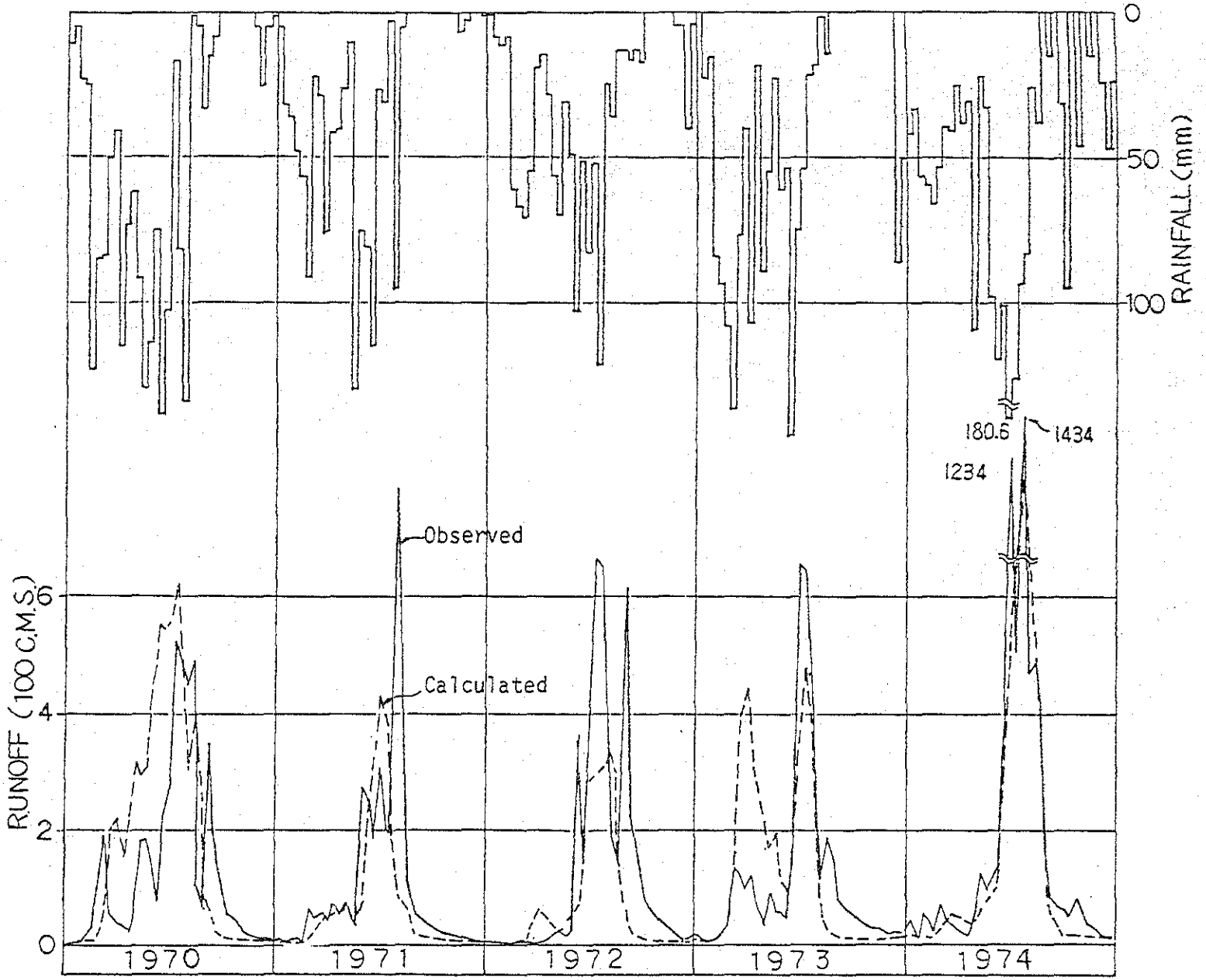


Fig. I-6(1) Runoff Simulation by Tank Model at CT-5A

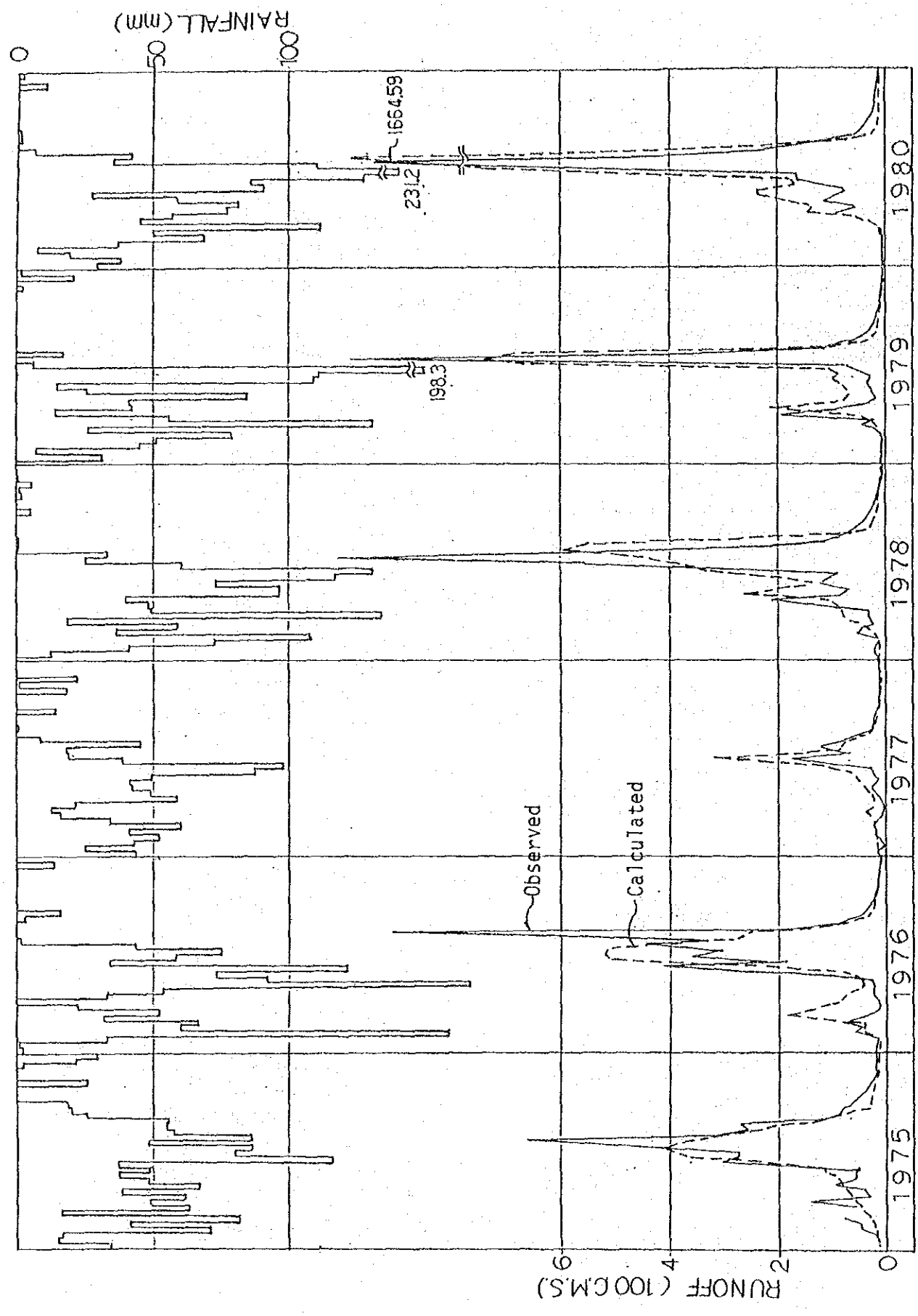


Fig. I-6(2) Runoff Simulation by Tank Model at CT-5A

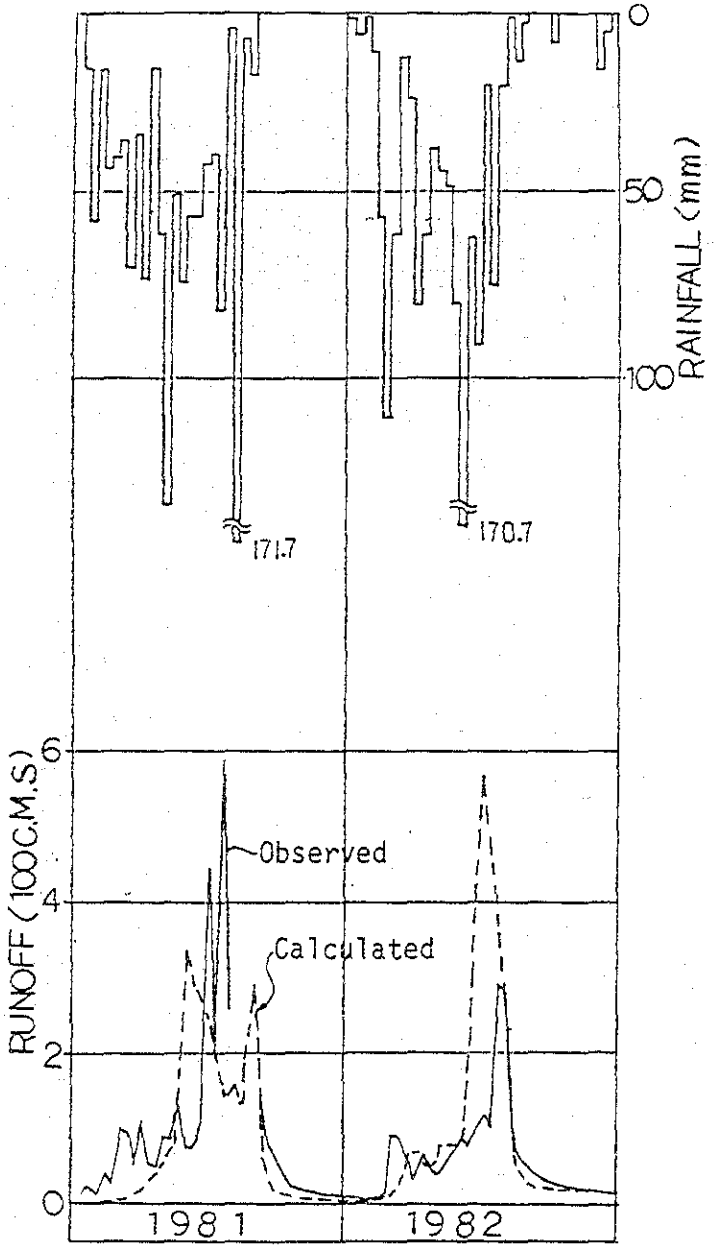


Fig. I-6(3) Runoff Simulation by Tank Model at CT-5A

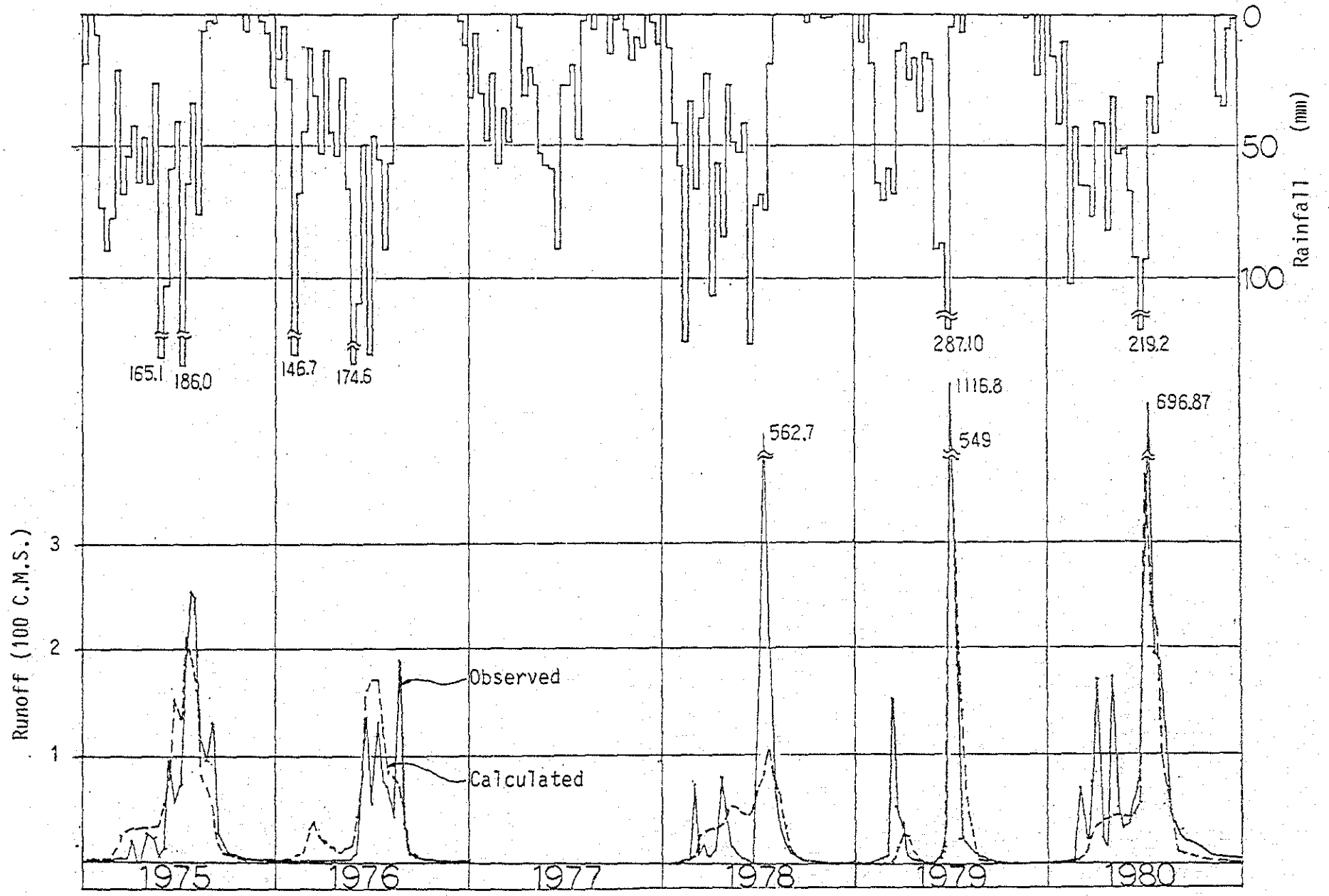


Fig. I-6(4) Runoff Simulation by Tank Model at CT-7

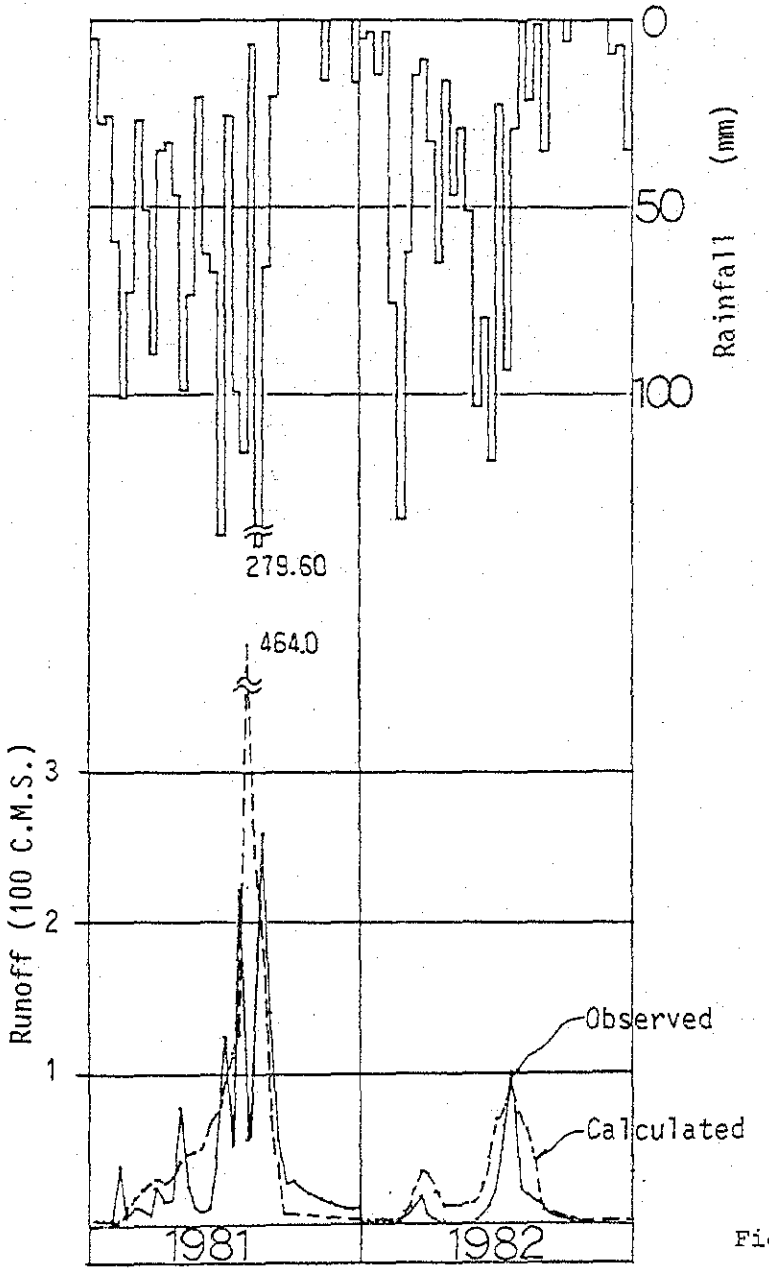


Fig. I-6 (5) Runoff Simulation by Tank Model at CT-7

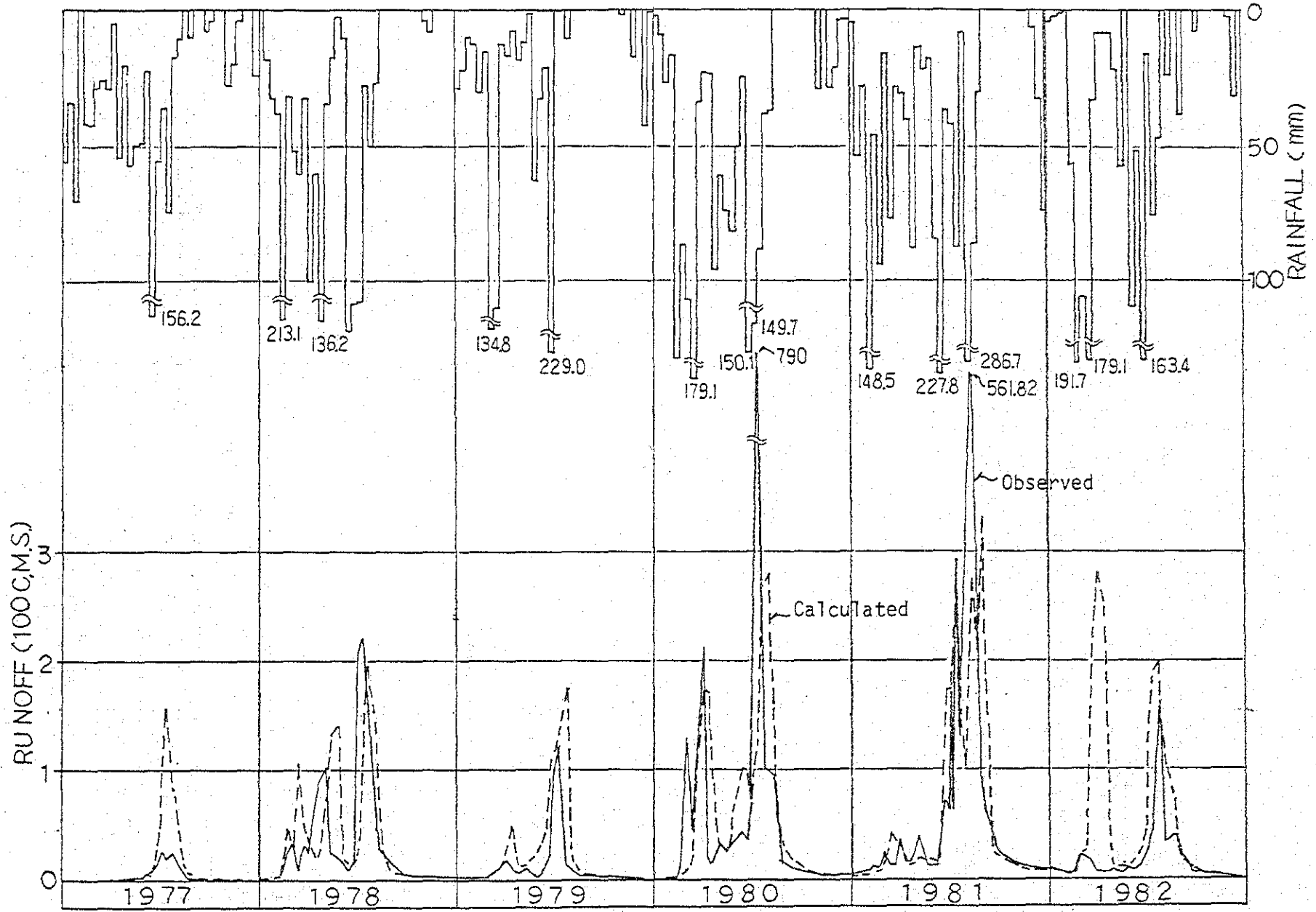


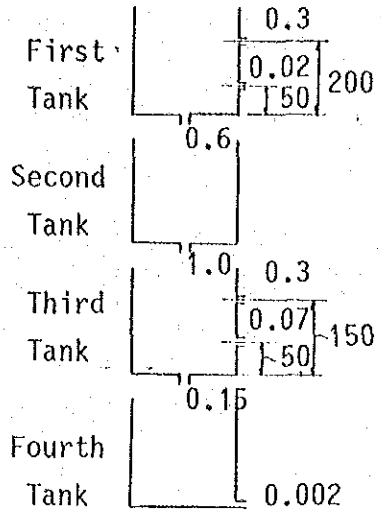
Fig. I-6(6) Runoff Simulation by Tank Model at CT-9

CT-5A

Catchment Area : 936 km²

First Storage Height

First Tank	0 mm
Second Tank	0 mm
Third Tank	0 mm
Fourth Tank	300 mm

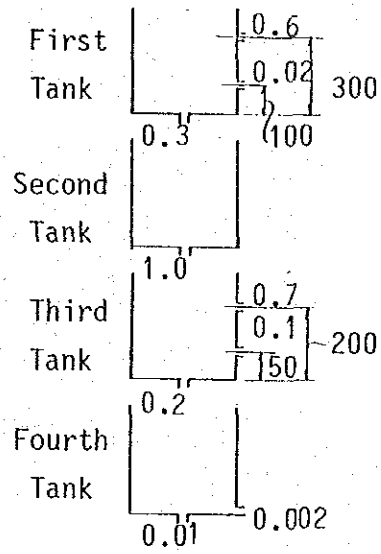


CT-7

Catchment Area : 403 km²

First Storage Height

First Tank	0 mm
Second Tank	0 mm
Third Tank	0 mm
Fourth Tank	300 mm



CT-9

Catchment Area : 541 km²

First Storage Height

First Tank	0 mm
Second Tank	0 mm
Third Tank	0 mm
Fourth Tank	300 mm

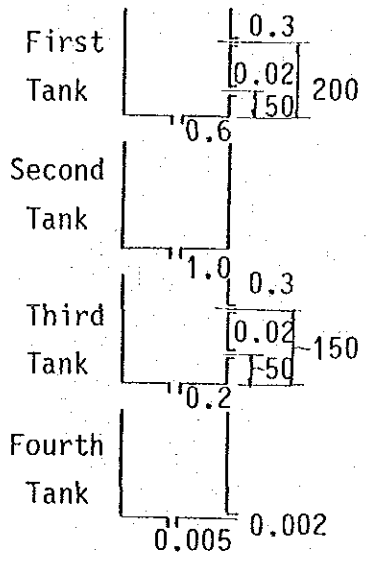


Fig. I-7 Tank Model Dimension

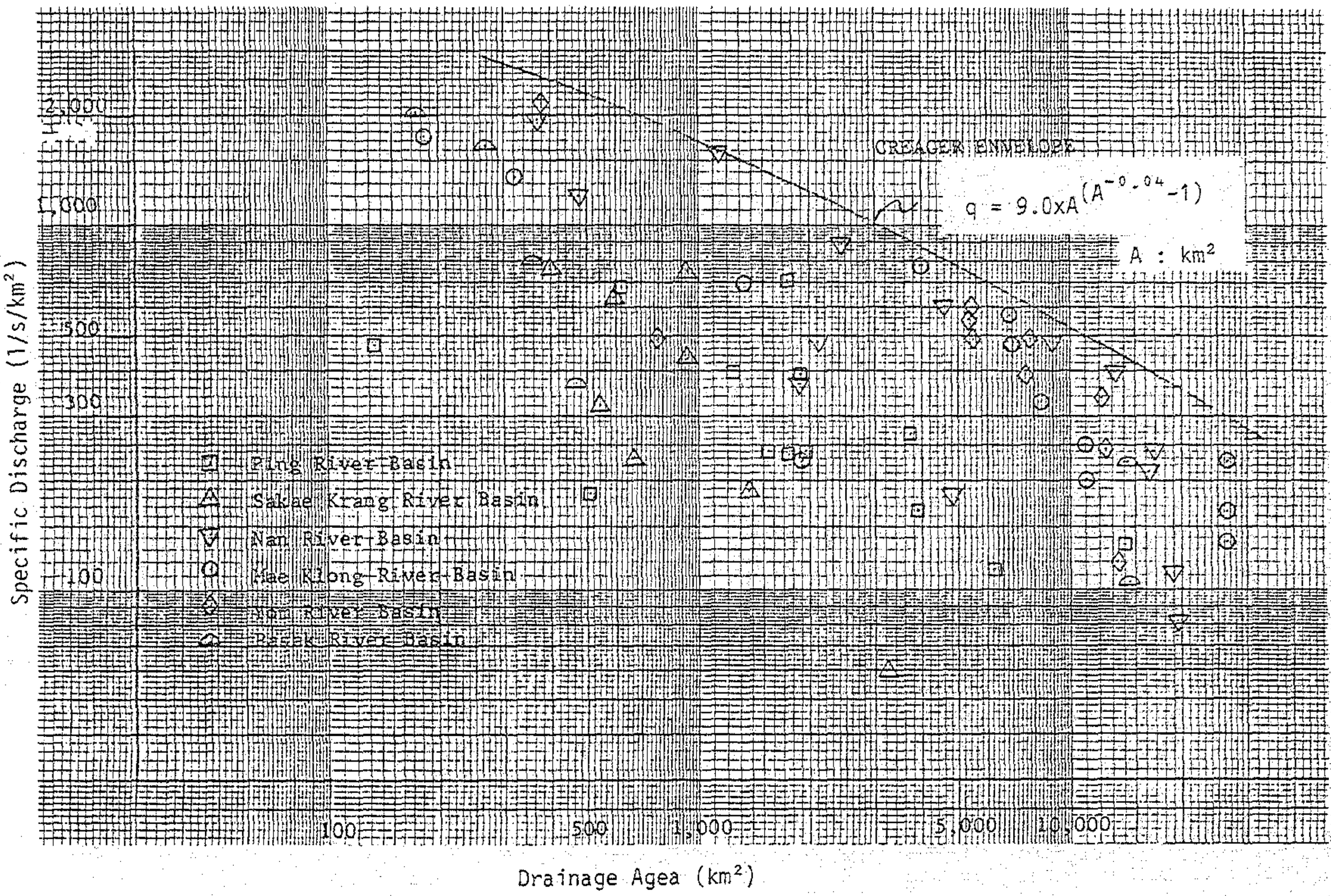


Fig. I-8 Creager Envelope

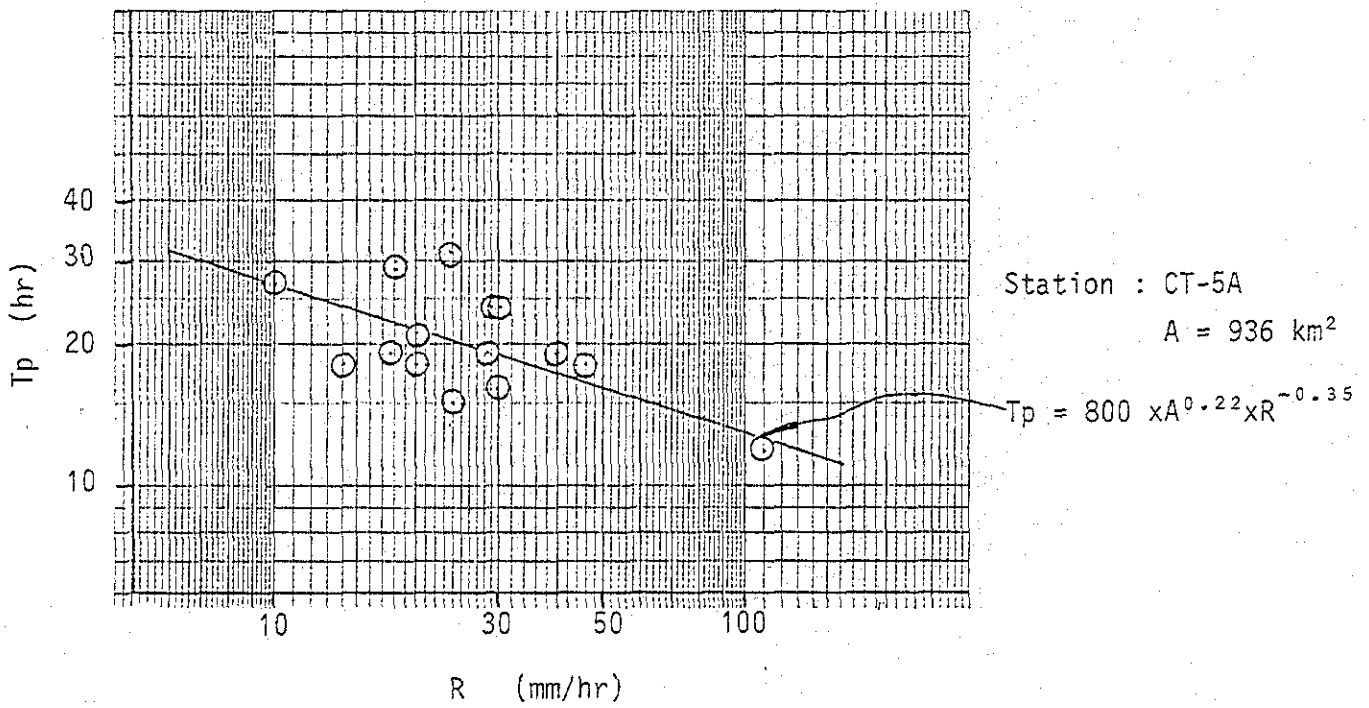
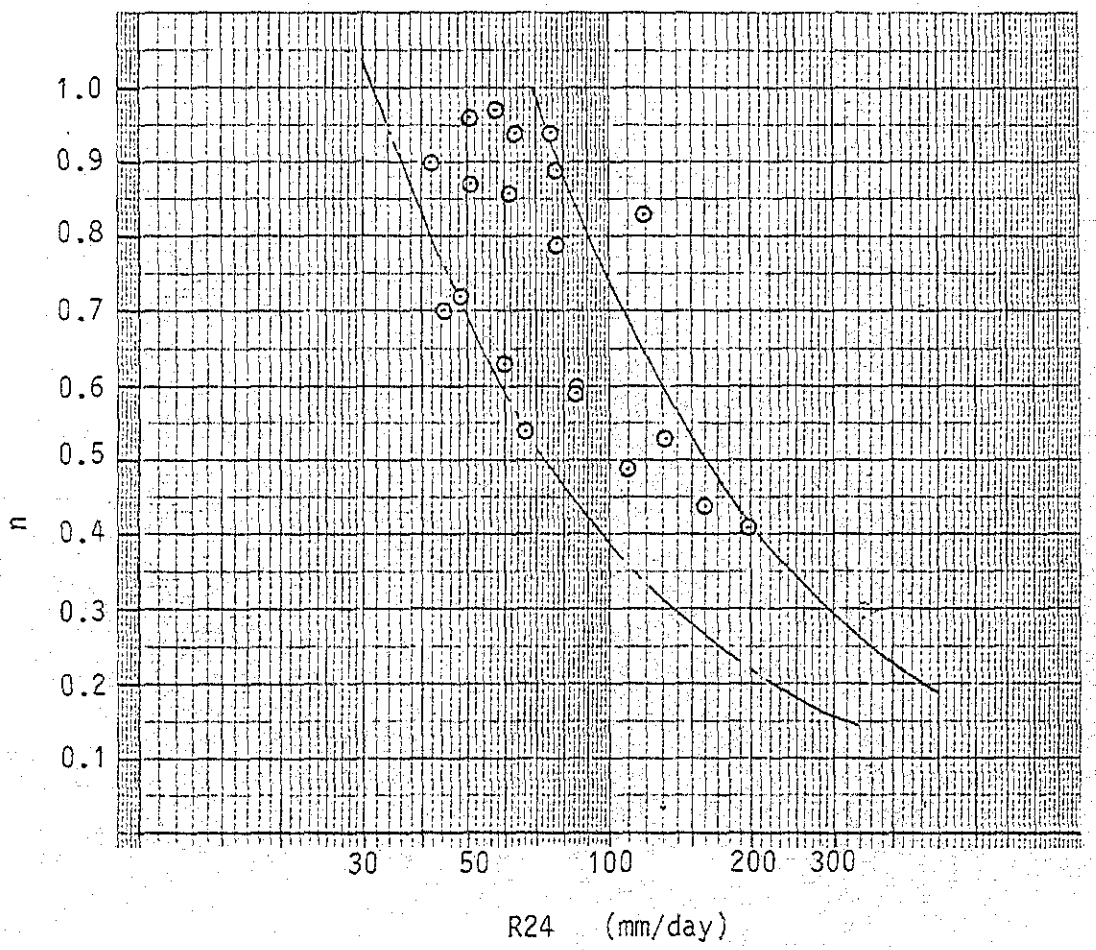


Fig. I-9 Runoff Concentration Time and Rainfall Intensity



$$Re = \left(\frac{R24}{24}\right) \times \left(\frac{24}{Te}\right)^{n}$$

Re: Rainfall Intensity (mm/hr)
Te: Concentration Time (hr)
R24:Daily Rainfall (mm/day)

Fig. I-10 Relation Between R24 and n

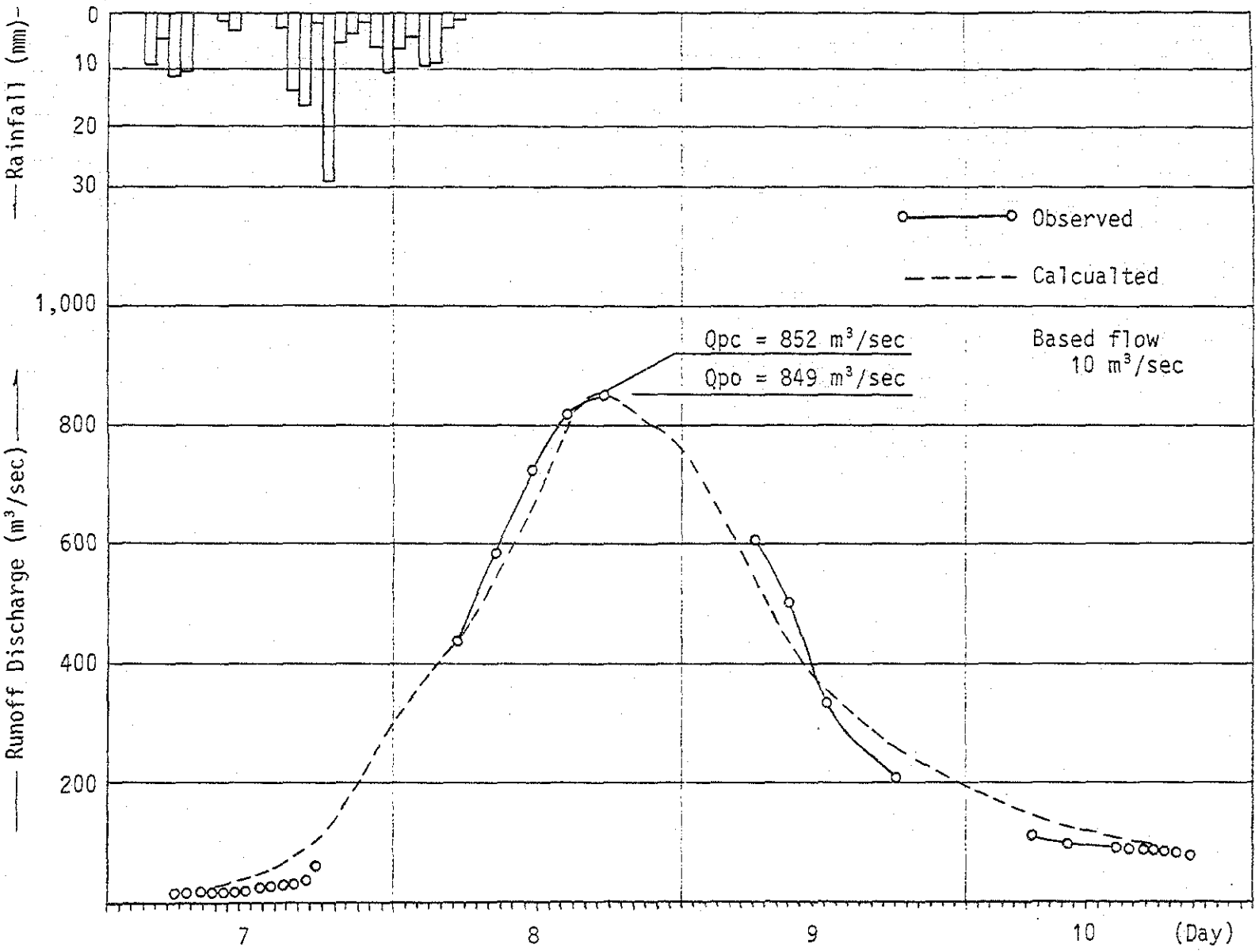


Fig. I-11 Unit Hydrograph Simulation

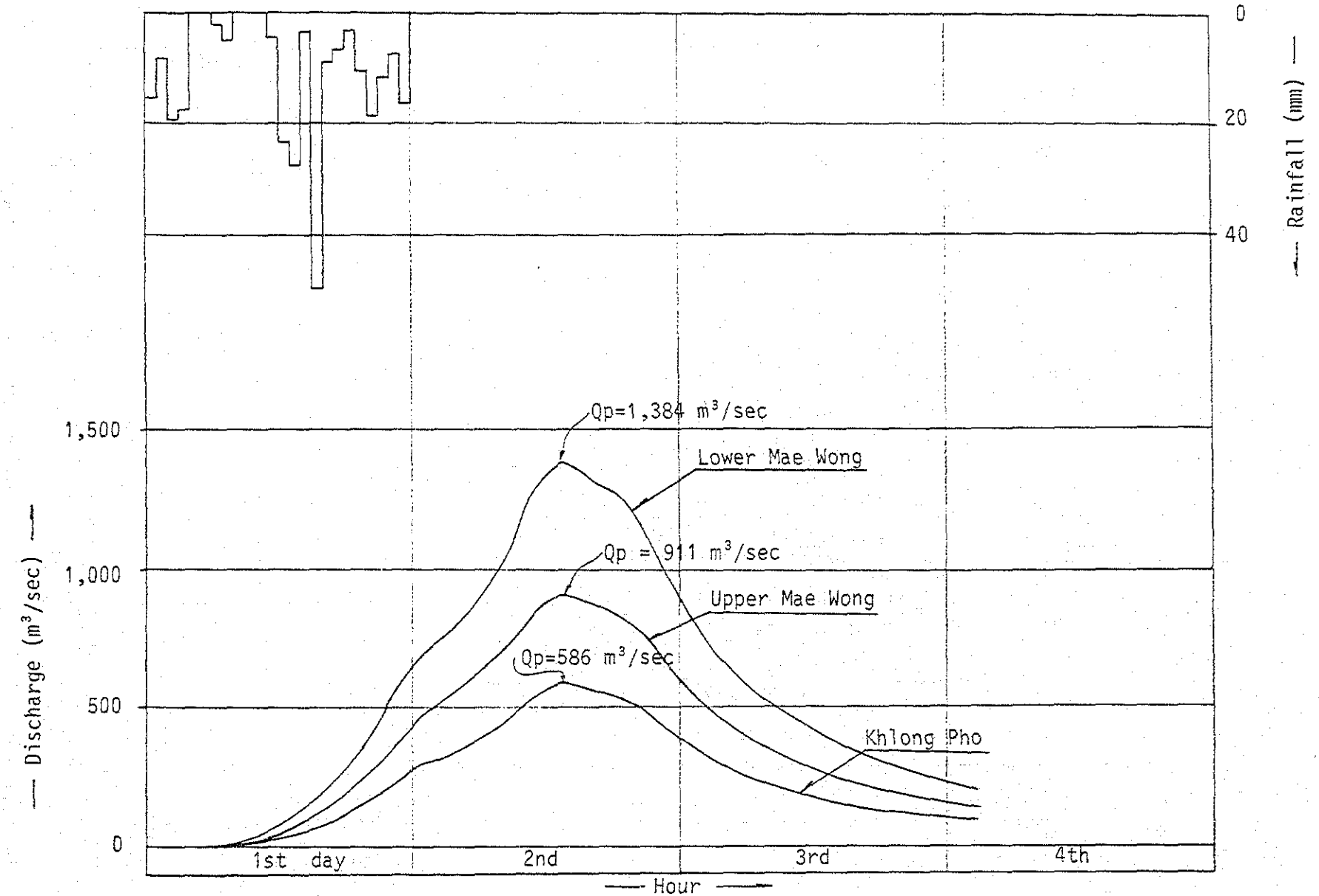


Fig. I-12 (1) Flood by Unit Hydrograph (Case 1)

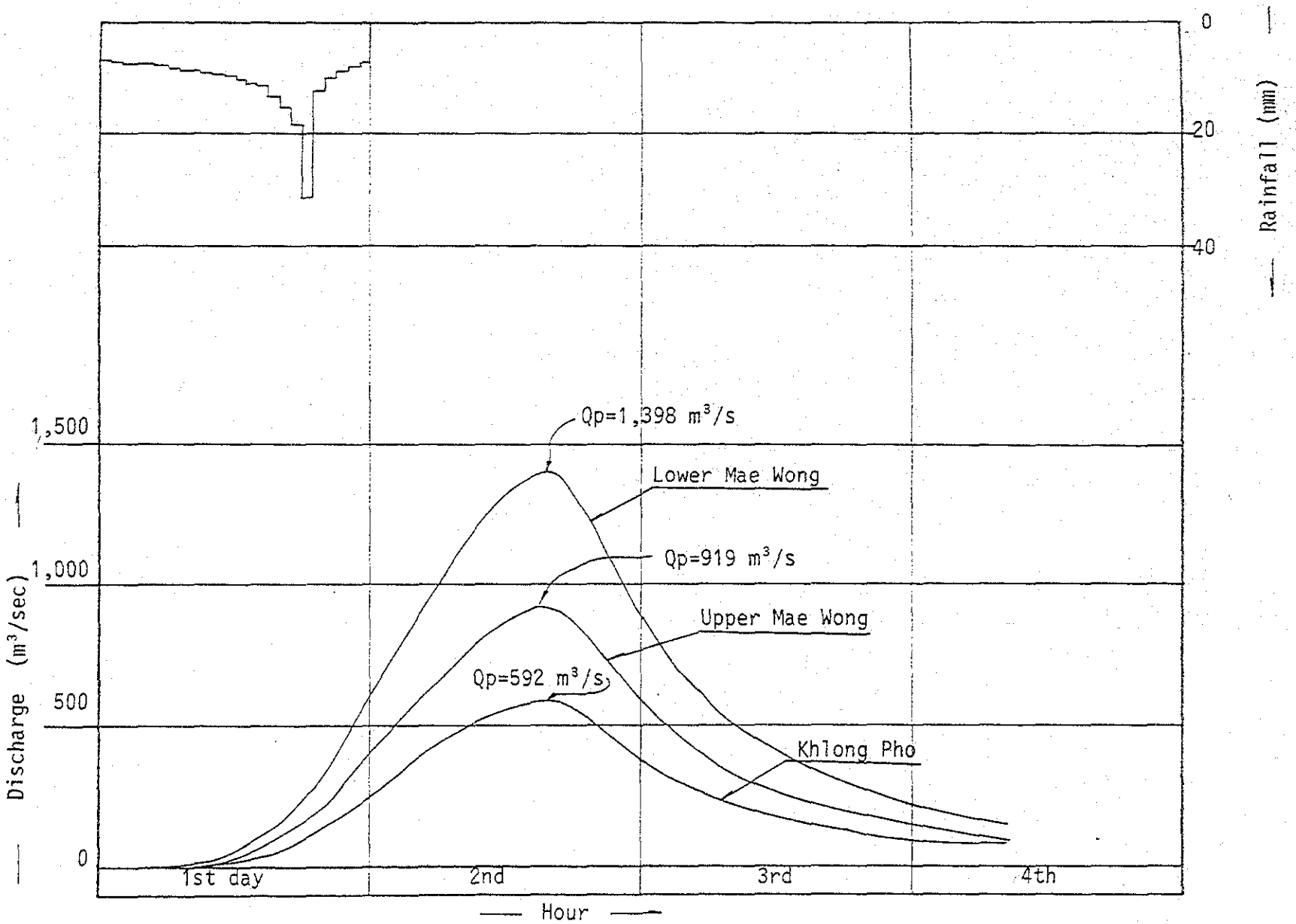


Fig. I-12 (2) Flood by Unit Hydrograph (Case 2)

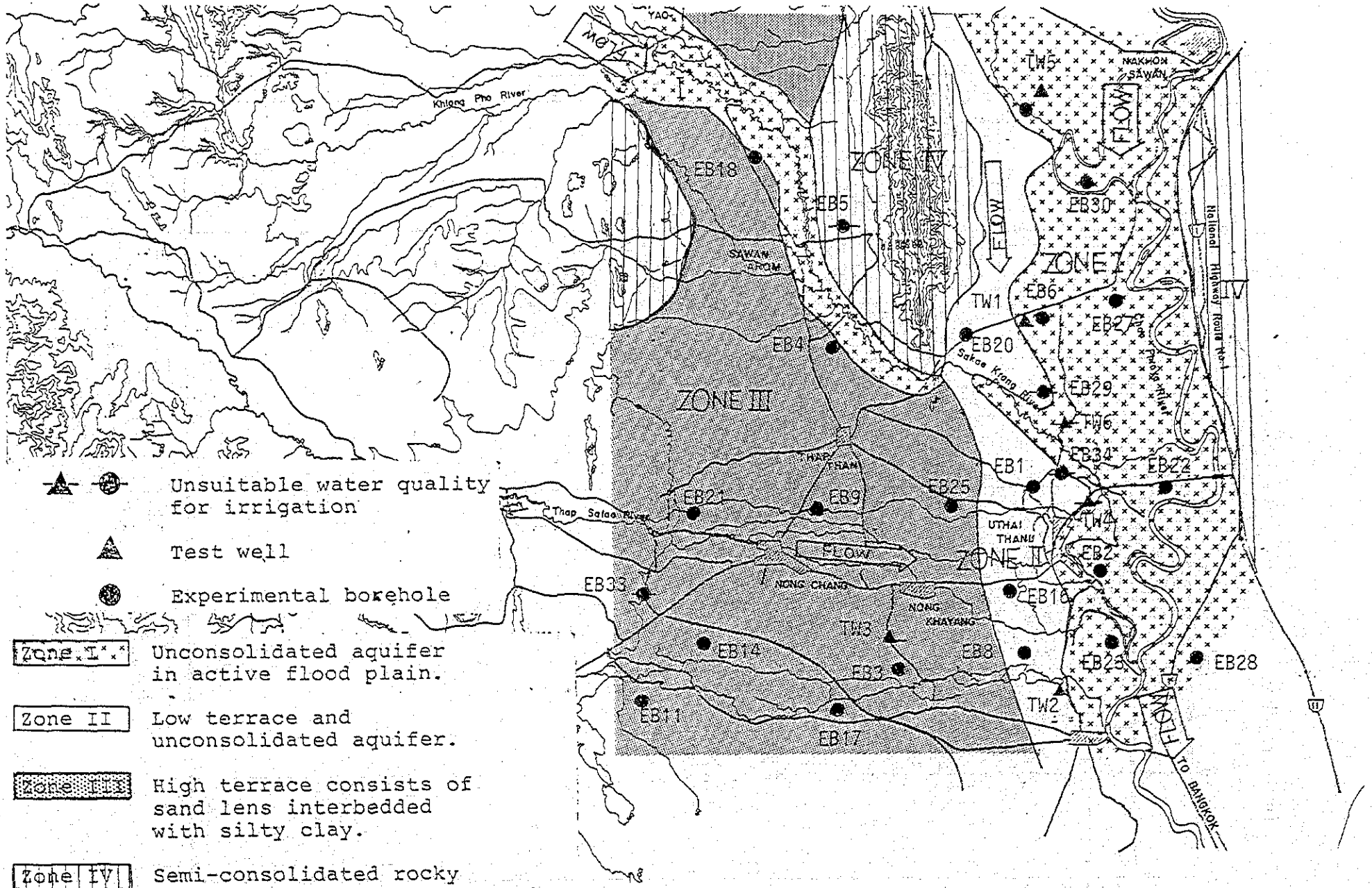


Fig. I-13 Groundwater General Map

ANNEX II
GEOLOGY

ANNEX - II

GEOLOGY

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GEOLOGY

1. BASIN GEOLOGY

1.1 General

The Sakae Krang river basin is divided roughly into two parts by Tertiaty volcanic belt along latitude of about E-99-30, the western Paleozoic zone and the eastern Mesozoic zone. The western paleozoic zone has a district N-S geological structure affected by the Burmese-Malaya geosynclinal movement of meridional trend. The proposed dams are located along the eastern edge of this Paleozoic zone. The eastern Mesozoic zone, in which a vast diluvial plateau develops, has more gentle, almost flat, geostructure and is suitable for cultivation.

These geostructural modes seen to have been formed as a result of the crustal movements during the Mosozoic and Tertiary periods. One of the last events of these structural movements is said to be an engraving character and occurred along the eastern margin of the Paleozoic zone.

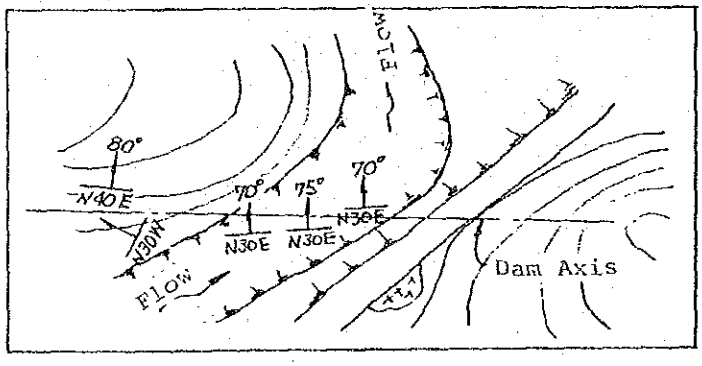
1.2 Chronology and Geological Map

Chronology of this area is summarized in Table II-1 and geological map is shown in Fig. II-1.

2. DAM GEOLOGY

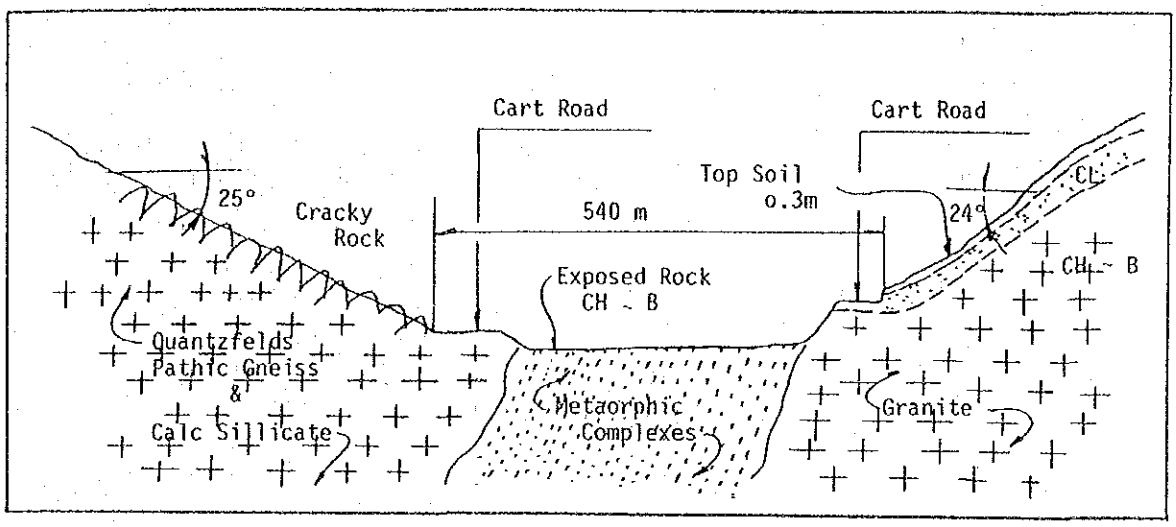
2.1 Upper Mae Wong Dam

The foundation rocks are Proterozoic-Precambrian Metamorphic complexes, called Uthai Thani complexes, and Mesozoic granite groups. River bed width is about 400 m. On the river bed, granite gneiss, amphibolite facics and banded quartzite, affected by complicated thermal metamorphic action, form massive hard rock foundation bearable for construction of concrete gravity type of dam. On the left abutment surface, quartzfelds pathic gneiss and calc-sillicate rocks are exposed and surface soil coverage in thin. Open cracks are developed on the left abutment rocks but cracks are closed on the river bed rocks.



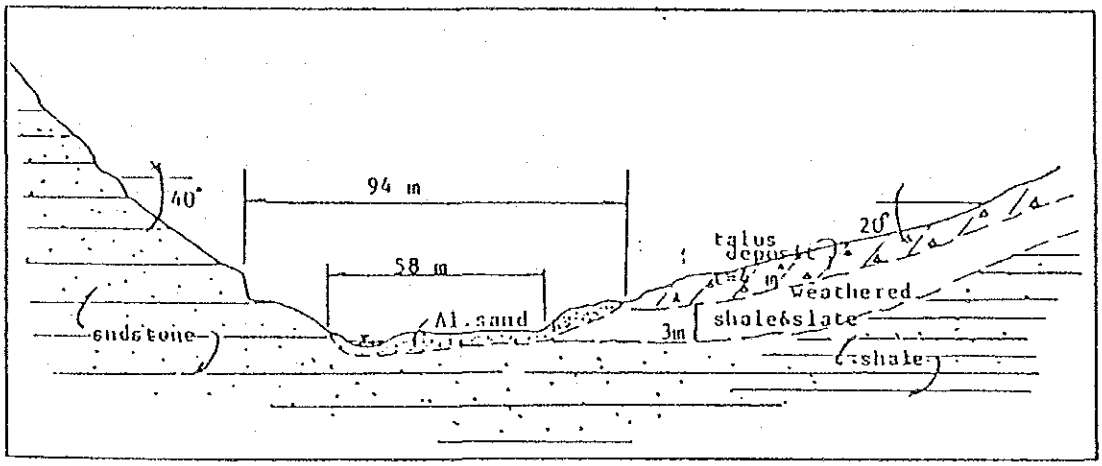
On the right side abutment, the coarse-grained granite is exposed and weathering, as seen from the cart road and river bank, is noticed on the surface rocks but it seems not deeply developed.

A fault is illustrated along the boundary of Uthai Thani complex and granite rocks on the geological map of 1/150,000 at about 1 km upstream of dam axis. Direct treatment of fault will not be necessary for dam construction as the fault is very old one and locates far from dam axis but careful investigation will be necessary. Elasticity modulus of foundation rock is estimated at a range of 50,000 to 10,000 kg/sq.cm.

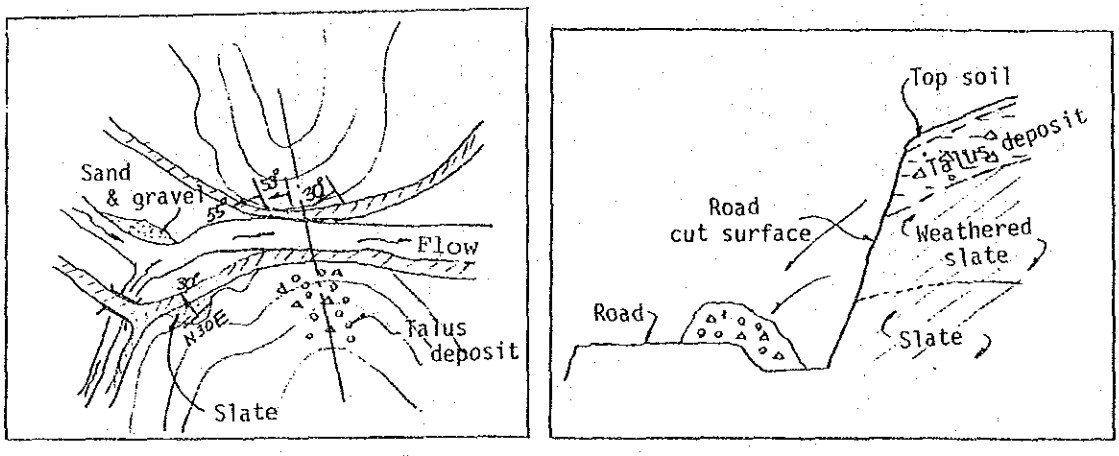


2.2 Lower Mae Wong Dam

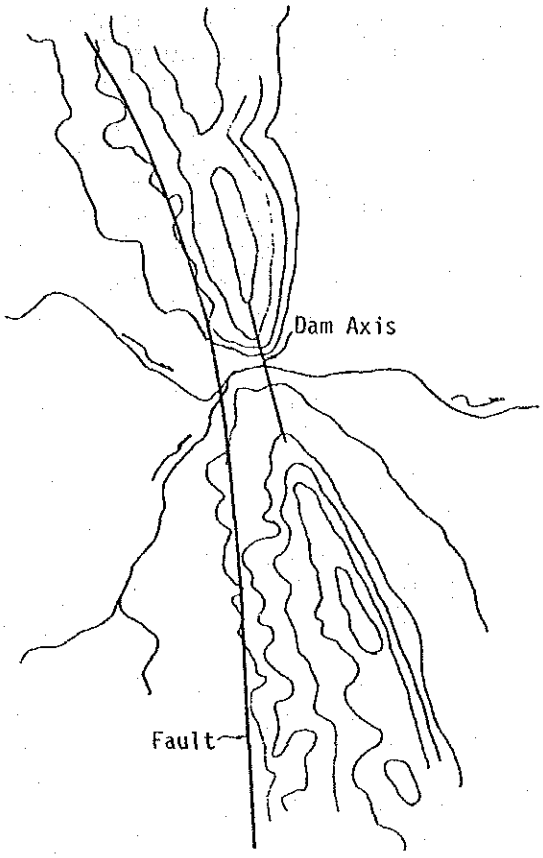
The proposed dam site is located geologically Mesozoic Jurassic, so called, Khao Chonkan Formation which is mainly formed of reddich sandstone, slate and minor conglomerates. River bed width is about 60 m.



On the left abutment, Mesozoic conglomerates and sandstones are exposed on the surface. The right abutment is thickly covered by talus deposit of about 4 m but weathered slate is exposed on the cut surface along the cart road. Alluvial deposits along the river course are composed of sand and gravels of chart, sandstone and quartz, which is considered suitable for filter zone of dam. Estimated values are about dmax at 10 mm, P4.8 at 10%, P2.0 at 40% and P0.074 at 0%. Talus deposit on the right abutment is considered suitable for core material. On the left side of the river at upstream, sand and gravel layers are distributed in a wide area. The layer is considered to be classified into GW in standard classification, having dmax at 50.8 mm and P0.074 at about 5%.



Strikes and dips of foundation rocks are about N30° and 30° upstream on the right abutment and N10° to N25°W, 30° to 55° upstream are prevailing on the left abutment exposed rocks. Strikes and dips for river bed rocks were not visible because of thick sand and gravel deposits.

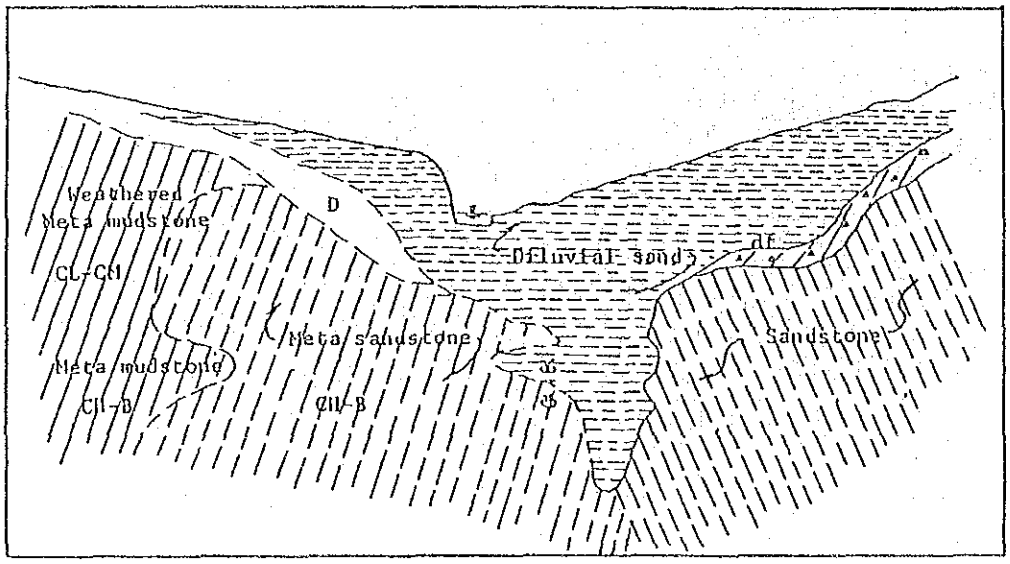


A structural fault is indicated by the geological map of the Royal Thai Survey Department at about 400 m upstream of proposed dam axis. The fault is estimated to be formed by the geological movement on Masozoic or Tertiary era. The detailed geological investigations are necessary to clarify the characteristics and location of the fault.

Weathering of dam site right abutment seems remarkable. The elasticity modulus will be in a range of 3,000 to 5,000 kg/cm^2 for weathered slate of class CL to D and 200 to 300 kg/cm^2 for talus deposits. Class CM to CH state will have elasticity modulus about 5,000 to 10,000 kg/cm^2. Evaluating from these characteristics, the dam site will not be suitable for the very high dam construction.

2.3 Khlong Pho Dam

The proposed dam site is located at Quaternary Pleistocen diluvial terrace in the peneplain area. The diluvial and deposit is comparatively consolidated having N value of 40 to 50. On the left abutment of the dam, the foundation rocks are formed by a part of Khao Chonkan formation in which slate and sandstone are developed. According to the bore hole drillings along the proposed dam axis, the dips of these foundation rocks are reported to be sharp at about 90°. The right abutment foundation is considered to be of the Uthai Thani complex in which sandstone and quartz felds pathic is dominant. The thermal metamorphic action on the right abutment seems weaker than the one on the left abutment.



Old fault or old eroded valley is supposed around the drilling hole No. 6. If it is an old fault, it may be connected with the fault indicated at the upstream of the Lower Mae Wong dam site. Evaluating from the N-values on the drilling holes as shown next page, the bearing capacity of diluvial sand layer should be carefully treated for dam construction.

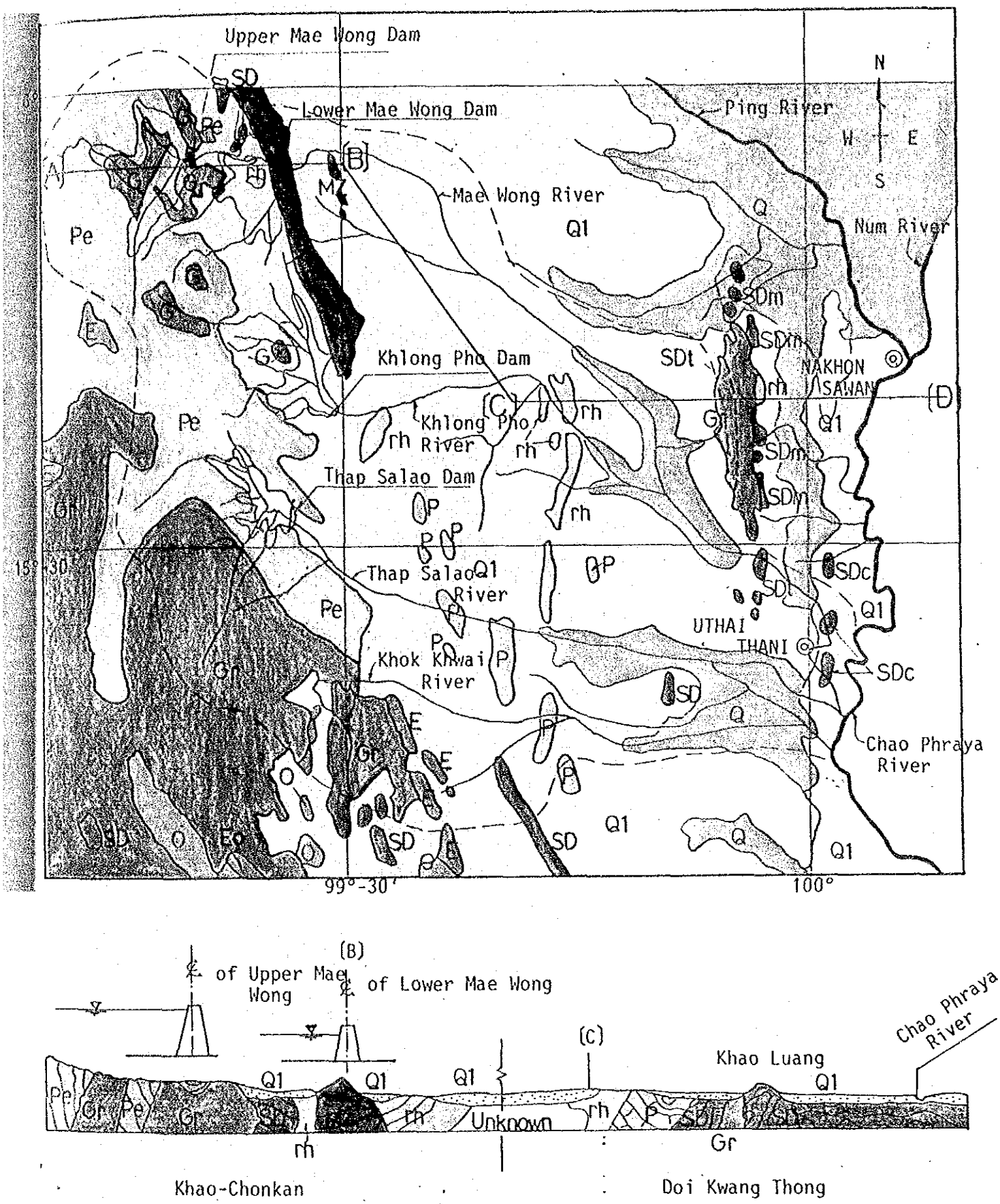
N-Value along Dam Axis

Depth (m)	Drilling Hole No.										
	DH-1	2	3	4	5	6	7	8	9	10	11
0 - 0.3	1	3	3	-	3	8	50	4	2	3	1
1 - 1.3	16	15	25	-	18	50	50	19	50	50	10
2 - 2.3	50	50	50	-	6	50	50	48	45	50	43
3 - 3.3		50	10	-	14	50	50	50	50	50	35
4 - 4.3			50	-	10	32	29	24	35	50	30
5 - 5.3			50	-		18	13	34	29		50
6 - 6.3			50			50		47	33		
7 - 7.3			50			22		40	50		
8 - 8.3			50			50		15	20		
9 - 9.3						50		28	18		
10 - 10.3						50					

Especially, the N-values at DH-5 shows considerably low and spring water in the depth is reported. These indicate the existence of suppressed ground water layer which is often formed in the diluvial deposit during the course of deposite procedure. In addition to this, the excavated surface of such sandy layers is easily loosened. For the dam design, special foundation treatment will be required, and high dam construction is considered difficult.

Table II-1 CHRONOLOGY

Symbol	Era	Period	Epoch/Series	Name	Remarks
Q	Cenozeic	Quaternary	Recent	Alluvial	flood plain alluvials, sand, silts develops at along rivers and back swamp
Q1			Pleistocen	Diluvial	old flood deposits of gravel, sand, silt and laterite
	(Unconformity)				
Gr				Igneous Rocks	granite, grano-diorite, diorite & quartz
rh	Mesozoic				rhyolite, andesite
Mz		Jurassic	Khao Chonkan Formation		mainly red sand stone, shales, minor conglomerates and volcanic conglome
	(Unconformity)				
P		Permian	Ratbri Group		massive, grey limestones with fusulinids, minor shale, chert and conglomerate
C	Paleozoic	Caboniferous	Takli Sand Stones		intercalation of red shale sandstone, quartz sand stone; intersified conglomerates and reddish grey shale and sandstone
		(Unconformity)			
SDc		Devorian	Kao Gob cherts		mainly chertbeds and thinly interbedded tuff and shale
SDm		Silurian	Kao Mano Marble		mainly grey to white, massive to poorly beeded marble
SDt			Kao Luang Tuff		mainly quartz, fields pathic tuff, green schist and greywake
SD					undifferentiated sequences of quartzite, phyllite; greywake chert bed and local conglomerates
		(Unconformity)			
O		Ordovician	Thung Song Group		
Eo		Canbro-Ordovician	Phubon Marble		micaschist, contorted marble and minor calc-silicate rock
E		Cambrian	Huai Wai Quartz		quartzite, phyllite and quartz biotite schist
			(Unconformity)		
Pe	Proterzoic	Precambrian	Uthai Thani Complexes		



Ref: Royal Thai Survey Department

Fig.II-1 GEOLOGICAL MAP

ANNEX III
SOIL AND LAND CLASSIFICATION

ANNEX-III

SOIL AND LAND CLASSIFICATION

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SOILS AND LAND CLASSIFICATION

1. SOILS OF THE SAKAE KRANG RIVER BASIN

1.1 *Physiography*

The Sakae Krang river basin occupies the north-western part of the Central Chao Phraya Plain; it is bordered by the mountain ridges on the west, the Chao Phraya river on the east, the northern ridge of the Mae Wong river on the north and southern ridge of the Khok Khwai river on the south.

According to the geological map prepared by the Department of Mineral Resources, the surface layers of the area is mainly composed of recent and pleistocene alluvial deposits. Recent alluvial deposits dominate broadly along the Sakae Krang river system. Pleistocene alluvial deposits are extensively observed over the rest of the area. Recent alluvial levee materials are found in narrow bands on both sides of the Chao Phraya river.

Isolated hills and mountains are scattered over the central and eastern parts of the Sakae Krang river basin. The mountain ridges stretch in north-south direction in the western part of the area. The land of the Sakae Krang river basin is classified into the following six (6) land from categories:

1. Flood Plain
2. Semi-recent Fan and Alluvium
3. Lower terraces
4. High terraces
5. Dissected Erosion Surface
6. Mountains.

The land-forms were identified on the basis of the detailed reconnaissance soil maps scaled 1 to 100,000 prepared by the Department of Land Development and have been confirmed through the present field observations. The land-form map is given in Fig. III-1. The proportional areas of each land-form category in the Sakae Krang river basin are as follows:

(Unit: km^2)

Sub-basin	Land-Form Categories						Total
	Flood Plain	Semi-recent Alluvium	Low Terrace	High Terrace	Errosion Surface	Mountains	
Mae Wong	-	544	187	546	256	638	2,171
Khlong Pho	-	348	25	158	479	201	1,211
Sakae Krang	95	255	17	17	84	89	557
Thap Salao	70	353	32	32	265	501	1,253
Khok Khwai	30	199	146	154	253	326	1,108
Total	195	1,699	407	907	1,337	1,755	6,300
(%)	(3.1)	(27.0)	(6.5)	(14.4)	(21.2)	(27.8)	(100.0)

1.2 Soils

Seven (7) Great Soil Groups and seventeen (17) soil series are identified in the Sakae Krang river basin. The results of the soil classification in each of sub-basin are given in Table III-1. The distributions of the identified soil groups are shown in Fig. III-2 (Soil Map). The soil map was prepared on the basis of the detailed reconnaissance soil maps scaled 1 to 100,000 prepared by the Department of Land Development and have been confirmed through the field observations. The major characteristics of all the soil series identified in each of land-form are as follows:

(1) Flood plains

THA MUANG SERIES (Tm)

The soils of this group are formed from the recent alluvium and occur on the lower-lying areas located along the downstreams of the rivers. The soils are generally deep and loamy to clayey textured. Soil reaction is moderately acid to neutral. The soils are generally poorly drained and permeability is low. The soils of this series are classified as Alluvial Soils in National Soil classification system or Typic Ustifluvents on USDA system (Soil Taxonomy). The Muang soils are predominantly used for broad-casted rice cultivation.

(2) Semi-recent fan and alluvium

NAKHON PATHOM SERIES (Np)

The soils of this group are formed from semi-recent alluvium and occur on low terraces. Relief is flat or nearly flat. Slopes are 1% or less. The effective soil depth is very deep and the soil is clay loamy to clayey textured. Soil reaction is slightly acid to moderately alkaline. The soils are somewhat poorly drained. Permeability and surface runoff are slow. The soils are classified as Non Calcic Brown Soils (National) or Utic Haplustalfs (USDA). Nakhon Pathom series are mainly used for transplanted rice cultivation. In places, sesame, beans and groundnuts are grown, together with sugar cane in the dry season.

PHETCHABURI SERIES (Pb)

The parent materials of this soil series are semi-recent alluvium. The soils occur on the lower parts of the semi-recent levees. Relief is flat to nearly flat. Slopes are 2% or less. The effective soil depth is very deep. The texture of A horizon is sandy loam and that of B horizon is clay loam. Soil reaction is medium acid to neutral. The soils are somewhat poorly drained. Permeability is moderate and surface runoff is slow. The soils of this group are classified as Utic Haplustalfs (USDA) or Non Calcic Brown Soils (National). Phechaburi series are predominantly used for transplanted rice cultivation.

KAMPHAENG SAEN SERIES (Ks)

The soils of this group are formed from semi-recent alluvium and occur on old levees and breach deposits of semi-recent terraces. Relief is flat to nearly flat, with a slightly undulating micro-relief. The effective soil depth is very deep. The soil texture is loam or clay loam. The soils are generally well drained, permeability is moderate and surface runoff is slow. Soil reaction is slightly acid to mildly alkaline. The soils are classified as Non Calcic Brown Soils (National) or Utic Haplustalfs (USDA). Kamphaeng Saen series are mainly used for transplanted rice cultivation. In places, they are put to upland crops such as maize, cotton and sugar cane.

MAE SAI (Ms)

These soils are formed from alluvium deposits on semi-recent terraces. Relief is flat or almost flat. The effective soil depth is very deep and the texture is silty loam or silty clay loam. The soils are somewhat poorly drained. Permeability and surface runoff are slow. Soil reaction is medium acid to alkaline. Mae Sai series are members of Non Calcic Brown Soils (National) or Aeric Tropaqualfs (USDA). The Soils are mainly used for transplanted rice cultivation with some areas under irrigated crops such as soy beans during the dry season.

(3) Low terraces

DEUM BANG SERIES (Db)

The soils of this group are formed from the old alluvium and occur on the low lying parts of local, coalescing alluvial fans. Relief is flat or nearly flat. The effective soil depth is very deep and the soil texture is sandy loam to sandy or silty clay. Soil reaction is slightly acid to mildly alkaline. The soils are somewhat poorly drained and permeability is moderate. The soils are classified as Low Humic Gley Soils (National) or Aeric Tropaqualfs (USDA). Deum Bang Soils are predominantly used for transplanted rice cultivation.

PAK THO SERIES (Pth)

The soils of this group are formed from old alluvium and occur on low terraces. Relief is flat to nearly flat. The effective soil depth is very deep and the soil texture is loam to clay. Soil reaction is strongly acid. The soils are somewhat poorly drained and permeability is low. The soils are classified as Low Humic Gley Soils (National) or Aeric Paleaquuts (USDA). Pak Tho soils are predominantly used for transplanted rice cultivation.

ROI ET SERIES (Re)

These soils are formed from old alluvium and occur on the low terraces. Relief is almost flat and the slopes are 2% or less. The effective soil depth is deep and the texture of A horizon is sandy loam overlying a sandy clay loam B horizon. Soil reaction is medium acid to strongly acid. The soils are poorly drained and the permeabilities of these soils are rapid to slow. The Roi Et series are family of Low-Humic Gley Soils (National) or Aeric Palequults (USDA). The soils are used for transplanted rice in the wet season and for some upland crops such as corn, water melon and beans after rice harvesting.

UBON SERIES (Ub)

The soils of this group are found on the higher parts of the low and the middle terraces, formed on sandy alluvium. The relief is flat to gently undulating, and the slopes are 2% or less. The effective soil depth is deep and the soil texture is loamy sand. Soil reaction is medium to slightly acid. The soils are naturally well drained. Permeability is rapid and the surface runoff is slow. The soils are classified as Gray Podzolic Soils (National) or Aquic Dystropepts (USDA). The soils are mainly used for transplanted rice.

SAN PA TONG (Sp)

The soils of this group are formed from sandy or loamy textured quatzose old alluvium and old colluvium, and occur on undulating to rolling parts of the low terrace. The effective soil depth is very deep and the profiles have sandy loam A horizons and sandy clay loam B horizons. Soil reaction is moderately acid in the A horizons to very strongly acid in the B horizons. The Soils are well, moderately well and somewhat poorly drained. San Pa Tong series are classified as Gray Podzolic Soils (National) or Oxic Dystropept (USDA). The vegetations of these soils are mainly opened Dipterocarp forest and low shrub Savannah with some cropping under shifting cultivation.

(4) High terraces

KORAT SERIES (Kt)

The soils of this group are formed from old alluvium and occur on high terraces. Relief is undulating, varying between 2 and 6%. The effective soil depth is deep. The soils have a medium texture, sandy loam or loamy sand in surface, and sandy loam to loam in the subsoil. These soils are excessively to moderately well drained. Permealibity and surface runoff are rapid. The soil reaction is medium to strongly acid. The soils of this group have a very weak horizon differentiation. The soils are classified as Grey Podzolic Soils (National) or Oxic Paleustnlts (USDA). In this area, parts are cleared for upland crops such as kenaf, water melon, maize, cotton, beans, castor bean, cassava, etc. and settlement areas. Mostly are dry dipterocarp forest and mixed diciduos forest.

NAM PHONG SERIES (Ng)

The soils of this group are formed from sandy old alluvium and locally colluvium, and occur on middle terraces and footslopes. Relief is undulating to rolling which slopes range from 3 to 10%. The soils are somewhat excessively drained. Permeability and surface runoff and rapid. The effective soil depth is shallow and the texture is sand to loamy sand. The soils are classified a Regosols (National) or Ustoxic Quartzipsamments (USDA). Nam Phong soils are mainly low opened dipterocarp forest. Parts are cleared for shifting cultivation. Those crops are kenaf, water melon, and maize.

(5) Dissected erosion surfaces

CHIANG KHAN SERIES (Ch)

The soils of this group are formed from residium and local colluvium derived from shale and metamorphic rock equivalent to shale and occur on erosion surface and footslopes. Relief is undulating to hilly which slopes range from 4 to 20%. The soils are shallow gravelly and loamy to gravelly clayey textured. Reaction is medium to nutral acid. The soils of this series are well drained soils. Permeability and surface runoff are rapid. Chiang Khan soils are classified as Reddish Brown Lateritic Soils (National), Paleustults (USDA). This area is originally mixed diciduous forest. Parts are cleared for shifting cultivation such as corn, cotton and also used as road building material.

THAP SALAO SERIES (Tas)

The soils of this group are formed from granitic rock and occur on the erosion surfaces. Relief is undulating, and the slopes range from 2 to 8%. Drainage is well. Permeability is moderate to rapid. The effective soil depth is shallow, and the soil texture is gravelly loamy sand to gravelly silty loam.

The soils commonly show a distinct horizon differentiation in the profile. Normally, soil reaction is medium to slightly acid, and the pH becomes lower with depth. The soils are classified as Red-Yellow Podzolic Soils (National) or Ustoxic Quartzipsamments. THAP SALAO soils are mainly covered with forest and are partly cleared for upland cropping.

THA YANG SERIES (Ty)

The soils of this group have mainly been developed from residuum and local colluvium. The soils are found on dissected erosion surface and residual hills. The relief is mainly rolling to hilly. Slopes range from 4 to 20%. The effective soil depth is shallow and the profiles have slightly gravelly sandy loam or loam A horizons and gravelly clay loam argillic B horizon. The soils are well drained. Permeability is moderate to rapid and surface runoff is moderate to rapid. Soil reaction is strongly to slightly acid. The soils are classified into Red Yellow Podzolic Soils (National) or Paleustults (USDA). The vegetations are mixed deciduous and dipterocarp forest, locally cleared for shifting cultivation.

CHAN TUK SERIES (Cu)

Chan Tuk series are residual soils derived from granitic rock and are mainly found on erosion surfaces. Relief is undulating, and the range of slope is 2 to 5%. The soils are somewhat excessively drained. Permeability and surface runoff are rapid. The effective soil depth is shallow and the profiles have loamy sand A horizons overlying loamy sand or gravelly loamy sand C horizons. Soil reaction is medium acid to slightly acid. The soils of this group are classified as Regosols (National) or Ustipsamments (USDA). The vegetations are low opened diptercarp forests and natural pastures.

1.3 Land Classification

1.3.1 Procedure for mapping

Land classification survey of the central and eastern parts of the Sakae Krang river basin was carried out by the Soil and Geology Division of RID in 1977. In addition, land suitability classification maps of Nakhon Sawan, Uthai Thani, Kamphaent Phet and Chainat provinces scaled 1 to 100,000 have already been prepared by the Department of Land Development.

The land classification study by RID covers only part of the area. The preliminary field survey was therefore made to supplement the existing data and informations. The soil maps and land suitability classification maps were fully utilized during the course of the field survey.

For the preparation of land classification map, the following items of soil and land features are taken into consideration:

1. Soil texture
2. The effective soil depth
3. Soil reaction (pH (H_2O))
4. Topography (Slope)
5. Drainage
6. Permeability
7. Surface runoff
8. Vegetation and Land use

1.3.2 Land classification system

The land classification system used in this Study is that developed in the Greater Mae Khlong Multi Purpose Project in 1968, and since adopted in many project studies by RID.

The RID system has been formulated through the past experience of the observations and studies on soil, drainage and topographic characteristics and their effects on crop productivity. The standard specification for land classification is shown in Table III-2. The framework of the system is basically three (3) classes rating for rice and upland crops. Limitations on suitability of land due to soil, drainage and topography are indicated by the symbols "s", "d" and "t", either individually and collectively. The definitions of these land class groups are as follows:

Land Class Group	Definition
U1	Land best suited for upland irrigation crops.
U2	Land less suitable for upland irrigated crops with one or two limitations in the soil, topography or drainage.
U3	Land of distinctly restricted suitability for upland irrigated crops because of extreme limitations in the soil, topography or drainage characteristics.
R1	Land best suited for irrigated rice production.
R2	Land adapted for rice production but with one or more limitations.
R3	Land usable for rice production but with severe limitations often necessitating special methods of cultivation, or cultivation only when general conditions permit.

Land Class Group	Definition
U2/R2	Land suitable for either upland crops or rice particularly, but with one or more limitations for both upland crops and rice.
6	Non-arable land. Land unsuitable for the production of crops.

The land classification for the Sakae Krang river basin was made in accordance with the RID specification, and the following land class groups were identified.

Land Class Group	Land Class	Area	
		Km^2	%
R1	U3sd/R1	308	4.9
R2	U3sd/R2s	730	11.6
U2/R2	U2s/R2s	199	3.2
	U2s/R2s	272	4.3
R1	U1/R2s	76	1.2
U2	U2s/R3s	716	11.4
U3/R3	U3st/R3st	2,244	35.6
6	6	1,755	27.8
Total		6,300	100.0

The land classification for each soil series was studied on the basis of the explanatory note on soil series given by the Land Development Department. The study results are, together with detailed data for land classification, given in Table III-3. The land classification map is shown in Fig. III-3.

The results of land classification study shows that about 37% of the total study area, or about 2,301 km^2, are suitable for agricultural production, of which about 1,038 km^2 are suitable for paddy, 792 km^2 for upland crop and 471 km^2 are suitable both for paddy and upland crops.

2. SOILS OF PRIORITY AREAS

2.1 Priority Areas

The priority areas for development envisaged under the Mae Wong and Khlong Pho projects with a total net irrigable area of 657 km^2 (720 km^2 in gross area) are located on the north-eastern part of the Sakae Krang river basin. These areas occupy the alluvium plain extending between Mt. Mai Krathu and Mt. Luang.

The priority areas are located within two different sub-basins of Sakae Krang river; i.e., (1) Mae Wong river basin of about 2,170 km^2, and (2) Khlong Pho river basin of about 1,210 km^2.

The shape of the Mae Wong river basin is long and narrow stretching from north-west to south-east. The longest distance in this direction is about 50 km, and the width ranges from 10 to 20 km.

The Khlong Pho river basin also extends narrowly along the river. It is about 60 km long with narrow width of 2 to 5 km.

2.2 Physiography and Soils

The great part of the lands extending in the priority areas are classified as semi-recent Fan and Alluvium. The surface layers are composed of recent and semi-recent alluvial deposits derived from Mae Wong and Khlong Pho river systems.

The elevation of the Mae Wong river basin area ranges from 60 m to 100 m, and that of the Khlong Pho river basin area ranges from 20 m to 80 m.

The soils of the priority areas are classified into six (6) soil series. The results of soil classification are summarized as follows:

	Mae Wong area		Khlong Pho area	
	km^2	%	km^2	%
Non Calcic Brown Soils				
1. Phetchaburi series	257.1	53.8	118.2	65.9
2. Mae Sai series	94.1	19.7	5.9	3.3
3. Nakhon Pathom series	73.7	15.4	41.3	23.1
4. Komphaeng Saen series	32.0	6.7	-	-
Sub total	456.9	95.6	165.4	92.3
Low Humic Gley Soils				
5. Roi Et series	11.4	2.4	13.6	7.7
Gray Podzolic Soils				
6. Ubon series	9.7	2.0	-	-
Total	478.0	100.0	179.0	100.0

The results of the soil classification in the priority areas show that more that 90% of the total area are covered with Non Calcic Brown Soils. The rests are composed of two Great Soil Groups, Low Humic Gley Soils and Gray Podsolic Soils.

2.3 Land Classification

The land classification in the priority areas is summarized as follows:

(Unit: km^2)

	Mae Wong	Khlong Pho	Total
R1	73.7	41.3	115.0
R2	268.5	131.8	400.3
R2/U2	94.1	5.9	100.0
U2	41.7	-	41.7
Total	478.0	179.0	657.0

The results of land classification study indicate that about 78% of the total priority area, or about 515 km^2 are suitable for paddy cultivation, and about 15%, or about 100 km^2 are suitable both for paddy and upland crops. The remainning 7% of this area are suitable only for upland crop.

The land classification map covering the priority areas are given in Fig. III-3.

2.4 Agricultural Limitation and Suggested Land Use

The general features of the major land classes are given in Table III-4, together with suggested land use for each of land class.

3. SOIL SURVEY FOR FEASIBILITY STUDY

Supplemental soil survey for the feasibility study should be carried out, with special attention to the distribution and the depth of coarse textured soils, i.e., Phetchaburi series and Kamphaeng Saen series.

The soil distribution in the central part of the Mae Wong river basin near Lat Yao is complicated. The soil boundaries will have to be confirmed. To complete the detailed soil and land classification study for the priority area, the following items should be included in the feasibility study:

a. Detailed soil profile survey,

b. Soil infiltration test,

c. Soil sampling for laboratory tests,

d. Soil laboratory tests,

e. Analysis of data obtained from field survey and laboratory tests,

f. Preparation of detailed soil map,

g. Land classification study and preparation of detailed land classification map.

Table III-1 RESULTS OF SOIL CLASSIFICATION

(Unit: km^2)

Land Form	Great Soil Group	Soil Series	Sub-basin: Mae Wong Area	Mae Wong %	Khlong Pho Area	Khlong Pho %	Thap Salao Area	Thap Salao %	Khok Khwai Area	Khok Khwai %	Sakae Krang Area	Sakae Krang %	Total Area	Total %
Flood Plains	Alluvial Soils	Tha Muang	-		-	-	46	3.7	15	1.4	16	2.9	77	1.2
	-do-	Alluvial Complex	-		-	-	24	1.9	15	1.4	79	14.2	118	1.9
	(Sub-total)						(70)	(5.6)	(30)	(2.8)	(95)	(17.1)	(195)	(3.1)
Semi-Recent Pan and Alluvium	Non Calcic Brown Soils	Phechaburi	207	9.5	120	9.9	48	3.8	54	4.9	204	36.6	633	8.6
	-do-	Nakhon Pathom	74	3.4	41	3.4	154	12.3	-	-	39	7.0	308	4.9
	-do-	Mae Sai	51	2.3	26	2.1	-	-	-	-	-	-	77	1.2
	-do-	Kamphaeng Saen	212	9.8	761	13.3	151	12.0	145	13.1	12	2.2	681	12.2
	(Sub-total)		(544)	(25.0)	(348)	(28.7)	(353)	(28.1)	(199)	(18.0)	(255)	(45.8)	(1699)	(26.9)
Low Terraces	Low Humic Glay Soils	Deum Bang	67	3.1	13	1.1	19	1.5	33	3.0	-	-	132	2.1
	-do-	Pak Tho	-	-	-	-	13	1.0	37	3.3	17	3.1	67	1.1
	-do-	Roi Et	85	3.9	12	0.1	-	-	-	-	-	-	97	1.5
	Gray Podzolic Soils	Ubon	35	1.6	-	-	-	-	-	-	-	-	35	0.6
	-do-	San Pa Tong	-	-	-	-	-	-	76	6.9	-	-	76	1.2
	(Sub-total)		(187)	(8.6)	(25)	(1.2)	(32)	(2.5)	(146)	(13.2)	(17)	(3.1)	(407)	(6.5)
High Terraces	Gray Podzolic Soils	Korat	449	20.7	135	11.1	-	-	81	7.3	-	-	665	10.6
	Regosols	Nam Phong	97	4.5	23	1.9	32	2.6	73	6.6	17	3.1	242	3.9
	(Sub-total)		(546)	(25.2)	(158)	(13.0)	(32)	(2.6)	(154)	(13.9)	(17)	(3.1)	(907)	(14.5)
Dissected Erosion Surfaces	Regosols	Chan Tuk	119	5.5	135	11.1	31	2.5	-	-	-	-	285	4.5
	Red Yellow Podzolic Soils	Thap Salao	35	1.6	338	29.3	213	17.0	253	22.8	84	15.1	923	14.6
	-do-	Tha Yang	22	1.0	-	-	21	1.7	-	-	-	-	43	0.7
	Red Brown Lateritic Soils	Chiang Khan	80	3.7	6	0.1	-	-	-	-	-	-	86	1.4
	(Sub-total)		(256)	(11.8)	(479)	(40.5)	(265)	(21.2)	(253)	(22.8)	(84)	(15.1)	(1337)	(21.2)
Mountains		Slope Complex	638	29.4	201	16.6	501	40.0	326	29.3	89	15.8	1755	27.8
	Total		2171	100.0	1211	100.0	1253	100.0	1108	100.0	557	100.0	6300	100.0

TABLE III-2 SPECIFICATION FOR SEMI-DETAILED LAND CLASSIFICATION

Classification Characteristics	Upland			Rice-Land		
	U1	U2	U3	R1	R2	R3
SOIL						
Soil texture	SL-fri. CL	LS-p. C LS<30 cm	LS-sp. C LS<60 cm	CL-vsp. C CL<30 cm	SL-VSP. C SL<15 cm L < 30 cm CL>30 cm	LS-vsp. C LS<15 cm
Depth of soil	150 cm	120 cm	90 cm	90 cm	60 cm	30 cm
pH (paste)	5.5 - 8.0	5.0 - 8.5	4.5 - 8.5	5.0 - 8.0	4.5 - 8.5	4.0 - 8.5
Salinity $EC_e \times 10^3$	<4	<6	<8	<4	<6	<8
Exchangeable sodium meq/100 gm	<2	<2	<3	<3	<4	<4
Water-holding capacity in 120 cm depth	15 cm	11 cm	8 cm	Not applicable	Not applicable	Not applicable
TOPOGRAPHY						
Relief	Smooth	Uneven	Rough	Smooth	Uneven	Rough
Slope	<2%	<4%	<6%	<2%	<4%	>4%
Leveling requirement	Low	Medium	High	Low	Low	Medium
Gravel or rock	Few	Few	Some but tillable	Few	Few	Some but tillable
Rock removal	None	None	Some	None	None	Some
Trees or brush cover	Slight clearing	Moderate clearing	Heavy clearing	Slight clearing	Moderate clearing	Heavy clearing
DRAINAGE						
Surface	Good	Good-fair	Fair-poor	Good	Good-fair	Fair-poor
Sub-surface	Good	Good-fair	Fair-poor	Poor	Good-fair	Good
Flood	None	None	Occasional	Infrequent damaging floods	Periodic damaging floods	Annual damaging floods

Class 6: Non-arable lands - includes all lands which do not meet the minimal requirements for class 1, 2 and 3.

Table III - 3 (1) RESULTS OF LAND CLASSIFICATION

Land Form	National Soil Series (Symbols)	Classification 1. National 2. USDA	Range of Slope (%)	Effective Soil Depth	Texture a. Surface b. Sub-surface	Colour Profile a. Surface b. Sub-surface	a. Drainage b. Permeability c. Surface Runoff	Reaction (pH)	Vegetation or Present Land Use	Land Classification	Area (km^2)
Flood Plains	Alluvial complex (Ac)	1. Alluvial Soils 2.		shallow						U2s / R2s	118
	Tha Muang (Tm)	1. Alluvial Soils 2. Typic Ustifluvents	<2	deep	a. loam b. clay loam	a. grayish brown b. darkyellowish brown	a. poor b. slow c. medium	a. 6.0 b. 6.5	broadcasted rice,	U2s / R2s	77
Seni-Recent Fan and Alluvium	Nakhon Pathom (Np)	1. Non Calcic Brown Soils 2. Ultic Haplustalfs	<1	very deep	a. clay loam b. light clay or clay loam	a. dark brown b. dark grayish brown	a. poor b. slow c. slow	a. 6.0∿7.0 b. 7.0∿8.0	transplanted rice,	U3sd / R1	308
	Phechaburi (Pb)	1. Non Calcic Brown Soils 2. Ultic Haplustalfs	<2	very deep	a. sandy loam b. clay loam	a. brown b. yellowish brown	a. poor b. slow c. slow	a. 6.0 b. 6.5	treansplanted rice,	U3sd / R2s	633
	Kamphaeng Saen (Ks)	1. Non Calcic Brown Soils 2. Udic Haplustalfs	<1	very deep	a. loam b. clay loam	a. brown b. brown	a. well b. medium c. slow	a. 6.5 b. 7.5	rice, upland-crops and orchards	U2sd / R3s	681
	Mae Sai (Ms)	1. Non Calcic Brown Soils 2. Aeric Tropaqualfs	<1	very deep	a. silty loam b. silty clay loam	a. dark gray b. grayish brown	a. poor b. slow c. slow	a. 6.0 b. 7.5	transplanted rice,	U2 / R2s	77
Low Terraces	Deum Bang (Db)	1. Low Humic Gley Soils 2. Aeric Tropaqualfs	<1	very deep	a. sandy loam b. sandy clay	a. grayish brown b. grayish brown	a. poor b. medium c. medium	a. 5.0 b. 6.0	transplanted rice,	U2sd / R2s	132
	Pak Tho (Pth)	1. Low Humic Gley Soils 2. Aeric Paleaquults	<1	very deep	a. loam b. clay loam	a. grayish brown b. light gray	a. poor b. slow c. slow	a. 4.5 b. 5.5	transplanted rice,	U2sd / R2s	67

Table III - 3 (2) RESULTS OF LAND CLASSIFICATION

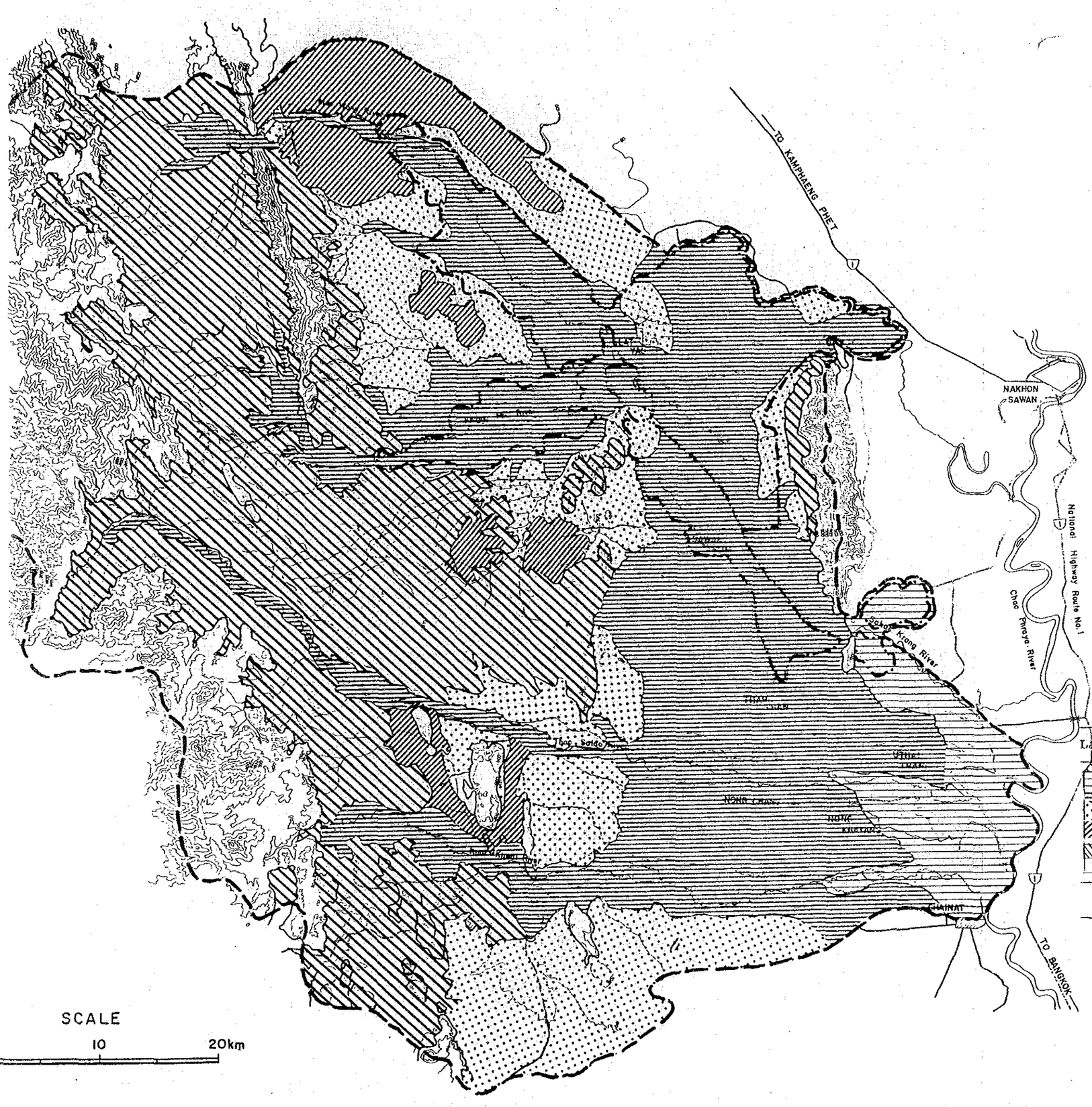
Land Form	National Soil series (Symbols)	Classification 1. National 2. USDA	Range of Slope (%)	Effective Soil Depth	Texture a. Surface c. Sub-surface	Colour Profile a. Surface b. Sub-surface	a. Drainage b. Permeability c. Surface Runoff	Reaction (pH)	Vegetation or Present Land Use	Land Classification	Area (km^2)
Low Terraces	Roi Et (Re)	1. Low Humic Gley soils 2. Aeric Paleaquults	<2	deep	a. sandy loam b. sandy clay loam	a. grayish brown b. light brown	a. poor b. rapid ∿ slow c. slow	a. 5.0∿6.5 b. 4.5∿6.0	transplanted rice,	U3sd / R2s	97
	Ubon (Ub)	1. Gray Podzolic soils 2. Aquic Dystropepts	<2	deep	a. loamy sand b. sandy loam	a. light brown b. light brown	a. well b. rapid c. slow	a. 6.0 b. 6.0	transplanted rice	U2s / R3s	35
	San Pa Thong (Sp)	1. Gray Podzolic Soils 2. Oxic Dystropepts	<2	very deep	a. sandy loam b. sandy clay loam	a. light brown b. pale brown	a. well ∿ medium b. rapid c. slow	a. 5.5∿6.0 b. 4.5∿5.0	opened dipterocarp forest, upland crops	U1 / R2s	76
High Terraces	Korat (Kt)	1. Gray Podzolic Soils 2. Oxic Paleustults	2 ∿ 6	deep	a. sandy loam loamy sand b. loam ∿ sandy loam	a. grayish brown b. brown	a. well b. rapid c. rapid	a. 5.5∿6.5 b. 4.5∿5.5	forest	U3st / R3st	665
	Nam Phong (Ng)	1. Regosols 2. Ustoxic Quartzipsamments	3 ∿ 10	shallow	a. loamy sand b. loamy sand	a. grayish brown b. pinkish brown	a. excessive b. rapid c. rapid	a. 5.0∿6.5 b. 4.5∿5.5	forest	U3st / R3st	242
Dissected Erosion Surface	Tha Yang (Ty)	1. Red Yellow Podzolic Soils 2. Paleustults	4 ∿ 20	shallow	a. sandy loam (gravelly) b. clay loam (gravelly)	a. dark brown b. brown	a. well b. rapid c. rapid	a. 5.5∿6.5 b. 5.0∿6.0	forest	U3st / R3st	43
	Chiang Khan (Ch)	1. Reddish Brown Lateritic Soils 2. Paleustults	4 ∿ 20	shallow	a. gravelly loam b. gravelly clay loam	a. dark brown b. reddish brown	a. well b. rapid c. rapid	a. 5.5∿7.0 b. 4.5∿5.5	forest and upland crops	U3st / R3st	86

Table III - 3 (3) RESULTS OF LAND CLASSIFICATION

Land Form	National Soil Series (Symbols)	Classification 1. National 2. USDA	Range of Slope (%)	Effective Soil Depth	Texture a. Surface b. Sub-surface	Colour Profile a. Surface b. Sub-surface	a. Drainage b. Permeability c. Surface Runoff	Reaction (pH)	Vegetation or Present Land Use	Land Classification	Area (km^2)
Dissected Erosion Surface	Thap Salao (Tas)	1. Red Yellow Podzolic Soil 2. Ustoxic Quartzipsamments	2 ∿ 8	shallow	a. gravelly loamy sand b. gravelly silty loam		a. well b. rapid c. rapid		forest and upland crops	U3st / R3st	923
	Chan Tuk (Cu)	1. Regosols 2. Ustipsamments	2 ∿ 5	shallow	a. loamy sand b. loamy sand	a. dark brown b. pale brown	a. well b. rapid c. rapid	a. 6.0∿7.0 b. 5.5∿7.0	forest	U3st / R3st	285

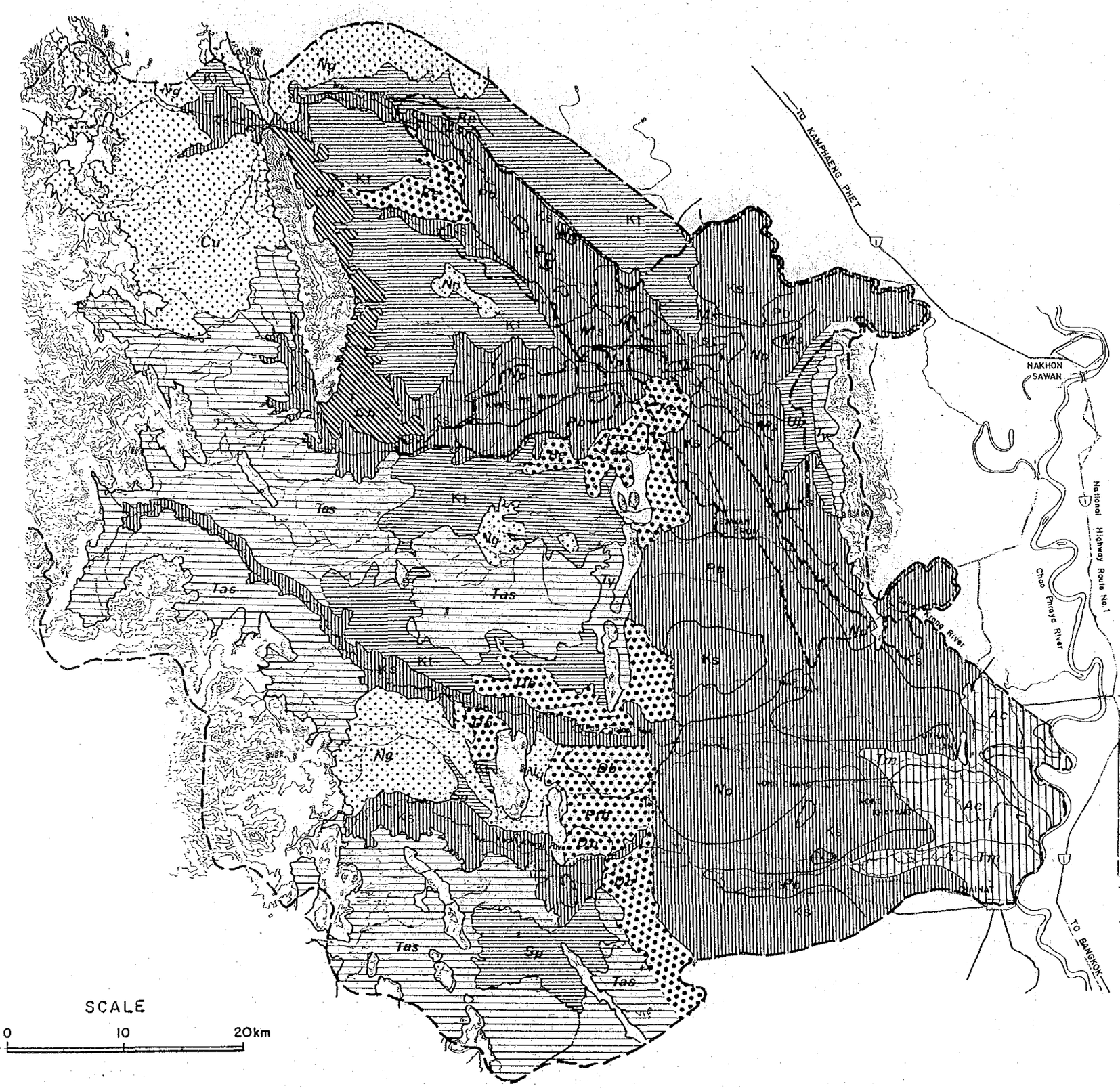
TABLE III-4 GENERAL FEATURES OF LAND CLASSES AND SUGGESTED LAND-USE

Land Class	Area (km^2)	Agricultural Limitations for 1) rice cultivation, and 2) upland cropping	Present Land-Use	Suggested Land-Use	Management Factors for Suggested Land-Use
R1 : U3sd/R1	115.0	1) No limitation 2) Heavy texture, poor drainage, moderate fertility	Irrigated rice	Best suitable for irrigated double cropping of rice or raining season paddy combined with upland dry season cropping under irrigation.	Use of fertilizers on the basis of experimentation.
R2 : U3sd/R2s	400.3	1) Loamy texture, moderately low fertility 2) Moderately poor drainage, moderately low fertility	Mostly irrigated rice	Suitable for irrigated double cropping of rice or rainy season paddy combined with upland dry season cropping under irrigation.	Adequate water supplies and fertilization.
U2/R2 : U2sd/R2s	-	1) Low fertility 2) Poor drainage, Heavy texture	Semi-irrigated rice	Suitable for irrigated rice cultivation or combination with irrigated upland cropping.	Drainage improvement, adequate use of fertilizers.
U2/R2 : U2s/R2s	100.0	1) Low fertility, loamy texture 2) Low fertility	Semi-irrigated rice or rainfed rice	Suitable for either irrigated upland crops or irrigated rice cultivation.	Rotational cropping for upgrading soil fertility and adequate supplies of water and fertilization.
U2 : U2s/R3s	41.7	1) Slightly coarse texture, moderate infiltration, low fertility 2) Low fertility	Mung beans, maize and, in places, rainfed rice cultivation	Suitable for irrigated upland crops or adaptable for irrigated rice cultivation.	Land levelling and laying out of small fields, and adequate water supplies and fertilization.
Total	657.0				



Land Form	Area (Km^2)
Flood Plains	195
Semi-Recent Fan and Alluvium	1,699
Low Terraces	407
High Terraces	907
Dissected Erosion Surface	1,337
Mountains	1,755
Total	6,300

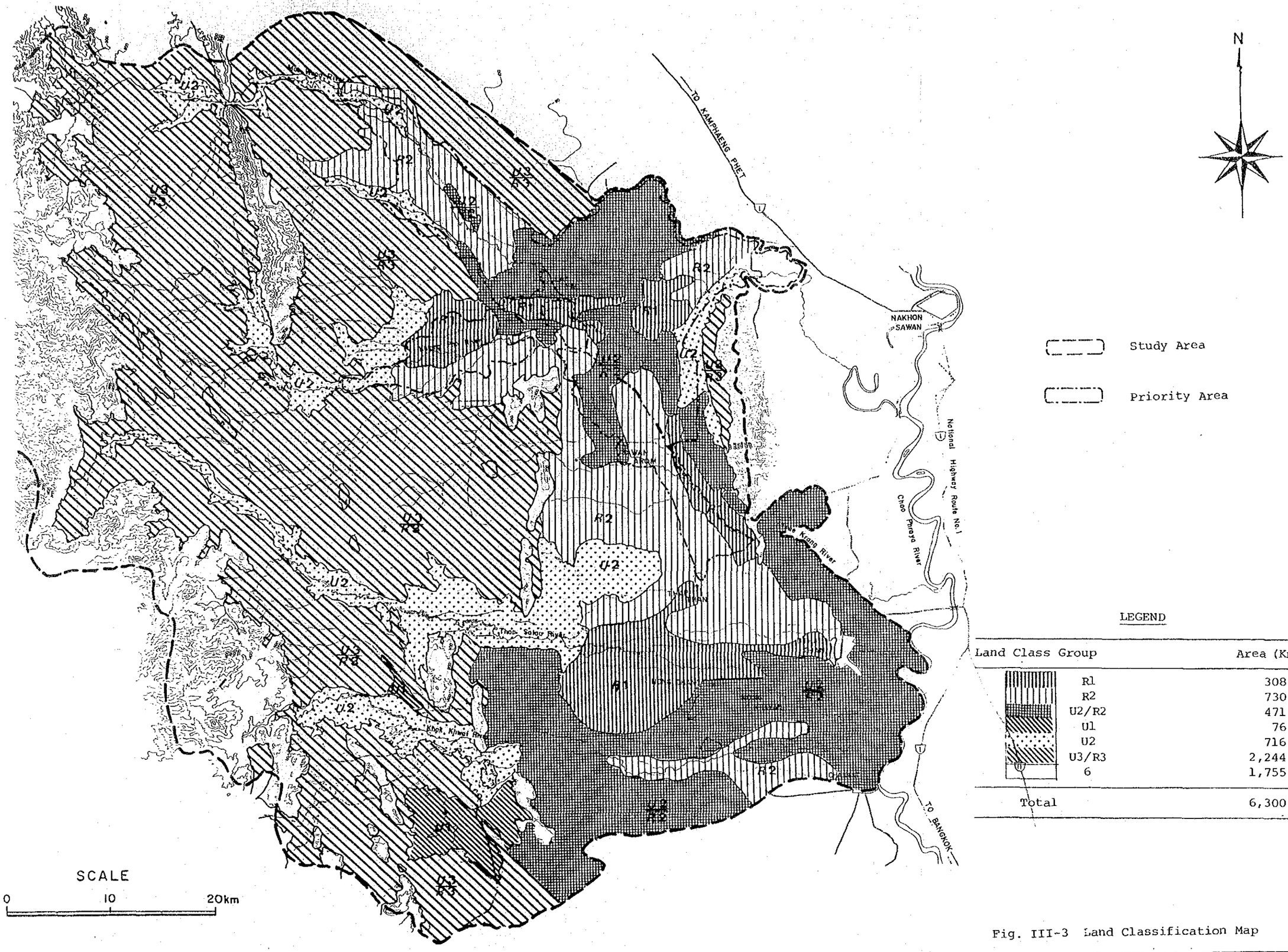
Fig. III-1 Land Form Map



LEGEND

Great Soil Group	Area (Km^2)
Alluvial Soils	195
Non Calcic Brown Soils	1,699
Low Humic Gley Soils	296
Gray Podzolic Soils	776
Regosols	527
Red Yellow Podzolic Soils	966
Red Brown Lateritic Soils	86
Mountain Slopes	1,755
Total	6,300

Fig. III-2 Soil Map



LEGEND

Land Class Group	Area (Km^2)
R1	308
R2	730
U2/R2	471
U1	76
U2	716
U3/R3	2,244
6	1,755
Total	6,300

Fig. III-3 Land Classification Map

ANNEX IV
AGRICULTURE

ANNEX-IV

AGRICULTURE

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AGRICULTURE

1. PRESENT CONDITION OF AGRICULTURE

1.1 Demography

The past census results indicate that the total population of the Study Area is about 240,000 persons in 1970 and about 295,000 persons in 1980, and has been increasing at the rate of 2.4% per annum. The present population as of 1984 is estimated at about 324,000 in total. The population density is about 50.9 persons per km^2. Total number of household is about 61,400, out of which farm household accounts for 43,800 or 71% of the total. Average size of farm household is 4.8 persons. Farm labour force ranges 2-3 persons per farm household on an average. The demographic data of the Study Area are given in Table IV-1.

1.2 Land Tenure and Land Holding

The agricultural census in 1978 reveals that in the Study Area, about 98% of farm household own their farm land with an average holding size of 27 rai (4.3 ha). Distribution of farm household by different size of holding is as follows (for details, see Table IV-3):

Land Holding size (rai)	Percentage of farm household (%)
Less than 6	5.9
6 to 15	11.9
15 to 25	18.8
25 to 40	29.1
40 to 60	19.8
60 to 100	11.1
More than 100	3.4

1.3 Present Land Use

Of the total area of 3.94 million rai (6,300 km^2) in the Sakae Krang river basin, permanent agricultural holdings account for 1.16 million rai (1,860 km^2). The rest of 2.78 million rai (4,440 km^2) are mountains, steep slopes, forest reserve, rivers and swamps, roads and public facilities compounds. The major types of agricultural land use are paddy, upland crops, orchard, forest and pasture. The distribution of these major land use types are shown in Fig. IV-1. The pattern of land utilization closely relates with the land-form patterns and soil-type distribution. Paddy field is mostly confined to semi-recent alluvial plain of the Sakae Krang river and the low terraces. Upland crops field mainly extends on middle and high terraces, while orchard and pasture are observed sporadically within upland crop areas.

Present agricultural land use is summarized as follows:

(Unit: km^2)

River Basin	Agricultural Land Use			Non-agric Land	Total
	Paddy	Upland Crops	Orchard & others		
Mae Wong	520	170	20	1,461	2,171
Khlong Pho	158	52	41	960	1,211
Sakae Krang	248	17	30	262	557
Thap Salao	298	23	8	924	1,253
Khok Khwai	166	98	11	833	1,108
Total	1,390	360	110	4,440	6,300

Paddy rice is by far the most important crop, grown on about 75% of the total agricultural land. Upland crops occupy virtually most of the remaining agricultural land. Major crops grown on the upland field are maize, sorghum, mung beans, cassava and sugar cane.

Interpretation of Landsat imagery made between 1978 and 1982 by the Forestry Department indicates serious destruction of forest area in two provinces of Nakhon Sawan and Uthai Thani which cover most of the Study Area. For the 1978-1982 period, a reduction of 228 km^2, or 6.9% of previously forest area, is observed:

(Unit: km^2)

Province	Total Area	Forest Area		Deforested Area
		1978	1982	
Nakhon Sawan	9,593	1,142	1,037	105
Uthai Thani	6,730	3,050	2,867	183

The deforested land has partly been brought under upland crop cultivation and partly laid bare or covered only with scrub mainly due to poor soil conditions.

1.4 Present Cropping Pattern

There exist about 869,000 rai of paddy field (139,000 ha) and about 225,000 rai of upland crop field (36,000 ha) in the Sakae Krang river basin. Different cropping patterns are observed on the paddy field, depending on the degree of irrigated condition.

Irrigation facilities are well developed in this area. About 534,000 rai (85,500 ha) or 61% of the existing paddy fields, are more or less presently provided with irrigation facilities, while all of the upland crop fields are rainfed. In this area, existence of irrigation facilities does not mean continuous year-round irrigation, but supplemental water supplies for rainy season paddy cultivation. Even though irrigation facilities are provided, all these paddy fields are not always actually irrigated due to limited availability of water. In general, paddy fields extending along

upstreams of major rivers, are rather sufficiently irrigated, while the ones along the downstreams are less irrigated or not actually irrigated and are likely subject to annual drought damages.

Difficulties are involved in estimating the extent of well irrigated paddy field, because the area well-irrigated largely fluctuates year by year depending upon seasonal water availability. The 1978 Agricultural Census indicates that some double cropping was carried out on about 146,000 rai of the paddy fields (23,400 ha) in 1978/79. This suggests that these double cropping areas are sufficiently irrigated, and that other paddy fields with irrigation facilities are supplementarily irrigated only for rainy season paddy cultivation or partly put under rainfed cultivation due to lack of water. Water balance study on existing condition indicates that about 58% of the total paddy fields with irrigation facilities, or about 308,000 rai (49,300 ha) of the paddy fields are irrigated in the rainy season under normal condition with 80% probability rainfall. Field observations confirm these preliminary study results; i.e., the existing paddy field is classified:

Paddy Field	Area		Percentage (%)
	rai	ha	
Paddy Field with Irrigation Facilities	534,000	85,500	61.5
(1) irrigated (double cropping)	146,000	23,400	16.8
(2) irrigated (single cropping)	162,000	25,900	18.6
Sub-total	308,000	49,300	35.5
(3) mainly rainfed (single cropping)	226,000	36,200	26.0
Rainfed Paddy Field	335,000	53,500	38.5
Total:	869,000	139,000	100.0

As seen from the above, only 36% of the paddy field is actually irrigated. The representative cropping patterns on these categorized paddy fields are shown on Fig. IV-2.

The irrigated paddy field where some double cropping is carried out, mainly extends along the upstream of the Mae Wong river. In these areas, paddy is planted from mid-June and harvested in November-December. Local varieties of paddy like Luang Pra Tarn and Kao Dawk Mali are planted on about 60% of the area; the rest is planted with high yielding varieties (H.Y.V.) like RD 7 and RD 21. Dry season cropping usually starts immediately after harvesting of rainy season paddy. The extent of dry season cropping is around 20% of the area. Major crops in the dry season are mung beans (15%) and paddy (5%).

The paddy field where irrigated single paddy cropping is almost guaranteed with adequate supply of irrigation water, is observed on the upstream areas of each existing irrigation block. In these area, only rainy season paddy is cultivated on almost 100% of the paddy field. Local varieties are predominantly used for about 75% of the area. Paddy is usually planted from early July and harvested in December-January.

Rainfed paddy field has two categories as previously mentioned; i.e., (1) paddy field with irrigation facilities however not actually irrigated due to lack of water supplies, and (2) ordinary rainfed paddy field without irrigation facilities. These paddy fields extend over the downstream areas. Only rainy season paddy cropping is practiced in these areas. Planted area, however, largely fluctuates year by year; only about 50% of the area is planted in drought years and almost 100% in rainy years (however, harvested area is usually smaller than the planted area due to drought damages in drought years and flood damages in rainy years). Average planted/harvested area is estimated at about 75% of the paddy field.

Upland crop area extends mainly on middle and high terraces and mountain slopes. In the rainy season, maize is the major crop. In Nakhon Sawan province, sorghum is also planted, together with maize, in the rainy season. In Uthai Thani province, upland crop area is subject to annual flood damages; therefore, rainy season maize is planted in mid-April and harvested in August in order to avoid the major flood season in September/October. Dry season cropping is common. About 40% of the upland crop field are utilized for dry season cropping. Major crop is mung beans.

1.5 Farming Practices

The farming practices in the Sakae Krang river basin are still of conventional.

Land preparation: A combination of tractor power (8 ps class two wheel hand tractor) and animal draft are used; in interview with extension workers, it appeared that about 70% of paddy field are cultivated by hand tractors and 30% by buffaloes. This greater dependence on tractor power may be attributed to the large farm size and the fact that only short period is generally available for land preparation due to uncertain water supplies in the rainy season. Before land preparation, previous season's paddy stubble is burred in the dry months of March-April, and the field is ploughed using light showers of rain, or taking the irrigation water into the field where water is available, to moisten the soil, in May-June. A second harrowing is common. According to the information obtained from agricultural extension office in each Amphoe concerned, about 20% of farmers own their tractors and lend them to the neighbours at the cost of 150-200 Baht per rai. Second harrowing is usually carried out with standing water in the field, mainly in June.

Nursery/Transplanting: Nursery establishment is made in June-July and transplanting of 3-4 week old seedlings is in July-August. In the Sakae Krang river basin, the transplanted rice is predominant. Boardcasted rice is confined to only the flooded areas. Most of the rice grown in the area is non-glutinous.

Crop management: This comprises weed control, fertilizer application, control of plant pests and diseases and distribution of irrigation water. Weed control is generally made by hand. Investment for weeding is however, generally low and present condition of weed control is unsatisfactory. Use of fertilizers is generally limited. The local varieties do not receive any fertilizers, but HYVs do receive an application of some fertilizers. Chemical control of pest and diseases is not common. There is no farmer's institutions responsible for collective irrigation water distribution. Farmers take water at discretion from rivers/canals as they require if water is available. No rotational irrigation schedule is applied. Two wheel small tractors are fully used as power source for pumping water from river/ canal and tube wells.

Harvesting: The rainy season paddy is harvested in the dry months of November/December. Harvesting is carried out manually with sickle knives; the sheaves are left in the field for a period of drying and thereafter bundled and removed to the threshing floor. Threshing is usually made by tractor or under the feet of buffaloes. Winnowing is effected manually. Threshing/Winnowing is rather leisurely operation carried out over a 2-3 month period. The rice is thereafter bagged and transported, eigther for storage or for sale.

1.6 Crop Yield and Production

Paddy yield largely fluctuates year by year. Reasons are manifold. Decisive factor is, however, unstable water supply resulting from uneven seasonal distribution of rainfall as well as irregular total depth of annual rainfall which causes drought and flood repeatedly. Fig. IV-3 shows annual paddy yield and production in past 10 years in Nakhon Sawan and Uthai Thani. Relationship between paddy yield and annual rainfall is shown in Fig. IV-4.

Crop production in the Sakae Krang river basin is roughly estimated, by multiplying the estimated crop areas and unit yield data given in the agricultural production statistics (1973/74 - 1982/83), as follows:

Crop	Crop Area (1,000 Rai)	Crop Production (1,000 ton)		
		Highest	Lowest	Average
Major Rice	869	283	137	234
Second Rice	7	5	4	4
Mung Beans	99	18	6	13
Maize	132	53	21	36
Sorghum	64	14	8	11
Cassava	13	40	27	33
Sugar Cane	12	114	54	102
Cotton	4	-	-	-

1.7 Livestock

Various kinds of livestock; i.e., buffaloes, cattle, swine, goat, chicken and duck, are raised individually in the Sakae Krang river basin. Buffaloes still play an important role in land preparation. Others are not economically significant in present farm economy.

1.8 Crop Marketing and Processing

Paddy rice is both the subsistence crop and the only significant cash crop in the basin. In visits to the agricultural extension offices at each changwat concerned, it was learned that about 50% of paddy production was intended for sale. In addition, part of the produce stored for consumption will also be sold, when the following harvest is secured. The value of paddy depends in past on its grain quality which is in turn chiefly a matter of variety and cultivation method. Greding of paddy is normally undertaken by hand milling of a few sample grains and quality is judged by eye. The marketing of paddy remains largely a private sector activity. The farmer usually negotiates a sale at his home, to either a middle man, or directly with an agent of the rice mills.

There are about 800 rice mills in the provincial areas of Nakhon Sawan and Uthai Thani. Paddy is not necessarily milled in the area where it is grown. Provincial middlemen may transport it to other centres inside or outside the province, seeking the best price. The miller may sell some of the rice locally, but much of the rice will go to the Bangkok wholesale market, and prices there largely influence what the miller can offer for paddy to the farmer. In an overall sense, the private marketing system appears to operate efficiently within the Basin area. There are inevitably disputes between farmers and merchants on the grading of the paddy; however, each farmer has an opportunity to compare offers from several merchants and/or agents of the rice mills.

The farm gate price of paddy fluctuates seasonally. Present average farm gate price of paddy is 2,800-2,900 Baht per ton.

1.9 Agricultural Institutions

A number of governmental and non-governmental organizations play a major role for improvement of rural life and increase of agricultural production. Among the organizations, the Ministry of Agriculture and Cooperatives is systematically leading the agricultural supporting services for the farmers.

Agricultural extension: The Sakae Krang river basin area is covered by the early phase of the National Agricultural Extension Project, financed by the World Bank in 1977. According to the provincial extension offices in the Basin area, the Project components are already finalized and in operation. The full staff complement of extension workers is also in place with transport. Package of practices has been determined and pre-season training and visiting schedules are established. In each tambon at least one extension worker is assigned. Extension work is concentrated on rice and maize.

Farmer organization: There are several agricultural cooperatives in the Basin area. Apart from the informal exchange and hire of farm labour and equipment, there is little evidence of cooperative movements in farming and marketing. There is no water user's association in the existing irrigation areas.

Agricultural research: The Basin area is well served by the Chainat Rice Experiment Station which is part of the Rice Division of the Department of Agriculture. All important aspects of rice research are covered by this station, including seed multiplication, crop rotation and plant protection in rice crops. Field extension workers are trained in rice production technique by the staff of this station.

The Chainat Field Crop Research Institute is one of the branch stations under the Department of Agriculture. In this station, emphasis is laid on testing dry season upland crops rotations with rainy season paddy.

Agricultural credit: The main sources of institutional credit are (1) the Bank for Agriculture and Agricultural Cooperatives (BAAC). (2) the Agricultural Cooperatives and (3) the Farmers' Marketing Organization. Agricultural loans are extensively utilized for the purchase of equipments, land, seasonal inputs and hire of labour. In addition, large portion of farmers receives consumer goods and farm inputs on credit terms from local merchants.

Input distribution: All farm inputs are supplied by the private merchant; however, credit-linked inputs such as fertilizers are increasingly supplied through the credit institutions themselves. Fertilizer is obtained from the Farmers' Marketing Organization at Bahts 4,200/ton for cash and Bahts 4,400/ton on credit terms for compound fertilizer (16-20-0).

2. AGRICULTURAL CONSTRAINTS AND BASIC STRATEGIES FOR DEVELOPMENT

2.1 Current situations

About 0.32 million people lived in the Sakae Krang river basin primarily rely on agriculture. Farm household accounts for about 70% of the total household. Others are mostly engaged in trading, transportation, and public administration which support the agricultural activities. Agriculture contributes to about 45% of gross regional product, while it accounting for only about 25% of GDP in national economy. Agriculture has been and will continue to be the most important key determinant in regional economy of the basin area.

The Sakae Krang river system consists of four major rivers; i.e., the Mae Wong, Khlong Pho, Thap Salao andKhok Khwai. The river discharge in the basin reaches maximum in October and becomes minimum in March. Annual rainfall averages about 1,200 mm, of which almost 90% concentrates in the rainy season from May to October. Of total basin area of 6,300 km^2, the agricultural land is about 1,860 km^2. The rests of 4,440 km^2 are non-agricultural lands like mountains, steep slopes, forest reserve, rivers and swamps, roads and urban areas. The agricultural land consists of 1,390 km^2 of paddy field, 360 km^2 of upland crop field and 110 km^2 of orchard and others.

Paddy rice is by far the most important crop, grown on about 75% of the total agricultural land. Paddy cultivation is concentrated in the rainy season and extremely limited in the dry season, bacause the dependable water reasources are completely exhaused during the dry season. The planted area of paddy, even in the rainy season, widely fluctuates year by year depending on the endowed rainfall and river flow. The paddy yield is directly affected by total depth of annual rainfall. After harvesting the rainy season paddy, the farmers grow upland crops mainly mung beans in the very limited area where irrigation water is readily available. It is not common that dry season paddy is planted as a second crop.

About 61% of the existing paddy fields, or 534,000 rai (85,500 ha) in area, are presently covered with the existing irrigation schemes of 56 in number; one large scale (Thap Salao), five medium scale and 50 small scale irrigation projects. However, most of the paddy fields still remain under rainfed condition. Present water balance study on existing condition indicates that the dependable water resources is not sufficient for supplying the irrigation water throughout the growth period of rainy season paddy, to a whole irrigation area. The preliminary result of the study implies that only about 58% of the existing irrigation area are actually served with water supplies and others are laid under rainfed condition under normal rainfall condition with 80% probability.

Most of the irrigation canals aligned in the existing paddy fields are unlined. These canals are generally deteriorated due to improper maintenance. The density of the existing canal network is very low. This makes equitable distribution of irrigation water difficult. No technical drainage system has been provided so far in the existing irrigation area. Most of the existing canal have dual function of irrigation and drainage. This substantially contributes to repeated use of the limited water resources.

The present farming practices is still of conventional; local varieties are still predominant, use of fertilizers is limited, agro-chemicals for plant protection are not used, use of certified extension seeds is very rare, etc. These apparent limitations for agricultural production increase come from present unreliable water availability, because most of the improved farming practices are possibly introduced only under the condition that irrigation water is assured.

2.2 Agricultural Constraints

The Sakae Krang river basin is endowed with vast land resources suitable for agricultural production. Nevertheless, land productivity is still very low, due to various problems and constraints involved in the current agriculture. The major problems and constraints are:

(1) Annual shortage and uneven distribution of rainfall,

(2) Occasional floods,

(3) Unreliable water sources for irrigation,

(4) Inadequate canal networks and insufficient density of canals which make equitable water distribution difficult,

(5) Improper water management and lack of water user's associations,

(6) Insufficient farm road network,

(7) Scattered type of land holding pattern and small size of field plots, and

(8) Conventional farming practices.

The problems are manifold; however, the most important single constraint to agricultural development in the basin is the lack of assured irrigation facilities coupled with the shortage of available water. The rainy season paddy crop often suffers from moisture stress at critical periods of growth, resulting in total or partial crop damages. There is a great concern among the farmers in the basin for such almost regular drought conditions than crop damages from any other causes. Other constraints such as yield limitations of local variety, low input use and inadequate crop management should become secondary in importance when considered against regular crop damages caused by present irregularity in water supply.

2.3 Basic Strategies for Development

The Kingdom of Thailand sustained about 8% of the economic growth rate during the recent decade of 1970's. Such rapid stride of the economic growth in the country caused serious and complex economic problems and social tensions (for detail, see Chapter II). In order to overcome such problems and tensions, the Fifth Economic and Social Development Plan (1982-1986) has been set out containing long term strategies and new approaches. Major objectives given in the Development Plan are:

(1) to restructure the key productive sectors like agriculture so as to improve the current economic and financial situations,

(2) to reduce absolute poverty and accelerate rural development in backward areas, and

(3) to uplife rural living standard as well as strive more equitable distribution of income.

Two provinces of Nakhon Sawan and Uthai Thani where most of the Sakae Krang river basin are included, have about 2.6% of the Kingdom's population. The share of the provinces in GDP is however only less than 1.3%. The relatively poor position of the area is also indicated by its lag in percapita income; the average in past five years amounts to about 3,670 Bahts, corresponding to roughly two-third of national average (5,610 Bahts). The area suffers also from the instability in annual income which fluctuates largely year by year. Such poor economic situation of the area is mainly derived from low productivity of agriculture which is definitely ascribed to lack of assured irrigation system coupled with the shortage of available water.

Paddy cultivation is a mainstay in the Sakae Krang river basin. It is surely suited to the area in economic-social-histrical-cultural-physical context. The area is endowed with good soils and climate (except rainfall) suitable for paddy cultivation and the farmers are accustomed to paddy cultivation. Farmers heavily rely on paddy production economically. It however gives them only instable results of yield due to irregular water availability. The most important sole constraint to rural development in this area is again shortage of available water.

The Government of Thailand has emphasized the importance of paddy production increase in the Fifth National Development Plan. It is generally recognized among the government officials that for increase of paddy production, more attention will be given to the improvement of unit yield per rai because expansion of paddy field has become rather difficult in the country, and the priority is given to the improvement of unit yield in the existing paddy fields of the Central and Northern Regions where exploitable water resources still remain. The Sakae Krang river basin is one of the areas endowed with such exploitable water resources.

The irrigated paddy field in the Sakae Krang river basin is limited to only 36% of the total existing paddy fields; others are presently put under rainfed condition. The irrigated paddy field is mostly located along the upstream of each river, and the rainfed paddy fields extend over the downstream areas. There is clear difference in crop yield and therefore in farm income between irrigated area and rainfed areas. It is reported that serious disputes for river water are often occured between farmers in upstream areas and those in the downstream areas. This causes some social tensions in the area.

Considering all these, basic strategies for development in the Sakae Krang river basin are considered as follows:

(1) The area is endowed with large potential for rice production and therefore the current poor economic position should be improved through full utilization of the endowed resources for increase of paddy production.

(2) The present rural living standard should be uplifted with particular emphasis on improvement of present income disparity in the area.

These basic principles are exactly conformed to the government policy given in the Fifth National Development Plan. With these in mind, the basic development concept for the Sakae Krang river basin is conceived as in the following. Major items of the basic concept are:

(1) exploitation of new water resources by means of dam construction,

(2) full utilization of existing irrigation systems and improvement of existing facilities, and

(3) expansion of irrigated paddy field.

These measures will significantly contribute to the realization of the above basic requirement for rural development in the Sakae Krang river basin. In order to realize these measures and attain the prospective goals, more precise guidelines for formulation of development plans will be required. The proposed guidelines for development planning in the fields of agriculture are given as follows:

(1) Cultivation of rainy season paddy should be stabilized through optimum utilization of newly exploited water resources.

(2) Unit yield of rainy season paddy should be maximized through proper supplemental irrigation and improved farming practices.

(3) Supplemental irrigation area for rainy season paddy should be maximized with full use of the limited exploitable water resources; however, first priority should be given to the existing irrigation area, the rainfed areas should be benefited within economically reasonable range.

(4) Special attention should be paid to the rainfed areas, in connection with further studies on possibility of groundwater exploitation.

(5) Dry season cropping should be considered as secondary importance; if water is still available during the dry season, irrigation for dry season cropping should be considered to a possible maximum extent. In order to save the water consumption and to use the limited water resources more effectively, some upland crops other than paddy should be considered as second crop in the dry season.

3. AGRICULTURAL DEVELOPMENT PLAN FOR HIGH PRIORITY PROJECTS

3.1 General

For selection of high priority projects, preliminary evaluation was made over the proposed six (6) possible projects, using the parametres of dam and reservoir performance, potential irrigable areas, construction costs including costs for compensation and resettlement. After full discussion with the authorities concerned, three (3) projects, i.e., Upper Mae Wong, Lower Mae Wong and Khlong Pho projects were selected as the high priority projects.

The major objectives of the present pre-feasibility study which is defined as part-B in the "Scope of Work", are (1) to formulate the development plans for the selected high priority projects (2) to make the preliminary design of project facilities, (3) to estimate the project costs and benefits, and (4) to propose the priority ranking for selection of the first priority project.

The study of the agriculture and agricultural economy at the present stage has therefore been designed for the purpose to measure the possible difference in agricultural froduction between conditions with and without each of the projects and to estimate the project benefits for priority ranking.

3.2 Delineation of Irrigation Areas

Water balance studies indicate the potential irrigable areas (for details, see ANNEX-V). The irrigation areas under the project will vary with the cropping intensity; the lower cropping intensity meakes the irrigation areas larger, and on the other the higher cropping intensity smaller irrigation areas. The representative combinations of irrigation areas and cropping intensity are as follows (See Fig. IV-5):

Project	Irrigation Area (ha)	Cropping Intensity (%)
Upper Mae Wong	36,800*	130
	47,800**	105
Lower Mae Wong	36,800*	140
	47,800**	115
Khlong Pho	10,600*	190
	17,900**	140

* existing irrigation area

** potential maximum area

In the above table, the smaller areas mear the existing irrigation area and larger areas the potential maximum areas for irrigation development which have been determined on the basis of topographic features, soil and land suitability classification, and the present land use. The areas delineated area, irrespective of large and small in area, selected within the existing paddy fields.

The cropping intensity mentioned above means 100% of wet season paddy and the rest of percentage allocated for mung beans cultivation in the dry season.

3.3 Changes in Land Use

The potential irrigation areas are delineated within the existing paddy field. Paddy cultivation is a mainstay in the area and its importance in rural economy will increasingly continue.

The existing paddy fields are classified into three (3) categories, depending on the degree of irrigation; (1) irrigated, (2) semi-irrigated and (3) rainfed fields. The "irrigated" means the paddy fields equipped with irrigation facilities and full supplemental irrigation for wet season paddy is guaranteed, and the "semi-irrigated" means the ones covered with irrigation facilities but not actually irrigated due to shortage of available water.

The selected high priority projects areas are considerably matured for agricultural production, where rumerous irrigation systems have been implemented and the available water is fully utilized with almost fixed cropping systems. There is no water available at present for the existing rainfed paddy fields. Under such conditions, significant changes in agricultural production will not be expected unless new water resources are exploited. With this in view, future condition without the project is considered same as the present condition. In the long run, the production techniques such as new varieties and efficient use of farm input and agricultural engineering investment are always changing and progressing and will certainly lead to some changes of agricultural production even if no project is realized. These factors will, however, be neglected in the estimate of possible changes attributed to the project partly because these will have influences on both with and without the project and partly because the effects of these factors is considered insignificant.

The paddy fields under future condition without the project are considered same as the present condition. These are classified:

Project	Existing Irrigation Area	Potential Maximum Area
Upper Mae Wong		
irrigated	23,600	23,600
semi-irrigated	13,200	13,200
rainfed	-	11,000
Total	36,800	47,800
Lower Mae Wong		
irrigated	23,600	23,600
semi-irrigated	13,200	13,200
rainfed	-	11,000
Total	36,800	47,800
Khlong Pho		
irrigated	8,900	8,900
semi-irrigated	1,700	1,700
rainfed	-	7,300
Total	10,600	17,900

After completion of the projects, all these paddy fields will be convented into the irrigated paddy fields.

3.4 *Proposed Cropping Pattern*

Paddy and mung beans are selected as main crops in the priority projects areas. Paddy will be cultivated in the wet season and mung beans will be grown after haruest of wet season paddy in the dry season.

Paddy is Thailand's most important crop. It is the main staple for domestic consumption and is also the major source of foreign exchange earnings. Thailand produces about earnings. Thailand produces about 14 to 17 million tons of paddy annually. Its production fluctuates largely depending on the weather, especially seasonal patterns and amounts of rainfall. About two-thirds of production is consumed domestically and the rest is exported. The annual export ranges between 2.7 and 3.0 million tons of rice (4.1 to 4.6 million tons of paddy).

In recent years, world rice production amounted to around 410 million tons, while only about 13 million tons or about 3.2% of production were internationally traded. Thailand's export accounts for about one-fourth of the total trade. The small rate of trade against production means that a small change in world production will affect world trade and prices. This indicates that the country's exports are largely dependent on world production.

In January 1985, the Government of Thailand announced that about 19-21 million tons of paddy would be produced in the 1984/85 crop and in anticipation of over-production problems, the Government would change its policy for rice and seek the possibility of a reduction in local paddy production by encouraging rice farmers to grow other cash crops yielding parallel income. The Government accorded its priority to sorghum and mung beans as substitute crops.

Mung bean is one of the prospective crops since its demand in the world market is high. Thailand is one of the major producers and experters of mung beans. Thailand produces about 10% of the world output and exports a value of over one (1) billion bahts annually (about 133,000 tons).

The proposed cropping patterns is shown in Fig. IV-6. Two kinds of paddy varieties will be introduced; i.e., (1) high yielding varieties (H.Y.V.), and (2) improved local varieties. High yielding varieties will be cultivated mainly for export and improved local varieties will mainly be for home consumption.

3.5 Proposed Farming Practices

After the proposed projects are realized, the existing paddy fields will be fully irrigated and new production techniques will be gradually introduced to the areas. The recommendable farming practices will be those developed by the Chainat Rice Experimental Station and the Field Crop Research Institute, and are summarized in Table IV-18 labour and farm inputs requirements for the proposed farming practices are estimated in monetary term and included in the estimate of crop production costs under the condition with the project.

3.6 Anticipated Crop Yield and Production

Crop yields under the present condition vary place by place and year by year, depending on the degree of irrigation water supplies. The present crop yields are estimated through field observations and interview with local farmers:

Wet season paddy		
irrigated	400 kg/rai	(2.5 ton/ha)
semi-irrigated	250 kg/rai	(1.6 ton/ha)
rainfed	200 kg/rai	(1.2 ton/ha)
Dry season paddy	600 kg/rai	(3.7 ton/ha)
Mung beans	100 kg/rai	(0.6 ton/ha)

Crop yields will be substantially increased after completion of the Project with introduction of improved farming practices under assured irrigation system. The anticipated crop yields under the condition will the Project are estimated as follows:

Paddy	
H.Y.V.	820 kg/rai (4.5 ton/ha)
Local	640 kg/rai (4.0 ton/ha)
Mung Beans	190 kg/rai (1.2 ton/ha)

Crop yields and production under future condition without Project are considered same as these of present condition. The incremental crop production attributed to the Project is estimated as follows:

(1) Existing Irrigation Areas

a. Crop Production Without Project

Projects/Orops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)
1. Upper Mae Wong			
- Wet Season Paddy			
irrigated	23,600	2.5	59,000
semi-irrigated	13,200	1.6	21,120
rainfed	-	-	-
- Dry Season Paddy	510	3.7	1,890
- Mung Beans	1,530	0.6	920
2. Lower Mae Wong			
- Wet Season Paddy			
irrigated	23,600	2.5	59,000
semi-irrigated	13,200	1.6	21,120
rainfed	-	-	-
- Dry Season Paddy	510	3.7	1,890
- Mung Beans	1,530	0.6	920
3. Khlong Pho			
- Wet Season Paddy			
irrigated	8,900	2.5	22,250
semi-irrigated	1,700	1.6	2,720
rainfed	-	-	-
- Dry Season Paddy	190	3.7	700
- Mung Beans	570	0.6	340

b. Crop Production With Project

Projects/Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)
1. Upper Mae Wong			
Paddy	36,800	4.25	156,400
Mung Beans (30%)	11,040	1.20	13,250
2. Lower Mae Wong			
Paddy	36,800	4.25	156,400
Mung Beans (40%)	14,720	1.20	17,660
3. Khlong Pho			
Paddy	10,600	4.25	45,050
Mung Beans (90%)	9,540	1.20	11,450

c. Incremental Crop Production

Projects/Crops	Without Project (ha)	With Project (ton)	Increment (ton)
1. Upper Mae Wong			
Paddy	82,010	156,400	74,300
Mung Beans	290	13,250	12,330
2. Lower Mae Wong			
Paddy	82,010	156,400	74,390
Mung Beans	920	17,660	16,740
k. Khlong Pho			
Paddy	25,670	45,050	19,380
Mung Beans	340	11,450	11,110

(2) Protential Maximum Areas

a. Crop Production Without Project

Projects/Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)
1. Upper Mae Wong			
- Wet Season Paddy			
irrigated	23,600	2.5	59,000
semi-irrigated	13,200	1.6	21,120
rainfed	11,000	1.2	13,200
- Dry Season Paddy	510	3.7	1,890
- Mung Beans	1,530	0.6	920
2. Lower Mae Wong			
- Wet Season Paddy			
irrigated	23,600	2.5	59,000
semi-irrigated	13,200	1.6	21,120
rainfed	-	-	-
- Dry Season Paddy	510	3.7	1,890
- Bung Beans	1,530	0.6	920
3. Khlong Pho			
- Wet Season Paddy			
irrigated	8,900	2.5	22,250
semi-irrigated	1,700	1.6	2,720
reinfed	-	-	-
- Dry Season Paddy	190	3.7	700
- Mung Beans	570	0.6	340

b. Crop Production with Project

Projects/Crops	Cultivated Area (ha)	Unit Yield (ton/ha)	Production (ton)
1. Upper Mae Wong			
Paddy	47,800	4.25	203,150
Mung Beans (5 %)	2,390	1.20	2,870
2. Lower Mae Wong			
Paddy	47,800	4.25	203,150
Mung Beans (15 %)	7,170	1.20	8,600
3. Khlong Pho			
Paddy	17,900	4.25	76,080
Mung Beans (40 %)	7,160	1.20	8,590

c. Incremental Crop Production

Projects/Crops	Without Project (ton)	With Project (ton)	Increment (ton)
1. Upper Mae Wong			
Paddy	95,210	203,150	107,940
Mung Beans	920	2,870	1,950
2. Lower Mae Wong			
Paddy	95,210	203,150	107,940
Mung Beans	920	8,600	7,680
3. Khlong Pho			
Paddy	34,430	76,080	41,650
Mung Beans	340	8,590	8,250

3.7 Marketing and Price Prospects

Production surplus of rice in the year of 1995, when full development of the Project is attained, is estimated as follows:

Item	Existing Irrigation Area		Potential Maximum Area	
	Mae Wong	Khlong Pho	Mae Wong	Khlong Pho
Polulation in 1980	50,000	15,000	65,000	25,000
Population Growth Rate (%)	5.2	2.4	5.2	2.4
Population in 1995	107,000	21,000	139,000	36,000
Rice Consumption per Capita (kg)	150	150	150	150
Total Consumption in 1995 (ton)	16,000	3,200	20,900	5,400
Total Paddy Production in 1995	156,400	45,050	203,150	76,080
Total Production of Milled Rice in 1995	101,700	29,300	132,000	49,500
Surplus	85,700	26,100	111,100	44,100

The balance of demand and supply for rice in whole Nakhon Sawan and Uthai Ihani provinces, in the year of 1995, is also estimated as follows:

Item	Nakhon Sawan Province	Uthai Itani Province
Population in 1980	942,000	220,000
Population Growth Rate (%)	2.2	2.4
Population in 1995	1,306,000	314,000
Per Capita Rice Consumption (kg)	150	150
Total Consumption in 1995 (ton)	196,000	47,000
Rice Production in 1980	344,000	103,000
Rice Production Increase by the Projects	70,000	27,000
Total Rice Production in 1995	414,000	130,000
Surplus	218,000	83,000

Anticipated surplus of rice in 1995 will be significant in and around the Projects areas. These surplus will be transported to the outsides of the provinces particulaly to the Bangkok market.

Present production of mung beans in the priority areas is about 1,260 tons in total. About a half of the products are consumed in the area and the surplus in directly sold at the local markets or to Bangkok through local merchants. After completion of the Projects, the incremental production of mung beans will be remarkable, ranging from 1,950 tons to 16,740 tons. All these surplus will be marketed to Bangkok for export.

For making preliminary evaluation of the priority projects, economic prices of paddy and mung beans of farm gate are estimated as follows (for details, see Table IV-9):

Paddy : ฿5,200 per ton

Mung Beans : ฿8,700 per ton

These prices are estimated on the basis of the projected international market prices forecasted by IBRD for the year of 1990.

3.8 Crop Production Cost

Crop production costs under "without Project" condition are estimated on the basis of farm economy survey carriedout by the Office of Agricultural Economics. Detailed estimates are given in Table IV-10. Those under "with Project" condition are also estimated on the basis of farm inputs and labour requirement for recommendable farming practices. In the estimates of crop production costs, economic prices of inputs and labour are used. These estimates are shown in Table IV-11.

Unit production costs per ha thus estimated are:

Without Project

- Wet Season Paddy
  - irrigated : ฿4,640/ha
  - semi-irrigated : ฿4,000/ha
  - rainfed : ฿3,160/ha
- Dry Season Paddy : ฿6,110/ha
- Mung Beans : ฿2,190/ha

With Project

- Paddy : ฿6,510/ha
- Mung Beans : ฿3,920/ha

3.9 Gross and Net Crop Production Values

Gross and net production volues under conditions with and without the Project are estimated as follows (Details are given in Table IV-13):

(1) Existing Irrigation Areas

a. Without Project

Projects	G.P.V. (฿ Million)	Production Costs (฿ Million)	N.P.V. (฿ Million)
1. Upper Mae Whong			
Paddy	426.5	165.4	261.1
Mung Beans	8.0	3.4	4.6
Total	434.5	168.8	265.7
2. Lower Mae Whong			
Paddy	426.5	165.4	261.1
Mung Beans	8.0	3.4	4.6
Total	434.5	168.8	265.7
3. Khlong Pho			
Paddy	133.5	49.2	84.3
Mung Beans	3.0	1.2	1.8
Total	136.5	50.4	86.1

b. With Project

Projects	G.P.V. (฿ Million)	Production Costs (฿ Million)	N.P.V. (฿ Million)
1. Upper Mae Wong			
Paddy	813.3	239.6	573.7
Mung Beans	115.3	43.3	72.0
Total	928.6	282.9	645.7
2. Lower Mae Wong			
Paddy	813.3	239.6	573.7
Mung Beans	153.6	57.7	95.9
Total	966.9	297.3	669.6
3. Khlong Pho			
Paddy	234.3	69.0	165.3
Mung Beans	99.6	37.4	62.2
Total	333.9	106.4	227.5

c. Incremental N.P.V.

Projects	Without Project (฿ Million)	With Project (฿ Million)	Increment (฿ Million)
1. Upper Mae Wong	265.7	645.7	380.0
2. Lower Mae Wong	265.7	669.6	403.9
3. Khlong Pho	86.1	227.5	141.4

(2) Potential Maximum Areas

a. Without Project

Projects	G.P.V. (฿ Million)	Production Costs (฿ Million)	N.P.V. (฿ Million)
1. Upper Mae Wong			
Paddy	495.1	200.2	294.9
Mung Beans	8.0	3.4	4.6
Total	503.1	203.6	299.5
2. Lower Mae Wong			
Paddy	495.1	200.2	294.9
Mung Beans	8.0	3.4	4.6
Total	503.1	203.6	299.5
3. Khlong Pho			
Paddy	179.0	72.3	106.7
Mung Beans	3.0	1.2	1.8
Total	182.0	73.5	108.5

b. With Project

Projects	G.P.V. (฿ Million)	Production Costs (฿ Million)	N.P.V. (฿ Million)
1. Upper Mae Wong			
Paddy	1,056.4	311.2	745.2
Mung Beans	25.0	9.4	15.6
Total	1,081.4	320.6	760.8
2. Lower Mae Wong			
Paddy	1,056.4	311.2	745.2
Mung Beans	74.8	28.1	46.7
Total	1,131.2	339.3	791.9
3. Khlong Pho			
Paddy	395.6	116.5	279.1
Mung Beans	74.7	28.1	46.6
Total	470.3	144.6	325.7

c. Incremental N.P.V.

Projects	Without Project (฿ Million)	With Project (฿ Million)	Increment (฿ Million)
1. Upper Mae Wong	299.5	760.8	461.3
2. Lower Mae Wong	299.5	791.9	492.4
3. Khlong Pho	108.5	325.7	217.2

Table IV-1 BASIC SOCIO-ECONOMIC DATA OF THE STUDY AREA

Province & district	Whole related districts									Study Area		
	Population			Area	Population density (1980)	Total Households (1980)	Family size (1980)	Number of farm Households (1980)	% of farm Household (1980)	Coverage in Study Area	Number of Population (1980)	Number of Households (1980)
	1970	1980	Growth rate 1970/1980									
			(%)	(km^3)	(Person/km^2)				(%)	(%)		
Uthai Thani	(177,644)	(225,632)	2.4	(6,730)	33.5	(47,093)	4.8	(33,336)	70.8			
1. Uthai Thani	48,218	41,644	Δ1.5	217	191.9	8,765	4.8	3,225	36.8	100	41,644	3,225
2. Thap Than	27,269	30,130	0.6	324	93.0	6,495	4.6	4,669	71.9	100	30,130	4,669
3. Swang Arom	15,800	20,621	2.7	341	60.5	4,329	4.8	3,573	82.5	100	13,314	3,573
4. Nong Khayang	15,285	14,376	Δ0.6	348	41.3	3,126	4.6	2,137	68.4	100	14,376	2,137
5. Nong Chang	36,793	36,357	Δ0.1	385	94.4	7,548	4.8	5,094	67.5	100	36,357	5,094
6. Ban Rai	44,804	53,256	Δ1.4	4,044	13.2	10,699	5.0	9,288	86.8	25	13,314	2,322
Nakhon Sawan	(758,891)	942,068	2.2	(9,598)	98.2	190,081	5.0	(120,927)	63.6			
Lat Yao	77,595	128,576	5.2	2,124	60.5	26,389	4.9	21,152	80.2	100	128,576	21,152
Kamphaeng Phet	(339,862)	(507,532)	4.1	(8,608)	59.0	(99,284)	5.1	(74,927)	75.5			
1. Khun Waralaksaburi	71,332	99,330	3.4	2,100	47.3	19,629	5.1	15,930	81.2	5	4,967	797
2. Khlong Khlung	68,982	95,067	3.3	2,650	35.9	18,544	5.1	14,440	77.9	1	951	144
Chai Nat	(261,513)	(318,068)	2.0	(2,470)	128.9	(66,717)	4.8	(43,229)	64.8			
Wat Sing	38,838	42,679	0.9	623	68.5	8,915	4.8	6,527	73.2	10	4,268	653
Total	444,916	562,036	2.4	13,156	42.7	114,439		86,035			295,204	43,766

Source; Population & Housing Census in 1970, 1980. Office of the prime Minister.

Table IV-2 POPULATION OF RELATED PROVINCES

I t e m s	Uthai Thani	Nakhon Sawan	Kampheng Phet	Chainat
1. Total population	225,632	942,068	507,532	318,068
(a) % of males	49.09	49.50	50.05	48.27
(b) % of population aged under 15 years	36.84	36.56	40.31	33.88
(c) % of population aged over 65 years & over	4.23	5.87	2.67	4.91
2. Number of persons in-migreted to this province during 1975 - 1980	12,820	47,581	41,114	9,667
% of persons in-migreted to this province during 1975 - 1980	6.40	5.68	9.31	3.37
3. % of population 11 years old & over working in major occupational group				
(a) Farmers and related workers	84.07	76.57	85.99	79.57
(b) Claftman, production worker	4.87	8.17	4.98	8.01
(c) Sales workers	4.66	6.94	4.98	5.35
(d) Professional, technical & related workers	2.49	2.34	1.42	2.57
(e) Service workers	a 1/	a	1.05	a

1/ "a" means the lower percentage or lower ranking order than those shown in the colums

Source; Population & Housing Census 1980. Office of Prince Minister