops		
2) Agricultural Land (A)	32,140	68.8
Paddy (R)	12,430	
Coconuts (Cn)	3,970	
Rubber (Ru)	6,550	
Rubber and Coconuts (Ru+Cn)	1,845	
Coconuts and Rubber (Cn+Ru)	1,190	
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Coconuts, Rubber and Tree (Cn, Ru+Tr)	900	
Rubber and Tree (Ru+Tr)	2,550	
Coconuts and Tree (Cn+Tr)	180	
Field Crops (Fc)	720	
Orchards (Orc)	980	
Grass (Grass)	480	
3) Forest Land (F)	12,710	27.2
Tree (Tr)		
Swamp Forest (Sf)		
4) Water Body (W)	1,030	2.2
5) Miscellaneous (M)	340	0.8
Shrub (Sh)	85	
Non-Utilizing Land (Non)	155	
Others (O)	100	
Total	46,700	100.0

3.4.2. Annual Crops

(1) Paddy

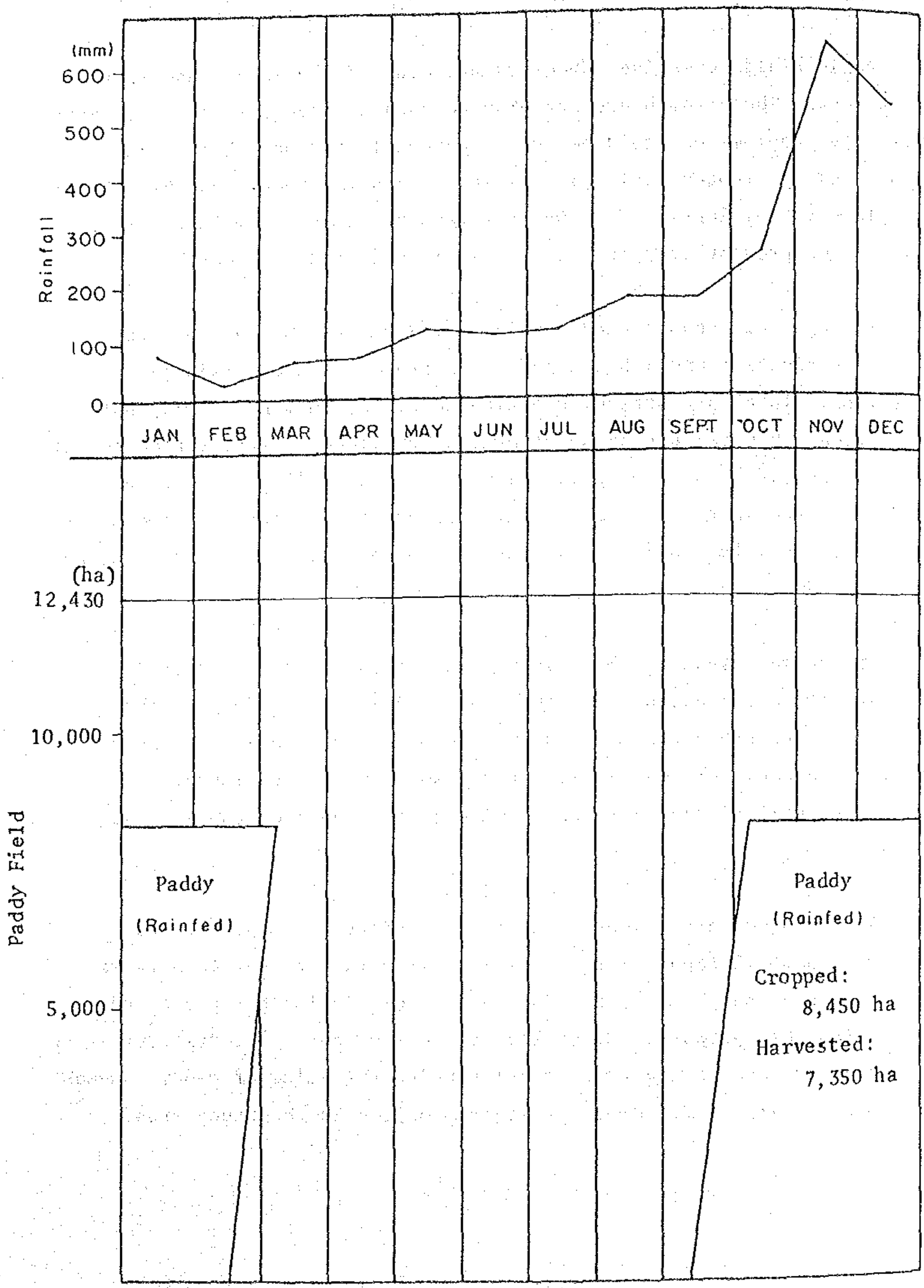
Paddy fields comprise about 27 per cent of the total land in the Study area. Those which are not planted usually have a flooding or soil fertility problem, or would be due to personal reasons. The average area of paddy cropped fields in the wet season is about 8,450 ha. Crops are planted from September to October, and harvested from February to March. The present cropping pattern is illustrated in Figure 3-21.

Average main-season paddy yields are 2 ton per ha in areas for normal cultivation and 1.5 ton per ha in areas for poor drainage situation. Total production is estimated at 12,130 ton in 1984, but production would be reduced substantially by flood in wetter than normal years. The medium size of paddy farms is 1.8 ha. Almost 90 percent of paddy farmers own the land they cultivate and 60 percent of farmers rely mainly on paddy for their income, and 40 percent grow rubber and coconut besides paddy.

In the main season, about 70 percent of the crop is native photosensitive varieties including Saali and Kaao, and 30 per cent varieties like Nahng Praya 132 which are promoted by DOA. At the end of the main season, only small areas are transplanted with improved non-photosensitive rice like RD 7, with irrigation from pumped river water.

In the Study area almost all of paddy crops are transplanted excluding part of Amphoe Yingo. Tiller-using land preparation takes place in more than half of fields, largely displacing buffaloes and cattle for this purpose. Generally, farmers do not use fertilizer at an adequate rate due to higher cost relative to the value of paddy. Weeds and rats as well as flooding are major problems in the Study area.

Figure 3-21 Present Cropping Pattern in the Study Area



Summary of the current paddy cultivation practices is mentioned as below:

Land preparation : More than half of land preparation is done with tillers, and the remaining with a simple wooden plough and a rake drawn by a buffalo or by a pair of cattle. Normally, ploughing and harrowing are necessary before the land is ready for transplanting. Between each operation there is an interval of 5 to 10 days, depending on the availability of water and on the renewed growth of grasses and weeds.

Farmers who have work animals are compelled to hire them. Land preparation is normally done during the morning hours only. In the afternoon grass has to be collected for the work animals. Many farmers complained about the difficulty of finding grass. Not only it is scare but the places where grass could be cut are often far away from their homestead, so grass collecting takes at least 2 hours everyday during the land preparation period. Although land preparation with animal drawn implements is most common, there are farmers who make use of the services offered by contractors to have their land prepared.

Varieties : The varieties of paddy which are planted by the farmers during the main season are indigeous varieties with a growing period varying 4 to 7 months including a nursery period ranging 40 to 50 days. Nahng Praya 132 and Pinkaro 56 are seen as improved ones besides indigenous varieties. According to the information obtained from the Patthalung Rice Experiment Station as well as DOA, Bankhen, flood resistant varieties Khao Puang, Leb Men Nhang III, Pin Gaw 56, Nahng Praya 132, etc. of which Nahng Praya 132 is useful for the southern Thailand.

Fertilizing ; Normally no fertilizer is applied to the nursery of the main season paddy if available organic manure is applied. For the field, DOAE, Narathiwat recommends an application of 15 kg per ha of NPK compound mixture (16:20:0) available at a price of ฿350 per bag of 50 kg.

Transplanting : Pulling, bundling and transplanting of seedlings are generally done by women if possible assisted by their children. Only when time is short, men assist in pulling the seedlings. Men normally transport the bundled seedlings from the nursery to the field.

Control of pests and diseases: Most reported are attacks by rats, red leaf disease, stem borers, etc. Pests diseases are normally reported to the Tambol extension workers. Unfortunately, DOAE is not in position to take adequate control measures due mainly to lack of funds. The farmers are quite willing to take control measures by themselves. Lack of money to buy agro-chemicals and apparatuses, however, limits the measures taken to those that are common among Muban people such as beating rats to death.

Harvesting : The main season paddy is harvested with a small cutting tool. After cutting the stalks, the bundled panicles are transported to the homestead to be stored in the house or in a storage shed. When needed the panicles are threshed by trampling with their feet by women.

(2) Field Crops

The main field crops grown in the Study area are mungbeans, groundnut, sweet corn, water melon, long beans and various types of vegetables.

The field crops are mainly sown in May to June, and harvested in July and August. Most are sown without fertilizer, and weed control is practiced in less than half of the area. The level of insect control is minimal. These are seldom irrigated. Residual moisture from the rice crop plus April and May rain is usually more than enough for the crop requirements during the first half of the growing season, but in the second half of its season moisture stress may occur.

Mungbeans are grown on a limited scale in the Study area, especially in Amphoe Tak Bai and Rangae. The Thai variety Uthong 1, selected by local cultivators, mature in 65 days. Under local conditions rather poor quality seed is available at ฿ 14 per kg. Little fertilizer is applied and pest control is poor.

Groundnut is mainly grown as an intercrop in new rubber plantings. Three varieties of groundnut are available. These are Lampang, Sukothai 36 and Tainan 9. Seed is available via local merchants, but seed quality is not good due partly to early shelling. Rust and stem rot are the major diseases in the Study area.

Sweet corn is also grown on a limited scale. The main varieties grown are Mexico hybrid, and CLIMMYT. The crop is usually sold as fresh cobs, but it is possible to produce baby corn by harvesting the corn early. Crop residues are useful for cattle feed.

(3) Vegetables

The total acreage under vegetables in the Study area fluctuates year by year and occupies only a relatively small part of the total cultivated land. Practically, some vegetables are grown in backyards and kitchen gardens, and those are too small to be included in the official statistics on acreage. On the other hand, there are fluctuations in the area under cultivation between the different years in particular Tambol, due to various reasons such as the effect of weather including flood and drought, profitability of vegetable cultivation, etc. This is very clear from the field survey.

Vegetable production in the Study area is largely divided into two, namely (a) production of vegetables for home consumption and (b) commercial vegetable production. In case of home consumption, production in excess of family use is sold in the local market.

Commercial vegetable growing is undertaken by a few farm families on a relatively small scale and the farms average 0.1 to 0.3 ha. As seen in the above, farms are small because vegetables require intensive care. Almost all of commercial vegetables in the Study area are for local market, but some is exported to Malaysia.

A number of vegetables exceeding 25 types are cultivated in the Study area. The same farms may grow several types of vegetables at any one time. It is quite common for farmers to change the types that are grown in the different months of the year, but there is no systematic rotation. Generally, vegetables that are cultivated depend on the farmer's own preference and on such factors as the expected market price, type of soil, weather conditions, availability of inputs, etc. With favourable climatic conditions, there is continuous cropping throughout the year but sudden changes in the weather sometimes result in crop losses and a shortage of fresh vegetables in the consuming areas.

Since the above-said commercial plantation farms are small, the preparation of the vegetable plots is manually carried out but some farmers hire four-wheel tractors for this purpose. The vegetable crops are grown on beds of about 1 m wide and 20 - 30 cm high. The length of the bed varies according to the slope and shape of the land but generally averages about one chain.

Most of seeds and planting materials are generally derived from the farmer's previous crop. But sometimes farmers buy imported seeds because certain hybrid seeds such as K-K hybrid seed of cabbage are not produced locally. Both organic manure and chemical fertilizers are used, especially organic manure in the Study area. The rate of application is higher when compared with those of other crops. Common organic manure in use is dust, chicken dung, animal manure, etc.

Pests and diseases are prevalent in the Study area and may sometimes result in serious crop losses. Some vegetables are more prone to such attacks. Disease problems are not so serious when compared to insect pests. Insecticides are more widely used than fungicides. Most of farmers use hand sprayers for the application of insecticides. The frequency of spraying depends on weather conditions, and no spraying takes place on rainy days as the chemicals may be washed away.

For reference, a table in V-2 of Appendix V shows vegetable planted ratio by region in Thailand, 1984. In the Study area, most of the vegetables are at present grown though the production is low.

3.4.3. Perennial Crops

(1) Rubber

The rubber planted area in the Study area is about 8,320 ha or nine per cent of the Changwat total for Narathiwat. Rubber plantations within the Study area are mainly concentrated in undulating to moderately steep area in Amphoe Rangae and Muang Narathiwat which account for above 80 per cent of the total. About 30 per cent of the rubber is necessary for replanting because of old age or low yield potential.

Data on rubber production in the Study area are very poor and largely based upon the subjective estimates:

- While some of the rubber grows in the better soils with fair drainage, the rubber planted in the flood-prone area which is estimated at about 80 percent of the total area is water-logged for part of the year with consequent reductions in yield. Rubber area is nearly unfenced and permits the stock grazing. There is no attention to maintenance or weeding, apart from the immature period.

- The rubber production practices in the Study area are featured by a low input - low output approach. Most of the current rubbers are either unselected seedling material of low yield potential or over-aged, and have not been fertilized. Even in the case of high yield potential, growers have not applied the fertilizers at all or only during the immature period when supplied by ORRAf as part of the replanting grant.

- Most of the farmers tap daily and suspend during the period of rainfall, ranging 120 to 180 days in a year. Standards of tapping are generally low, especially among hired tappers, resulting in excessive bark consumption and damaged and infected panels.

- The average yield of rubber in the Study area is considered to range from 660 to 760 kg per ha according to the discussion with ORRAF, Narathiwat. It has been, therefore, judged that the rubber yield over the flood-prone area would be at the level of 710 kg per ha.

- Many of the rubber producers are small to generate sufficient returns, resulting in the need to seek the off-farm employment with the consequent neglect of rubber trees. In addition, it appears that they are reluctant to replant for such reasons as (1) cash flow problems during the immature phase and (2) lack of knowledge of future benefits and of the Government assistance available.

Most rubber is processed only to unsmoked sheets (USS) on-farm and sold through middlemen for further processing to ribbed smoked sheets (RSS). Rubber prices within the Study area are set by dealers on a daily basis. Most smallholders sell their sheets to Muban dealers and receive about 85 to 90 per cent of the Narathiwat buying price for RSS. Recently, these producers were receiving about ฿ 16.5 for USS.

From the viewpoint of the present knowledge of soils, climate, land capability, and returns, rubber growing is expected to remain as the most important rural occupation in the Study area. The main development potential of the rubber sector is intensification of production on the existing rubber area. According to the land use survey, it appears that about eight per cent of the rubber are grown in areas which are unsuitable or only marginally suitable. For example, some rubber areas are located in low lands which are usually inundated in the wet season. It was pointed out by ORRAF, Narathiwat, that there may be some opportunities to plant rubber in some inaccessible areas with high suitability ratings, and to remove some of the rubber currently grown on unsuitable soils.

As pointed out in GRBDS, the major development potential for rubber in the Study area is principally to intensify the production on the existing areas. Potential for the intensification of rubber production lies in three main activities, namely i) to increase the production through a replanting program; ii) to increase the production by improving management standards and crop husbandry practices; and iii) to improve the quality of rubber for securing further grower's return.

Meantime,rubber tapping labor is one of the most important problems for rubber development. The problem is discussed as below:

- Tapping is done by both male and female laborers. Generally, three-fourth tapping labor force is males. On most small holdings tapping is started between 5:30 and 6:30 a.m. A few small holders said that they started around 7:30, but never later than 8:00 a.m., while those starting earlier mentioned 5:00 and even 4:00 a.m. Whenever possible a bicycle is used to go to the farms, but generally the tappers have to walk to the rubber farms. Depending on the distance to be covered and the topography of the high-laying areas this take 15 to 45 minutes.

- Tapping of rubber trees requires 2 to 3 hours, or 2.5 hours on average. Collecting of latex starts between 8:30 to 9:30 a.m. The time required to latex collecting varies from 45 to 75 minutes, or 1 hour on an average. Processing is usually started between 11:00 a.m. and noon, and is finished 30 to 90 minutes later.

- The above time specification indicates that when leaving the homestead at 5:30 a.m., the tapping and processing activities can be completed at 10:00 a.m. at the earliest and at 2:30 p.m. at the latest.

- Tapping is generally conducted in March to October, especially in April to August.

(2) Fruit Trees

According to the statistics obtained from DOAE, Narathiwat, the area of fruit trees in the Study area amounts to 1,180 ha, viz. 800 ha in Amphoe Rangae, 280 ha in Amphoe Muang Narathiwat, 50 ha each in Amphoe Tak Bai and Yingo. Fruit growing is relatively important in the Study area, especially in Amphoe Rangae from the viewpoint of the productivity and marketability. Long Kong is one of the most important fruits in the Study area followed by rambutan, durian and banana.

Most rubber smallholders grow fruit trees as secondary crop, whereas paddy farmers grow vegetables as secondary crop. Yields of the major fruit trees are roughly estimated based on data and information obtained from DOAE, Narathiwat.

(kg/tree/year)

Item	Long Kong	Rambutan	Durian
Age of first yield (years)	7-8	5-7	4-
Life (years)	40-50	25 and above	20
Average for years 8-15	50	50	90
Average for years 16-25	75	65-155	
Average for years 25 and above	110-160	65	

The Study area is characterized by producing various kinds of fruit tree crops, and has already established a reputation as a supplier of good quality fruits such as Long Kong, rambutan and durian.

(3) Others

(a) Coconut

Coconut field in the Study area is 4,380 ha and 32 percent of the farm land in Changwat Narathiwat. 46 per cent of coconut field is located in Amphoe Tak Bai and 49 per cent in Amphoe Muang Narathiwat. Most of the coconut fields in Amphoe Tak Bai and Muang Narathiwat are mainly located within the beach ridges and intervening swales(Bris) area. According to the land use survey, 55 percent of the coconut fields is largely sole coconut, 30 percent mixed coconut and settlements, and 15 percent mixed coconut and scrub forest.

Information on coconut field is not so available and considered quite unreliable. Potential yields depend to a great extent on type of the planting material selected. The varieties currently planted in the Study area are classified as tall and dwarf. The tall varieties are more tolerant of varying soil conditions than the dwarf coconut, but the latter is the higher yielding group. Dwarf coconut is not so suitable if intercropping or grazing is contemplated in the early years and it is considered that the type may be better suited to conditions in the Study area.

In regards to coconut yields, a coconut farmer pointed out the yield is only about 1,600 nuts per ha. This is equivalent to 19 nuts per palm per year assuming the yield of 85 palms per ha on an average. Furthermore. it has been pointed out that the highest yielding coconut is estimated to yield 100 nuts per palm or 11,250 nuts per ha per year, hence, it is worked out that the coconut yields might be 10,000 nuts per ha per year on Bris soils along the coast, and 9,400 nuts per ha per year on inland soils on an average.

It is said that the development potential for coconut in the Study area is limited. The above limitations would arise mainly from the socio-economic factors. The major constraint is the very small size of holding which means that there are many coconut growers who regard coconut as anything more than a minor sideline, and the use of low yield variety. Unless an attempt is made to amalgamate coconut holdings into viable size areas and the management is improved based on the advanced farming techniques, there would be unlikely to be much response from smallholders to any Government-promoted rehabilitation scheme. It would be sure that the socio-economic feasibility of rehabilitating the coconut smallholders seems limited. But it would be technically possible to improve the productivity of coconut to some extent. In the rehabilitation, attention must be also paid to the use of fertilizer and improved planting materials including highyielding varieties.

(b) Forage crops

Perennial forage crops require less management than most of the field crops which are usually annual, therefore, require more management. In cultivating annual forage crops, management techniques such as minimum tillage farming would reduce the labor involved and also reduce the potential for soil erosion.

Weed control before seeding is a major consideration. Land grading would reduce low spots where weeds tend to become established. Once the land preparation for irrigation is completed and weeds are reduced, a seedbed are prepared. Seed is planted with a seed drill or by broadcasting taking care not to place the seed more than 0.6 cm deep.

Irrigated pasture management requires coordination of the irrigation and harvesting system. Whether pastures are grazed or harvested mechanically, they should not be muddy during the harvest. Therefore, part of the pasture is not irrigated for several days prior to grazing or harvesting. If the pastures are to be grazed, this requires a pasture rotation system that coordinates the irrigation with the rotation of the livestock. A pasture is subdivided into as many segments as necessary to facilitate animal and irrigation rotation.

It is desirable that the grasses would be used for pasture, hay and soiling crops. Some of tentative suggestion of grasses prepared by DLD are as follows:

- It is assumed that paddy soils which are flooded easily would remain in use for paddy. If, however, areas of these soils are drained and used for improved pasture the following plants would be well adapted, among others:

  Torpedo, Para grass, Dallis grass and Greenleaf desmondium

- On deep, moderately well to poorly drained soils being subject to flooding:

  Torpedo and Para grass

- On deep, well drained loamy to sandy soils of low to medium fertility:

  Torepedo, Para grass, Buffel grass coastal bermuda grass and Guinea grass

3.4.4. Crop Production

Practically, all of the paddy field in the Study area is single cropped in the main season, and only small areas are cropped with improved paddy at the end of the main season applying irrigation from pumped river water. Local varieties of paddy cropped on some 8,450 ha (about 70 per cent of paddy field) are the dominant main season crop, and its production would be estimated at 12,130 ton. Apart from rubber and coconut, the upland crops grown in the Study area are mainly tobacco, sugarcane, soybeans and mungbeans. The conventional cropping pattern prevailing in the Study area is generally fed by natural rainfall.

Main season paddy is grown from October to February. About 90 percent of the main season paddy area is transplanted. Transplanting is generally spread over a few weeks to make use of the available family labor. Broadcasting is done after the first shower in September. The low crop yield is the result of unreliable rainfall, lack of drainage, poor cultivation methods, the use of low quality seeds and the minimal usage of fertilizers and pesticides. All crops depend upon the spread of rainfall through the main season. Drought periods of 15-20 days duration, which commonly occur in the Study area, often seriously reduce paddy yield.

The official data of crop land in 1984 covering four Amphoe of Muang Narathiwat, Rangae, Tak Bai and Yingo concerned with the Study area which were obtained from DOAE, Narathiwat are compiled in Table 3-19. And the total paddy area, total planted area, total harvested area, and average yield and production by Amphoe in 1984 are shown in Table 3-20. To date, sufficient data to estimate the paddy production within the Study area have not been available, hence the following subjective estimate on the basis of local interviews has been employed for this purpose:

- Total paddy field = 12,430 ha
- Planted/Total = 0.68 and Harvested/Planted = 0.87
- Yield = (1) 1.5 ton per ha for poor drainage situation
  (2) 2.0 ton per ha for normal cultivation
- Paddy production =
  (1) 12,430 ha x 0.7 x 0.68 x 0.87 x 1.5 = 7,721 ton
  (2) 12,430 ha x 0.3 x 0.68 x 0.87 x 2.0 = 4,412 ton

  Total = 12,133 ton (paddy)
  or 8,008 ton (rice)
- Rice consumption in the Study area
  Total population = 63,810
  Consumption per head = 160 kg per year (rice)
  Rice consumption = 10,210 ton (rice)

It is considered that the paddy production in the Study area would be insufficient to meet the local demand.

3.4.5 Livestock

In the Study area, it has been explained that the grazing cattle has rapidly expanded during the recent 10 years being the secondary sources of income for smallholders. The livestock is largely dominated by cattle with minor population of buffalo, sheep, goats and pigs. Poultry is much popular in meeting home consumption needs. It appears that the Study area is well placed to develop a secure export market in beef or live cattle taking advantage of the import demand from Malaysia where Sg. Kolok is a major entry point with adequate quarantine facilities.

Table 3-19. Crop Land in the Study Area by Amphoe, 1984 *1

(Unit: ha)

Crop/ Amphoe	A.M. Narathiwat		A. Rangae		A. Tak Bai		A. Yi Ngo		Total	
	Actual	Ratio	Actual	Ratio	Actual	Ratio	Actual	Ratio	Actual	Ratio
		(%)		(%)		(%)		(%)		
- Rubber	3,010	35.3	4,590	44.9	320	4.6	400	52.6	8,320	-
- Rice *2	3,020	35.4	4,600	45.0	4,530	64.8	280	36.8	12,430	-
- Upland rice	60	-	30	-	-	-	-	-	90	-
- Coconuts	2,130	25.0	190	1.9	2,030	29.0	30	3.9	4.380	-
- Tobacco	-	-	-	-	30	-	-	-	30	-
- Sugarcane	-	-	-	-	30	-	-	-	30	-
- Soybeans	10	-	20	-	-	-	-	-	30	-
- Mungbeans	10	-	-	-	-	-	-	-	10	-
- Fruits *3	280	3.3	800	7.8	50	-	50	6.6	1,180	-
TOTAL	8,520	100	10,230	100	6,990	100	760	100	26,500	-

Note : *1 ..... Estimated based on Changwat Data by Amphoe prepared by DOAE, Narathiwat.
*2 ..... Planted area in 1984 is estimated at 8,450 ha.
*3 ..... Including Long Kong, rambutan, durian, cashew, mangostin, banana, pineapple and others.

Table 3-20. Total Paddy Area, Total Planted Area, Total Harvested Area, Average Yield and Production by Amphoe, 1984

Item/Amphoe	Muang Narathiwat	Rangae	Tak Bai	Yi Ngo	Total
- Total Paddy Area (A), (ha)	5,385	14,619	8,589	3,542	32,135
- Total Planted Area (B), (ha)	4,316	8,764	5,447	3,317	21,844
- B/A x 100 (%)	80.1	59.9	63.4	93.6	68.0
- Total Harvested Area *1/ (C), (ha)	4,156	7,371	4,586	2,879	18,992
- C/B x 100 (%)	96.3	84.1	84.2	86.8	86.9
- Average yield *2/ (ton/ha)	2	2	2.31	1.88	2.06
- Production (ton)	8,312	14,742	10,594	5,413	39,061

Note: *1/ ... Estimated based on the figures obtained from DOAE, Narathiwat.

*2/ ... Obtained from DOAE, Narathiwat.

Virtually, all the grazing animals in the Study area rely on the limited quantities of natural unimproved pastures growing on waste or idle land which are low in protein and digestibility and generally over-grazed. There are basically two management systems adopted in the Study area. The first system is the traditional smallholder with herds of 1 to 5 animals allowed to graze during the day under rubber or some open areas, roadsides and so on, under minimal supervision and then penned at night and given some supplementary cut feed. The basis of their nutrition is natural pasture. This probably accounts for 60 to 70 percent of numbers. The other system, mainly located in Amphoe Tak Bai, is the one where cattle are grazed in herds of up to 60-70 animals owned by a number of villagers. These are group grazing schemes mainly promoted in the Muno project area. During the flood, animals are kept on higher ground commonly the roadside, and grass is cut and carried to them. Natural pasture is still the basis of these schemes, the cattle are under the supervision of 1 or 2 herdsmen and they are penned at night and fed rice straw or cut natural pasture.

3.4.6. Fisheries

(1) General Situations

The highway from Narathiwat to Taba carries a considerable traffic of trucks exporting the boxed, iced fish to Malaysia and Singapore through the Taba-Pengkalan Kubor crossing Mae Nam Kolok. The marine capture fisheries of the east coast of Southern Thailand are dominated by the activities of the fishing ports at Songkhla and Pattani with the minor contribution at Narathiwat port. It has been explained that the fish at the daily markets of Amphoe Yingo, Rangae and Sg. Padi come from Pattani.

Although the fisheries sector is of relatively minor importance to the overall economy of the Study area, the inshore marine fisheries situated immediately adjacent to the Tak Bai lagoon are by far the most important. Marine and brackishwater aquaculture are practised only on a limited scale in the Tak Bai lagoon, while some of cage cultures are seen at recently settled at Ban Ao Manao located at the estuary of Mae Nam Bang Nara under the assistance of community development worker.

Freshwater captu~e fisheries are of minor contribution to the Study area's economy although these provide many rural households with valuable protein supplies during the floodings. Freshwater aquaculture is limited to a very few farm ponds since there is virtually no tradition of the fish farming in the Study area in contrast to the rest of Thailand. DOF, Narathiwat has provided the Study Team with the fish production data in the Study Amphoe as shown in Table No. 3-21.

Table 3-21 Marine and Freshwater Fish Production

(Unit: ton)

Amphoe	1980		1981		1982		1983		1984	
	M	F	M	F	M	F	M	F	M	F
Muang	1,447	96	1,345	95	1,424	101	1,424	73	1,129	92
Yingo	-	12	-	n.a	-	11	-	11	-	13
Rangae	-	9	-	5	-	5	-	5	-	5
Tak Bai	82	6	220	9	200	7	770	6	736	7
Total	1,529	123	1,565	(109)	1,624	124	2,194	95	1,865	117

Source: Department of Fishery, Narathiwat

Note : Marine water fish (M) includes short bodied mackerel, trash fish, shrimp, miscellaneous species, etc. Fresh water fish (F) includes snake head fish, cat fish, common climbing perch, swamp eel, etc.

(2) Marine Fisheries

Along the coastline stretch, the fishing activities are concentrated upon the villages of Ban Bu ku and Ban Khlong Tan as well as the scattered homesteads especially near Tak Bai lagoon. The general opinion indicates that the fishing activities are carried out by small trawlers (about 30 GRT) and small outboard