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No. 8

THE ROYAL GOVERNMENT OF THE KINGDOM OF THAILAND

MAIN REPORT
ON
BASIC DESIGNING SURVEY FOR CONSTRUCTION OF SMALL-SCALE DAMS IN PRACHINBURI, THAILAND

November 1980

JAPAN INTERNATIONAL COOPERATION AGENCY
TOKYO

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PREFACE

In response to the request of the Royal Government of the Kingdom of Thailand, the Japanese Government decided to conduct a survey on the Basic Design of the Small-scale Dams Project and entrusted the survey to the Japan International Cooperation Agency (JICA). The JICA sent to Thailand a survey team headed by Mr. Hiroshi Yonehara (Japan Engineering Consultants Co., Ltd.) from September 11 to October 15, 1980.

The Team had discussions with the officials concerned of the Royal Government of the Kingdom of Thailand and conducted a field survey (in Ta Phraya area, Prachin Buri). After the Team returned to Japan, further studies were made and the present report has been prepared.

I hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between our two countries.

I wish to express my deep appreciation to the officials concerned of the Royal Government of the Kingdom of Thailand for their close cooperation extended to the Team.

November, 1980

Keisuke Arita

Keisuke Arita
President
Japan International Cooperation Agency

LETTER OF TRANSMITTAL

Mr. Keisuke Arita
President
Japan International Cooperation Agency
TOKYO

Dear Sir,

I have the pleasure of submitting herewith, in accordance to the contract which was signed between the Japan International Cooperation Agency (JICA) and the Japan Engineering Consultants Co., Ltd. (JEC) on the consulting services pertaining to the Basic Construction Designing of the Small-scale Dams in Thailand, the Final Report containing the outcome of our survey work which has been continuing on since September 1980.

The survey team was assigned to work out the construction plan of a dam, a conveyance canal and a regulating pond, a set of engineering devices to provide the Kampuchean refugees being accommodated in the Khao-I-Dang Holding Center with the subsistence-water and to also supply the irrigation-water to the local Thai villagers.

Our Team, after submitting the Field Report on this project in October 1980, soon after its completion of a month-old field survey in Thailand, continued confirming, devetailing and consolidating at home the findings outlined in the Field Report. It must be quite natural for us to hope that this project should start implementing at an early date so as it could be completed by the end of June 1981.

In submitting this Report, the Team-members including the undersigned, wish to acknowledge with sincere thanks the kind assistance liberally afforded them in execution of their work by the officers of the JICA Headquarters in Tokyo and its Bangkok Office, the officials of the Ministry of Foreign Affairs and the Embassy in Thailand as well as the authorities concerned of the Royal Thai Government, especially the Royal Irrigation Department.

Yours very truly,

Hiroshi Yonehara
Leader
Survey Team for Basic Designing of
the Small-scale Dams in Thailand
(Osaka Branch Sub-Manager, JEC)

November 1980

SUMMARY

The Royal Thai Government had approached the Government of Japan for cooperation in constructing a dam in the neighbourhood of the Khao-I-Dang Holding Center in view of providing the subsistence-water to the Kampuchean refugees being accommodated in it and also of supplying the irrigation-water to the local Thai villagers. In its response, Mr. Itoh, Foreign Minister, declared in Bangkok at mid-August 1980 on the occasion of his formal visit to Thailand, that the Japanese Government was prepared to entertain the Royal Thai Government's request.

Accordingly, the Japan International Cooperation Agency (JICA) dispatched a Survey Team to Thailand in September-October 1980 to carry out the basic study required for implementation of the project, and the Team concluded its basic design, within a month upon its return to Japan, on the basis of the findings obtained during its field operations.

The present Report contains the main features of the outcome of such study and designing which may be summarized as follows:

A. Net Content of the Work

The construction works under this project will consist of:

i) Ta-Kien Reservoir;

ii) Conveyance canal extending from Ta-Kien Reservoir to the Khao-I-Dang Holding Center (total length about 8.1 km), and

iii) Kud Toey Regulating Pond.

The principal features of the above-mentioned works are given in the statement that follows. As a direct benefit of their completion, the Khao-I-Dang Holding Center will enjoy ample supply of the subsistence-water on behalf of the Kampuchean refugees upto about 90,000, and the local Thai villagers will have about 500 ha of their farmland irrigated all through the year thereby given opportunity to greatly enhance agricultural productivity which has been basically confined to rainfed farming.

B. Construction Cost

The total construction cost estimated for implementation of this project amounts to Yen 1,000 Million (approx. 91 Million Bahts).
The total cost may be itemized as follows:

		(Yen)		(Bahts)
i)	Ta-Kien Reservoir	¥ 771,800,000		(฿70,164,000)
ii)	Conveyance canal	99,400,000		(9,031,000)
iii)	Kud Toey Regulating Pond	33,000,000		(2,990,000)
iv)	Physical Contingencies	25,800,000		(2,345,000)
v)	Construction supervision	70,000,000		(6,370,000)
	Total:	¥1,000,000,000	or	(฿90,900,000)

C. Construction Period

In view of completing the entire project within 1980-81 dry season, the construction work will have to be commenced in December 1980 and completed by the end of June 1981. Failure to start before mid-January 1981, at the latest, would collapse the scheme of completing the project during the coming dry season. This is to be avoided by all means through the mutual efforts of the both Government as carrying-forward of the work to November 1981 should mean postponement of the benefits to the Kampuchean refugees and the local Thai villagers for full one year.

PRINCIPAL FEATURE OF THE PROJECT

1. Takien Reservoir

Catchment Area	61 km^2
Reservoir Area	3.57 km^2
Normal Water Level (F.W.L.)	EL. 56.80 m
Design Flood Stage (H.W.L.)	EL. 57.50 m
Total Storage Capacity	10,000,000 m^3
Effective Storage Capacity	9,700,000 m^3

Dam

Type	Homogeneous type	
Crest Length		2,450 m
Crest Level		EL. 59.10 m
Maximum Height		10.30 m
Top Width		5.00 m
Side Slopes	1 on 2.5 U/S and 1 on 2.0 D/S	
Embankment Volume		300,000 m^3

Spillway

Type	Overflow Weir	
Design Flood Discharge		58.6 m^3/s
Width of Spillway		50.0 m
Length of Tail Channel		153.0 m
Width of Tail Channel		50.0 m
Width of Emergency Spillway		50.0 m

Outlet Works

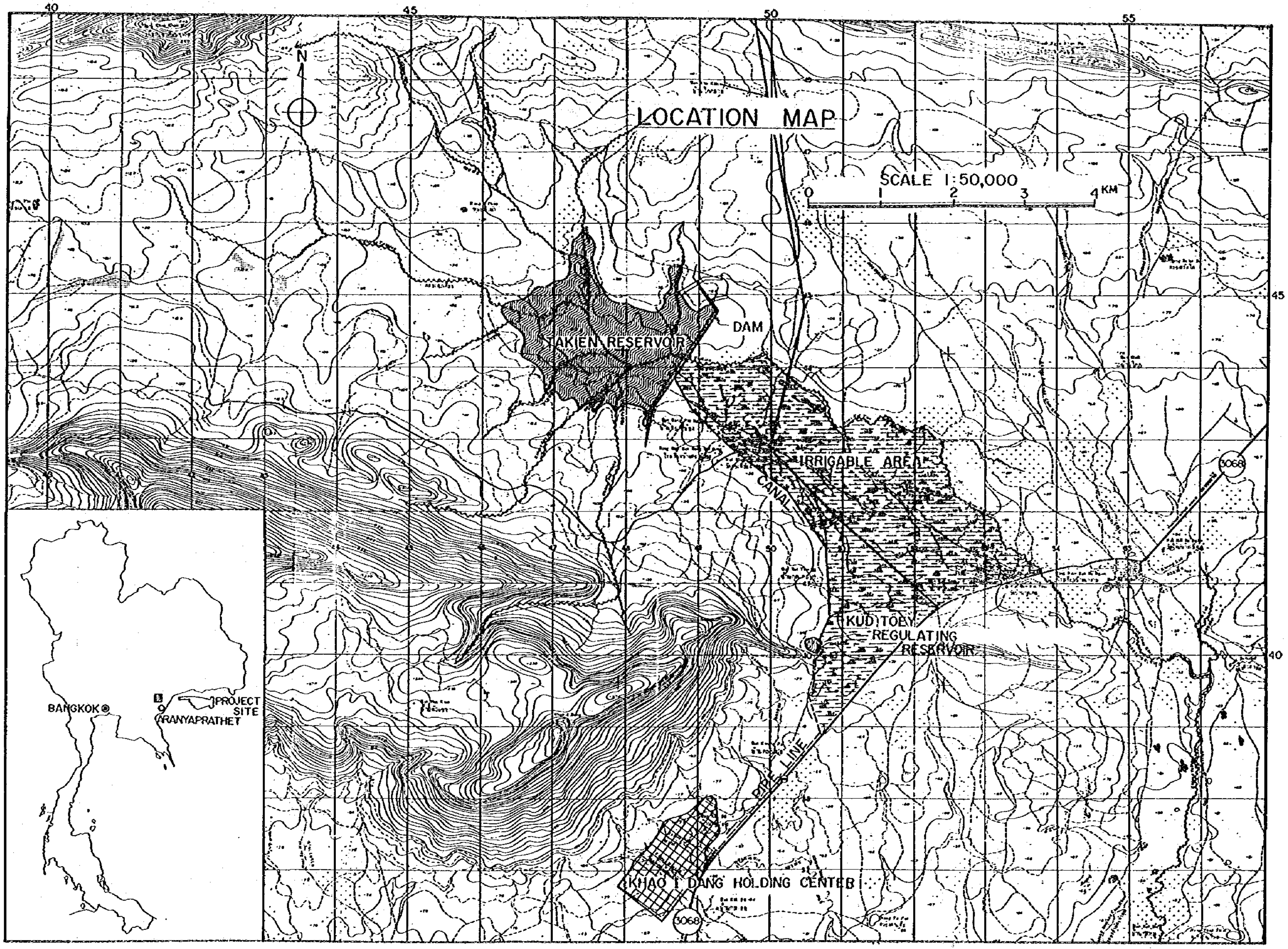
Type	R.C. Tower Type	
Discharge		1.3 m^3/s
Sill Level		El. 51.00 m
Irrigation Area		500 ha
Number of Beneficiaries (refugees)		90,000

2. Main Canal

Type	A; (Dam - Regulating Pond)	Earthen Canal
	B; (Pond Reservoir - Camp)	Pipe Line
Length of Canal	(A; 4,475 m B; 3,643 m)	8,118 m
Discharge	A; 1.3 - 0.5 m^3/s B; 0.05 m^3/s (for Refugee)	

3. Kud Toey Regulating Pond

Dam Type	Homogeneous Type
Crest Length	324 m
Maximum Height	3.00 m
Reservoir Area	17,520 m^2
Storage Capacity	31,300 m^3
Outlet Works Valve Type	ϕ250 m
Spillway Overflow Weir Type	L6.50 m x 2.7 m^3/s


LOCATION MAP
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SCALE 1:50,000
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50
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45
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DAM
TAKIEN RESERVOIR
IRRIGABLE AREA
CANAL
KUD TOEY
REGULATING
RESERVOIR
PIPE LINE
KHAO I DANG HOLDING CENTER
3068
3068
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PROJECT
SITE
ARANYAPRATHET

MAIN REPORT ON BASIC DESIGNING SURVEY FOR CONSTRUCTION OF SMALL-SCALE DAMS IN PRACHINBURI, THAILAND

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TABLE OF DESIGNS

CHAPTER I INTRODUCTION

Contributions by the Japanese Government towards the welfare of the Kampuchean refugees in Thailand were given effective directions in such as (i) medical care; (ii) foodstuff supply, and (iii) water supply, through the visit of the Kampuchean Refugee Fact Finding Mission (headed by Madame Sadako Ogata), between 18 to 21 November 1979. Since then, these relief measures have continuously been provided in full coordination with the Royal Thai Government and the UNHCR.

In the meanwhile, the Royal Thai Government developed a plan to construct small-scale dams in the neighbourhood of the Khao-I-Dang Holding Center to solve the water difficulties among the Kampuchean refugees being accommodated there and to also supply irrigation water to the local Thai villagers, and approached to the Government of Japan for financial assistance in their construction.

In response to this request, Mr. Itoh, Foreign Minister, declared in Bangkok at mid-August 1980 on the occasion of his official visit to Thailand that the Japanese Government was prepared to entertain the Royal Thai Government's request.

Accordingly, Japan International Cooperation Agency (JICA) dispatched a Basic Designing Survey Team to Thailand which conducted, from September 11 to October 15, 1980, the field operations covering the collection of data, the field investigation, the surveying, the geological studies and the other basic studies required for designing of a dam, a regulating pond and a conveyance canal which links up the above two with the Khao-I-Dang Holding Center. Upon completion of its field work in Thailand, the Survey Team submitted, on October 24, 1980, a Field Report containing an outline of its study results, a basic design of the project and its construction cost estimate, in particular.

This Report presents a gist of the principal results obtained by the Survey Team through a month-long home work since its return to Japan on October 15, 1980. The Survey Team has tried its best to incorporate the opinions expressed by the Royal Irrigation Department in finalization of the basic design required for implementation of the project.

CHAPTER II BACKGROUND

The Japanese Government's assistance in securing water supply on behalf of the Kampuchean refugees in the Kingdom of Thai was initiated by the visit of a pre-feasibility study team (headed by Mr. Hirota) which was dispatched to Thailand by JICA during December 12 ~ 25, 1979. Along the basic line chalked out by this team, the under-mentioned projects were taken up in succession:

1. Survey on Water Supply to the Kampuchean Refugees
   (December 1979 - April 1980)
   Development of five (5) deep-wells in the Khao-I-Dang Holding Center (where UNHCR has been digging more wells by using the same Japanese drilling kits), and designing of a reservoir for Myruth Holding Center (its construction is going on under the auspices of UNHCR).

2. Intake Barrage Project for Water Supply to Sakeo No. 2 Camp
   (April 1980 - December 1980)
   Construction of an intake barrage equipped with pumps across the Phra Prong River to supply subsistence water to the Kampuchean refugees in Sakeo No. 2 Holding Center as well as irrigation water to the local Thai villagers.

As a result, two (Sakeo and Myruth) of the three important Kampuchean Refugees' Holding Centers in Thailand will have been relieved of their water difficulties, but the Khao-I-Dang Holding Center, now accommodating some 80,000, is yet depending by two-thirds of its water requirements on outside supply (from as far as Watthana Nakhon and Sakeo, 55 and 100 km away respectively) by use of fleets of tank-lorries which cost as much as 2 - 3 Million Bahts per month.

It was to solve such a grave water shortage in the Khao-I-Dang Holding Center and to divert the expenses thus incurred for the more productive purposes that the Royal Thai Government developed a plan to construct small-scale dams in its neighbourhood which would also supply irrigation water to the local Thai villagers.

The Royal Thai Government's request to the Government of Japan to assist materializing the plan was immediately answered by a dispatch of a pre-feasibility study team (headed by Mr. Imagawa) in July-August 1980 and subsequently confirmed by its Foreign Minister's declaration at mid-August 1980.

CHAPTER III PRESENT CONDITION OF THE PROJECT AREA

3 - 1 Location

The project area is located in Taphraya District, Prachin Buri Province in the southeastern region of the Kingdom of Thai. It is bordered by highway No. 3068 to the east, and the dam-site can be reached by a 5 km-long unmetalled road which is branching off from the highway at 35 km point from Aranya Prathet. It is about 8 km north of the Khao-I-Dang Holding Center.

3 - 2 Topography

Southeastern region of Thailand consists for the most part of flat lowlands below 100 m (generally 30 - 70 m) but occasionally interrupted by ridges which run north to south or north-west and rise abruptly from the plains, forming types of inselbergs or whole mountain massifs. Such mountain massifs are rising to south and north (with an interval of 8 - 9 km) of Ta-Kien reservoir; on the southern slope there are standing two (2) hills of 400 - 500 m height, viz. Khao-I-Dang (424 m) and Khao Lon (547 m).

The beneficiary area is extending in-between these two mountain massifs in the north and the south, slanting gradually from the west (120 m) towards the east (70 m). Huay-Ta-Kien is running through the center of this valley towards Cambodia.

The projected dam-site is located on a flat land (85 - 95 m) being penetrated by Huay-Ta-Kien which is joined by the minor rivulets such as the Prong E Yong, the Him, the Sap Meg, the Sap Yang, etc. in the upstream of the dam-axis. These rivers invariably dry up druing the Dry Season and run off timidly even during the Rainy Season because of little gradient.

3 - 3 Geology & Soils

South-eastern region of Thailand consists of a land massif wrought by Permian and Jurassic orogenesis (Indochinese Era) and is believed to have been covered by a Tertiary sediment rock, a layer called the Kanchanaburi Formation. Along lines of disturbances, molten rock was forced up, raising the surface into ridges and mountains, forming batholiths and metamorphosing parts of the neighbouring sedimentary rocks through heat and pressure. The batholiths cooled into granite and, after a weathering process of the overlying rocks, were finally exposed.

Later there was localized volcanic activity and formations of igneous rocks of different age and composition can now be found: Trassic granite and granodiorite followed by Pre-Permian gneiss and schist, and finally, Tertiary to Quaternary basalts in a few places in the eastern border zone of the area. Embedded into these igneous rocks, extended massifs of sedimentary, and metamorphic rocks reach the eastern border area, consisting of formation of the Korat Group (Phu Phan and Phu Kradung formations).

Ta-Kien reservoir and its beneficiary area lie on the bedrock of Phu Kradung formation of Jurassic period, on which are spreading thick layers of Tertiary to Quaternary deposits consisting of sandy clay and sandy silt. On the top of them all, alluvium, eluvium, etc. are being thinly distributed (see Fig. 3-1).

Soils there are generally covered by clayey soils, showing a slight angulation.

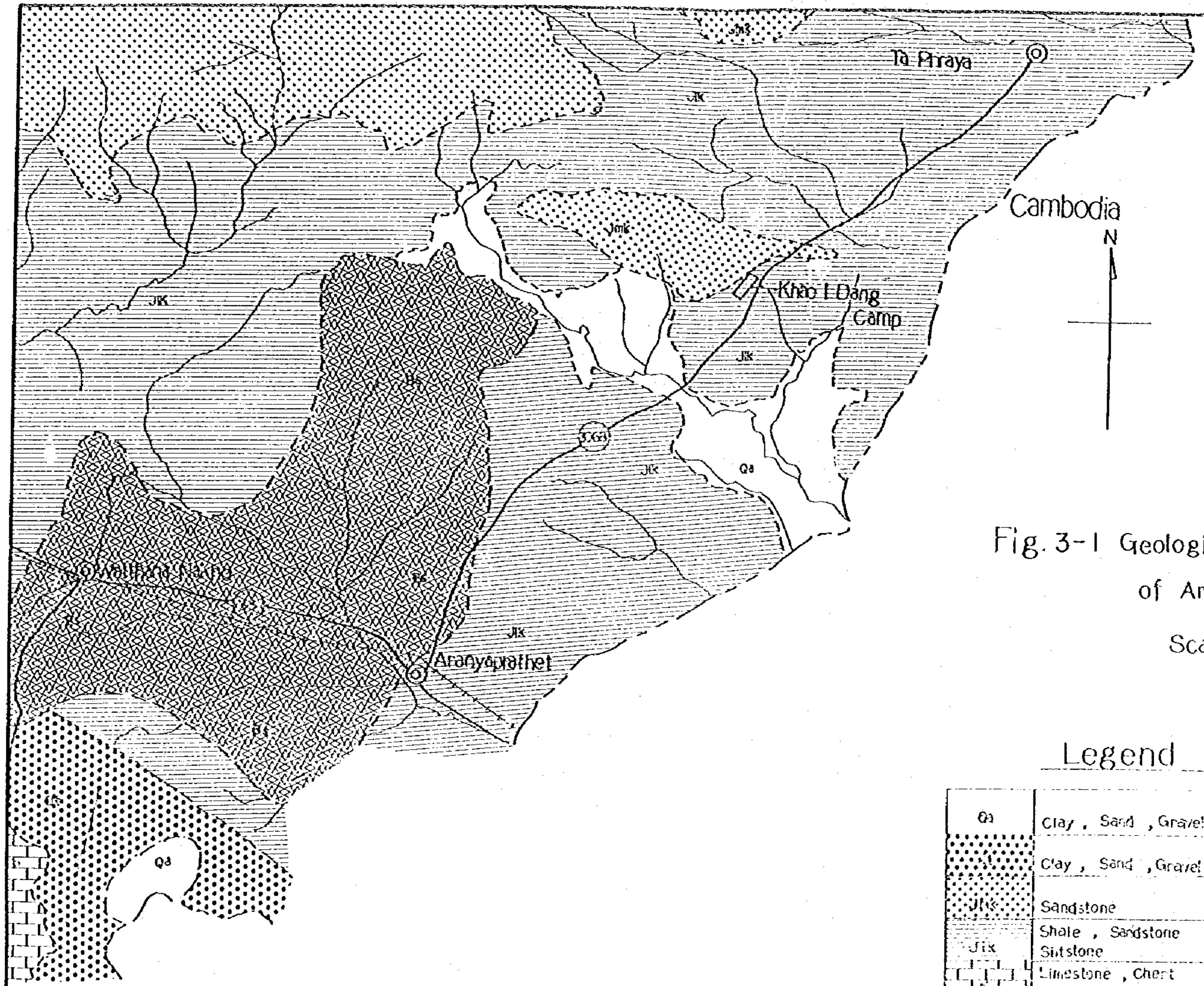


Fig. 3-1 Geological Map
of Aranyaprathet – Ta Phraya Area
Scale 1: 250,000

Legend

Qa	Clay , Sand , Gravel	River Deposits	Tertiary ~Quaternary
	Clay , Sand , Gravel	Terrace Deposits	
Jmk	Sandstone	Phrawihan Formation	Mesozoic (Jurassic)
Jlk	Shale , Sandstone Siltstone	Pukradung Formation	
	Limestone , Chert Shale	Palaeozoik Deposits	Palaeozoic (Devonian ~Carboniferous)
B3	Basalt	Volcanic Rock (Dike)	Tertiary ~Quaternary

3 - 4 Prevailing Conditions in Khao-I-Dang Holding Center

3-4-1 Water Supply in the Camp

According to the results obtained during a survey effected at mid-March 1980, the Kampuchean refugees (about 114,000) were getting supply of water @15 - 20 litre/day per head from the combined sources of (a) ground-water lifted from deep-wells in the Camp and (b) river-water transported by tank-lorries:

Deep-wells	per day	200 - 250 m^3
Tank-lorries (98 vehicles)	"	2,150 m^3
		2,400 m^3

However, as transportation of water by tank-lorries was quite costly (3 Million Bahts per month), UNHCR tried very hard to exploit more ground-water by digging deep-wells which were increased to 23 (including those developed by the Japanese team) by August 1980, yielding nearly three-times more groundwater (600 - 700 m^3/day) than that available in March the same year.

The second survey was conducted during the rainy season (end-September 1980) when the number of the refugees had been decreased to about 70% of that at Mid-March the same year (about 80,000). This survey disclosed that 70 tank-lorries were still being employed for transportation of water from Watthana Nakhon with a monthly cost of about 2 Million Bahts.

3-4-2 Water Distribution in the Camp

In the latter part of 1979 when the number of the Kampuchean refugees in the Camp was at its peak of 120,000, they were accommodated in temporary sheds which were grouped into nine (9) blocks. Each block had, on an average, 9 metal water tanks among which the tank-lorries distributed water. Refugees were provided with ration-water from these tanks twice a day. Actual rationing of water took place under the refugees' own autonomous control supervised by the Water Police appointed by each block leader.

With an increase of deep-wells, the groundwater came to to be conveniently distributed among the refugees who happened to be housed nearer to the deep-wells while the others were meted out with the water which was transported by tank-lorries from unidentified sources outside the Camp and of more or less polluted nature.

Complaints from amongst the latter part of the refugees urged the UNHCR Construction Unit in the Camp to adopt a pipeline distribution system of the groundwater by erecting towers and spreading pipeline network which, however, remain uncompleted to this date.

3-4-3 Water Problems in the Camp

Ideally speaking, supply of the pure groundwater available from deep-wells should be confined to drinking and cooking for distribution through common taps at the ends of pipelines, while the water transported by tank-lorries and that hopefully available from Ta-Kien reservoir from the end of 1981 would be used for washing and bathing purposes. As no more deep-wells can be successfully dug in the Camp, however, the groundwater might as well be supplied in a restricted manner only to the hospital wards and among the nurslings, for instance.

3 - 5 Socio-Economic Conditions

3-5-1 Direct & Indirect Beneficiary Areas

Three (3) villages (ban) are supposed to be involved in the project's beneficiary area, the two (Ban Song Pin Nong and Ban Kud Toey) directly, and one (Ban Na Ngam) indirectly.

Table 3-1 Area, Household and Population of the Beneficiary Area

Name of Villages	Total Area (rai)	Total Household	Total Population
Ban Song Pin Nong	6,500	96	842
Ban Kud Toey	3,500	140	722
Ban Na Ngam	6,000	126	1,240
Total	16,000	362	2,804

3-5-2 Direct Beneficiary Area & Its Characteristics

The particulars of the direct beneficiary area will be known from the following Table:

Table 3-2 Particulars of the Direct Beneficiary Area

Name of Villages	Total Area (rai)	Cultivated Land			Other	Livestock	
		Paddy-field (rai)	Upland field (rai)	Total (rai)	Land (rai)	Cow	Buffalo
Ban Song Pin Nong	6,500	3,500	2,000	5,500	1,000	76	215
Ban Kud Toey	3,500	2,000	100	2,100	1,400	38	133
Total	10,000	5,500	2,100	7,600	2,400	114	348

As is shown in the above Table, 76% of the total area has been brought under cultivation; nearly three-quarters of the cultivated land consists of the paddyfield on the flat ground and the remainder spreads on the highland and slopes as upland field. Paddyfield has been used for rice production once a year during the rainy season alone, and the upland field has been exclusively devoted for cultivation of cassava (tapioca).

This area emerged from thick jungle only since the last 15 - 20 years ago through the streneous efforts of the colonists volunteering from amongst the land-hungry North-East Thailand farmers, but still assumes undevelopment atmosphere because of arid nature of the land which can be confirmed by three dry years out of each five years, in the past.

The absolute majority of the inhabitants consist of the Lao, with a minority of the Khmer, though all of them are given Thai nationality.

Racial Composition

	Lao	Khmer
Ban Song Pin Nong :	93%	7%
Ban Kud Toey :	95%	5%

Members of household and family labour composition are, on an average, as follows:

Household-members		Family Labour Composition
Man & wife	2.0	2.0
Children	3.5	1.5
Aged	1.5	0.5
Total	7.0	4.0

3-5-3 Fundamental Structure of Agriculture

Due to a particular history of the inhabitants who cut and burnt as much virgin forest as they could and obtained the licenses from the Government for hereditary use of the land thus developed by themselves, the size of their holdings is uneven. A preliminary socio-economic survey in this area has brought out a tentative structural framework as shown in Table 3-3.

Table 3-3 Fundamental Structure of Agriculture in the Direct Beneficiary Area

Rural Households Settled in Two Villages			Paddyfield (rai)		Cassava Field (rai)	
Status	Households	%	Statuswise Average Holdings per Household	Statuswise Total Holdings	Statuswise Average Holdings per Household	Statuswise Total Holdings
Rich farmers	12	5	30 - 100 (@55)	655	5	60
Average farmers	189	80	20 - 30 (@25)	4,725	10	1,890
Poor farmers	12	5	10	120	12.5	150
Marginal farmers	23	10	-	-	-	-
Total	236	100		5,500		2,100

3-5-4 Analysis from Agro-Economic Aspect

Average yields of the nuclear crops are: 250 kg of paddy and 3,500 kg of cassave each per rai. While paddy is primarily for the cultivators' own consumption with any surplus for marketing, cassava is exclusively for marketing; the farm-gate price of paddy is ฿3.00 and that of cassava, ฿0.70 each per kg.

For cultivation of paddy, the "average farmers" who comprise of 80% of the total require no cash expenditure as they plough with their own buffaloes, apply their own manure to the field, and transplant and harvest through the traditional "neighbourhood joint labour." For cassava cultivation, however, growers have to pay ฿300.00/rai for tractor-ploughing and cash wages for the labourers who would be hired for uprooting and washing.

Cash income per average farm-household is calculated at ฿30,000/year: ฿10,000 from paddy and ฿20,000 from cassava. These averages can be obtained in the "good year" (plenty of rainfall) only and, from the long-range point-of-view taking into consideration 3 dry (bad) years out of each 5 years, their mean annual income must be evaluated much less than those given above.

CHAPTER IV WATER UTILIZATION PLAN

4 - 1 Water Resources

The source of water for this project is Huay-Ta-Kien. Huay-Ta-Kien is joined by several rivulets in the upstream of the proposed dam-site. The catchment area is 61 km^2. Since no runoff record is available with Huay-Ta-Kien, its runoff has had to be estimated from the rainfall data obtainable from the nearby rainfall stations.

4 - 2 Hydrology

The project area is located about 180 km inside from the sea-shore and is lying on a semi-falt plain about 90 m above-sea-level.

There are three (3) rainfall stations within the radius of 50 km from the dam-site:

Taphraya	20 km
Aranya Prathet	35 km
Watthana Nakhon	45 km

That in Aranya Prathet is manned with a full-time staff who keeps regular daily observation on rainfall, but that at Taphraya is not keeping daily rainfall record regularly.

Monthly and daily rainfall records since 1952 have been collected as far as possible. Meteorological data available from Aranya Prathet are shown on the following page.

Temperature (1951 - 1975) Unit = °C

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Monthly average	25.8	28.0	29.6	30.0	29.0	28.3	27.7	27.5	27.3	27.2	26.2	25.2	27.5
Past maximum	38.0	38.5	40.0	41.0	40.5	39.8	36.0	35.7	35.5	35.3	36.5	35.6	41.0
Past minimum	7.6	12.5	13.7	17.0	21.5	20.3	20.8	20.7	20.5	17.0	10.2	10.0	7.6

Rainfall (1951 - 1975) Unit = mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Monthly average	13.0	29.7	54.9	109.4	171.5	183.3	200.3	200.3	304.3	224.5	54.7	8.7	1554.6
Daily maximum	85.5	90.0	69.7	129.7	94.1	85.3	119.9	71.6	108.5	107.7	109.5	51.3	129.7
Mean rainfall days	1.6	2.9	5.4	9.2	15.9	18.0	18.7	20.2	19.5	14.7	5.7	1.6	133.4

Evaporation (1951 - 1975) Unit = mm

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Monthly average	125.2	112.9	131.8	115.4	89.1	72.1	65.9	62.0	55.1	68.1	83.9	102.6	1084.1

Relative Humidity Unit = %

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Year
Monthly average	63.0	63.0	65.0	69.0	77.0	80.0	82.0	83.0	83.0	80.0	75.0	68.0	74.0
Mean maximum	87.3	88.0	88.9	90.0	92.8	93.7	94.2	95.2	95.7	94.4	91.5	89.6	91.8
Mean minimum	44.0	43.8	44.9	49.3	58.3	63.5	66.0	67.5	68.4	64.9	58.1	50.8	56.6

(i) Rain fall

The maximum probable daily rainfalls arrived at through Hazen method at each rainfall station are as follows:

1/25 & 1/50 Maximum Daily Rainfall (mm)

Rainfall Station	Probability 1/25	Probability 1/50
Aranya Prathet	123	135
Watthana Nakhon	128	140
Taphraya	127 (130)	140

(ii) Flood Discharge

The maximum flood discharge obtainable from the 1/25 maximum daily rainfall at Taphraya (130 mm) is 166 m^3/sec. In designing spillway, flood follow-up calculation based on the assumed overflow width and depth of the spillway was carried out by taking into consideration its flood regulating capacity (the function of temporarily holding a part of the flood in surcharge portion of a reservoir). As a result, spillway capacity has been determined at 58.6 m^3/sec.

Amplitude of rainfall being rather big, the flood which may be caused by daily rainfall above 1/25 probability will be coped with by an emergency spillway.

4 - 3 Water Requirements

The end-use of the reservoir water can be divided into the subsistence water for the Kampuchean refugees in the Khao-I-Dang Holding Center and the irrigation water for the local Thai Villagers.

4-3-1 Subsistence Water for Refugees

Water requirements of the refugees have been calculated on the basis of:

Population : 90,000
Unit amount of supply : 30 litre/day/head
Total amount of supply : 2,700 m^3/day = 81,000 m^3/month

The subsistence water on behalf of the refugees will be supplied by a pipeline extending from Kud Toey Regulating Pond. By adding 10% as possible conveyance loss, 3,000 m^3 will be daily supplied to the Khao-I-Dang Holding Center.

As the reservoir water will be brought to the regulating pond via open-dug earthern canal, the conveyance efficiency (including regulating pond loss) has been calculated at 80% during the rainy season (May - October) and 70% during the dry season (November - April):

Rainy season = 3,000 m^3/0.8 = 3,750 m^3/day = 113,000 m^3/month
Dry season = 3,000 m^3/0.7 = 4,300 m^3/day = 129,000 m^3/month

The reservoir water annually diverted for the use of the refugees would amount to:

$$3,750\ m^3 \times 184^{(days)} + 4,300\ m^3 \times 181^{(days)} = 1,470,000\ m^3$$

(say 1,500,000 m^3)

4-3-2 Irrigation Water

Irrigation water requirements have been calculated on the basis of (i) irrigation efficiencies, (ii) effective rainfall, and (iii) cropping calender, as follows:

(i) Irrigation Efficiencies

	Rainy season	Dry season
Field efficiency	75%	75%
Conveyance efficiency	80%	70%
Integrated efficiency	60%	52.5%

(ii) Effective Rainfall

Effective rainfall has been calculated by the following method on the basis of monthly rainfall (R):

Cropwise	Effective Rainfall	Upper Limit (mm/month)
Paddy	0.75R	200
Upland crop	0.75R	120

(iii) Cropping Calender

Assuming that the storage capacity of the dam is 10 million m^3, the acreage is estimated where about 80% success percentage will be guaranteed. Then, irrigation water requirements are determined on the basis of a cropping calender as proposed in Fig. 4-1.

Formulae for Calculation

(1) Net Water Requirements (NWR) = Crop consumptive use + Percolation + Water requirements for field preparation (land preparation, etc);

(2) Net Irrigation Requirements (NIR) = Net water requirements - Effective rainfall;

(3) Diversion Water Requirements (DWR) = Net irrigation requirement/Diversion efficiency.

Crop consumptive use = Evapotranspiration value (according to Penman method) x Crop consumption ratio

Percolation = 0.5 mm/day (rainy season); 1.0 mm/day (dry season)

Water requirements for land preparation, etc. =
paddy = 200 mm/upland crops = 40 mm

Irrigation water requirements for 1969 - 1980 have been identified according to the above-mentioned formulae.

4-3-3 Total Diversion Requirements

Water requirements for irrigating 500 ha (3,125 rai) all through the year on the assumption of rainfall averaging to the last ten (10) years, plus the subsistence water on behalf of the Kampuchean refugees in the Kaho-I-Dang Holding Center will be:

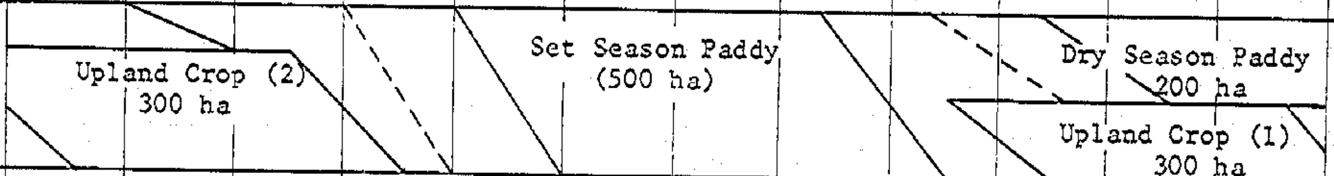
Average Monthly Diversion Requirements

May	277,000 m^3	November	1,118,000 m^3
June	166,000 "	December	444,000 "
July	122,000 "	January	1,212,000 "
August	1,806,000 "	February	1,692,000 "
September	140,000 "	March	1,545,000 "
October	354,000 "	April	1,127,000 "
Wet season:	2,865,000 m^3	Dry season:	7,138,000 m^3

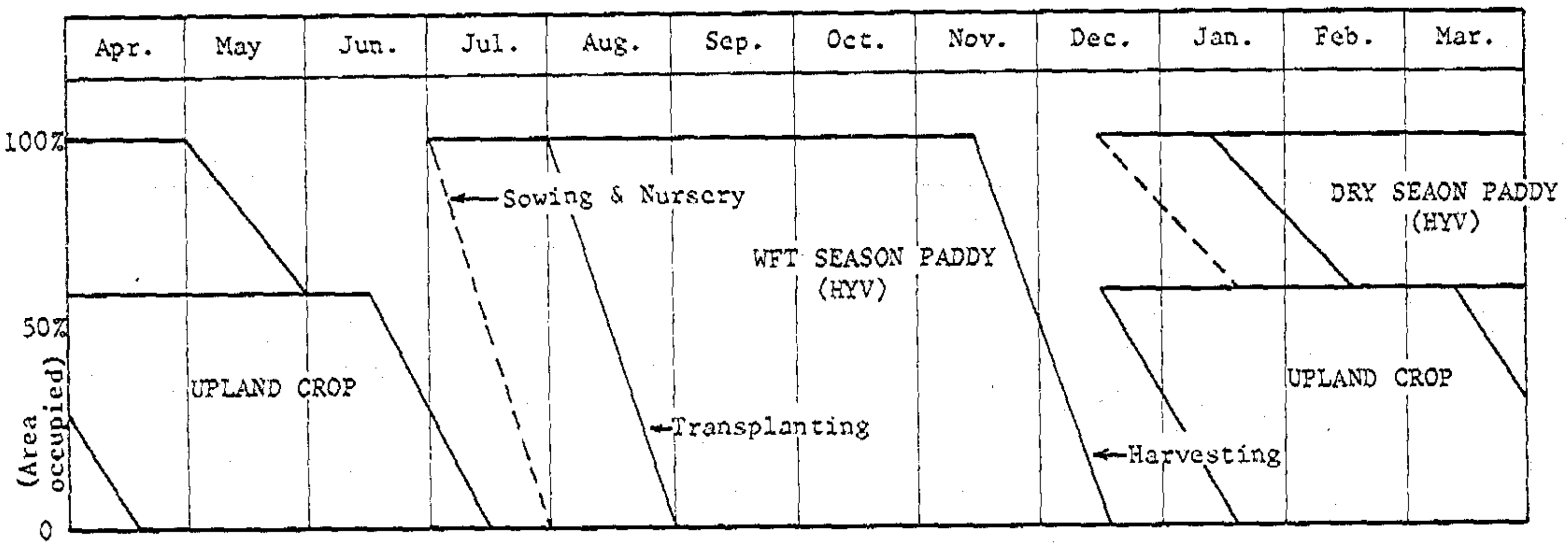
Annual Total : 10,003,000 m^3

Table 4-1 Monthly Diversion Water Requirements

Unit : 1,000 m^3

Month / Year	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Oct.	Jan.	Feb.	Mar.	Total	
													Annual	May - Oct.
1969	510	149	113	116	2,066	113	116	1,100	466	1,190	1,606	1,323	8,868	
1970	748	466	113	116	1,416	271	116	1,100	257	1,247	1,653	1,619	9,122	
1971	1,081	408	113	116	1,533	113	341	1,300	466				10,066	
1972										1,247	1,739	1,609		
1973	1,500	524	113	116	2,141	113	116	948	466	1,238	1,739	1,581	10,595	
1974	615	324	330	124	1,941	113	399	958	466	1,104	1,701	1,104	9,179	
1975	1,205	349	113	116	1,416	113	499	1,281	451	1,247	1,682	1,466	9,944	
1976	1,224	174	221	116	1,941	113	116	805	466	1,219	1,796	1,781	9,972	
1977	1,634	149	371	133	1,858	113	316	1,139	466	1,133	1,720	1,600	10,632	
1978	1,262	116	121	116	1,874	113	349	1,310	466	1,247	1,815	1,800	10,589	
1979	1,453	133	113	116	1,866	221	1,174	1,243	466	1,247	1,472	1,562	11,066	
1980	1,167	258	113	158	1,816									
Cropping calender														
Aver.	1,127	277	166	122	1,806	140	354	1,118	444	1,212	1,692	1,545	10,003	2,865

Note : Above monthly D.W.R are including diversion requirement for Refugees.



Note: Nursery area is equivalent to 5% of cultivation area.

Fig. 4-1 Proposed Cropping Calender

Table 4-1 Area of Irrigation Required per 100 ha

N	-	-	-	2.5	2.5	-	-	-	0.6	3.8	0.6	-	Paddy
LP	-	-	-	-	100	-	-	-	-	50	50	-	
G	100	50	-	-	50	100	100	87.5	12.5	12.5	87.5	100	
LP	50	-	-	-	-	-	-	-	50	50	-	50	Upland
G	100	100	875	12.5	-	-	-	-	12.5	87.5	100	100	

N : Nursery, LP : Land preparation (or puddling). G : Growing

Table 4-2 Monthly Rainfall at the Project Site

Unit : Millimeters

Month / Year	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Total	
													Annual	May - Oct.
1969	164.1	160.4	141.0	157.4	69.6	472.0	188.8	39.2	W 0	W 15.3	W 30.8	66.0	1,504.0	1,189.2
1970	127.5	W 93.8	212.7	196.0	338.0	144.3	425.2	38.0	155.0	0	24.0	25.7	1,780.2	1,410.0
1971	81.0	105.7	208.1	140.8	231.9	340.6	W 147.4	W 7.8	W 0	T 10.5	T 15.8	T 57.6	1,327.2	1,174.5
1972	-	-	-	-	-	-	-	-	-	W 0	W 10.7	W 26.4	-	-
1973	W 23.1	81.6	W 320.0	213.1	46.3	319.9	189.0	64.3	0	3.0	10.7	31.0	1,302.0	1,169.9
1974	146.5	120.7	47.4	104.1	108.2	W 175.3	W 138.3	W 63.2	T 0	A 33.3	A 16.7	A 97.6	1,051.1	694.0
1975	A 64.4	A 117.8	A 147.2	A 169.7	A 285.7	A 214.6	A 122.8	A 10.5	A 14.4	A 0	A 19.6	A 46.1	1,212.3	1,057.3
1976	60.8	151.8	81.4	122.1	109.4	283.9	250.6	A 87.1	A 0	A 5.0	A 2.0	A 2.2	1,156.3	999.2
1977	9.0	163.2	36.5	68.8	133.0	211.3	151.5	33.5	0	28.5	12.7	27.5	875.5	764.3
1978	55.4	239.4	111.8	140.5	128.1	357.4	146.8	A 6.1	A 0.5	A 0.3	A 0.3	A 0.3	1,186.9	1,124.0
1979	29.6	173.3	134.9	A 199.8	130.4	152.1	A 14.2	A 16.0	A 0	W 0	A 15.1	A 35.3	900.7	804.7
1980	68.9	134.3	313.0	32.8	146.8	-	-	-	-	-	-	-	-	-
Total	830.1	1,541.5	1,754.8	1,545.1	1,727.4	2,671.4	1,774.6	365.7	169.9	95.9	158.4	395.7		
n	11	11	11	11	11	11	11	11	11	11	12	12		
Aver.	75.5	140.1	159.5	140.5	157.0	242.9	161.3	33.2	15.4	8.7	13.2	33.0	1,180.3	1,001.3

Notes: A : (Data at Arayanphrathet) x 0.846 (May - Oct.) or x 0.675 (May - Apr.), T= Aver. rainfall at Taphraya
W : (Data at Watthana Nakhon) x 0.831 (") or x 0.908 (")

Table 4-3 Monthly Effective Rainfall

Unit : Millimeters

Month / Year	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual	
													Paddy	Upland
1969	(120) 123	120	106	118	52	(120) 200	(120) 142	29	0	11	23	50	974	869
1970	96	70	(120) 160	(120) 147	(120) 200	108	(120) 200	29	116	0	18	19	1,163	936
1971	61	79	(120) 156	106	(120) 174	(120) 200	111	6	0	8	12	28	941	771
1972	-	-	-	-	-	-	-	-	-	0	8	20	-	-
1973	17	61	(120) 200	(120) 160	35	(120) 200	(120) 142	48	0	2	8	23	896	674
1974	110	91	36	78	81	(120) 131	104	47	0	25	13	73	789	778
1975	48	88	110	(120) 127	(120) 200	(120) 161	92	8	11	0	15	35	895	767
1976	46	114	61	92	82	(120) 200	(120) 188	65	0	4	2	2	856	708
1977	7	(120) 122	27	57	100	(120) 158	114	25	0	21	10	21	657	617
1978	42	(120) 180	84	105	96	(120) 200	110	5	0	0	0	0	822	682
1979	22	(120) 130	101	(120) 150	98	114	11	12	0	0	11	26	675	635
1980	52	101	(120) 200	25	110	-	-	-	-	-	-	-	-	-
Total	(621) 624	(1,084) 1,156	(1,005) 1,241	(1,056) 1,160	(1,014) 1,228	(1,182) 1,672	(1,022) 1,214	274	127	71	120	297		
n	11	11	11	11	11	11	11	11	11	11	12	12		
Aver.	(56) 57	(99) 105	(91) 113	(96) 105	(92) 112	(107) 152	(93) 110	25	12	6	10	25	832	712

Note : ( ) is effective rainfall for upland-field.

Table 4-5 Computation Sheet of Net Water Requirements for Wet Season Paddy

Item		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
Cropping Calender								Wet season paddy						
① Evapotranspiration	(mm/day)	4.2	3.6	3.1	3.1	2.9	2.9	3.0	3.2	3.3	3.5	4.1	4.3	-
	(mm/month)	127	112	94	96	90	86	92	96	101	109	113	134	2,500
② Crop Factors		-	-	-	1.00	1.13	1.30	1.33	1.20	1.10	-	-	-	-
③ Crop Consumptive Use	(mm/month)	-	-	-	96	101	112	122	155	111	-	-	-	657
④ Porcolation	(mm/month)	30	16	15	16	16	15	16	30	31	31	28	31	275
⑤ Net Water Requirements	(mm/month)	-	-	-	112	117	127	138	145	142	-	-	-	781
⑥ W.R.for Land Preparation	(mm)	-	-	-	-	200	-	-	-	-	-	-	-	-
⑦ Net Irrigation Area	(ha/100ha)	-	-	-	3	(100) 53	100	100	88	12	-	-	-	-
⑧ Weighted NWR	(mm/month)	-	-	-	3	262	127	128	128	17	-	-	-	675

Notes : ⑦ ( ) is land preparation area.

⑤ is not including W.R. for land preparation.

⑧ = ⑤ x ⑦ /100 + ⑥×⑦ ( )/100

Table 4-6 Computation Sheet of Net Water Requirements for Dry Season Paddy

Item		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
Cropping Calender														
① Evapotranspiration	(mm/day)	4.2	3.6	3.1	3.1	2.9	2.9	3.0	3.2	3.3	3.5	4.1	4.3	-
	(mm/month)	127	112	94	96	90	86	92	96	101	109	113	134	2,500
② Crop Factors		1.30	1.10	-	-	-	-	-	-	1.00	1.00	1.25	1.35	-
③ Crop Consumptive Use	(mm/month)	165	123	-	-	-	-	-	-	101	109	142	181	821
④ Parcolation	(mm/month)	30	16	15	16	16	15	16	30	31	31	28	31	275
⑤ Net Water Requirements	(mm/month)	195	139	-	-	-	-	-	-	132	140	170	212	988
⑥ W.R. for Land Preparation	(mm)	-	-	-	-	-	-	-	-	-	200	200	-	-
⑦ Net Irrigation Area	(ha/100ha)	100	50	-	-	-	-	-	-	1	(50) 16	(50) 88	100	-
⑧ Weighted NWR	(mm/month)	195	70	-	-	-	-	-	-	1	122	250	212	850

Notes : ⑤ is not including W.R. for land preparation.
⑦ ( ) is land preparation area.
⑧ = ⑤ x ⑦ /100 + ⑥ x ⑦ ( )/100

Table 4-7 Computation Sheet of Net Water Requirements for Upland Crop

Item		Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
Cropping Calender		Upland Crop									Upland Crop			
① Evapotranspiration	(mm/day)	4.2	3.6	3.1	3.1	2.9	2.9	3.0	3.2	3.3	3.5	4.1	4.3	
	(mm/month)	127	112	94	94	90	86	92	96	101	107	113	134	2,500
② Crop Factors		0.70	0.90	0.75	0.55	-	-	-	-	0.55	0.70	0.90	0.75	-
③ Crop Consumptive Use	(mm/month)	89	101	70	53	-	-	-	-	55	76	102	100	646
④ Percolation	(mm/month)	30	16	15	16	16	15	16	30	31	31	28	31	275
⑤ Net Water Requirements	(mm/month)	119	117	85	69	-	-	-	-	86	107	130	131	844
⑥ W.R. for preparatory works	(mm)	40		-	-	-	-	-	-	40	40	-	40	-
⑦ Net Irrigation Area		(50) 100	100	88	12	-	-	-	-	(50) 12	(50) 88	100	(50) 100	-
⑧ Weighted NWR	(mm/month)	139	117	75	8	-	-	-	-	30	114	130	151	764

Notes : ⑤ is not including W.R. for land preparation.

⑦ ( ) is land preparation area.

⑧ = ⑤ x ⑦/100 + ⑥ x ⑦( )/100

4 - 4 Water Balance

4-4-1 Terms of Computation

(i) Inflow

Rainfall in the catchment area of 61 km^2 will be collected into the reservoir as follows:

Rainy season (May - October)

Inflow = Monthly rainfall x 61$^{(km^2)}$ x 25%

Dry season (November - April)

Inflow = None

Rainfall on the water-surface of the reservoir, however, will be 100% effective:

Inflow = Monthly rainfall x water-surface in the previous month x 100%

(ii) Reservoir Loss

Evaporation = 80% of the pan evaporation value will be multiplied by the water-surface in the previous month

Leakage = 0.05% of the reservoir storage per day or 1.5% per month. Monthly leakage will be calculated: Reservoir storage of the previous month x 1.5%

(iii) Rainfall Data

Data obtained at Taphraya have been replenished by those available from the nearby rainfall stations. Rainfall data from 1969 to 1980 have been used on monthly basis.

4-4-2 Water Balancing

The results of water balancing calculation for the period of 1969 to 1980 according to the above-mentioned terms of computation and on the assumption of that the irrigable area will be 500 ha (3,125 rai) = 500 ha under paddy during the rainy season, and 200 ha under paddy and 300 ha under upland crops during the dry season = are as follows:

(1) Effective Storage Potential and Water Requirements (Outflow)

Year	Effective Storage Potential	Outflow
1970	17,494,000 m^3	8,722,000 m^3
1971	13,109,000	9,990,000
1972		
1973	13,505,000	10,713,000
1974	6,988,000	9,828,000
1975	12,380,000	9,458,000
1976	11,392,000	9,571,000
1977	7,825,000	10,975,000
1978	13,031,000	10,180,000
1979	8,021,000	11,647,000
Average	11,527,000 m^3	10,120,000 m^3

(2) Months of Overflowing from Spillway : 14 months out of 120 months

(3) Effective Utilization Ratio :
(Effective Storage Potential - Overflow)/Effective Storage Potential ≒ 80%

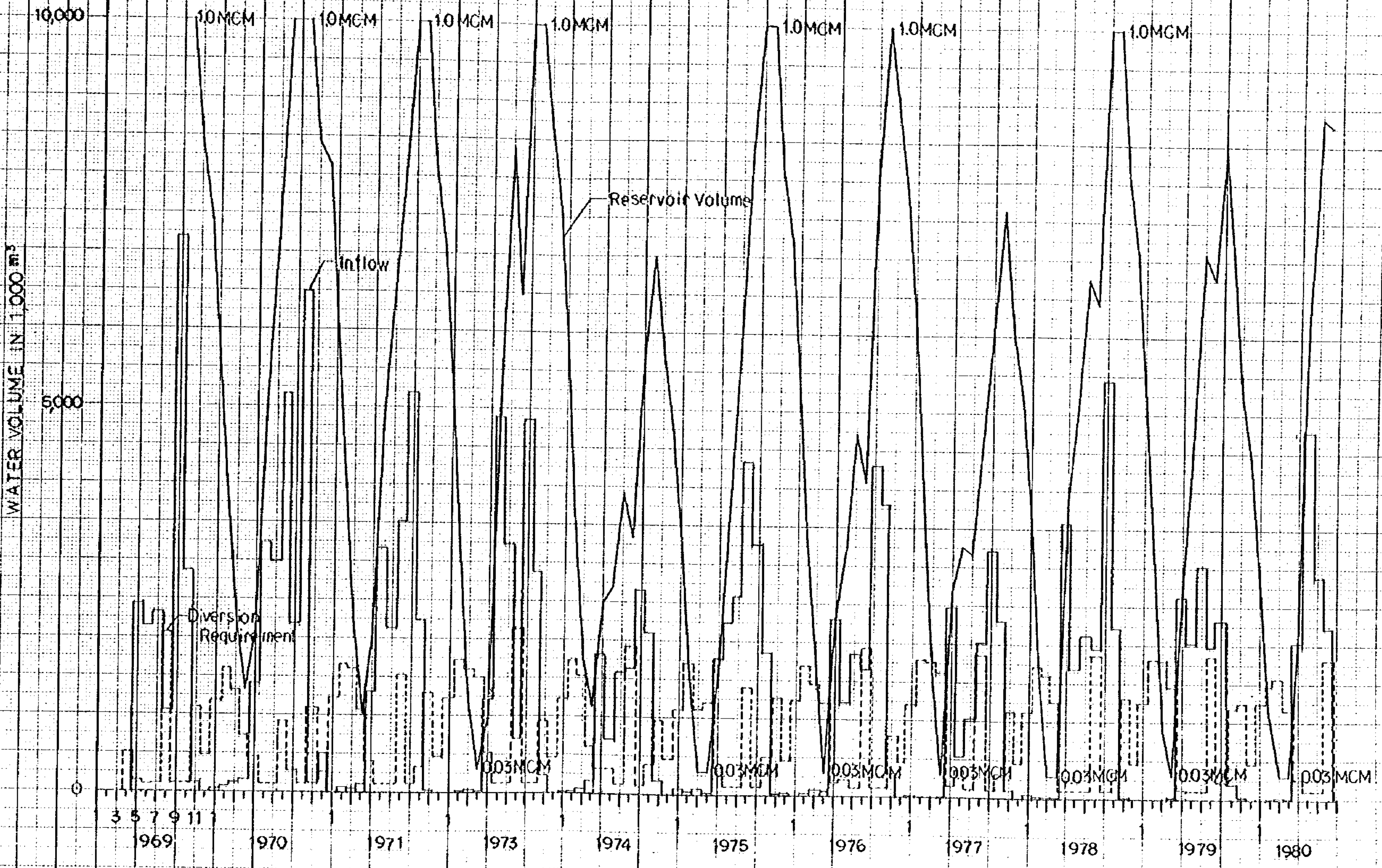
(4) Months of Water Shortage : 10 months out of 120 months

(5) Crop-wise Success Percentage :

Rainy season	Paddy (500 ha)		11/11 = 100%
Dry season	Paddy (200 ha)		6/11 = 55%
"	Upland crop	(300 ha) (A)	9/11 = 90%
"	Upland crop	(300 ha) (B)	3/11 = 30%

300 ha out of 500 ha is assumed to be used for upland crops during the dry season by two (2) shifts of (A) and (B) as per the proposed cropping calender.

Fig. 4-2 WATER BALANCE STUDY



CHAPTER V INSTALLATION PLAN

5 - 1 Dam

5-1-1 Dam-Axis

The survey team originally assumed that the topographic map prepared by RID would be reliable enough to be used for determination of the dam-axis on it and what remained was to finalize the dam-asix through center-line surveying on the spot. However, the contour lines given on the map along the left bank slope were found to be deceptive and thereby dam-axis needed to be amended before it was finalized to the proposed one.

The dam-axis is not running straight. It is bent at two (2) points but believed to be the best in due consideration of the topography, the storage capacity, the construction cost and the relative easiness of work.

5-1-2 Storage Capacity & Type

The storage capacity and the reservoir area obtainable in the proposed dam-site have been computed on the basis of the topographic map which had been prepared by RID (s = 1/4000). They are indicated in terms of H-V and H-A curves drawn on the attached Figure 5-1. Eventually, the storage capacity and the reservoir area have been diminished by about 4 million m^3 in case of the former and 0.6 km^2 in case of the latter, in comparison to the original plan worked out by RID.

In determining the scale of the storage capacity, the following three (3) items have been taken up for deliberate study:

(1) Effective storage potential which will be equalized to the balance between the inflow and reservoir loss (evaporation + leakage);

(2) Topography, and

(3) Construction Cost.

Some explanation will be made on these items in the below.

(1) Effective storage potential

As already computed under 4-4: Water Balance, the representative values are:

Maximum storage capacity (1970) = 17.5×10^6 m^3
Minimum storage capacity (1974) = 7.0×10^6 m^3
Average storage capacity = 11.5×10^6 m^3

Thus the optimal design storage capacity would be around $\underline{10 \times 10^6 m^3}$.

(2) Topography

The crest level proposed in the RID's original plan was set at 60.3 m (RID elevation 97.0 m, difference 36.7 m) and should this level need to be maintained, both the crest length and the crest height would have to be increased, on the basis of the actually surveyed topographic map, by:

	Original Plan	Revised Plan	Difference (+)
Crest length	2,320 m	2,870 m	550 m
Crest height	10.5 m	11.5 m	1.0 m

This means a considerable increase in the construction cost. Topographically speaking, again, there was discovered a gully on the left bank slope (elevation 59.24 m) and if the crest height needs to go above this gully, the crest length would have to be extended very much, requiring an enormous construction cost. The relationships ruling between the crest level and the dimensions of other items will be shown as follows:

Crest Level	Crest Length	Crest Height	Normal Water Level	Storage Capacity	Reservoir Area
(EL.m)	(m)	(m)	(El.m)	(1000 m^3)	(km^2)
60.3 (original)	2,870	11.5	58.0	14,700	4.53
59.8	2,670	11.0	57.5	12,500	4.15
59.3	2,600	10.5	57.0	10,600	3.71
59.1*	2,450	10.3	56.8	10,000*	3.57
58.8	2,410	10.0	56.5	9,000	3.35

(*) adopted

The above Table would indicate that, judging from the topographic point-of-view, the crest level may not be raised above 59.24 m, and the survey team adopted 59.1 m as the optimal crest level.

(3) Construction Cost

Although RID is desirous to have a much larger reservoir built, the optimal storage capacity technically possible within the predecided financial allocation would rest at 10 x 10^6 m^3 (10,000,000 m^3), with the crest level at 59.1 m.

Judging from the geological formation at the dam foundation and the materials available from the borrow areas, earth dam is the best and the most economical type recommendable here.

In consideration of the borrow area situation, the easiness of work, the economy, and the low height of dam itself (about 10 m), homogeneous type has been chosen out of other type like zone type or core type.

5-1-3 Foundation & Borrow Areas

(1) Dam Foundation Bedrock

As a result of dam foundation study through five (5) borings and eleven (11) test pitting, it was confirmed that the foundation bedrock is sandstone corresponding to Jurassic Phrawihan formation. It is in an advanced stage of weathering and presents clayey soil conditions. Over this bed rock, the end-Tertiary to Quaternary deposits consisting of sandy clay and sandy silt are spreading in layers. On top of it, modern deposits consisting of silty sand and sandy clay are being distributed.

Geological considerations of the dam foundation will be concluded as follows:

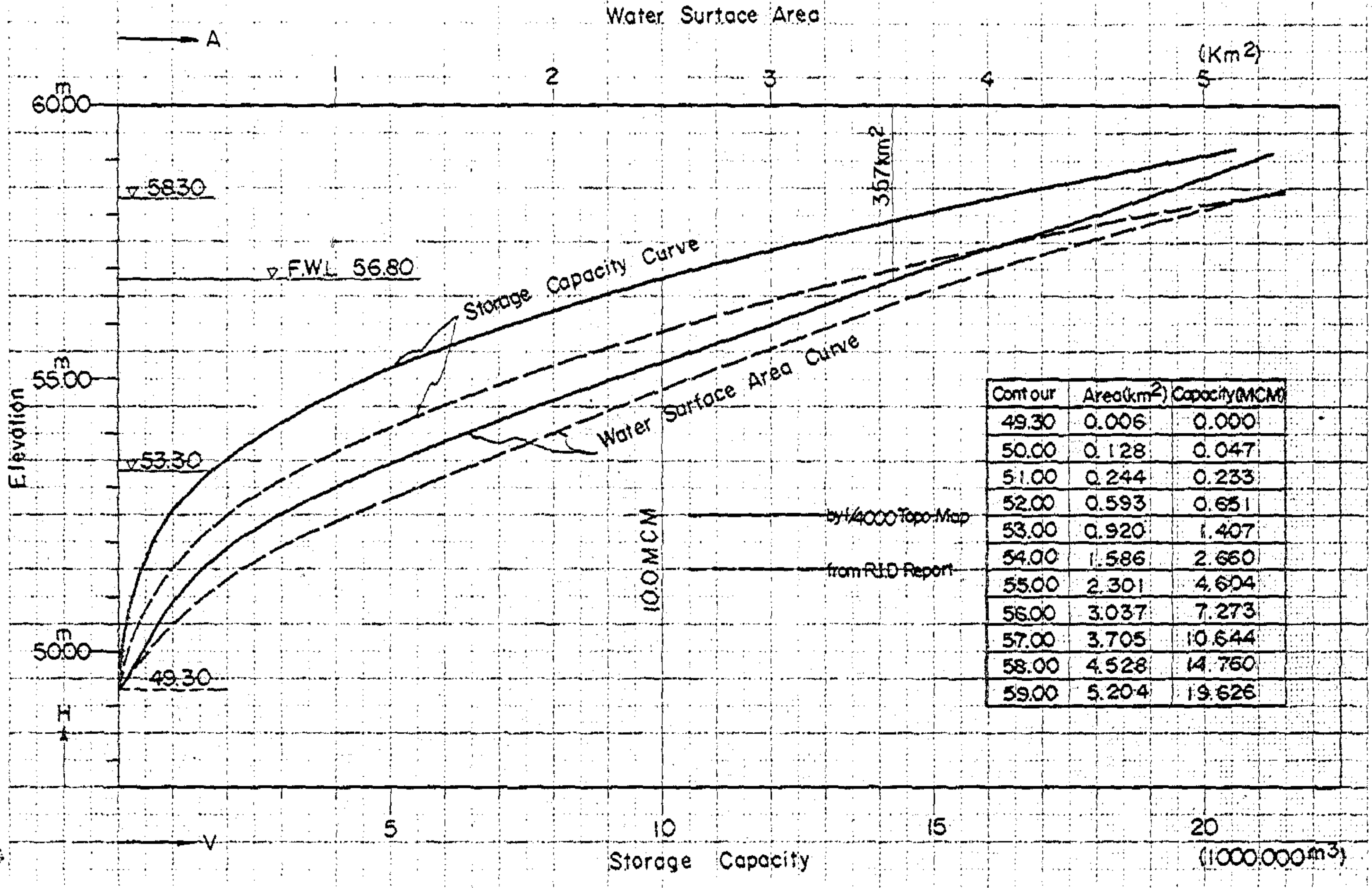
(Stability of Dam Foundation)

The stability to the design embankment is generally good except partial foundation treatment with sandy layer.

(Permeability of Foundation Bedrock)

Because silty sand and weathered sandstone which are spreading on the ground surface are quite permeable and clayey soils containing stumps and formicaries in cracked conditions are extending to the depth of 2.5 m below the surface, cut-off will have to be done to the depth of 3.0 m or more in order to excavate the undesirable portion and to replace cut-off portion by impermeable materials.

Fig.5-1 H-V, H-A CURVE



Contour	Area(km2)	Capacity(MCM)
49.30	0.006	0.000
50.00	0.128	0.047
51.00	0.244	0.233
52.00	0.593	0.651
53.00	0.920	1.407
54.00	1.586	2.660
55.00	2.301	4.604
56.00	3.037	7.273
57.00	3.705	10.644
58.00	4.528	14.760
59.00	5.204	19.626

Complete foundation treatment will, therefore, be given by cut-off as a rule and grouting as required.

(2) Borrow Areas

Borrow areas were selected through filed investigation at three (3) places, each one at both wings of the proposed dam-asix and the last one at its downstream located towards the right bank. Their selection was made in consideration of the water-level of the existing coffer-dam and the location of the proposed dam.

Altogether twelve (12) test pits were dug in these three borrow areas and the sampling test resulted at as follows:

Borrow Area	Depth	Soil Quality	Material Availability
Left Bank (submergible) (A)	Surface - 0.3m	Surface soil	A = 60,000 m^2
	0.3 - 2.0m	Sandy silt/ sandy clay*	D = 2 m V = 120,000 m^3
	2.0m and deeper	Weathered sand-stone (bedrock)	
Right bank (submergible) (B)	Surface - 0.4m	Surface soil	A = 175,000 m^2
	0.4m - 2.2m	Silty fine sand	D = 3 m
	2.2m and deeper	Sandy clay*	V = 525,000 m^3
Right Bank (downstream) (C)	Surface - 0.4m	Fine sand	A = 80,000 m^2
	0.4m and deeper	Sandy clay*	D = 3 m V = 240,000 m^3

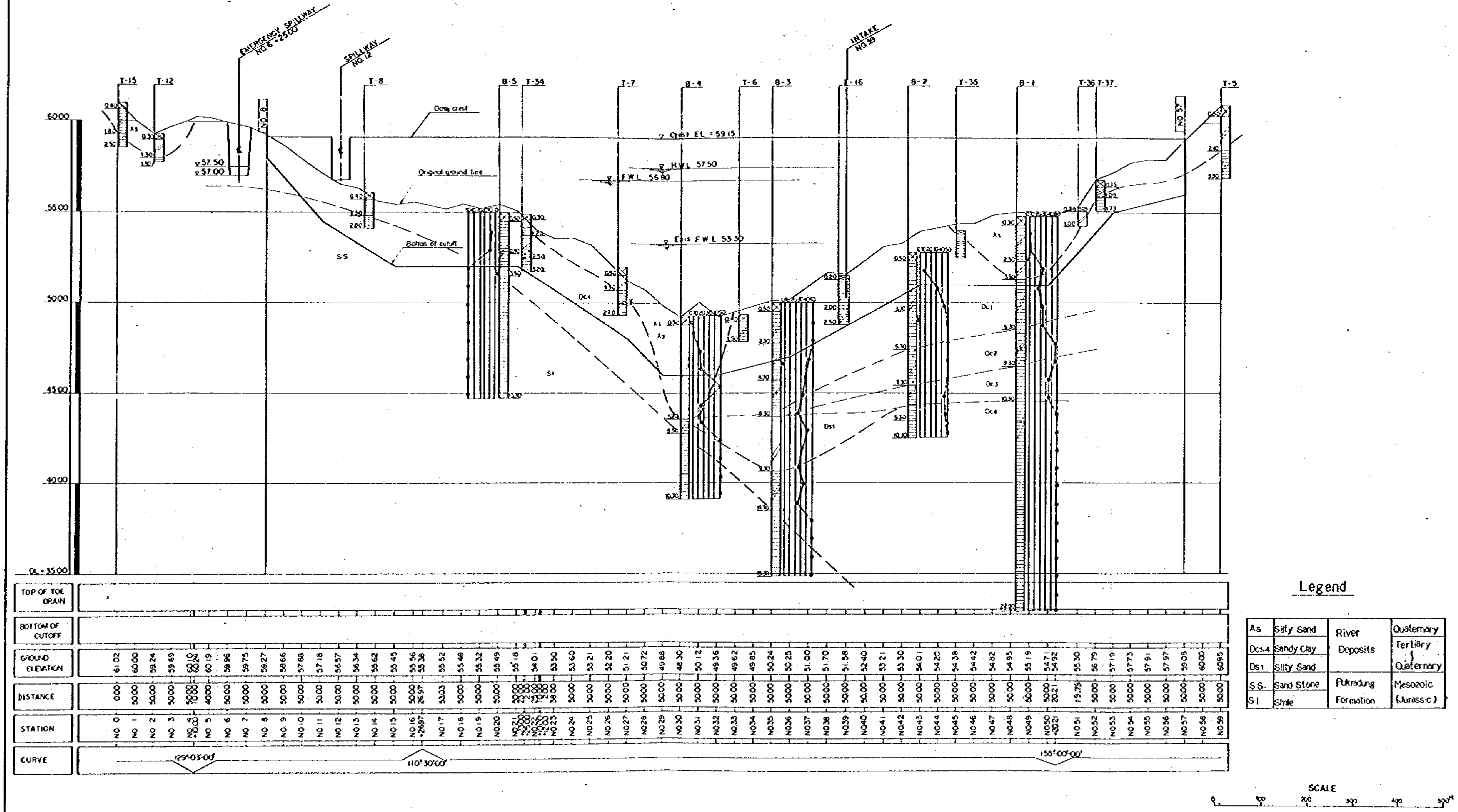
(A = Area/D = Depth/V = Volume) V = 885,000 m^3
(*) Embankment materials

Sandy silt/sandy clay, free from surface soil, silty fine sand and weathered sandstone, can be used as embankment materials, and there is little qualitative difference among those available from these three (3) borrow areas.

The entire requirement for the embankment material is about 300,000 m^3 which is liberally suppliable from these borrow areas.

A and C borrow areas are believed to be more advantageous than B in actual excavation of the embankment material.

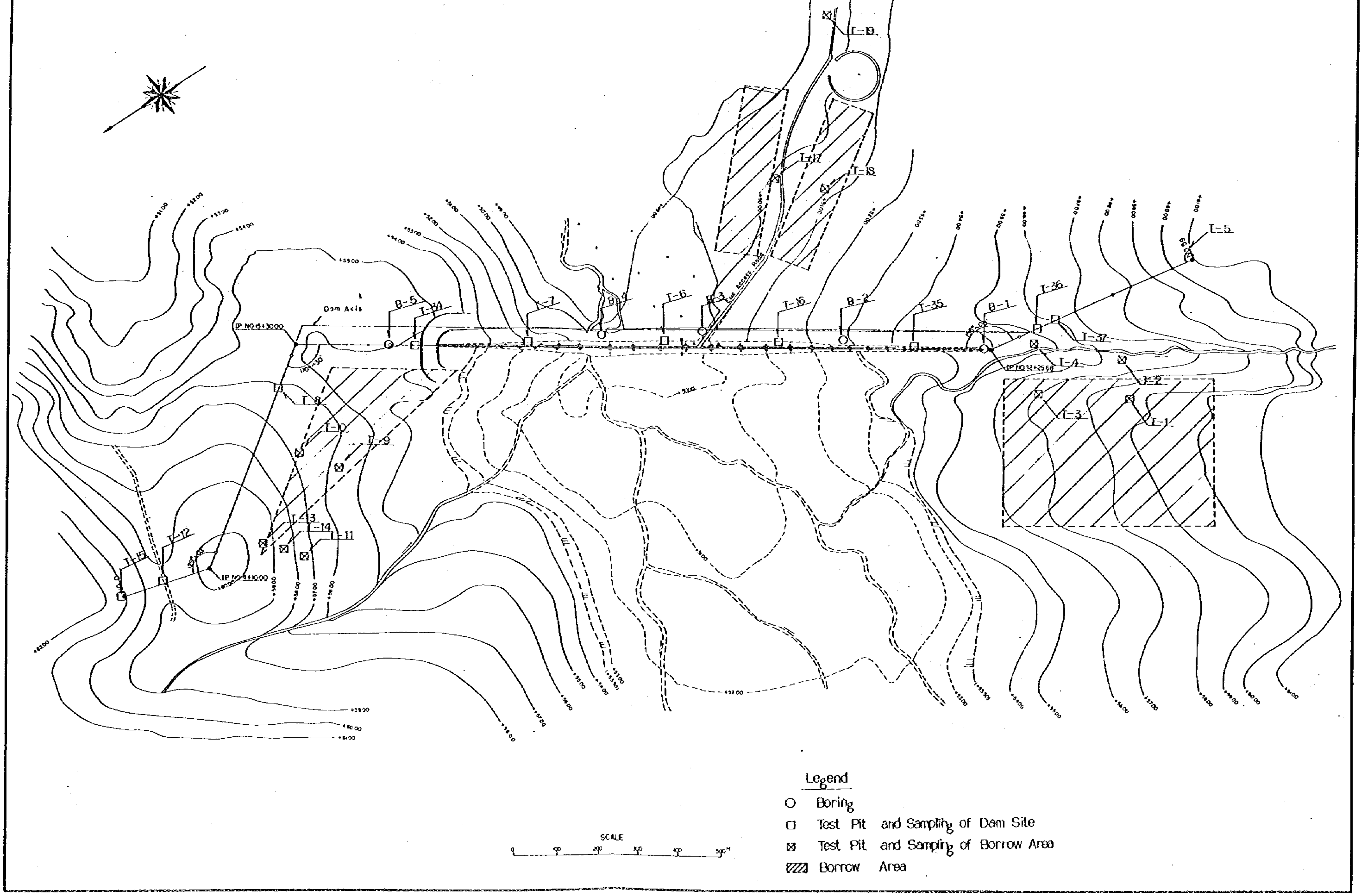
Fig. 5-2 GEOLOGICAL SECTION OF THE DAM AXIS



Legend

As	Silty Sand	River Deposits	Quaternary
Dc1-4	Sandy Clay		Tertiary Quaternary
Ds1	Silty Sand		
S.S.	Sand Stone	Pukradung Formation	Mesozoic (Jurassic)
S1	Shale		

Fig.5-3 LOCATION MAP



5-1-4 Dam Design

Coffer-dam had been built under the departmental construction of RID in June 1980 and the monsoon rainwater collected therein was expected to be supplied to the Khao-I-Dang Holding Center all through the coming dry season (November 1980 - April 1981). Unfortunately, a part of this coffer-dam collapsed on October 8 1980 and the water held in the reservoir flowed out lowering the water level down to 51.3 m. Emergency repair work followed the accident by the hand of RID.

It was previously designed to partly utilize the existing coffer-dam for constructing a higher dam-body but, after the above-mentioned collapse took place with the standing coffer-dam, RID strongly recommended to avoid such design from the safety point-of-view. The survey team, therefore, decided to build a new dam in the downstream side of the existing dam.

The newly designed dam will have an ample crest width of 5 m, paved with laterite to the depth of 40 cm. The slope will be 1 : 2.5 on the upstream side and 1 : 2.0 on the downstream side. Safety has been proven through computerized calculation using various soil test data. Upstream slope will be protected by stone-pitching upto 52.0 m, and the downstream slope will be equipped with drains with 5 m interval lengthwise and breadthwise to prevent wash-out and crack. Upward it will be covered by lawn.

Toe-drain will be provided at the foot of the downstream slope and the safety of the dam-body will be secured by lowering seepage line.

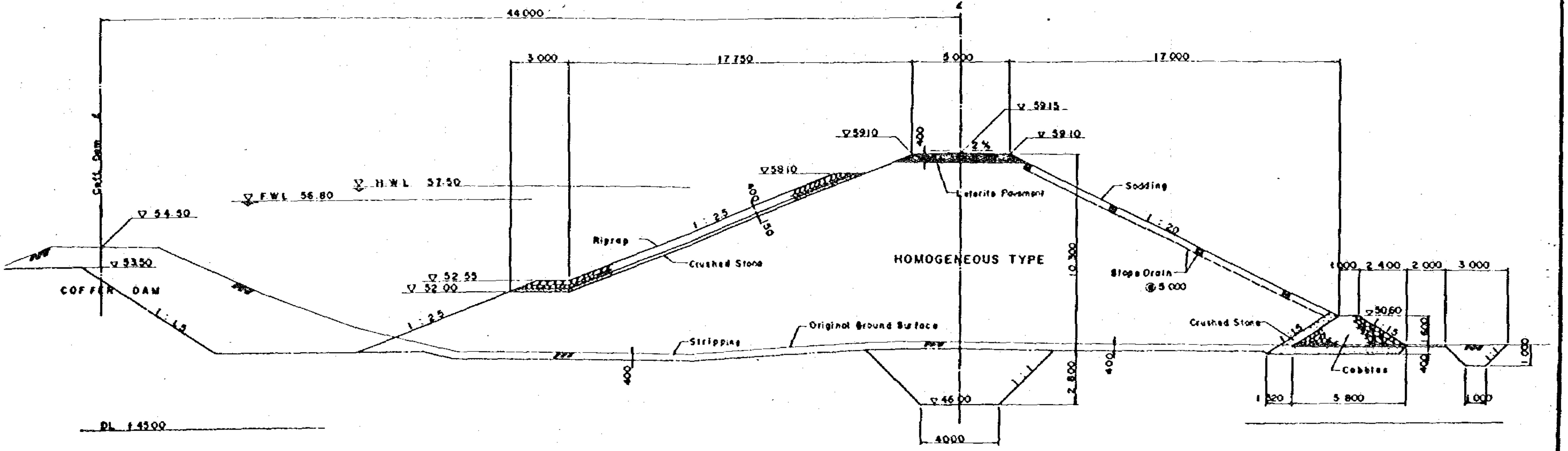
Foundation treatment will be done through cut-off and grouting in the light of the boring- and testpit- results. The depth of cut-off depends on the result obtainable from various surveying points and grouting will be effected at depressions.

The standard cross section of the dam-body is shown in Fig. 5-4.

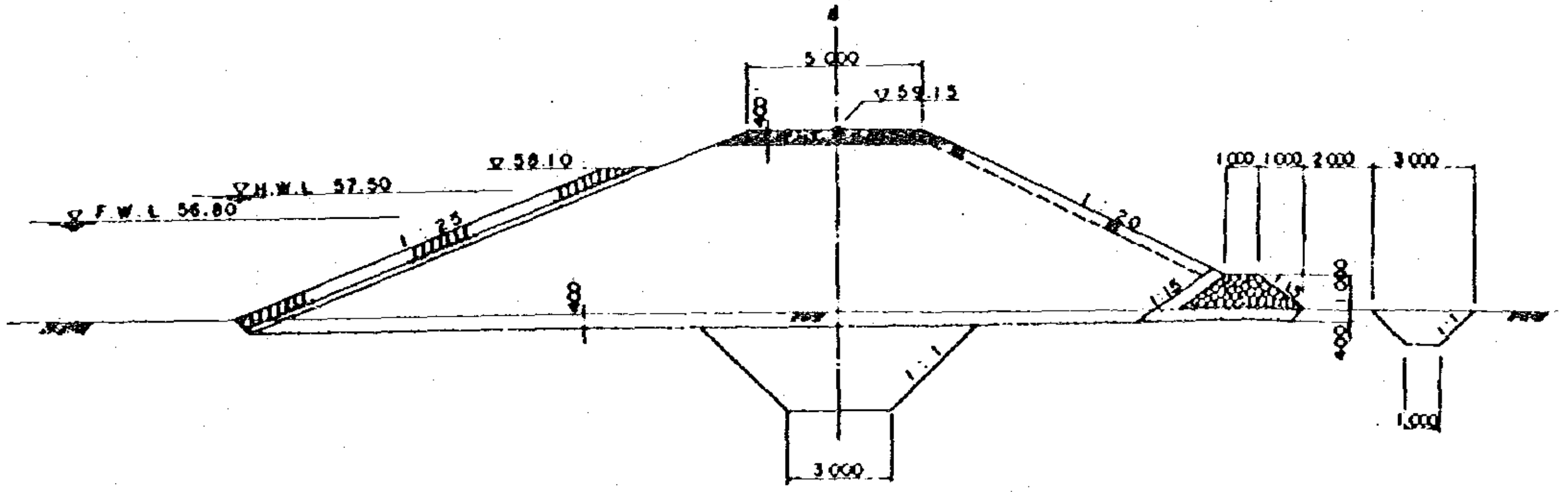
Slope Stability Analysis

Safety Factor / Case	Safety Factor		
	Upstream	Downstream	Standard
Full Storage Time	1.45	1.29	1.2
Rapid Drawdown Time	1.43	-	1.2

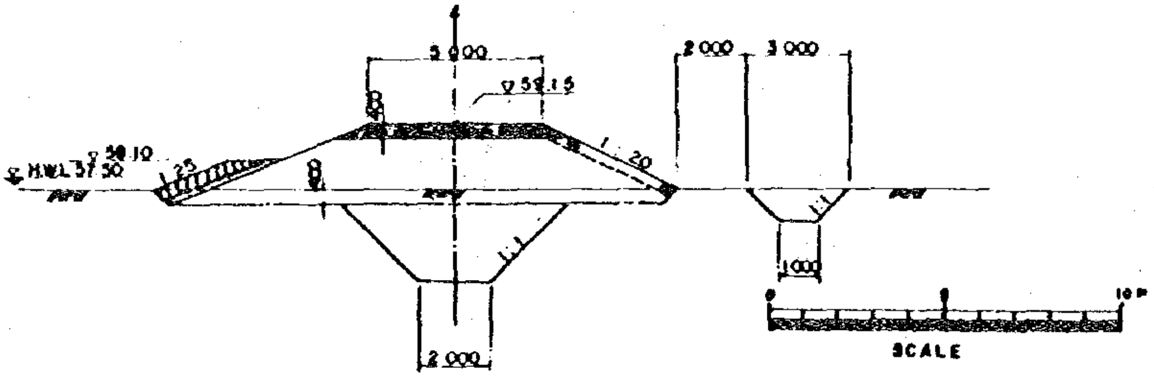
Fig.5-4 TYPICAL DAM SECTION



DAM SECTION AT ABUTMENT HIGHER THAN EL 54.0



DAM SECTION AT ABUTMENT HIGHER THAN EL 56.8



TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

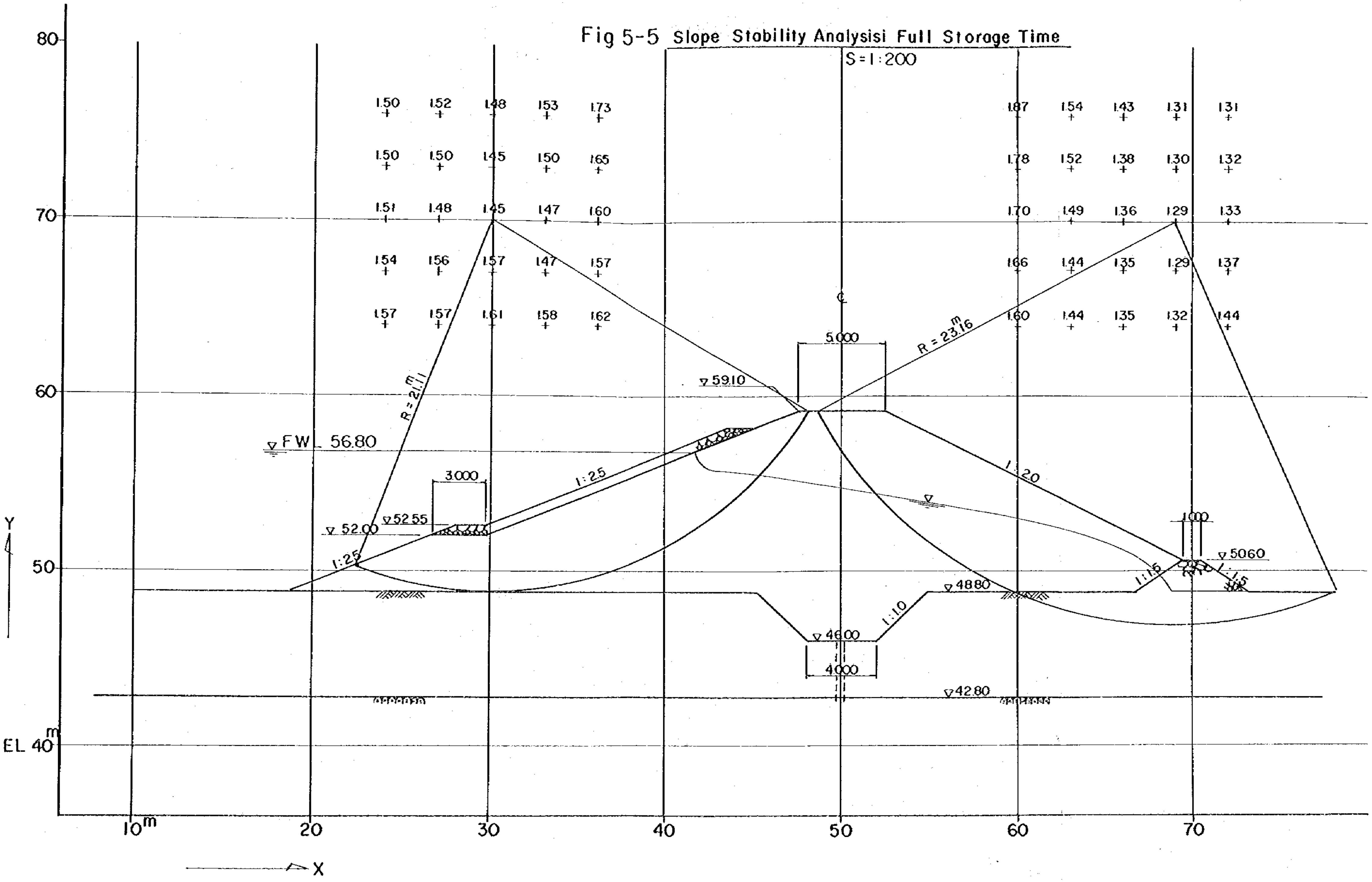
DAM
TYPICAL DAM SECTIONS

Date NOVEMBER 1980	D.W.G No. 4/29

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig 5-5 Slope Stability Analysisi Full Storage Time

S = 1 : 200



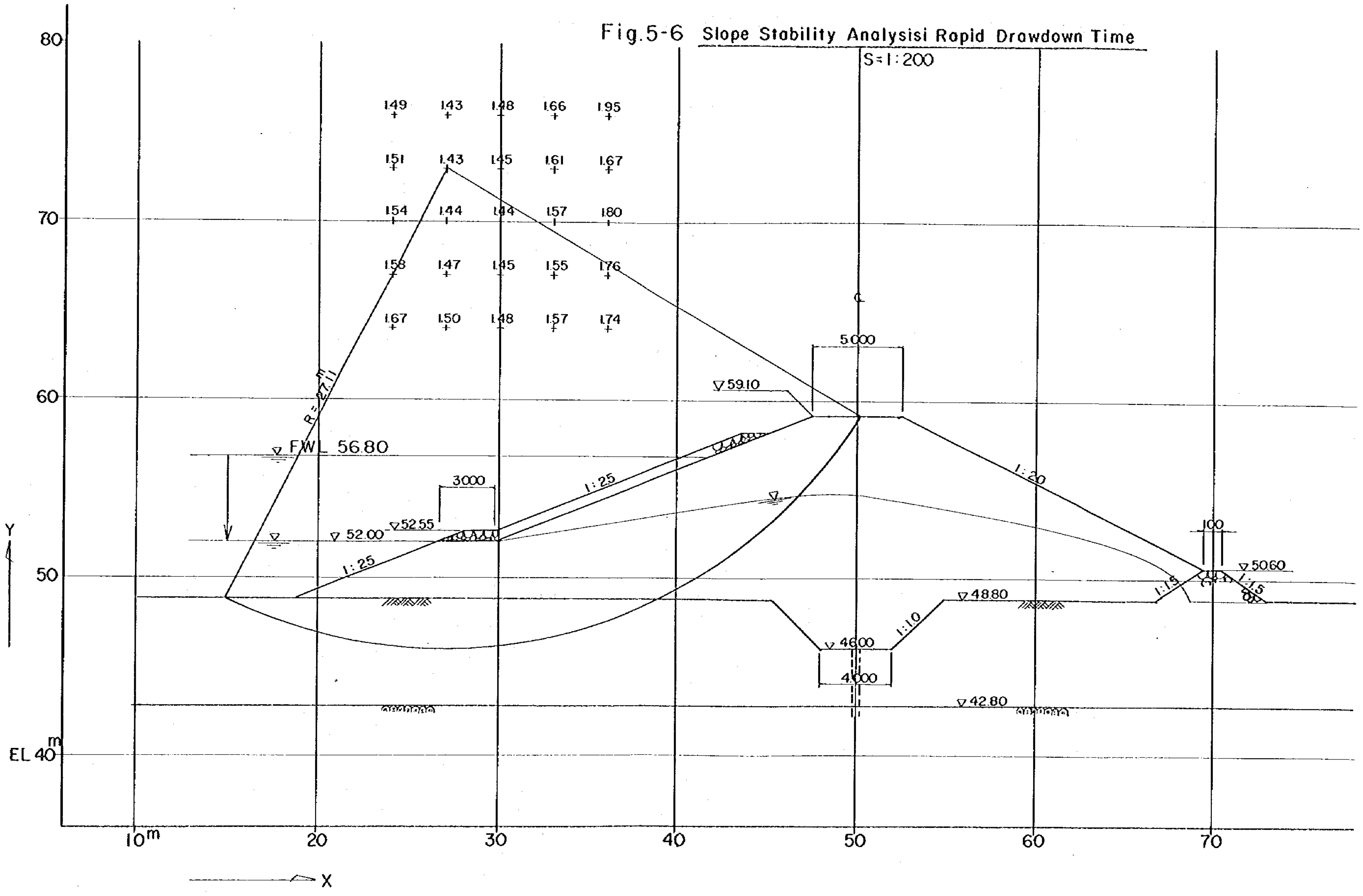


Fig.5-6 Slope Stability Analysisi Rapid Drawdown Time

S=1:200

5-1-5 Spillway Design

(1) Selection of Location

Spillway has been located at Point No. 12 on the left bank side. This decision is based on considerations as to the topography, geology, dam alignment, plus safety and economy.

Geologically speaking, the bedrock (sandstone) is spreading within 1 - 2 m depth from the ground surface providing good foundation for concrete structure in the neighbourhood of Point No. 12. Spillway tail channel, however, is disconnected to any natural river and the overflow water has to run through the plain.

Emergency spillway will be likewise located on the left bank side at Point No. 6 + 25.

(2) Determination of Type

Uncontrolled solid overflow weir type has been adopted from the topographical, geological and O&M considerations, plus hydraulic and economic reasons.

(3) Scale of Spillway

In this project, the reservoir area (3.75 km^2) is fairly large in comparison to the catchment area (61 km^2) and the reservoir will be equipped with uncontrolled solid overflow weir type spillway. Under these circumstances, an economical design has been sought by reducing the design flood discharge by taking into account the flood regulating capacity of the reservoir itself.

The present dam has been designed to have 59.1 m crest height and 10×10^6 m^3 storage capacity, with 56.8 m F.W.L. Accordingly, the freeboard and overflow depth is 2.3 m. Wave rideup height attainable by wind at 20 m velocity across 2.6 km fetch would be 1.6 m. This gives 0.7 m overflow depth. Follow-up calculation based on this value resulted at 50 m spillway width and 58.6 m^3/sec flood discharge.

(4) Spillway Tail Channel

It will be an open-dug earthern channel with 50 m bottom width and 1.8 m depth.

5-1-6 Intake Works Design

(1) Selection of Location

Location of the intake work has been determined at Point No. 39 because of the sound foundation and the convenience of connection with the proposed conveyance canal.

Effective water level has been tentatively decided at 51 m, sedimentation being taken into account, and driving ditch will be dug to this water level towards the end of dry season. As RID is desirous of using the reservoir water even after its level comes down below the effective water level, the intake conduit with 250 mm diameter which had been installed beneath the existing coffer-dam will be left as it is and extended by adding a new conduit of the same diameter.

(2) Choice of Type

Tower-type sluice with a slide gate which can regulate outflow of the reservoir water according to its water level and diversion requirements.

(3) Maximum Intake

The maximum intake for subsistence water on behalf of the Kampuchean refugees in the Holding Center and irrigation water put together will be 1.3 m^3/sec.

(4) Closed Conduit

Ferro-concrete pipe (diameter 1,000 mm) will be entirely armoured all around by ferro-concrete.

5 - 2 Conveyance Canal Design

5-2-1 Alignment

Conveyance canal route has been selected by paying due attention to the followings:

(i) To select straight course, as far as possible, to shorten the distance;

(ii) To avoid area whose soil quality does not satisfy engineering requirements and the residential compounds;

(iii) To select the course where embankment work is not required, and

(iv) To maintain the highest water level to facilitate for gravity irrigation.

The canal alignment proposed by RID without any reliable topographic map was found running more often than not through low-lying area necessitating embnakment for a considerable distance, and the total length of the proposed canal from the dam to the Khao-I-Dang Holding Center measured about 10 km due to zigzagging course.

The survey team, therefore, made an overall alteration to the canal alignment and carried out surveying anew to confirm its adequacy, and eventually the total length of the canal has been shortened to 8.1 km.

5-2-2 Canal Types & Cross Sections

The conveyance canal will have a regulating pond at the midway of its entire course; that from the reservoir to the regulating pond will be an open-cut earth canal for conveyance of both the refugees' subsistence water and the irrigation water. One side of its banks is meant for operation and maintenance purposes.

From the regulating pond to the Khao-I-Dang Holding Center, a pipeline will supply the subsistence water on behalf of the refugees.

(1) Open-cut earth canal (4,475 m)

It is designed for three (3) different discharges of: 1.3 m^3/sec., 0.9 m^3/sec, and 0.5 m^3/sec. Cross section to meet each different discharge is given in Table 5-1.

(2) Pipeline (3,643 m)

Asbestos cement pipe with 250 mm diameter will be installed to allow 0.05 m^3/sec flow between the regulating pond and the Center. The pipeline diameter has been arrived at by calculation following Hazen-Williams formula.

5-2-3 Pertinent Structures

Conveyance Canal	Structures	No.
Open-dug Earth canal	Box culvert	6
	Drop	3
	Cross culvert	6
Pipeline	Aqueduct	1
	Blowoff	1
	Air valve	7
	Check valve	1

Table 5-1 Hydraulic Calculation of Standard Cross Section for Main Canal

Type	Q m^3/s	I	n	$\frac{1}{n}\sqrt{I}$	b_m	d_m	A_{m^2}	P_m	$R=(\frac{A}{P})$	$R^{2/3}$	$V_{m/s}$	Q m^3/s	h_m	Hm (d+h)	B_m
1	1.3	1/2000	0.03	0.745	1.3	1.0	2.80	4.91	0.57	0.687	0.512	1.43	0.40	1.40	5.50
2	0.9	"	"	"	1.0	0.9	2.12	4.25	0.499	0.629	0.469	0.99	0.30	1.20	4.60
3	0.5	"	"	"	0.8	0.8	1.60	3.68	0.435	0.574	0.428	0.68	0.30	1.10	4.10

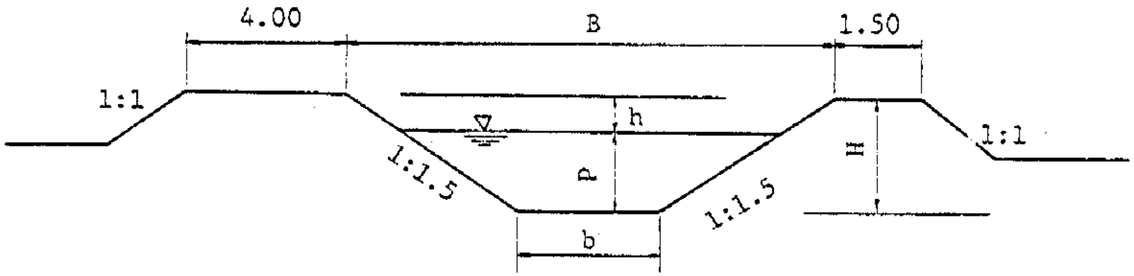
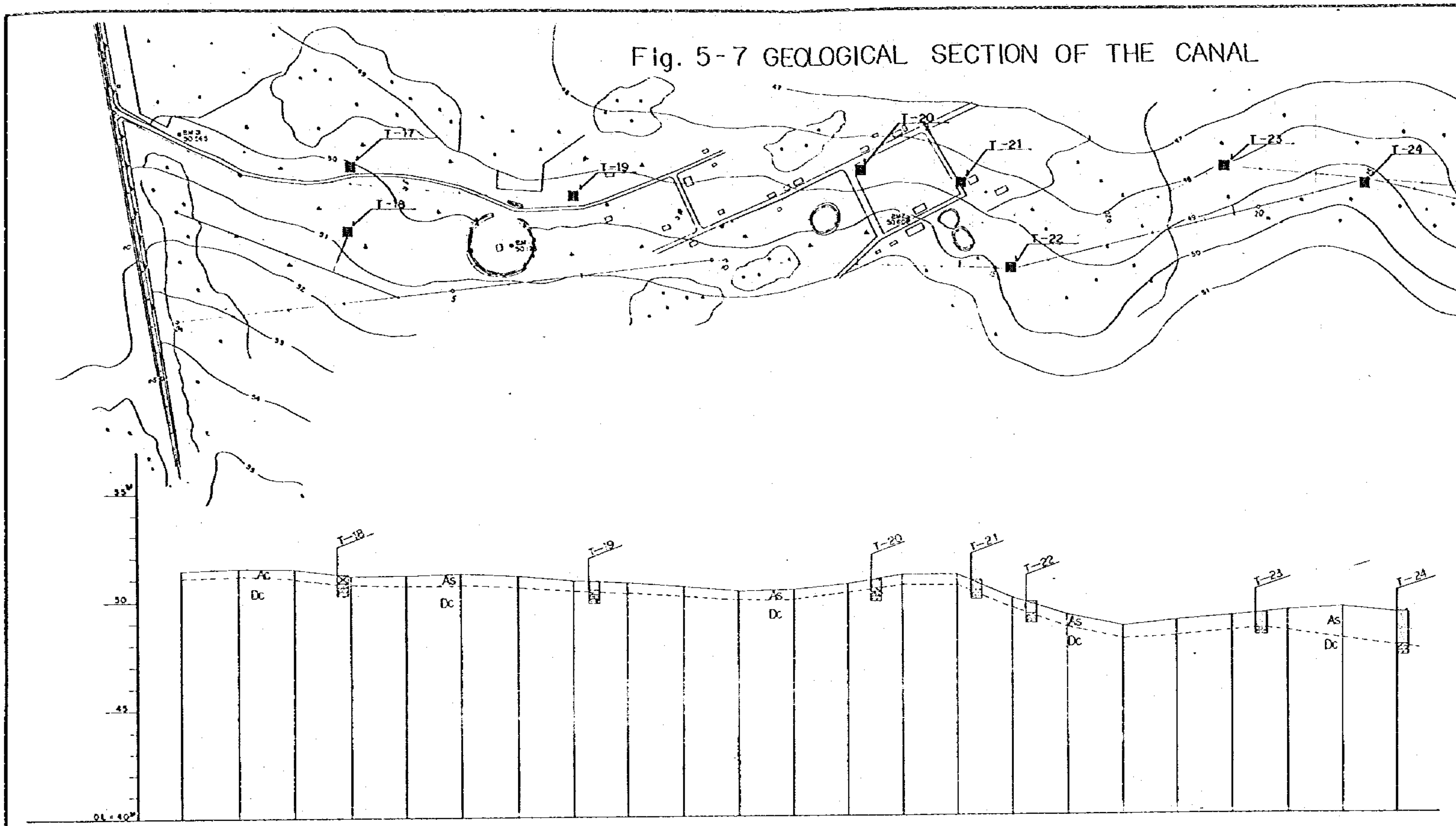


Fig. 5-7 GEOLOGICAL SECTION OF THE CANAL



Plan	Gradient	
	Depth of Exca.	
	Hight of Embon.	
	Top Bank	
	Water Surf.	
	Bottom of Canal	

Present Condition	Ground Elev.	51.40	51.55	51.48	51.16	51.21	51.25	51.16	50.90	50.83	5065	50.32	50.45
	Accum. Dist.	0	100	200	300	400	500	600	700	800	900	974	1000
	Dist.	0	100	100	100	100	100	100	100	100	100	74	26
	Station	NO.0	NO.1	NO.2	NO.3	NO.4	NO.5	NO.6	NO.7	NO.8	NO.9	+74.0	NO.10
	Curve											168° 40'	

Present Condition	Ground Elev.	50.51	50.76	51.17	51.12	5003	49.87	49.22	48.71	48.92	49.08	49.36	49.49	49.31
	Accum. Dist.	1100	1200	1300	1400	1500	1528	1600	1700	1800	1900	2000	2100	2200
	Dist.	100	100	100	100	100	28	72	100	100	100	100	100	100
	Station	NO.11	NO.12	NO.13	NO.14	NO.15	+28.0	NO.16	NO.17	NO.18	NO.19	NO.20	NO.21	NO.22
	Curve						164° 15'							207° 30'

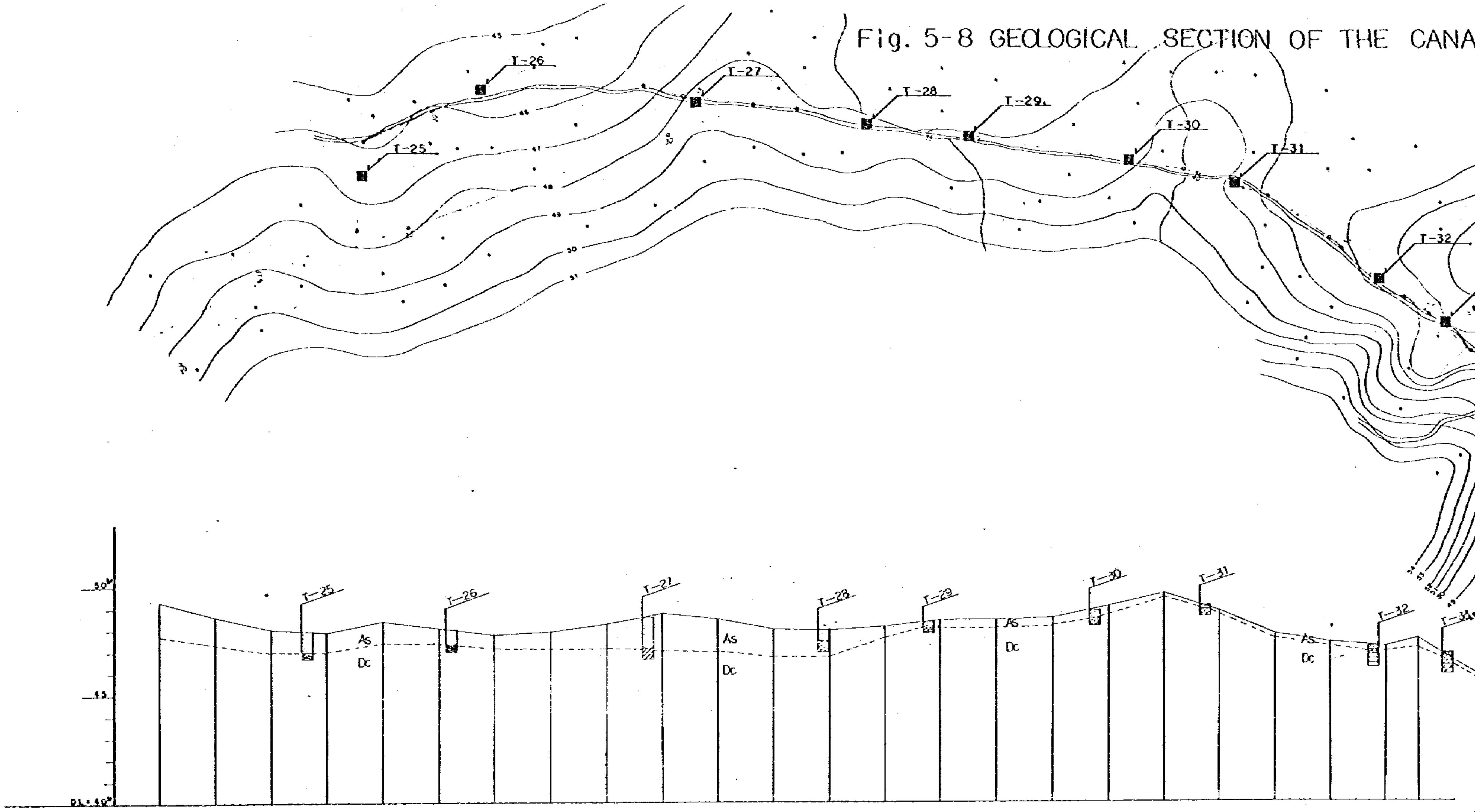
Legend

As	Fine Sand, Silty Sand	Alluvial
Dc	Sandy Silt, Sandy Clay	Diluvial

Scale

0 100 200 300 400M

Fig. 5-8 GEOLOGICAL SECTION OF THE CANAL



Legend

As	Fine Sand, Silty Sand	Alluvial
Dc	Sandy Silt, Sandy Clay	Diluvial

Scale

0 100 200 300 400m

Plan	Gradient											
	Depth of Exca.											
	Hight of Embon.											
	Top Bank											
	Water Surf.											
	Bottom of Canal											
Present Condition	Ground Elev.	49.31	49.22	48.56	48.03	47.91	48.37	48.06	47.76	47.88	48.17	48.72
	Accum. Dist.	2200	2210	2300	2400	2500	2600	2700	2800	2900	3000	3100
	Dist.	100	10	90	100	100	100	100	100	100	100	100
	Station	NO.22	+10.0	NO.23	NO.24	NO.25	NO.26	NO.27	NO.28	NO.29	NO.30	NO.31
	Curve	201°30'										

Plan	Gradient											
	Depth of Exca.											
	Hight of Embon.											
	Top Bank											
	Water Surf.											
	Bottom of Canal											
Present Condition	Ground Elev.	48.56	48.43	48.28	48.01	48.00	47.95	48.12	48.30	48.33	48.37	48.50
	Accum. Dist.	3165	3200	3250	3300	3370	3400	3500	3590	3600	3700	3800
	Dist.	65	35	50	50	70	30	100	90	10	100	100
	Station	+65.0	NO.32	+50.0	NO.33	+70.0	NO.34	NO.35	+90.0	NO.36	NO.37	NO.38
	Curve	205°45'		188°12'		172°50'			182°14'			

Plan	Gradient											
	Depth of Exca.											
	Hight of Embon.											
	Top Bank											
	Water Surf.											
	Bottom of Canal											
Present Condition	Ground Elev.	49.02	49.40	49.56	48.76	48.52	47.74	47.45	47.38	47.28	47.25	47.62
	Accum. Dist.	3900	3970	4000	4100	4132	4200	4272	4300	4372	4400	4450
	Dist.	100	70	30	100	32	68	72	28	72	28	50
	Station	NO.39	+70.0	NO.40	NO.41	+32.0	NO.42	+72.0	NO.43	+72.0	NO.44	+50.0
	Curve		174°54'			197°22'		187°02'		189°08'		

5 - 3 Regulating Pond Design

5-3-1 Location & Capacity

A slope at Survey Point No. 44 + 50 m has been selected as a site for Regulating Pond. The geological condition at its foundation has been found satisfactory through test pit studies.

In determining the storage capacity, the daily subsistence water requirement in the Khao-I-Dang Holding Center has been used as the basis for calculation. It is the survey team's opinion that the storage capacity of the regulating pond would be almost that which corresponds to 7 - 10 days' water requirement of the Kampuchean refugees in the Camp. As it has been computed at 3,000 m^3/day, the regulating pond's capacity was determined at about 30,000 m^3.

5-3-2 Dam Design

The earth excavated for preparation of the pond-bed will be used for embankment of the dam. Its crest width will be 4.0 m, and its slope will be 1 : 2.0 on both sides. The crest height is 3.0 m. The upperstream slope will be protected by stone-pitching.

5-3-3 Other Facilities

Uncontrollable solid overflow weir type spillway with 6.5 m width will be built. Steel pipe of 250 mm diameter will be equipped with a control valve outside of the dam.

5 - 4 Irrigation Plan

5-4-1 Outline

Detailed irrigation plan will be worked out by RID and as its preparatory step RID is now preparing a topographic map covering the beneficiary area.

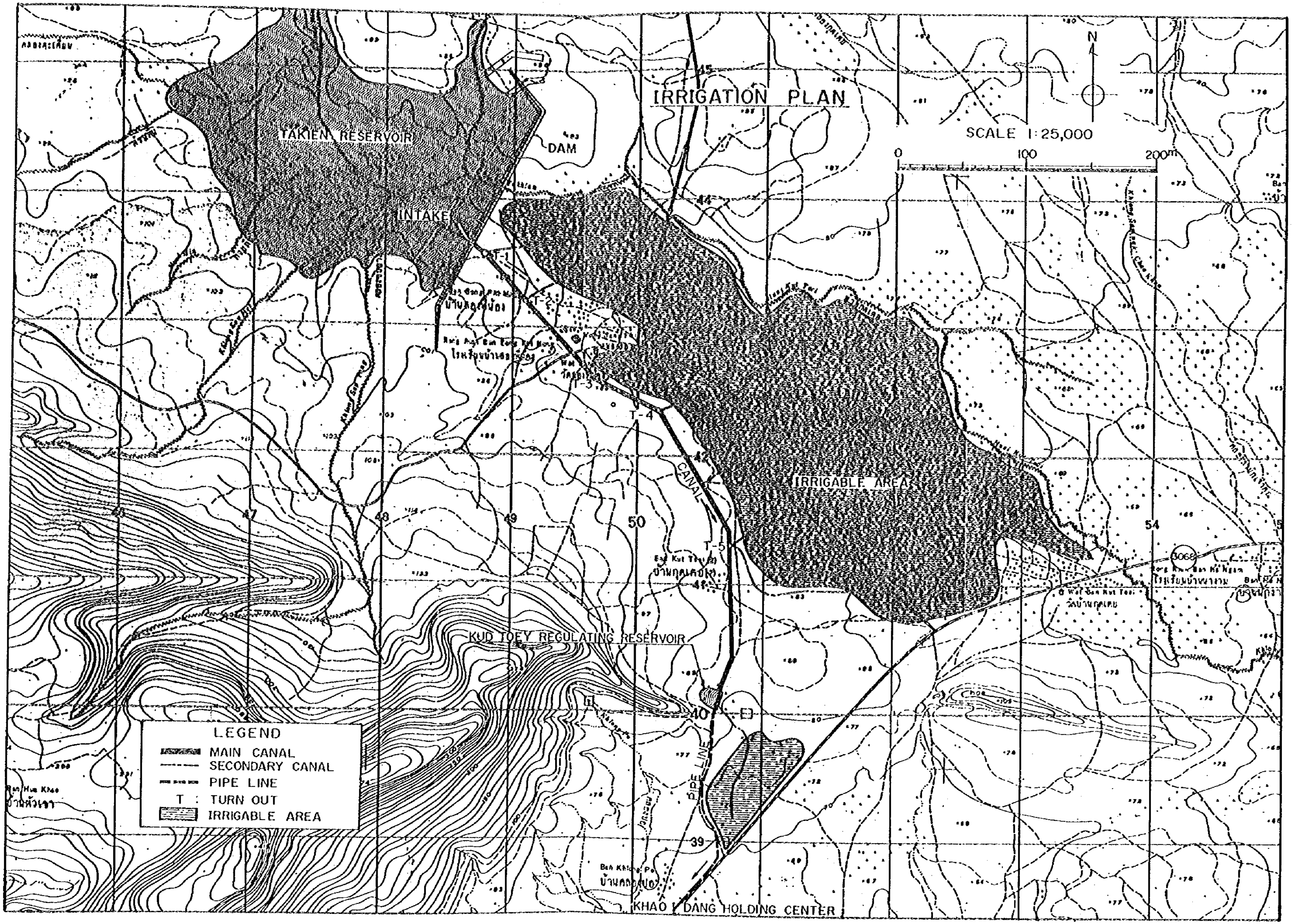
The canal extending from the reservoir to the Kud Toey regulating pond is meant for conveyance of both the subsistence water on behalf of the Kampuchean refugees in Khao-I-Dang Holding Center and the irrigation water for the local Thai villagers. Thus the upper half of the entire conveyance canal down to the regulating pond is also the main irrigation canal.

Planning and installation of distributory channels and field channels will be undertaken by RID.

As has been argued under 4-4 : Water Balance, about 500 ha will be made irrigable all through the year at the foot of the reservoir. As the beneficiary area is roughly made up of some 50% paddyfield and the remaining half remains in the form of thickets of miscellaneous trees and shrubs. The entire area will require overall consolidation and reclamation to maximize the irrigation benefit.

5-4-2 Canal System

Tentative plan is attached as Fig. 5-9. But it is simply for general guidance for RID's detailed planning.


IRRIGATION PLAN
SCALE 1:25,000
0
100
200m
N
TAKIEN RESERVOIR
DAM
INTAKE
T-1
T-2
T-3
T-4
T-5
CANAL
IRRIGABLE AREA
KUD TOEY REGULATING RESERVOIR
PIPE LINE
KHAO I DANG HOLDING CENTER
3068
45
44
42
41
40
39
46
47
48
49
50
54
LEGEND
MAIN CANAL
SECONDARY CANAL
PIPE LINE
T : TURN OUT
IRRIGABLE AREA

CHAPTER VI CONSTRUCTION PLAN

6 - 1 Outline

Construction work will have to be started in December 1980 and completed by the end of June 1981 to collect monsoon rain water in coming rainy season setting in May 1981.

It is hoped that embankment work will have been finished by end-April 1981 through the mutual efforts of the two Government.

Construction work will be initiated in early December 1980 while keeping the water behind the existing coffer-dam so as to continue supplying the subsistence water to the Khao-I-Dang refugees. As it is assumed to be exhausted within a few months, the last stage of the construction work will be executed in the dry condition.

Construction work will be executed according to the Specifications prepared separately.

6 - 2 Construction Schedule

Construction schedule is as per attached diagram. The long-term rainfall statistics promises that the earth work can be most productively carried out between December and March. Thus the dam embankment work needs to be completed by the end of April, before monsoon breaks in April. Only such jobs which may be forced under some rain can be taken up even after entering May. The date of completion of all the works is set on June 20 1981.

Preparatory works will, therefore, need to be started in good advance.

6 - 3 Construction Machinery

The combination of the construction machinery has been so arranged that the daily work duty can be fulfilled within a given construction period.

Machinery which will need to be mobilized for execution of the construction work are given on the following page:

List of Construction Machinery (not exhaustive)

1. Excavation & Loading

Bulldozer	(15 - 20 t)
Back hoe	(0.45 - 1.0 m^3)
Tractor loader	(1.0 - 1.5 m^3)
Motor scraper	(11 m^3)

2. Transportation

Dump truck	(6 - 12 t.)

3. Grading & Compaction

Motor grader	(B = 3.0 m,,more or less)
Tyre roller	(10 - 15 t.)
Tamping roller	(3 - 6 t.)
Tamper	(100 kg)

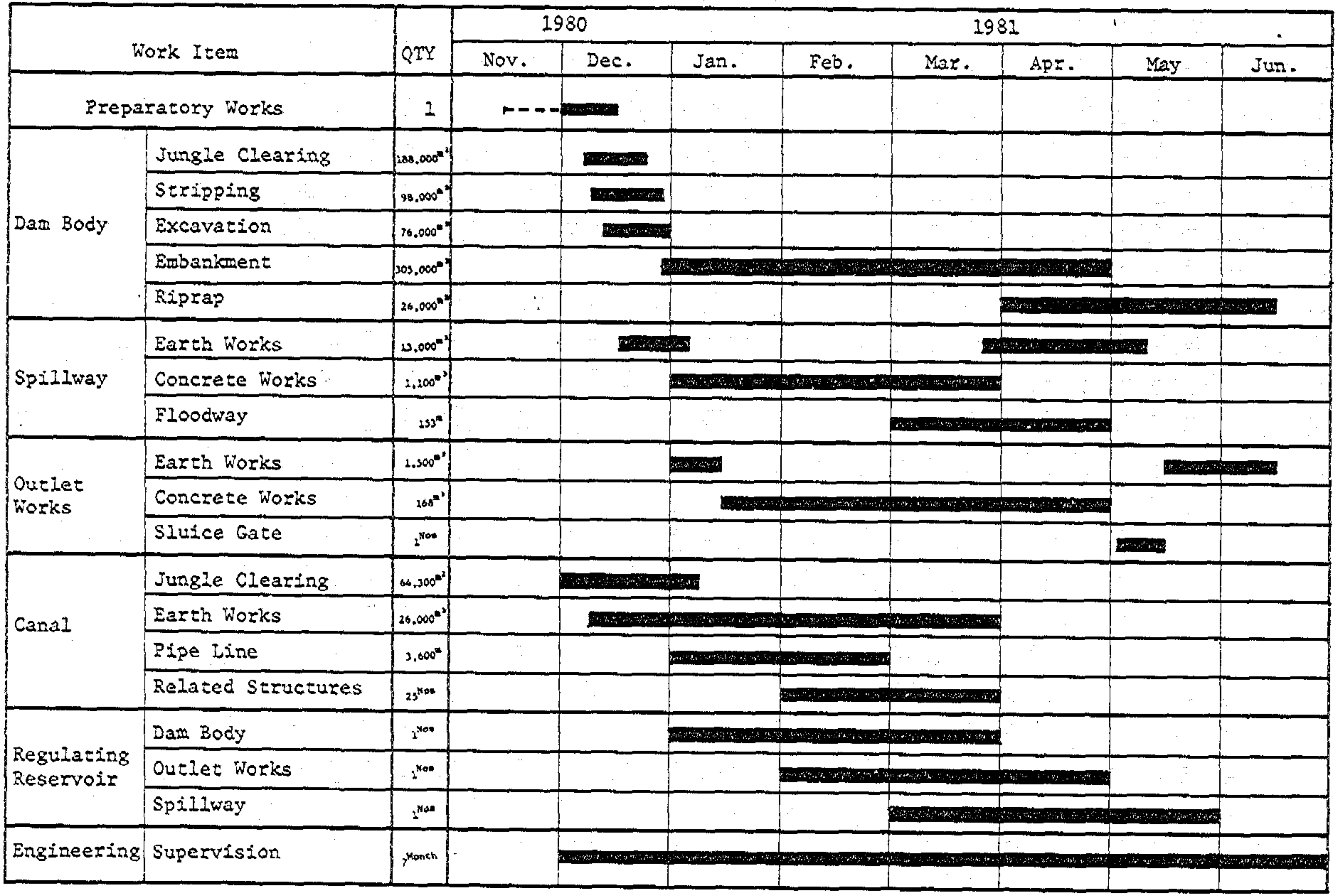
4. Water Sprinkling

Sprinkler truck	(6 - 10 t.)

5. Others

Concrete mixer	(0.3 - 1.0 m^3)
Disk harrow	
grouting machine	

Construction Schedule



Work Item		QTY	1980 Nov.	1980 Dec.	1981 Jan.	1981 Feb.	1981 Mar.	1981 Apr.	1981 May	1981 Jun.
Preparatory Works		1	- - -	■						
Dam Body	Jungle Clearing	188,000 m^2		■						
	Stripping	98,000 m^2		■						
	Excavation	76,000 m^3		■						
	Embankment	305,000 m^3			■	■	■	■		
	Riprap	26,000 m^3						■	■	■
Spillway	Earth Works	13,000 m^3		■	■		■	■	■	
	Concrete Works	1,100 m^3			■	■	■			
	Floodway	153 m					■	■		
Outlet Works	Earth Works	1,500 m^3			■				■	■
	Concrete Works	168 m^3			■	■	■	■		
	Sluice Gate	1 Nos							■	
Canal	Jungle Clearing	64,300 m^2		■	■					
	Earth Works	26,000 m^3		■	■	■	■			
	Pipe Line	3,600 m			■	■				
	Related Structures	25 Nos				■	■			
Regulating Reservoir	Dam Body	1 Nos			■	■	■			
	Outlet Works	1 Nos				■	■	■		
	Spillway	1 Nos					■	■	■	
Engineering	Supervision	7 Month		■	■	■	■	■	■	■

CHAPTER VII PROJECT COST

7 - 1 Outline

The basic design of this project has been done to obtain the optimal within the predecided financial allotment amounting to 1,000 Million Yen (90.9 million bahts). Project cost is made up of the construction cost and the supervisory cost. The former is broadly divided into that for (i) dam; (ii) conveyance canal, and (iii) regulating pond.

The land where construction is planned almost entirely belongs to the crown land which would evolve no serious problems relating to acquisition or compensation. Irrigation facilities are also expected to be provided by the Royal Thai Government.

7 - 2 Construction Cost

Estimation of the construction cost was made after careful comparative study with the similar projects in Thailand undertaken by both RID and local and international contractors.

Since the designing has been hurriedly made on the basis of one-month field survey only, contingencies have been appropriated to meet any possible alterations of the basic design. The cost required for additional borings at four sites are also included in contingencies.

7 - 3 Designing & Construction Supervision Cost

In estimating the designing and construction supervision cost, detailed designing which is being prepared for securing smooth commencement of the project and construction supervision service which will be carried out by three to four engineers for the period of 7 months have been taken into account.

7 - 4 Project Cost

Construction Cost Estimate

		(thousand Bahts)	(thousand Yen)
1.	Ta-Kien Reservoir	70,164	771,800
2.	Conveyance Canal	9,031	99,400
3.	Kud Toey Regulating Pond	2,990	33,000
4.	Physical Contingencies	2,345	25,800
	Sub-total	84,530	930,000
5.	Designing & Construction supervision	6,370	70,000
	Total	90,900	1,000,000

Conversion rates (as of October 1980)

1 US$ = 20฿　1 US$ = 220¥　1฿ = 11¥

1. Takien Reservoir

		Bahts
A)	Civil works	
	Dam structure	46,984,000
	Spillway	6,402,000
	Intake facilities	1,144,000
	Outlet conduit	332,000
	Terracing	49,000
	Access road	691,000
	Indirect works	3,336,000
	Sub Total	58,938,000
B)	Overhead expense (total x 16%)	11,226,000
	Total	70,164,000 (¥771,800,000)

2. Conveyance Canal

A)	Civil works	Bahts
	Unlined canal	4,487,000
	Pipe line	2,670,000
	Indirect works	429,000
	Sub Total	7,586,000
B)	Overhead expense (total x 16%)	1,445,000
	Total	9,031,000 (¥99,400,000)

3. Kud Toey Regulating Pond

A)	Civil works	Bahts
	Pond & related structure	2,370,000
	Indirect works	142,000
	Sub Total	2,512,000
B)	Overhead expense (total x 16%)	478,000
	Total	2,990,000 (¥33,000,000)

CHAPTER VIII EVALUATION

8 - 1 Agricultural Production & Farm Income

8-1-1 Agricultural Production

With the completion of Ta-Kien reservoir, 3,125 rai (500 ha) about 57% of 5,500 rai which belongs to Ban Song Pin Nong and Ban Kud Toey and which has been used for rice cultivation once a year during rainy season alone will be made irrigable all through the year.

To raise the agricultural productivity by taking full advantage of this perennial supply of irrigation water to 3,125 rai, the survey team recommends the local villagers to utilize the newly irrigable area according to a cropping calender as is proposed in Fig. 8-1. It is to put the entire area of the newly irrigable land under paddy during rainy season, and 40% (1,250 rai) of it under paddy again and the remaining 60% (1,875 rai) under upland crops during dry season.

Introduction of upland crops into 60% of the area during dry season is to cope with water shortage which does not allow 100% rice cultivation in dry season.

Yield per rai of these farm products under the proposed cropping pattern are expected to be as follows:

Rainy season :	Paddy	500 kg/rai
Dry season :	Paddy	500 kg/rai
	Mung beans	180 kg/rai
	Soya beans	180 kg/rai
	Peanuts	200 kg/rai
	Sesame	120 kg/rai

8-1-2 Farm Income

In the past, an average yield of paddy has been 250 kg/rai but it used to come down below half in dry years which would visit in three (3) years out of each five (5) years. Thus it may be assumed that the mean yield of paddy remained at a low level of some 200 kg/rai. Compared to this low yield in the past years, paddy cultivation in the perennially irrigable field will attain average yield of 500 kg/rai, irrespective of "good" or "bad" year. Such a dramatic rise of paddy yield is a logical consequence of the improved cultivation method which growers are tempted

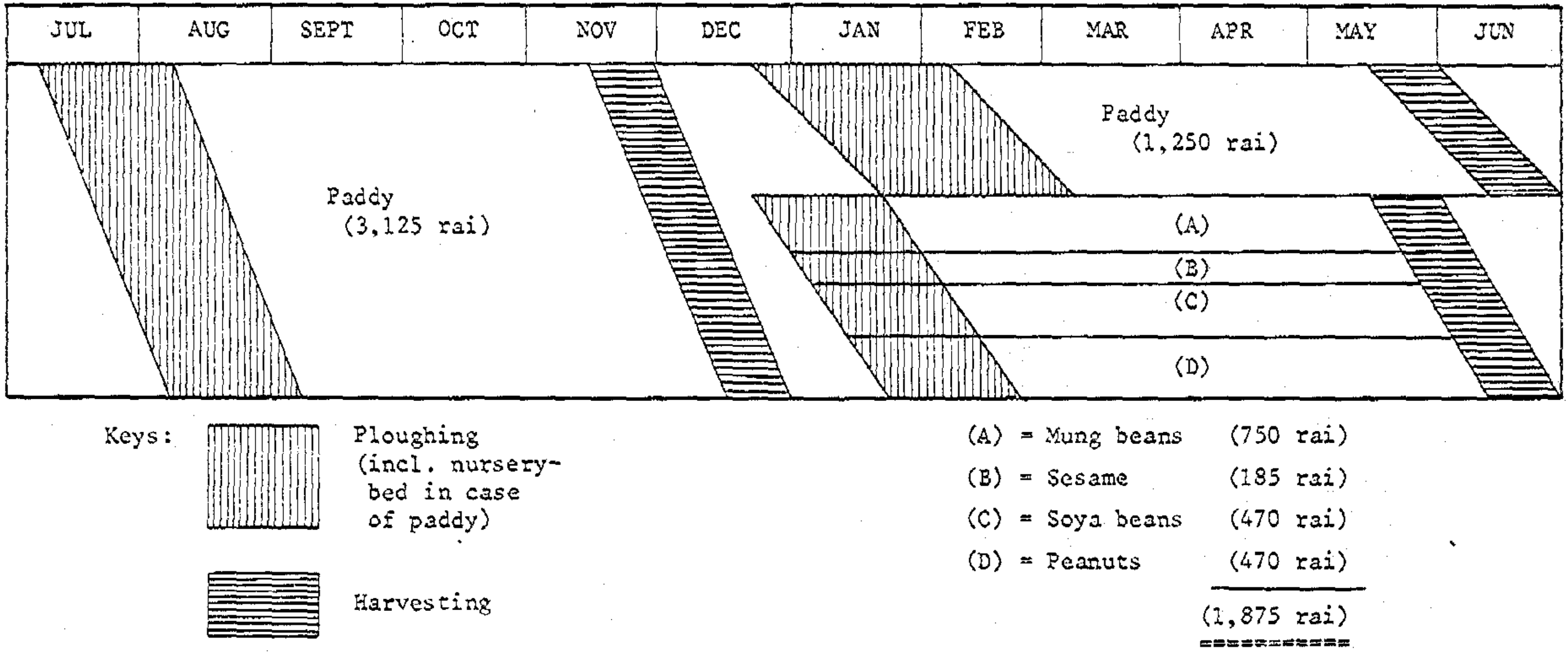


Fig. 8-1 Proposed Cropping Pattern in the Project Area

to adopt in terms of the use of HYV and fertilizer that prove rewarding only with the guaranteed supply of irrigation water.

Accordingly, pre- and post-project paddy production in rainy season would be as follows:

	Area which will be Made Perennially Irrigable			Area which will Remain Rainfed			Aggregated Total		
	Size (rai)	Yield (kg)	Product (ton)	Size (rai)	Yield (kg)	Product (ton)	Size (rai)	Yield (kg)	Product (ton)
Pre-Project	3,125	200	625.0	2,375	200	475.0	5,500	200	1,100.0
Unit price per ton (฿)			3,000			3,000			3,000
Value of production (000 ฿)			1,875.0			1,425.0			3,300.0
Post-Project	3,125	500	1,562.5	2,375	200	475.0	5,500	370.5	2,037.5
Unit price per ton (฿)			3,000			3,000			3,000
Value of production (000 ฿)			4,687.5			1,425.0			6,112.5
Increments									
i) Production (tons)			937.5			0			937.5
ii) Value (thousand bahts)			2,812.5			0			2,812.5

Dry season cultivation in the perennially irrigable area of 3,125 rai will bring the following results:

Paddy: $1{,}250^{(\text{rai})} \times 500^{(\text{kg})} = 625$ ton $625^{(\text{ton})} \times 3{,}000^{(\text{฿})} =$ ฿1,875,000

As for the upland crops, there are two Alternative I and II. Alternative I supposes straight sales of all the oil seed products after harvesting, and Alternative II means their processing or extraction of edible oil and use of the oil cakes as valuable feedstuff of animals and organic manures applicable to the field.

ALTERNATIVE I

Crops	Area (rai)	Yield (kg/rai)	Production (ton)	Unit Price (฿ per ton)	Sales Value (฿ 1,000)
Mung beans	750	180	135.0	5,800	783.0
Soya beans	470	180	84.6	6,300	533.0
Peanuts	470	200	94.0	5,800	545.2
Sesame	185	120	22.2	8,500	188.7
	1,875		Total (thousand		฿2,049.9

ALTERNATIVE II

Crops	Area (rai)	Yield (crude oil) (in kg/rai)	Production (crude oil) (in ton)	Unit Price (crude oil) (฿ per ton)	Sales Value (฿ 1,000)
Soya beans	470	50	23.5	20,000	470.0
Peanuts	470	65	30.55	20,000	611.0
Sesame	185	90	16.65	20,000	333.0
	1,125				1,414.0
(Mung beans)	(750)				(783.0)
Total	1,875				2,197.0

Without taking into account the benefit accruable from effective use of oil cakes as feedstuff and manure, Alternative II brings ฿147,120 more proceed than Alternative I. Survey team vehemently recommend the villagers to adopt Alternative II for their upland crop cultivation during dry season, as this would encourage rural cottage industry, increase employment opportunities, strengthen and help multiplying buffalo and cattle population.

Cassava cultivation on the highland and slopes would remain the same: 3,500 (kg) x 2,100 (rai) = 7,350 tons @ ฿0.70 = ฿5,145,000.

Project's Benefit Resulting from Production Increase

(in thousand Bahts)

	Paddy (rain)	Paddy (dry)	Dry Season (upland crop)	Cassava	Total
Post-Project	6,113	1,875	2,197	5,145	15,330
Pre-Project	3,300	-	-	5,145	8,445
Benefit	2,813	1,875	2,197	0	6,885

The above evaluation does not take into account the cost incurable for improved farming and products' processing (investment in and O&M of irrigation/drainage facilities, increased agricultural inputs, oil extraction facilities, marketing, etc.) but such cost will be covered by the benefit obtainable through productive use of oil seed cakes as feedstuff and manure.

8 - 2 Project Benefits

8-2-1 Cost Allocation & Recovery

This project is aimed at two purposes of (i) providing the Kampuchean refugees accommodated in the Khao-I-Dang Holding Center with subsistence water and (ii) supplying irrigation water to the local Thai villagers. Its scale has been requested to be made optimal within the prescribed financial allocation and its implementation is expected to be done within the shortest possible period of time.

The benefits accurable from this type of project, therefore, will need to be calculated not from the angle of "profit generation" or maximization of profit from the investment made, but rather from "value-creating" point-of-view that is the extent of attainment of the established purposes under the given conditions.

Thus project evaluation will be made by, first, allocation of the project cost between the two main objectives and, second, estimation of how soon the cost or investment made for each purpose can be recovered.

Now, the project benefits are expected through:

(1) supply of subsistence water for the welfare of the Kampuchean refugees in the Khao-I-Dang Holding Center, and

(2) supply of irrigation water to accelerate agricultral development in the downstream.

Apparently, the source of benefit is water supply and the reservoir water diversion ratio between these two is:

(1) Khao-I-Dang Holding Center 15%

(2) Local villages 85%

If spelled out in cost, this ratio will be expressed in terms of:

(1)	Khao-I-Dang Holding Center	฿13,635,000
(2)	Agricultural development	฿77,265,000
	Total project cost	฿90,900,000

8-2-2 Benefits

(1) Kaho-I-Dang Holding Center

Although the present refugee population is 80,000, UNHCR hopes to get water supply for 90,000 @30 litre/day/head, apart from the ground water available from the existing deep-wells.

The total water supply wanted there will thus be:

$30^{(\text{litre})} \times 90{,}000^{(\text{refugees})} = 2{,}700\ \text{m}^3/\text{day}$

Now, it is planned under the project to establish in the vicinity of the entrance gate of the Center a convenient facility to inject the water sent through the pipeline into the tank-lorry which will make rounds of water distribution among the metal water tanks inside the Center for re-filling. Tank lorries will therefore be relieved of shuttle-like voyages to and from various water sources 50 - 100 km away, and their maneuvering will be restricted only within the Center's compound.

Supposing each tank-lorry with 13,000 litre capacity can make 10 such rounds inside the Center, the total water supply per tank-lorry will be:

$13{,}000^{(\text{litre})} \times 10^{(\text{rounds})} = 130\ \text{m}^3$

$2{,}700\ \text{m}^3 \div 130\ \text{m}^3 = 20$ tank-lorries (number of vehicles required for water distribution)

Assuming a tank-lorry operation cost at ฿800 per day, the monthly cost would be:

$฿\,800 \times 20^{(\text{lorries})} \times 30^{(\text{days})} = ฿480{,}000$

thus, water transportation cost will be economized by:

฿2,000,000 - ฿480,000 = ฿1,520,000/month

The project cost allocated to the Khao-I-Dang water supply being ฿13,650,000:

฿13,650,000 ÷ ฿1,520,000 = 9 (months)

Consequently, the project cost allocated to Khao-I-Dang can be recovered in full within nine (9) months after the completion of the project.

(2) Agricultural Development

As was previously assessed under 8-1-2 of this Report, an annual agricultural production increase due to the project is supposed to be about ฿6,880,000. However, for a more accurate evaluation of its agricultural development benefit, it is necessary to take into account the success percentage in the direct beneficiary area during dry season, that is:

Dry season paddy production : ฿1,875,000 x 60% = ฿1,125,000
Dry season upland crop production : ฿2,197,000 x 80% = ฿1,757,600

Accordingly, the annual benefit to the villagers of Ban Song Pin Nong and Ban Kud Toey will be:

Rainy season paddy production	:	฿2,812,500
Dry season paddy production	:	1,125,000
Dry season upland crop production	:	1,757,600
Total		฿5,695,100

With this annual benefit, the project cost allocated for agricultural development will be recovered within less than 14 years as follows:

฿77,265,000 ÷ ฿5,695,100 = 13.6 (years)

Finally, it will be necessary to note that interest has not been taken into account in the above calculations.

CHAPTER IX OUTSTANDING ISSUES

9 - 1 Construction Aspect

Since the field survey period was limited to one month only, geological study through boring could not have been carried out thoroughly, and the foundation bedrock conditions were checked merely by test pitting along the left bank side. According to the results obtained through test pitting, weathering seems to be in a fairly advanced conditions. Therefore, it would be necessary to conduct additional boring test in this specific area to cope with the actual conditions if necessary.

The conveyance canal route has been determined without any topographic map but through field surveying on the spot. It would be desirable to carry out thorough surveying before actual work will be commenced to find out any alternative course which may be found more favourable from techno-economic point-of-view.

9 - 2 Agricultural Development Aspect

(1) Engineering

Construction of intake facilities, diversion channels and distribution channels from the main canal running from Ta-Kien reservoir to Kud Toey regulating pond as well as reclamation of the beneficiary area and consolidation of the existing paddyfield there. This work is preferably to be undertaken side by side with implementation of the project.

(2) Institutional (A)

Organization of the entire farmers residing in Ban Song Pin Nong and Ban Kud Toey into agricultural cooperative society, preferably before the end of the 1980-81 dry season, so that the villagers will be able to enjoy such services as credit, input (HYV, chemical fertilizers, agrochemicals, farm implements, packing materials, etc.) supply, marketing of farm products (paddy, cassava and upland crops) through their own cooperative society. This Co-operative Society will have to be strengthened, before the 1981 - 82 rainy season is over, to help its member-farmers to start extraction of crude oil from such oil-seeds like soya beans, peanuts and sesame and marketing of these processed commodities.

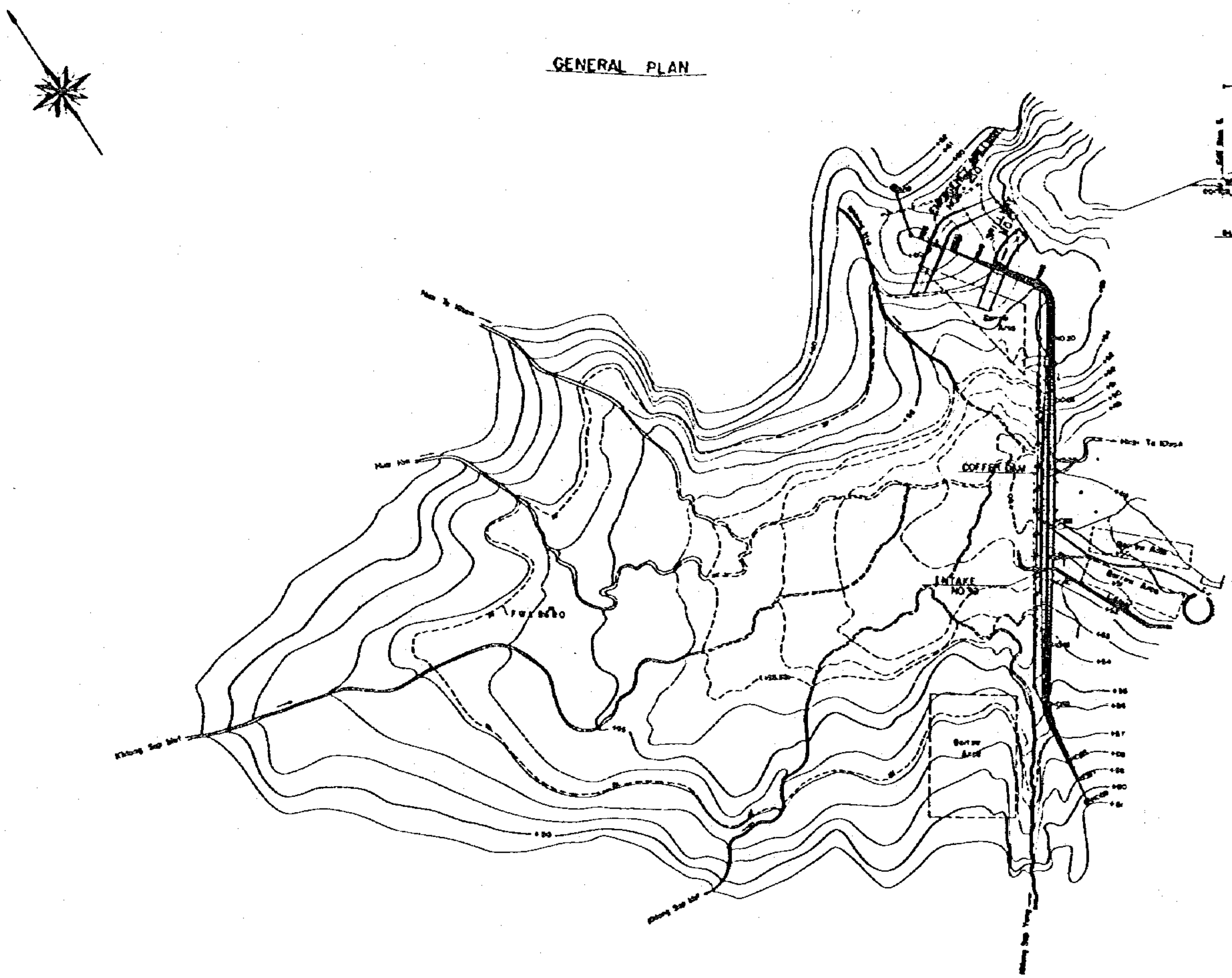
(3) Institutional (B)

Organization of the farmers belonging to the beneficiary area which will be turned parennially irrigable into Water Management Association by the end of 1981.

(4) Technical

Arrangement will have to be made so that agricultural extension services may be made amply available in the beneficiary area from the Agricultural Extension Office in Prachinburi Provincial Government through Taphraya District Office.

GENERAL PLAN



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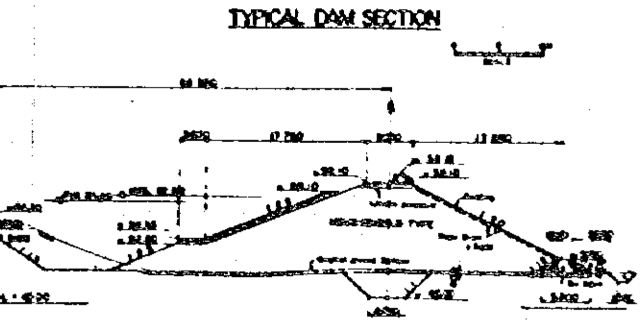
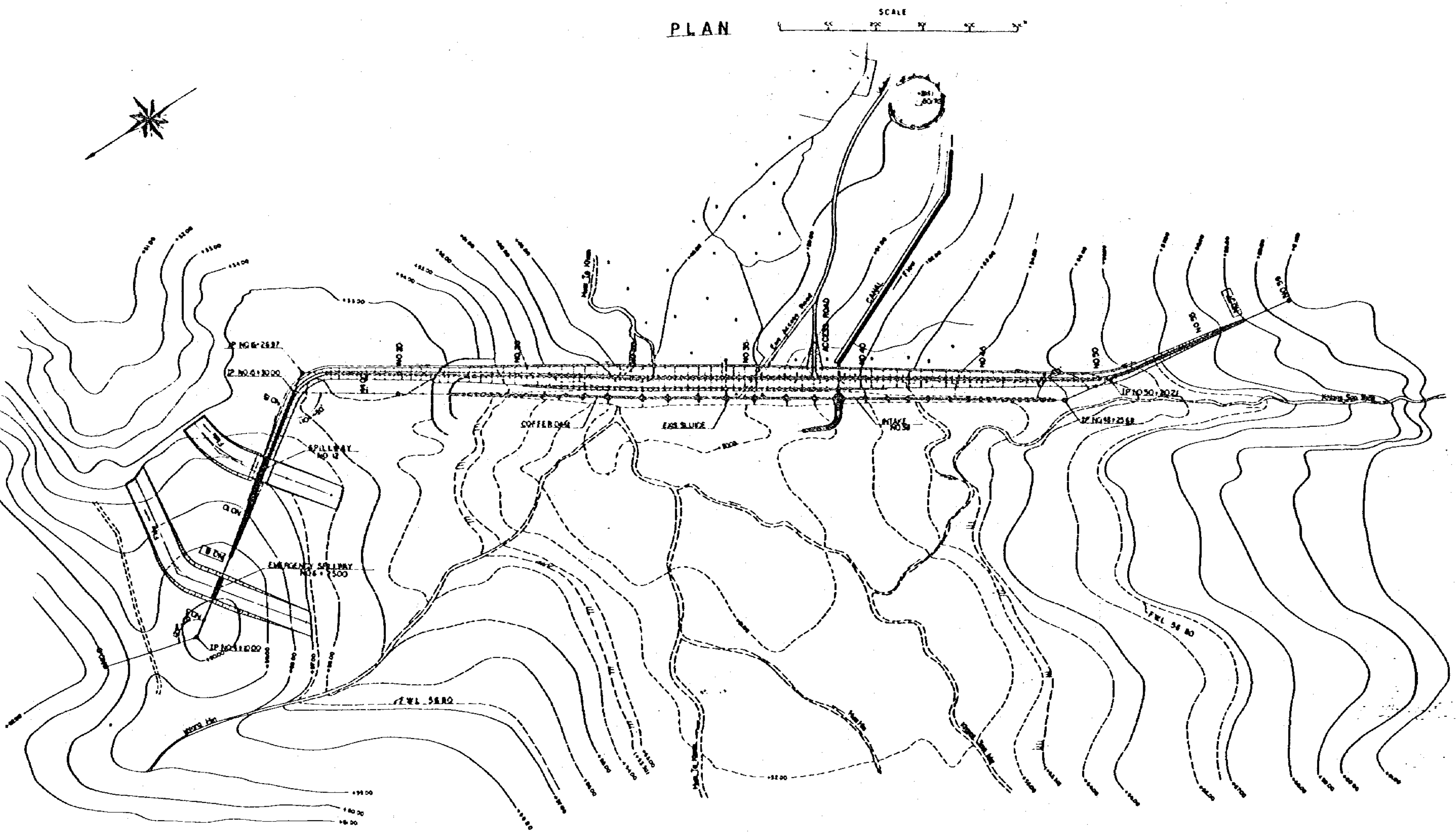


TA-KIEN RESERVOIR PROJECT	
THE KINGDOM OF THAILAND	
DAM GENERAL PLAN	
Date NOVEMBER, 1980	D.W.G. No. 1/
JAPAN INTERNATIONAL COOPERATION AGENCY	

PLAN



TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

DAM
PLAN

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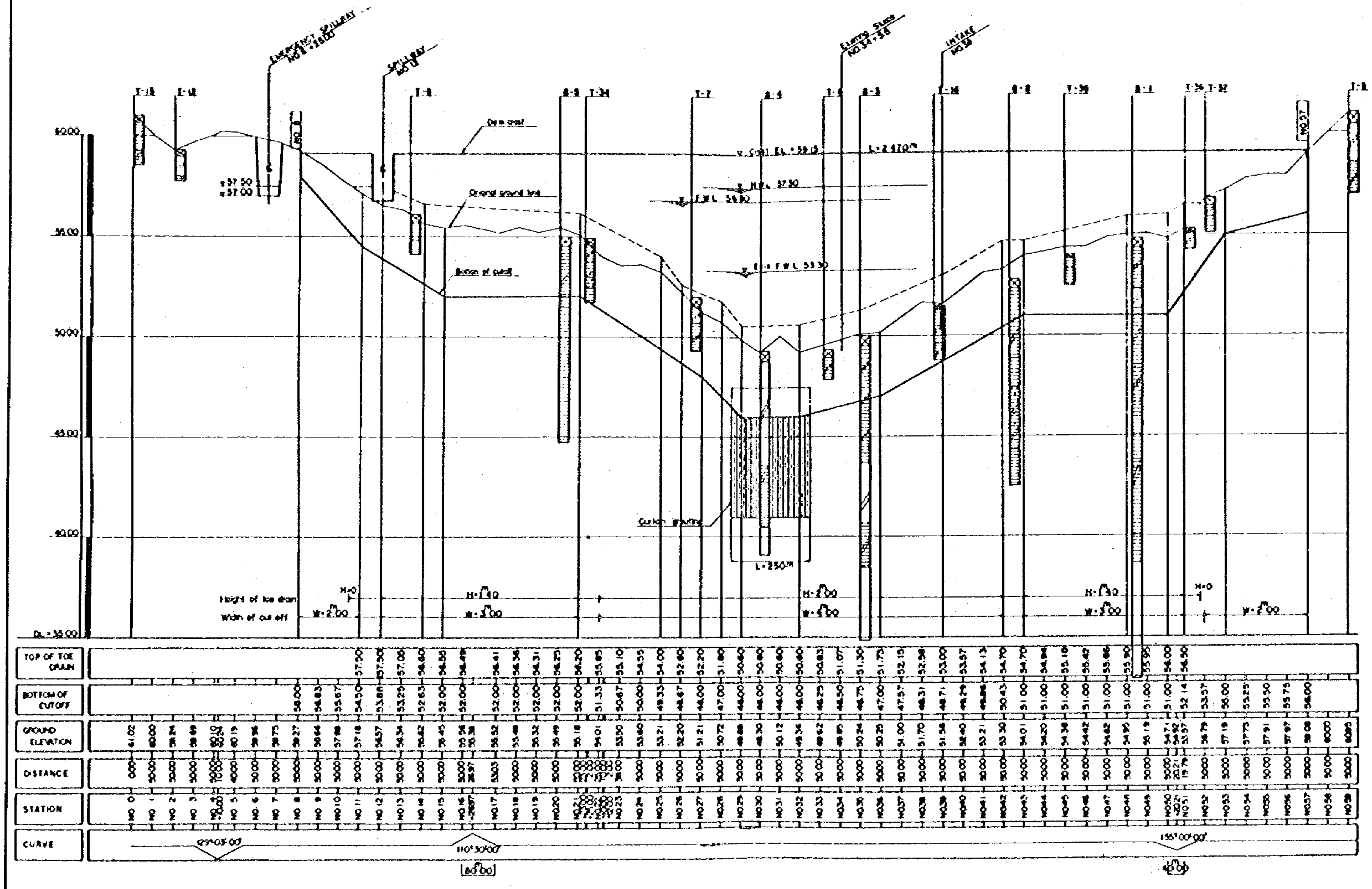

TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

DAM
PROFILE

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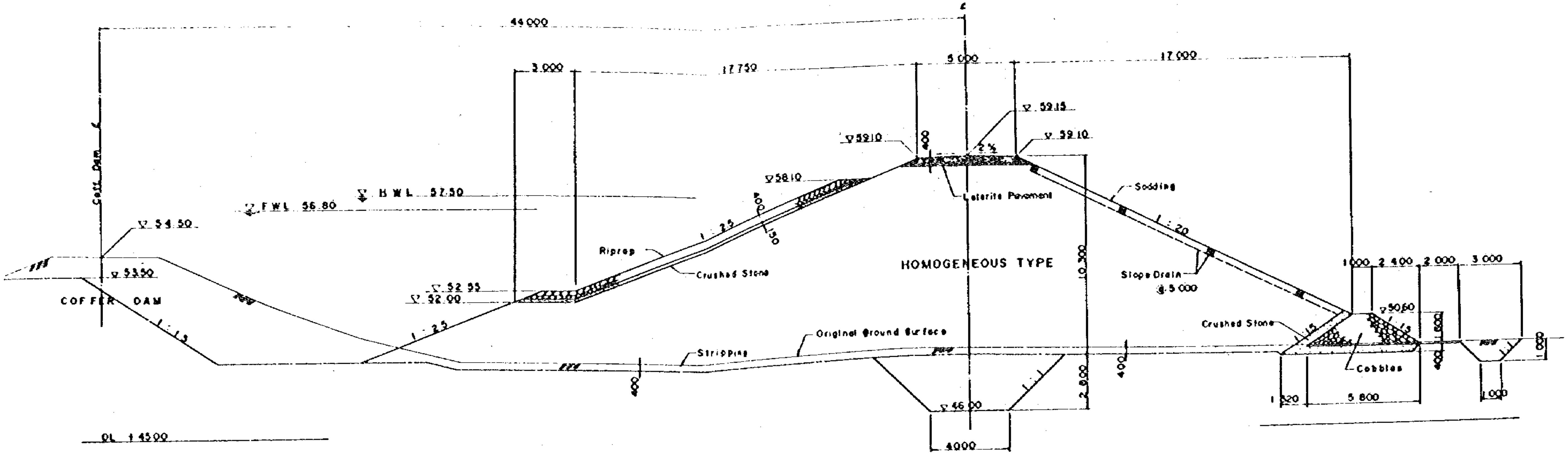

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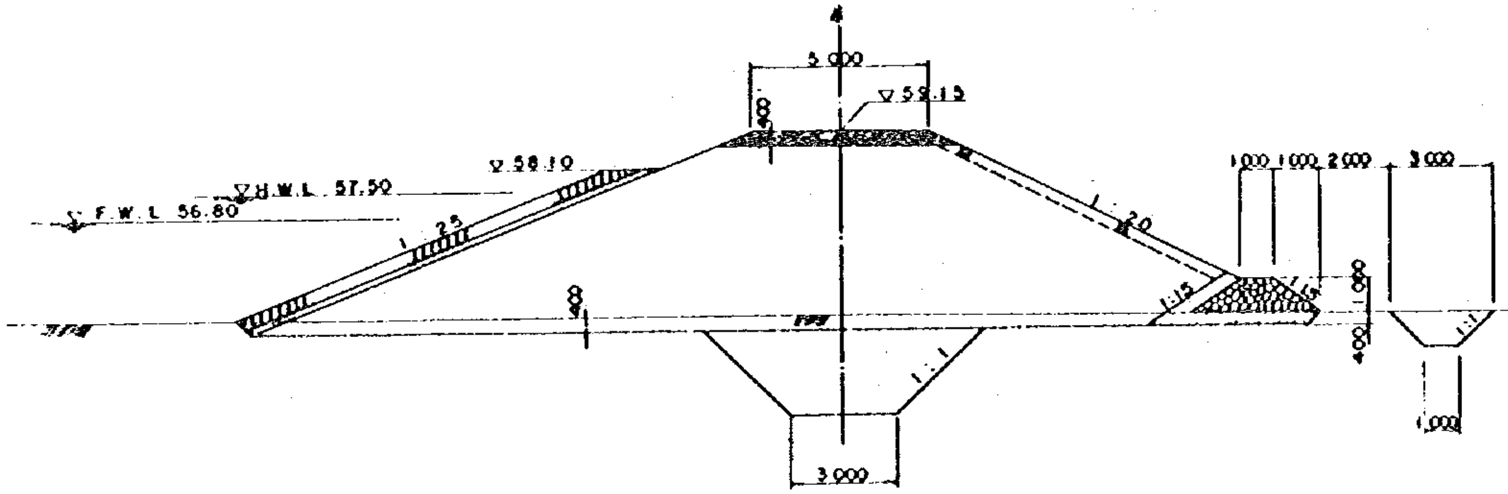

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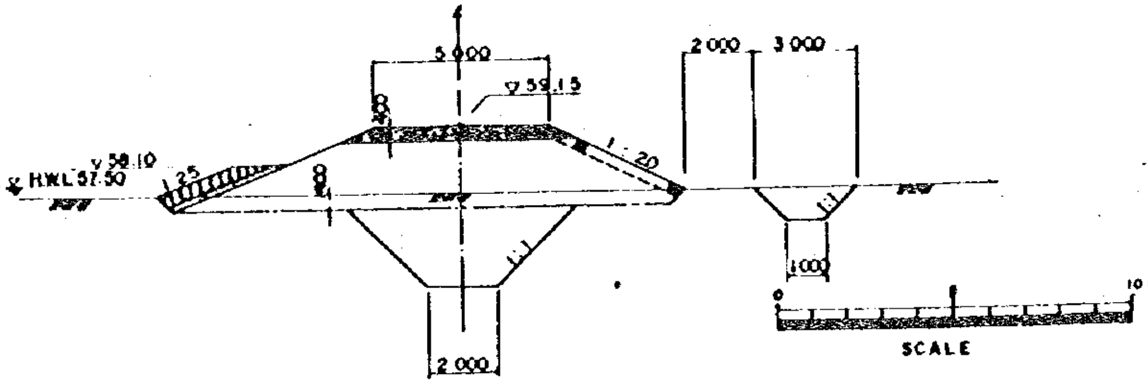

TA-KIEN RESERVOIR PROJECT
THE KINGDOM OF THAILAND
DAM
TYPICAL DAM SECTIONS
Date NOVEMBER 1980
D.W.G. No. 4/29
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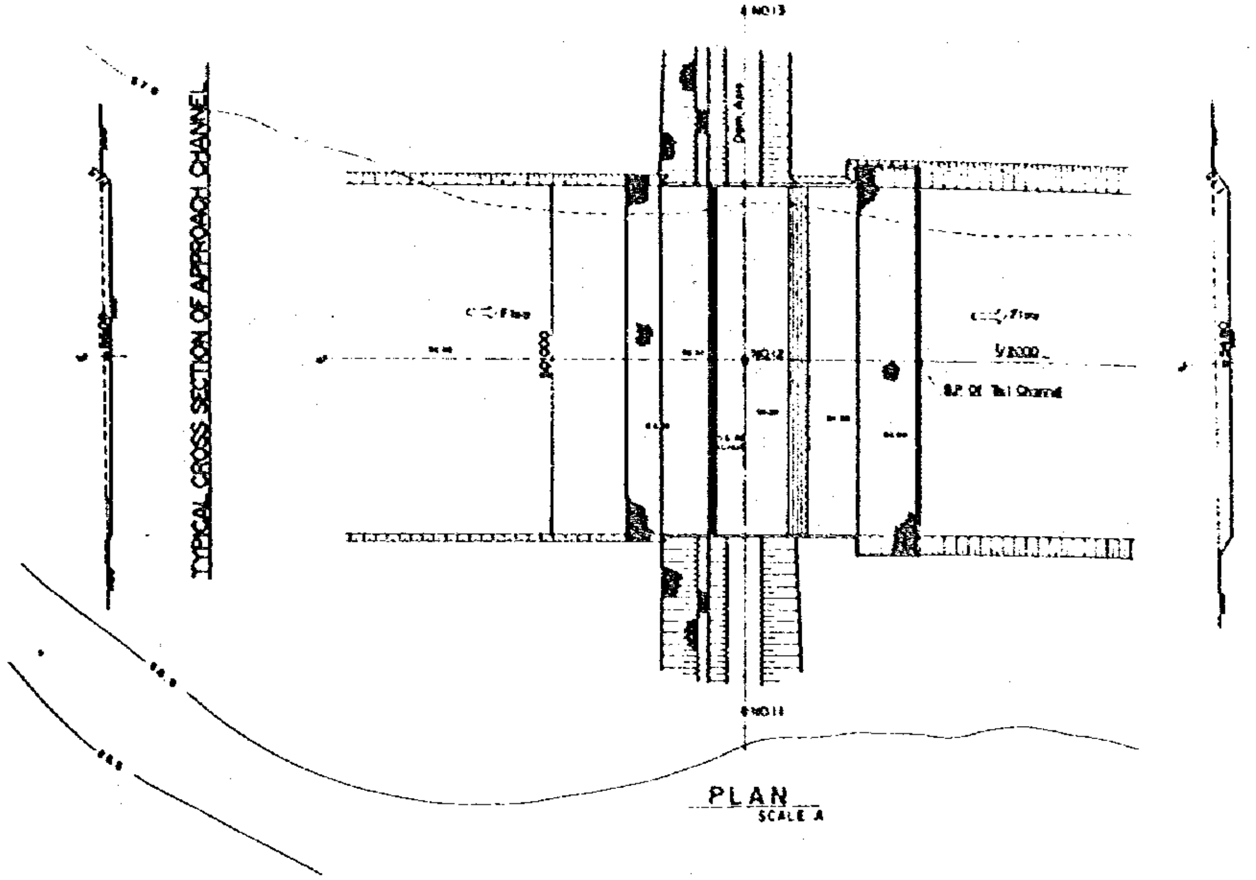

PLAN
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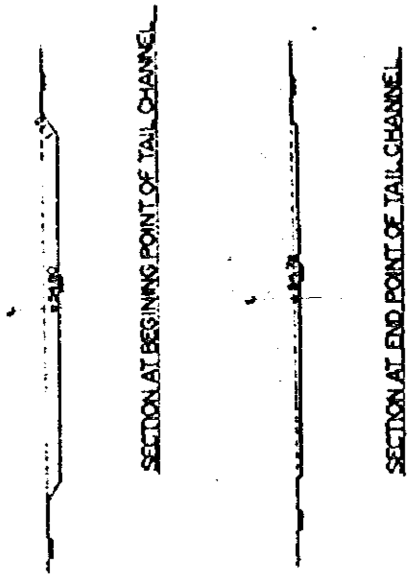

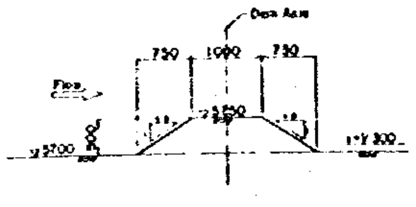

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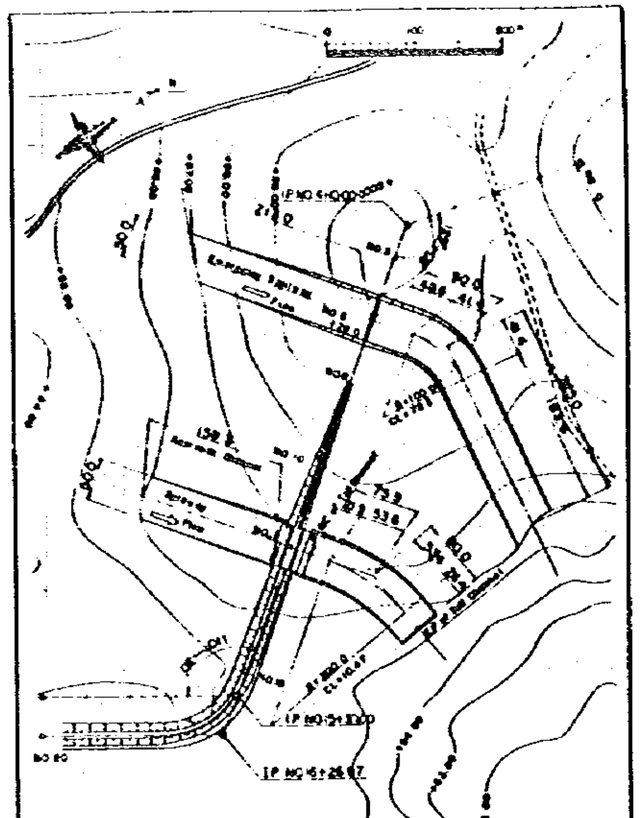

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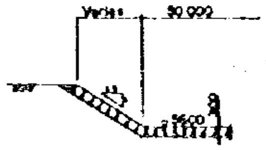

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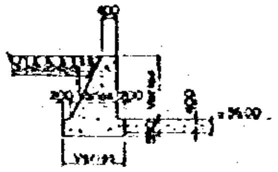

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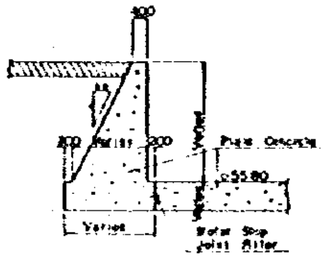

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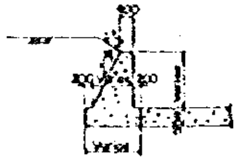

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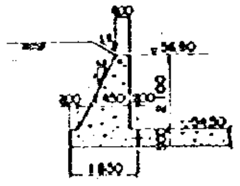

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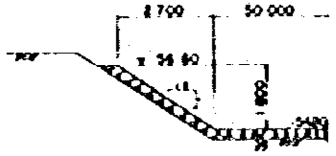

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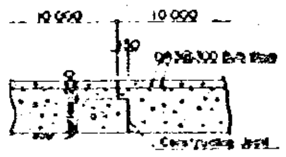

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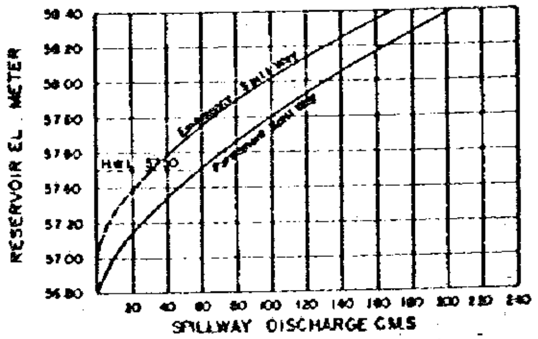
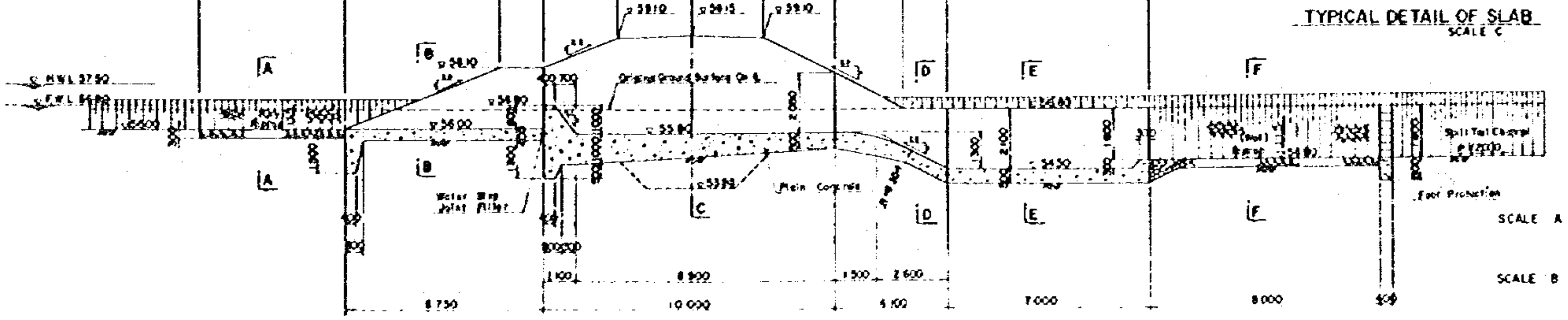


SPILLWAY DISCHARGE CURVE



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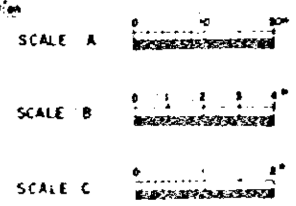

TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

D A M
SPILLWAY

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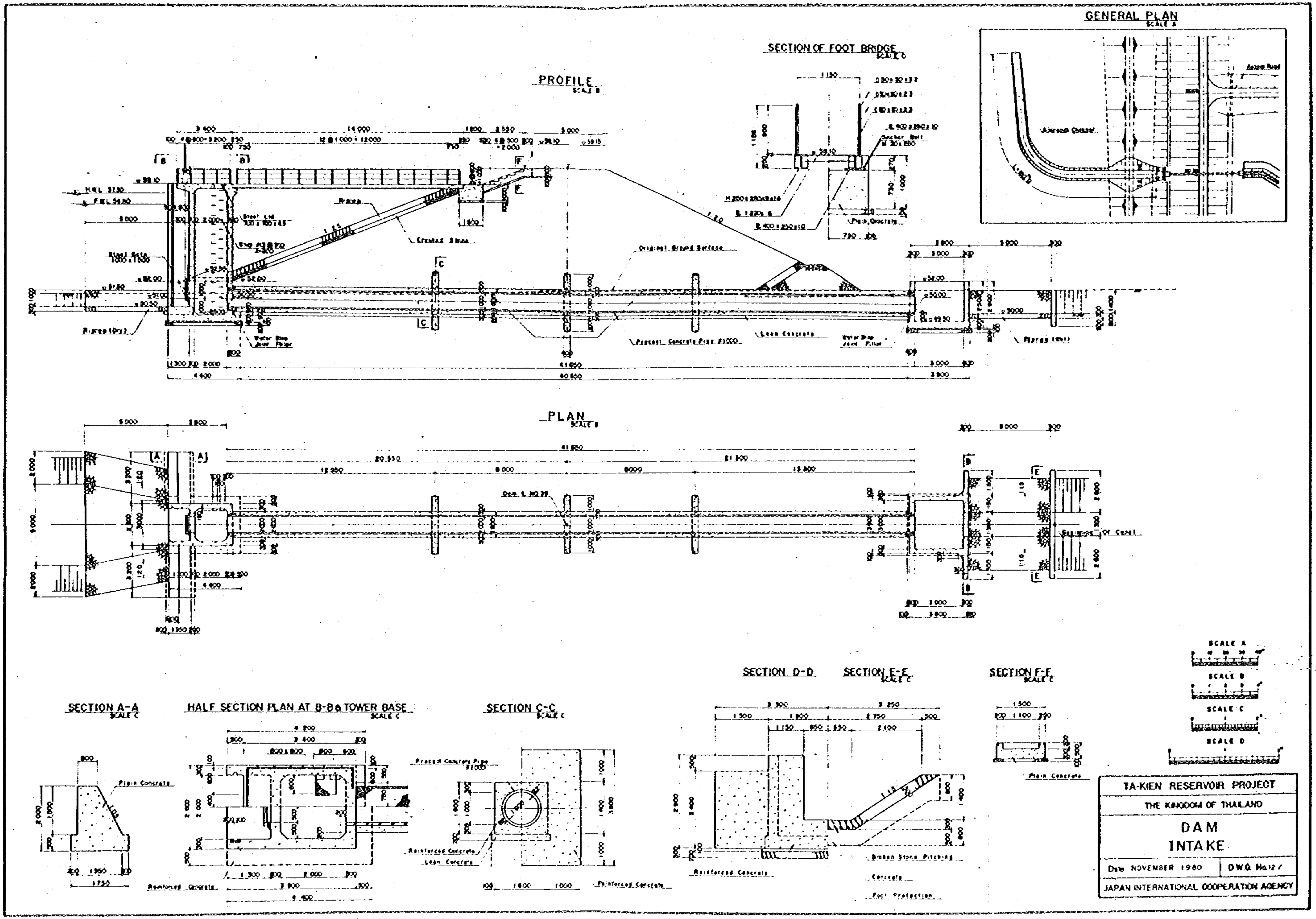

TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

DAM INTAKE

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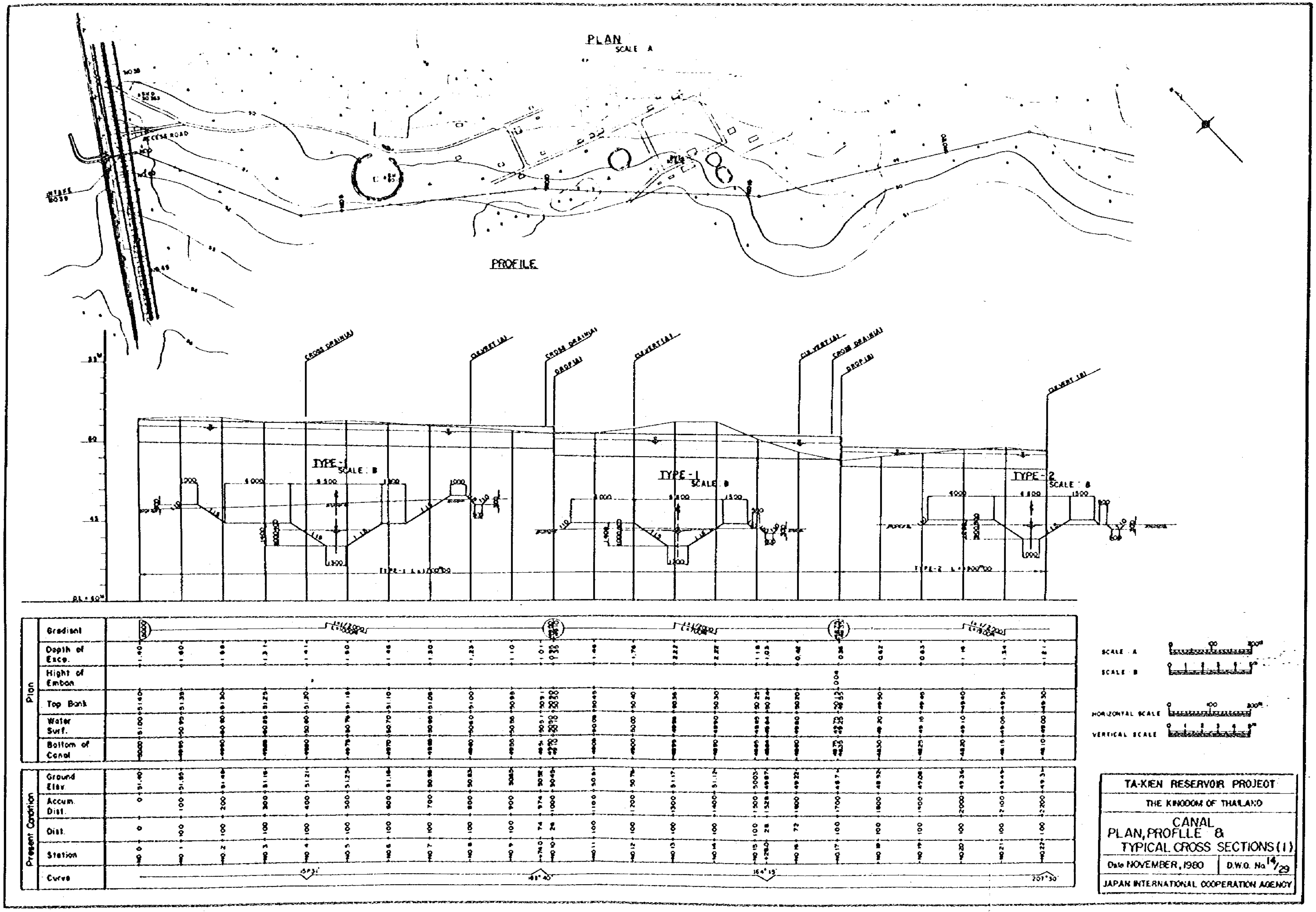

TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

CANAL
PLAN, PROFILE &
TYPICAL CROSS SECTIONS (1)

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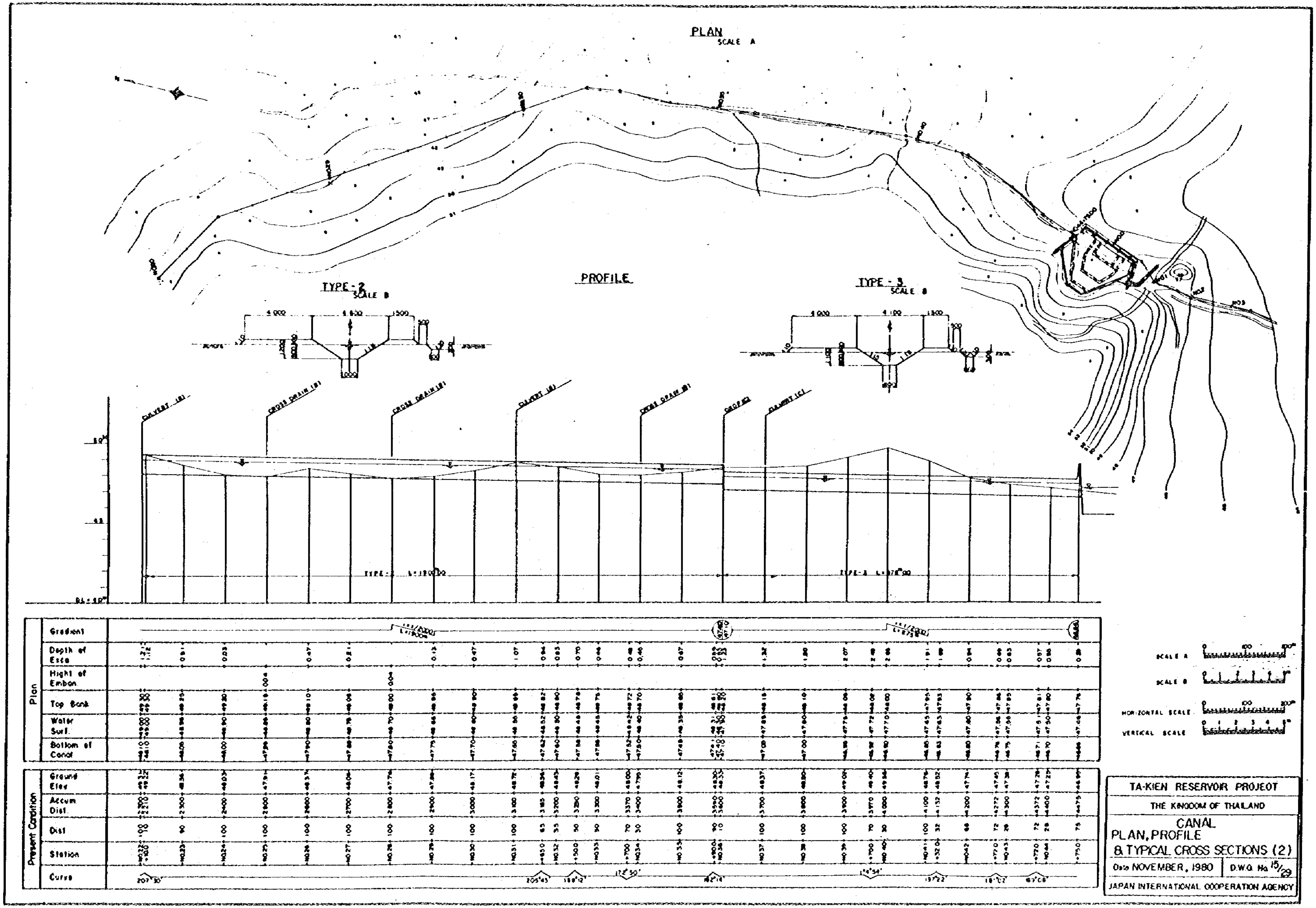

TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

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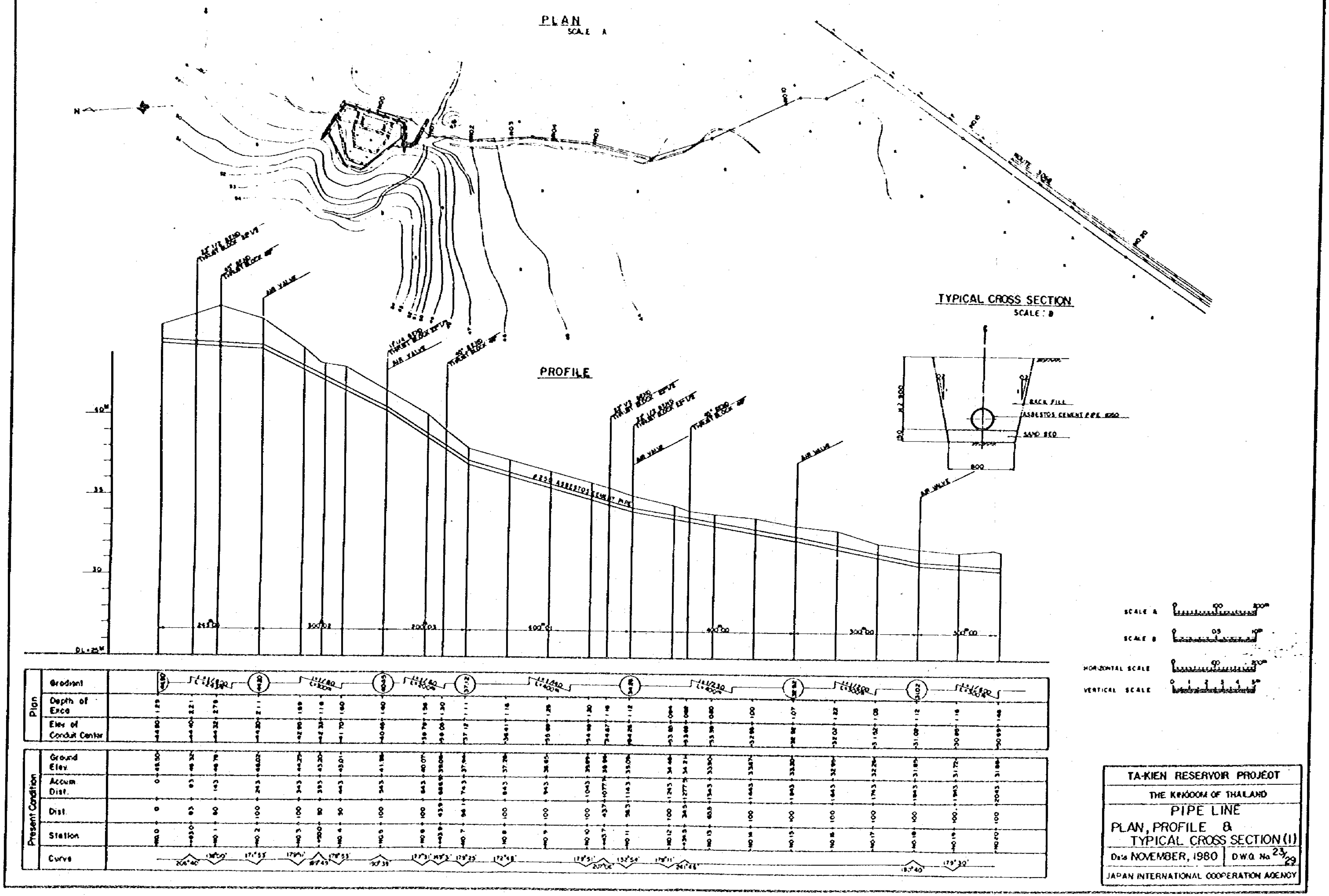


TA-KIEN RESERVOIR PROJECT

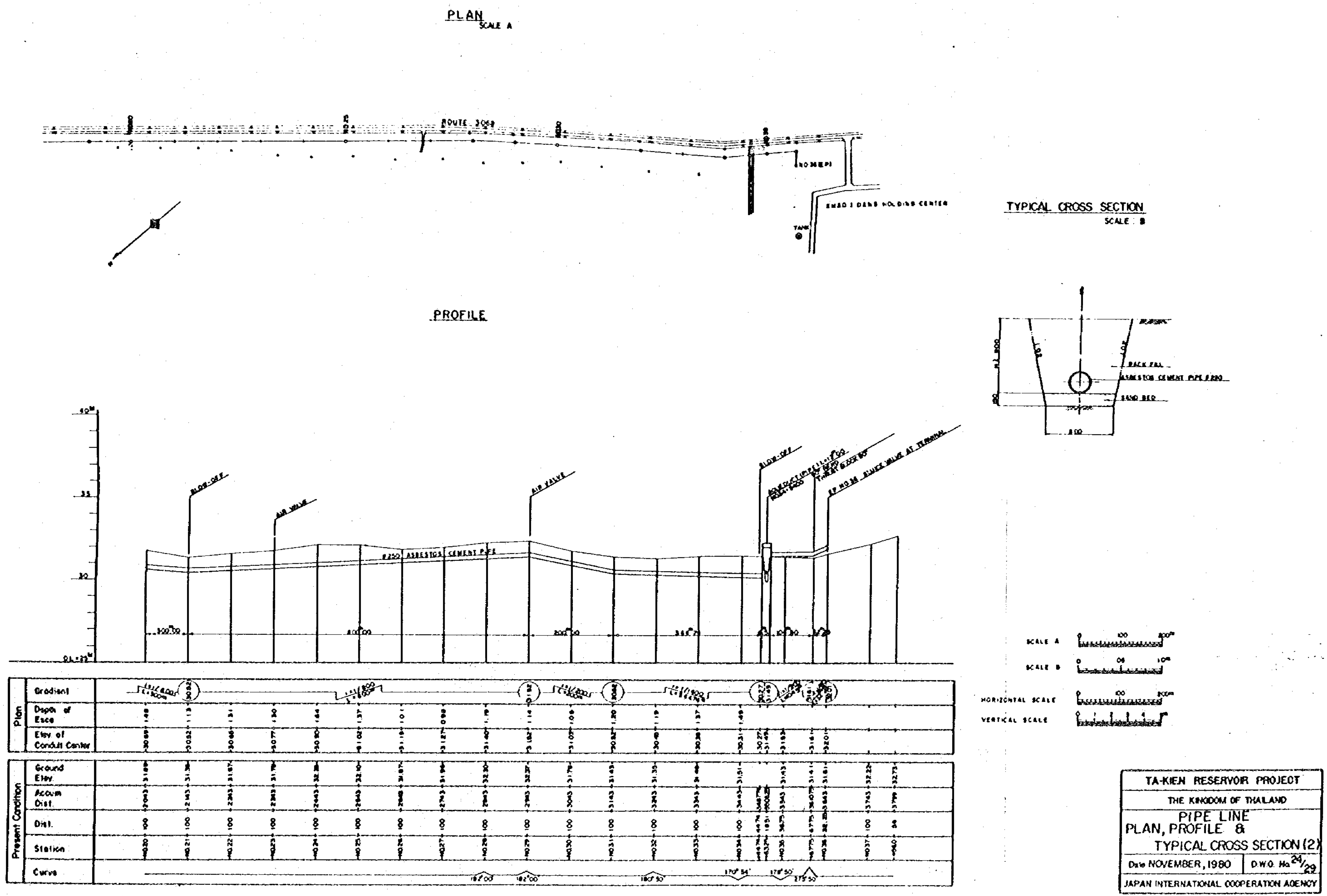
THE KINGDOM OF THAILAND

PIPE LINE

PLAN, PROFILE & TYPICAL CROSS SECTION (I)

Date NOVEMBER, 1980 | D.W.G. No. 23/29

JAPAN INTERNATIONAL COOPERATION AGENCY



TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

PIPE LINE
PLAN, PROFILE &
TYPICAL CROSS SECTION (2)

Date NOVEMBER, 1980 | D.W.G. No. 24/29

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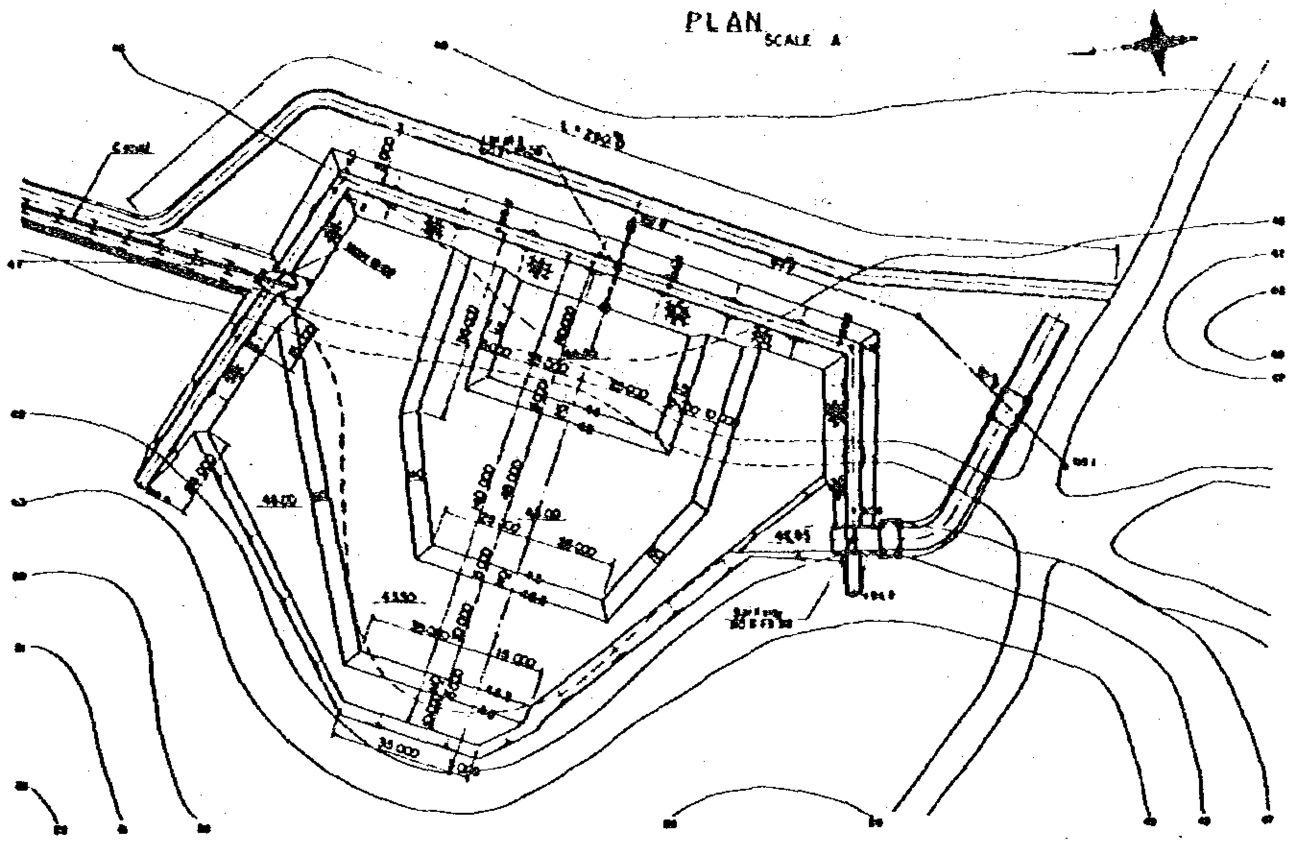

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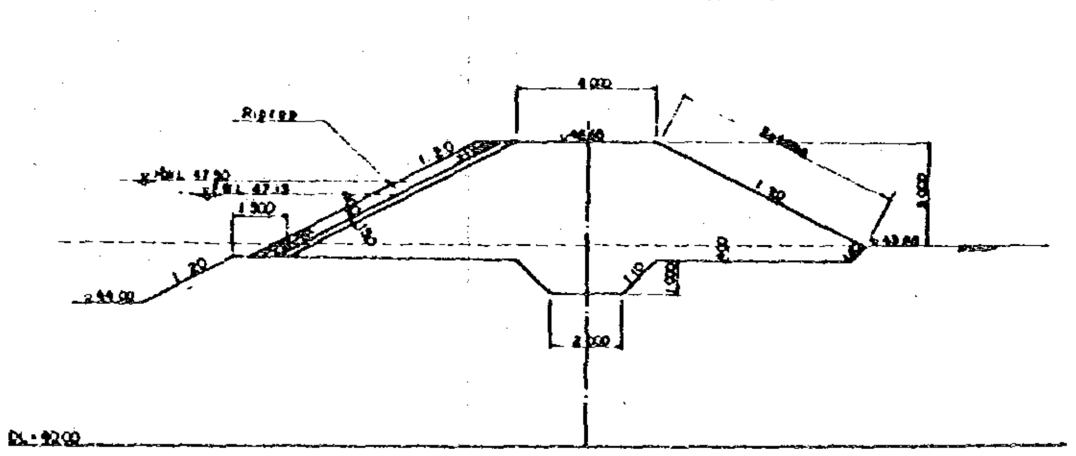
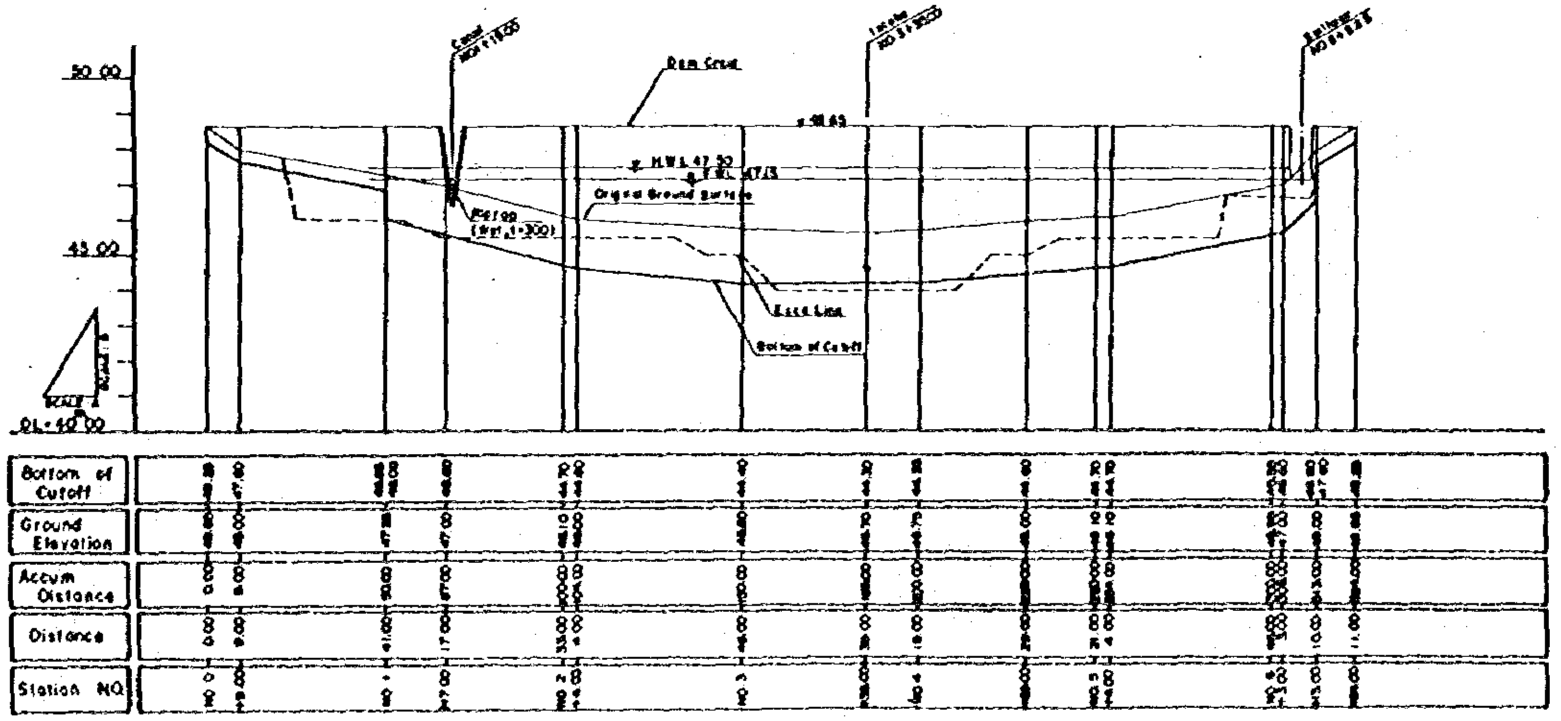
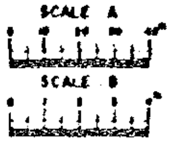


PROFILE





TA-KIEN RESERVOIR PROJECT

THE KINGDOM OF THAILAND

REGULATING RESERVOIR
PLAN PROFILE &
TYPICAL DAM SECTION

Date NOVEMBER 1980 | D.W.G. No. 27/29

JAPAN INTERNATIONAL COOPERATION AGENCY

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